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# bulletin

SPACE FOR EUROPE

European Space Agency
Agence spatiale européenne

## European Space Agency

The European Space Agency was formed out of, and took over the rights and obligations of, the two earlier European space organisations – the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO). The Member States are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Canada is a Cooperating State.

In the words of its Convention: the purpose of the Agency shall be to provide for and to promote for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

(a) by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
(b) by elaborating and implementing activities and programmes in the space field;
(c) by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
(d) by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

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## Agence spatiale européenne

*L'Agence spatiale européenne est issue des deux Organisations spatiales européennes qui l'ont précédée – l'Organisation européenne de recherches spatiales (CERS) et l'Organisation européenne pour la mise au point et la construction de lanceurs d'engins spatiaux (CECLES) – dont elle a repris les droits et obligations. Les Etats membres en sont: l'Allemagne, l'Autriche, la Belgique, le Danemark, l'Espagne, la Finlande, la France, la Grèce, l'Irlande, l'Italie, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaumi-Uni, la Suède et la Suisse. Le Canada bénéficie d'un statut d'Etat coopérant.*

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*(a) en élaborant et en mettant en oeuvre une politique spatiale européenne à long terme, en recommandant aux Etats membres des objectifs en matière spatiale et en concertant les politiques des Etats membres à l'égard d'autres organisations et institutions nationales et internationales;*
*(b) en élaborant et en mettant en oeuvre des activités et des programmes dans le domaine spatial;*
*(c) en coordonnant le programme spatial européen et les programmes nationaux, et en intégrant ces derniers progressivement et aussi complètement que possible dans le programme spatial européen, notamment en ce qui concerne le développement de satellites d'applications;*
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*Président du Conseil:* M. Lucena

*Directeur général: J.-J. Dordain*

**Editorial/Circulation Office**
ESA Communications
ESTEC, PO Box 299,
2200 AG Noordwijk
The Netherlands
Tel: +31 71 565-3408

**Editor**
Carl Walker
**Additional editing**
Peter Bond

**Design & Layout**
Eva Ekstrand & Roberta Sandri

**Advertising**
Lorraine Conroy

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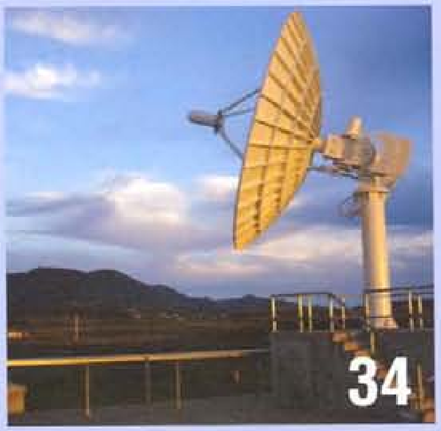
Artist's impression of Venus Express during the Venus orbit insertion manoeuvre on 11 April 2006. The spacecraft's main engine burned for about 50 minutes, to reduce its speed with respect to Venus to allow the the spacecraft to be captured by the planet's gravitation (ESA/AOES Medialab)


*Exploring Venus*


*Celebrating the Accomplishment, Preparing the Future*


*Space Tourism*


*Hands-on Activities in Education*




*Santa Maria Station*


*Vega Readies for Flight*

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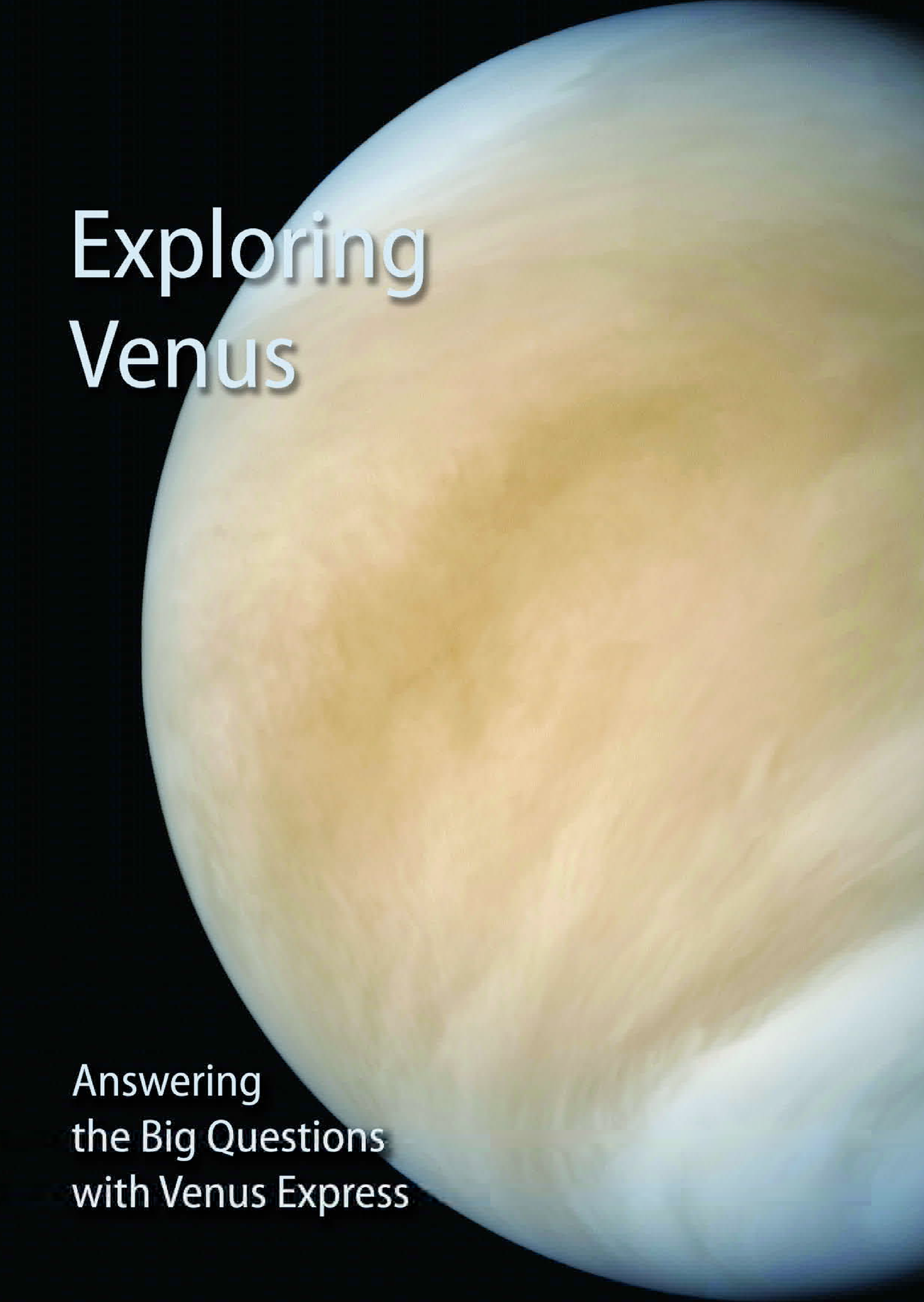
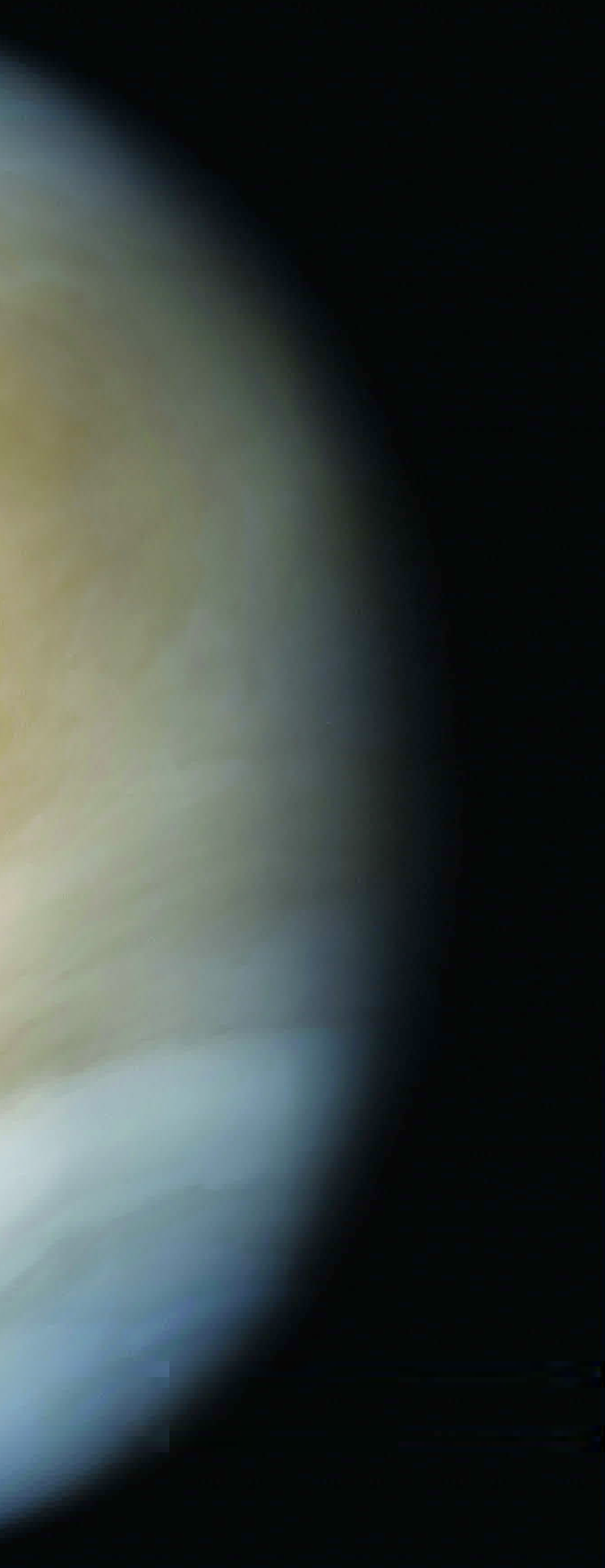
# Exploring Venus

## Answering the Big Questions with Venus Express







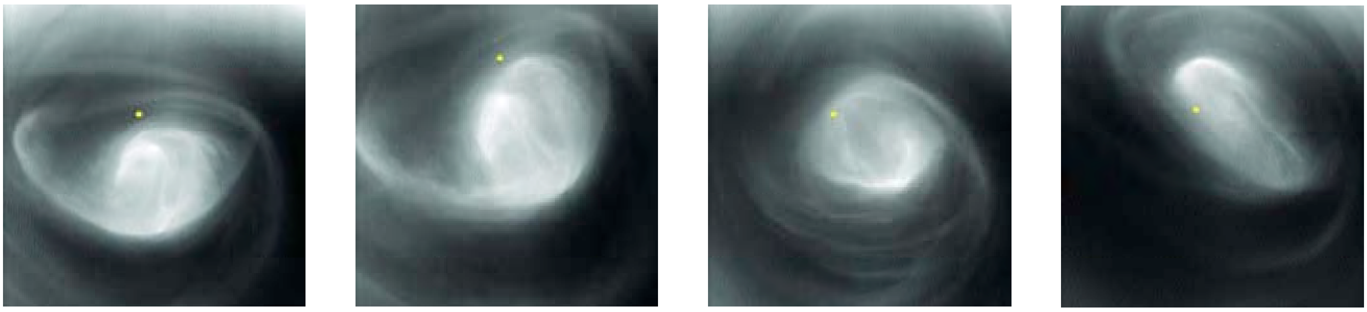
*Håkan Svedhem & Olivier Witasse*
Solar System Missions Division,
Directorate of Science and Robotic Exploration,
ESTEC, Noordwijk, The Netherlands

*Dmitry Titov*
Max Planck Institute for Solar System Research,
Katlenburg-Lindau, Germany

***After being seemingly 'forgotten', with no visitors from Earth for more than 15 years, Venus is back in the limelight as one of the most exciting planets to explore, and ESA's Venus Express is keeping scientists busy interpreting new data.***

Since arriving at Venus on 11 April 2006, ESA's Venus Express has provided a wealth of new data and is now keeping the scientists busy interpreting this information and modelling the results (see also *ESA Bulletin 124*, November 2007). With its design inherited from Mars Express, the Venus Express spacecraft has been performing very well during the two years in Venus orbit, in spite of being bathed in solar radiation four times more intense than at Mars and twice that at Earth.

Over 25 spacecraft have been previously targeted at Venus, but they have still left a great number of questions unanswered. Perhaps the most fundamental question is why Venus and Earth are so different today. Until even as late as the middle of the last century, it was generally believed that the



*A sequence of images taken by the VIRTIS instrument at a wavelength of 5 micrometres shows the vortex at the south pole of Venus at an altitude of approximately 60 km. After the first image, the second, third and fourth are four hours, 24 hours and 48 hours later respectively. Each frame is about 2000 km across. The yellow dot marks the position of the pole (ESA/VIRTIS/INAF/Obs.deParis-LESIA/Univ.Oxford)*

conditions on Venus were not too dissimilar from those of Earth and that possibly life existed there.

With the early missions of the 1960s, it became clear that no life could exist on the planet, at least not in the form that we know it. The surface has a temperature of over 450°C, hot enough to melt lead. The atmosphere is composed of 97% carbon dioxide and 3% nitrogen, at a pressure of 92 bar (about the same pressure as at a depth of 1 km under Earth's oceans). To add to these inhospitable conditions, the planet is covered in clouds of concentrated sulphuric acid.

## The Grand Question

Perhaps the most important problem to understand is why Venus has evolved in such a dramatically different way compared to Earth, despite many similarities like size, mass and (likely) bulk composition. Most probably Venus has had a significant inventory of liquid water in the past, perhaps even as much as Earth, while today the amount of water is equivalent to a global ocean with an average depth of only 3 cm (3 km for Earth).

Data from the SpicaV/SOIR instrument show that the ratio of HDO to $H_2O$ corresponds to a deuterium to hydrogen (D/H) ratio much higher than that on Earth (and the Solar System in general). This indicates that large amounts of hydrogen have escaped from the planet and left the heavier isotope deuterium in place. This lost hydrogen likely corresponds to the missing water.

How is this connected to the lack of a magnetic field and the time that the field disappeared? Is the lack of plate tectonics the key to the different evolution, or a consequence?

In the early days of the Solar System, the temperature must have been much lower. When and why did that change? Here are some of the results from Venus Express that could help us to answer these major questions.

## Venus's Atmosphere

The super-rotation of the atmosphere and the polar vortices are two of the major mysteries of the atmosphere. At the equator, winds reach over 100 m/s at an altitude of 60 km, and thus circle the planet in about four days. This is exceptionally fast, considering the long 243-day rotation period of the solid planet itself. Venus Express takes a few steps closer to solving these mysteries by mapping the atmospheric motion of the atmosphere in three dimensions and time. By measuring at infrared wavelengths of 1–3 micrometres, it is possible to probe different depths of the atmosphere and, thanks to the elliptical orbit with a pericentre over the north pole, it is possible to monitor the southern hemisphere for an extended time.

The sequence of four images demonstrates the highly variable character of the vortex at the south pole. It is not yet clear from where the driving force of this originates but it is obvious that there is a connection to the fast-rotating air masses at the mid and lower latitudes.

The next image shows a composite of a part of the southern hemisphere taken at a wavelength of 1.7 micrometres that shows the cloud structure at an altitude of about 45–50 km. By tracking features in several consecutive images of this kind taken at short time intervals, the wind speed can be estimated. By using different wavelengths, the wind speeds at different altitudes can be obtained. Elaborate models are used to take in many measured parameters, in particular

*A false-colour composite of the southern hemisphere on the night side of Venus made by the VIRTIS instrument at a wavelength of 1.7 micrometres. It shows the structure of the clouds at an altitude of about 45–50 km. The south pole is just above the top of the central frame(ESA/VIRTIS/INAF/Obs.deParis-LESIA)*

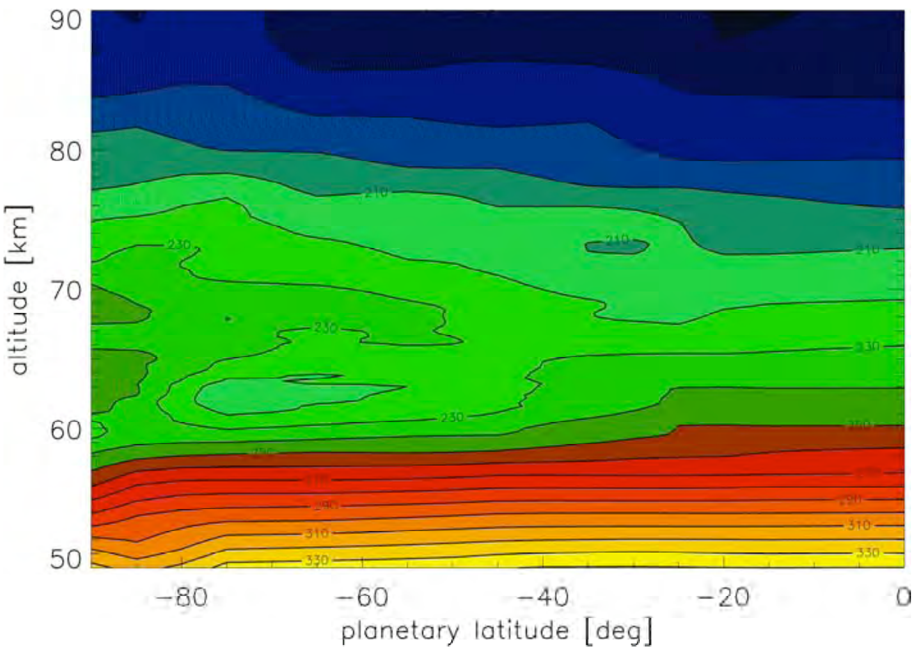
thermal profiles, and to try to reproduce these measured wind speed data.

The three-dimensional temperature distribution is very important for understanding the atmosphere. It is measured indirectly by three different methods, by the instruments VIRTIS, Vera and SpicaV, each focusing on different altitude ranges. The PFS instrument would have provided important additional data but, due to a malfunction, this instrument is not operational. The SpicaV instrument uses the stellar occultation technique to sound the temperature in the altitude range 100–140 km altitude

A warm layer at about 90 km altitude, close to the midnight position, has been discovered. This is believed to be caused by quickly downdrafting air that has been circulated from the sunlit side and migrated around the planet and being heated by compression while descending.

The Vera investigation uses a radio occultation technique through the telecommunication link to Earth to sound the temperature in the altitude range 40–90 km. This has revealed that the temperature in the lower atmosphere during the day and night is fairly similar around the planet for constant altitude. Between 60 degrees and 80 degrees northern latitude there is a thermal inversion in the tropopause at about 60 km altitude. This is a part of the 'cold collar', which marks the outer region of the polar vortex. This is likely to be caused by slowly downdrafting cold air making up the southern end of a 'Hadley cell'. This cell is a circulation pattern in the troposphere and mesosphere (below 90 km), with warm air rising in the equatorial region, transported polewards and descending to lower altitudes on cooling at these latitudes.

These two global circulation mechanisms, an East-West super-rotation combined with a meridional Hadley-type circulation below 100 km and a solar to anti-solar circulation above 100 km, co-exist and play a major role in the mixing of the different layers in the atmosphere.




*Temperature in a cross-section of the atmosphere from the equator to the south pole in the altitude range 50 km to 90 km for the night side. The cold 'polar collar' that encircles the pole can be seen between 60° and 80° southern latitude at about 65 km altitude*

## Atmospheric Composition and Chemistry

Apart from the major gases carbon dioxide and nitrogen, there are a large number of minor gases in the atmosphere, at the level of a few hundred parts per million or less. Of these, the most important are sulphur dioxide ($SO_2$), carbon monoxide (CO), water vapour ($H_2O$ and the related HDO), hydrogen chloride (HCl) and carbonyl sulphide (OCS). All these can be measured and mapped by Venus Express's SpicaV/SOIR and Virtis instruments.

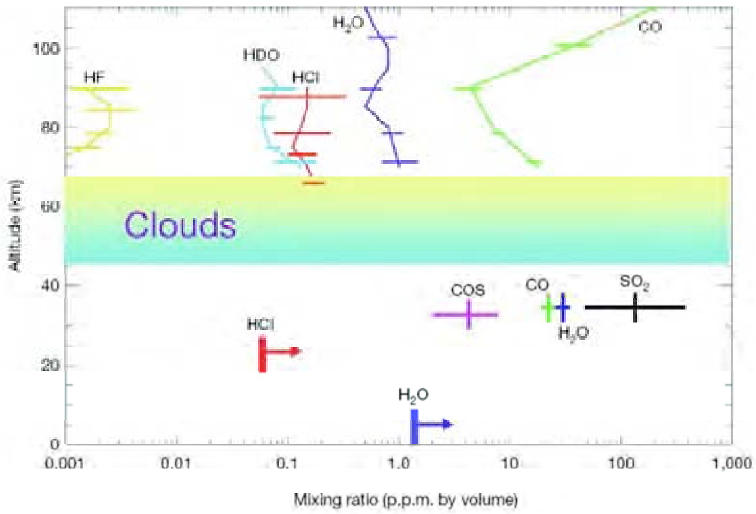
Recently, the hydroxyl radical (OH) was also detected by looking at the fluorescent light emitted by the excited molecule after having taken part in a chemical reaction. This very small amount of gas could be detected with VIRTIS by using limb-viewing geometry, where the amount of gas seen through a section of atmosphere at the limb appears to increase by up to a factor of 50 times as opposed to looking directly down to the surface of the planet. Hydroxyl is important because it is very reactive and normally has a short lifetime. The fact that we can see it means that there is a continuous production.

Nitrogen oxide (NO) and molecular oxygen ($O_2$) have been detected due to their fluorescent properties. Oxygen 'airglow' is fairly bright and can be observed also in nadir geometry and so images of its extension and dynamic behaviour can be used for general studies of the atmosphere at these altitudes (about 100 km).

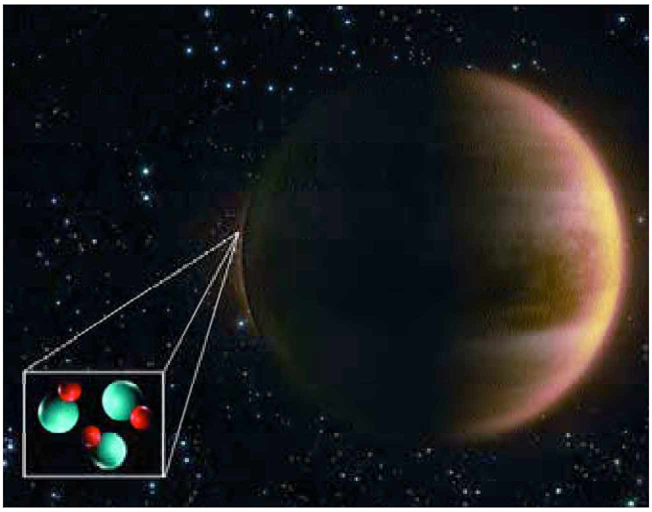
The oxygen comes from the $CO_2$ molecules on the sunward side of the planet that become dissociated into CO and O by the solar ultraviolet radiation in the upper mesosphere or lower thermosphere (about 100–120km). The oxygen atoms then travel around the planet to the anti-solar side where they descend and recombine with other oxygen atoms to form oxygen molecules ($O_2$). During the recombination the molecules become excited and they emit a photon with a characteristic wavelength of 1.27 micrometres. This is the 'airglow' observed.

## Cloud Layer and Hazes

Venus is constantly covered by a thick global cloud layer at an altitude of 50–70 km. This cover is the reason that




*Average abundance of the most important minor gases in the atmosphere. The horizontal bars are not error bars but the range that the data are spanning. Note that the sulphuric dioxide is very variable. The gases HCl and $H_2O$ in the lower atmosphere have not yet been measured. The bars indicate the minimum detectable amount*



*An artist's impression of the detection of the airglow of hydroxyl (OH) molecules on the night side of the planet. The signal is enhanced by looking at the limb of the planet*

Venus has an extraordinarily high albedo of 76%, meaning 76% of the incoming sunlight is reflected away from the planet by the clouds and does not contribute to the processes and the heating below. In visible light, almost no structure can be seen at the top of this cloud cover. In the ultraviolet light, however, an inhomogeneous distribution of an as yet still unknown absorber causes a significant amount of contrast that allows detailed studies of the top of the cloud layer. The VMC camera is well suited for this purpose with its wide field of view. Observations have shown a large temporal variation and that there are three distinctly distinguishable regions separated at latitudes of approximately 45 degrees and 70 degrees. VIRTIS data show that the cloud tops are located at about 70 km altitude except in the polar region, poleward of about 55 degrees latitude, where the cloud tops slowly drop to an altitude of 65 km at the pole.

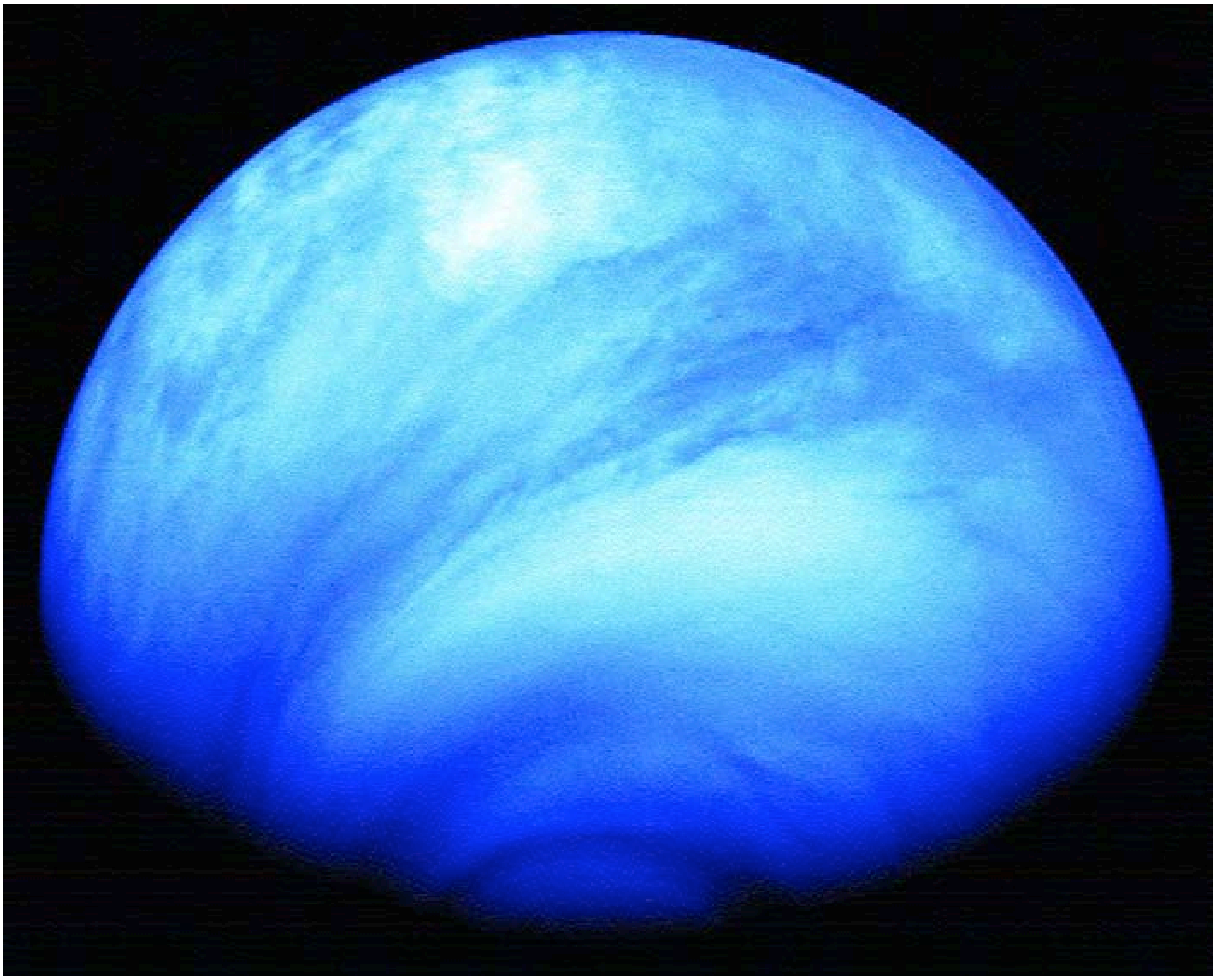
The sulphur cycle on Venus is very important since it includes also all the clouds and so has a major impact on the climate. The sulphur dioxide in the atmosphere is the source of the sulphuric acid in the cloud droplets. However, the sulphuric compounds on Venus have a lifetime of about 20 million years due to interaction with the surface. If there was no source to continuously supply sulphur dioxide to the atmosphere, the clouds would quickly disappear. The most likely mechanism for this supply is volcanic activity but no proof of existence of such activity has yet been found.

Data from the magnetometer give strong indications of the existence of lightning in the atmosphere. This is of great importance for the chemistry since lightning provides the extra energy required to synthesise many molecules. The frequency of the lightning appears to be similar to that of Earth but it has not yet been possible to estimate the energy of the individual lightning strikes. The lightning is not likely to occur between the clouds and the ground, but rather between clouds only.

## The Surface of Venus

From crater statistics, based mainly on data from the Magellan mission, it has been possible to determine that the surface of Venus is very young, geologically speaking, at 700 million years ±200 million years. Furthermore, there seems not to be any difference in the age of the different regions of the planet and therefore it is believed that a dramatic resurfacing event took place more or less simultaneously over the planet. The duration of this event does not necessarily need to have been short, it could be tens of millions of years or more, but it has no known comparison in the Solar System. Like the other terrestrial planets (except Earth), there does not appear to be any plate tectonic activity. Therefore it is of great interest to get a better understanding of the surface properties of this planet.

Both VIRTIS and VMC are capable of peering through the thick atmosphere and the cloud cover by using the 1 micrometre spectral 'window' in the infrared region and to study the surface on the night side of the planet. However, the droplets in the cloud layer will blur the images and limit the spatial resolution attainable to about 50–100 km. These images are maps of surface brightness temperature and not images in reflected sunlight. They will be used for the search for regions of anomalously high surface temperature that could indicate the presence of volcanic activity or fresh lava fields. For comparison, synthetic maps based on Magellan altimetric maps together with an altitude to temperature conversion factor are used. This comparison also yields maps of surface emissivity



*The sunlit side of Venus seen in ultraviolet light by the Venus Monitoring Camera from a distance of 30 000 km. The south pole is just below the lower end of the image and the equator is close to the upper limb running from left to right. The cloud structure in the equatorial region is dominated by turbulent regions, with convection cells forcing the air up or down in small packets. The mid-southern latitudes are characterised by long streaks in the clouds and clearly less convection while the polar region is dominated by the polar vortex (partly hidden behind the terminator) (ESA/MPS/DLR/IDA)*

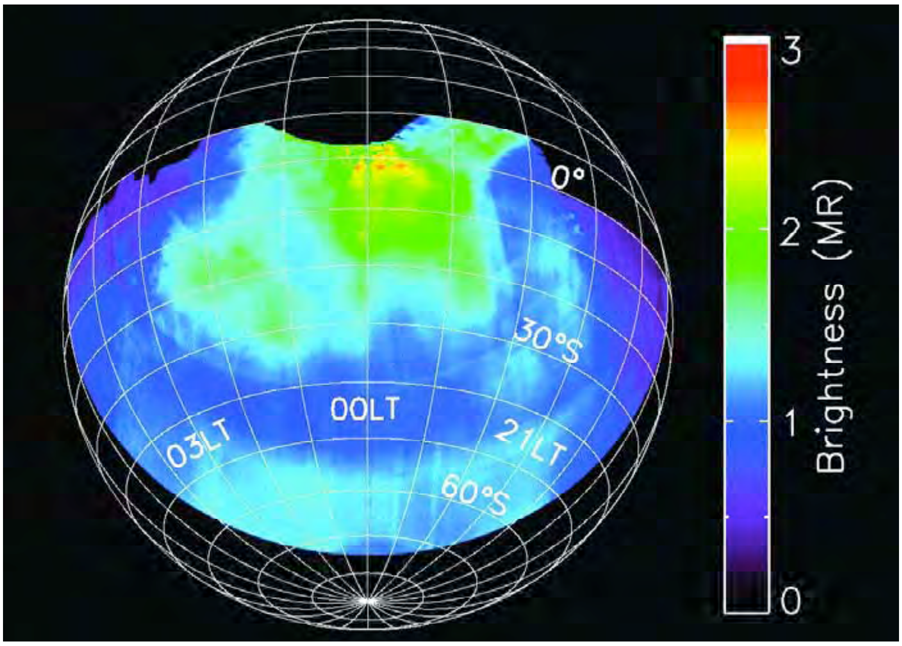
variations that are used for evaluation of different types of geological features.

## Impact of the Solar Wind

Venus does not have an internal magnetic field to protect the atmosphere, unlike Earth, so the solar wind can interact directly with the upper atmosphere and erode the atmosphere in a very different way. It is important to understand how this process works and what the impact on the evolution of the atmosphere has been in the past and will be in the future.

The Aspera instrument characterises energetic ions, electrons and neutral particles with respect to mass, flux, direction and energy in situ along the orbit of the spacecraft down to the pericentre at 250 km altitude. It is also characterising the different regions and boundaries of the induced magnetosphere together with the magnetometer. Both instruments make reference measurements of the solar wind when the spacecraft is outside the influence sphere of the planet. The two instruments together have determined the position of the bow-shock and the induced magnetospheric boundary and their relation to the solar wind parameters. Presently, the solar activity is near its minimum and these data complement well the data taken by Pioneer Venus in the 1980s during the solar maximum.

An important finding by Aspera is the absolute number of escaping hydrogen, oxygen and helium ions. A particularly interesting find is that the ratio of escaping hydrogen to oxygen is 2.6, which indicates that water is a major source of these ions. If all of both components of water escaped, the ratio would be 2, but since the oxygen is much heavier it does not escape as easily as hydrogen. This may explain the difference of 0.6. An




*A map of the oxygen airglow at 100 km altitude on the antisolar point. The maximum of the intensity is almost perfectly centred on the equator at local midnight. It is caused by oxygen atoms that combine to oxygen molecules and then fluoresce at infrared wavelengths*

in the atmosphere and the carbonate rock in the crust. We do not know how much carbonate rock there is on or below the surface but, at the present-day temperature on Venus, most of the carbon should be in the form of carbon dioxide in the atmosphere. This is in contrast to Earth for example, where most carbon is contained in carbonates in Earth's crust, while the total inventory of carbon on Venus and the Earth has been estimated to be equal, or at least within a factor of two.

## Conclusion

Perhaps the most likely answer to the 'Grand Question' is that the slight difference in distance to the Sun was the decisive factor. Due to this, the water on Venus started to evaporate creating a strong greenhouse effect that eventually cooked the carbon dioxide out of the

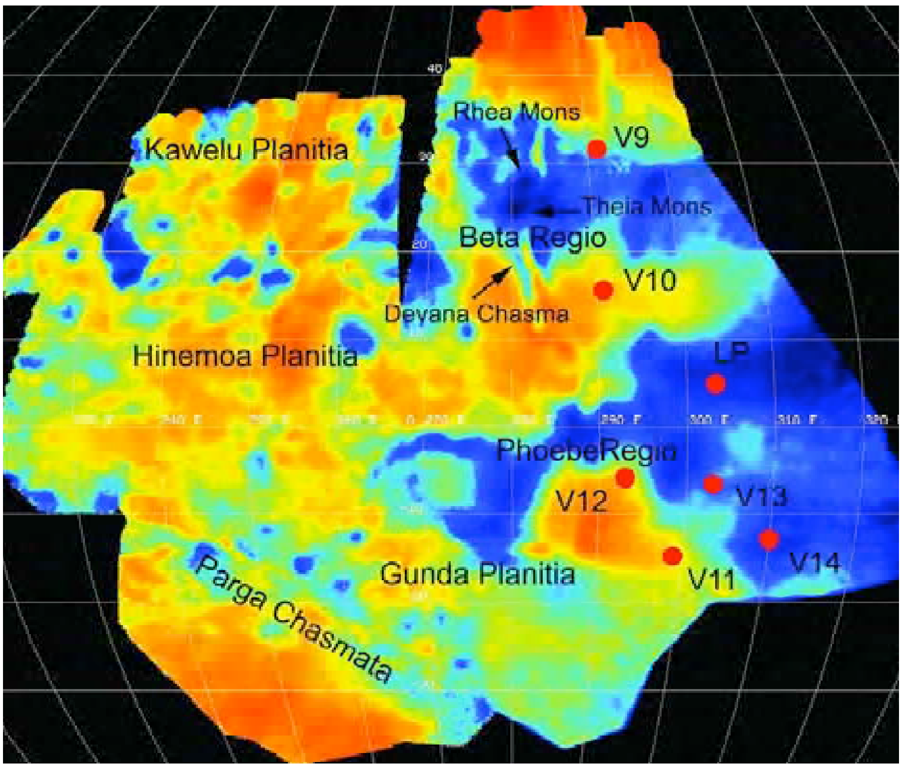
estimate of the present escape rate is a very important factor for understanding the evolution of water on the planet.

## Climate and 'Greenhouse Effect'

The greenhouse effect is strongly dominated by the vast amount of carbon dioxide in the atmosphere. The enhancement due to carbon dioxide only, on the surface temperature, has been estimated to about 420K. However the water vapour, even if at a low abundance, enhances the surface temperature by 70K and the cloud cover as much as 140K if the albedo effect is not accounted for. There are still important uncertainties in these numbers since the absorption lines of most gases at Venus conditions are not well known. Related laboratory studies in support of the Venus Express investigations are in progress. The net effect of the cloud cover on Venus, just as on the Earth, is not yet fully understood. Both extended theoretical work and more data will be needed for a better understanding.

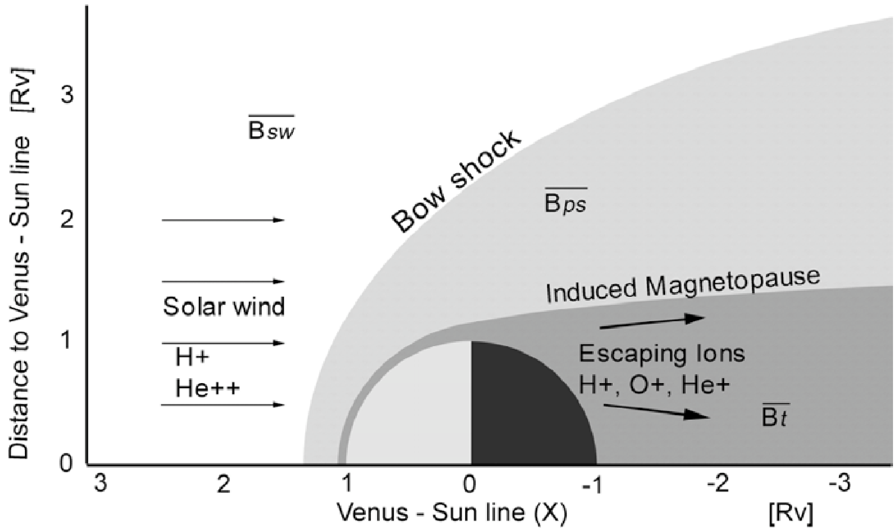
The carbon cycle is, or at least has been, very important since it relies on equilibrium between the carbon dioxide

*A composite of several images taken with the Venus Monitoring Camera. It shows the thermal radiation from the surface of the planet that is able to penetrate through the thick atmosphere, thanks to one of the spectral 'windows' at infrared wavelengths. The spatial resolution is limited due to strong scattering of the light while passing through the cloud layer. Orange-red areas indicate a high surface temperature (low elevation), while blue areas indicate a comparatively low surface temperature (high elevation). The red dots show landing sites of Russian Venera landers and the US Pioneer Venus Large Probe (ESA/MPS/DLR)*

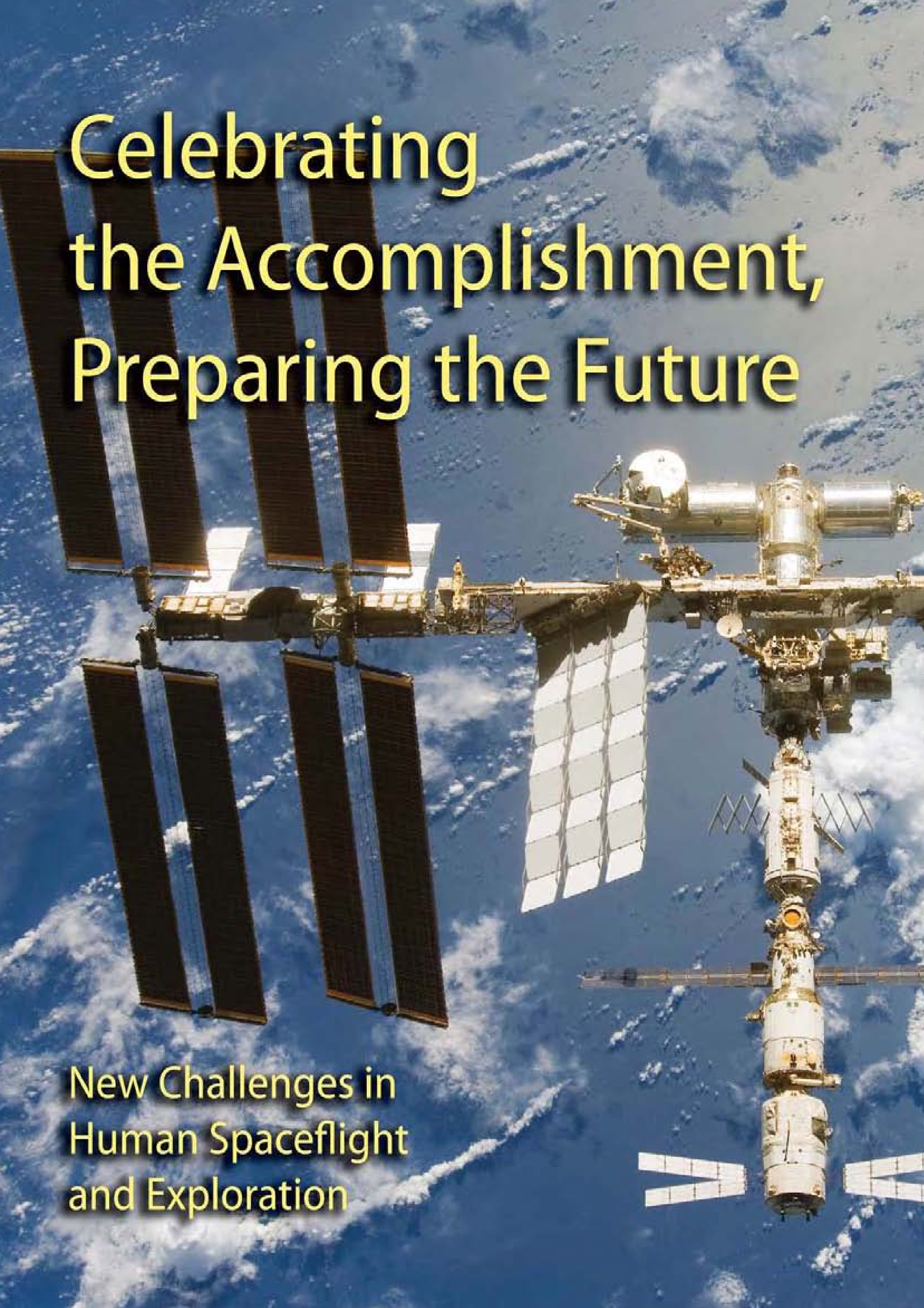


rocks, so putting the planet in a 'runaway greenhouse state'. On Earth, the oceans converted the carbon dioxide already in the atmosphere into carbonate rocks to become sediments on the ocean floor and so stabilise Earth's climate. More data still has to be collected and analysed, but data from Venus Express processed so far are all compatible with this scenario.

It is not possible to get a complete understanding of how the climate works and evolves on one planet without having an understanding of it works on all planets in the inner Solar System. Understanding Venus is essential for understanding Earth. The coming years will see several studies focusing on comparing the different aspects of the evolution of Mars, Venus and Earth, in order to progress toward such a general understanding.




*The plasma environment around Venus. The x-axis is pointing toward the Sun and the y-axis shows the distance to the Sun-Venus line (in radii of Venus). Venus has no internal magnetic field but, due to an interaction between the solar wind, the heliospheric magnetic field and the planet itself, an artificial protective bubble is set up around the planet. Due to the pressure of the solar wind, this bubble becomes deformed and very asymmetric and lets the solar wind come much closer than for example it does at Earth. The location of the boundaries called 'Bow shock' and 'Induced magnetopause' are found by both the magnetometer and the Aspera instrument. Planetary ions, notably hydrogen and oxygen (constituents of water), escape the atmosphere through the wake in the solar wind*


Celebrating
the Accomplishment,
Preparing the Future
New Challenges in
Human Spaceflight
and Exploration

Backdropped by Earth, the ISS is seen from Space Shuttle Discovery on 12 June 2008 during the STS-124 mission (NASA)

*Simonetta Di Pippo*
Director of Human Spaceflight,
ESTEC, Noordwijk, The Netherlands

***ESA's new Director of Human Spaceflight looks at how we have demonstrated Europe's ability to live up to our ambitions in human spaceflight, and how we are entering the next phase of the human exploration of space.***

The International Space Station (ISS) is today a beautiful reality, an international accomplishment which Europe, through ESA, is proudly part of. The European-built Node-2, the ESA Columbus laboratory and Automated Transfer Vehicle (ATV) are key contributions to an endeavour that has brought humanity to live and work in space uninterruptedly for almost a decade now.

Five international partners representing 14 nations have succeeded to bring to life the largest civilian cooperative project ever conceived. Hundreds of thousands of skilled workers throughout the world have been working to build and operate the ISS, learning from each other. Citizens from all over the world have witnessed in amazement male and female astronauts from many nations working together to assemble and utilise this first international human outpost in outer space.

Much has been said about the ISS, but it will always be a reminder of the human desire to explore and push the frontiers, a signpost for future directions in our space activities.

One cannot celebrate the ISS without thinking of those who have lost their lives in this enterprise, reminding us all that space activities, even though much safer than before, still represents a risk that requires all the possible safety measures.

The near-completion of the ISS however compels us to act rapidly in order not to waste the investment made so far and not to dissipate the human capital and knowledge gained over the last two decades.

This was the consideration that led ESA to define and propose to its Member States in 2001 the European space exploration programme Aurora. In a different context, this was also, at least partially, the underlying consideration in the US Presidential Vision for Space Exploration announced in January 2004 that eventually turned NASA in a 'space exploration agency'.

## The Next Phase of Space Exploration

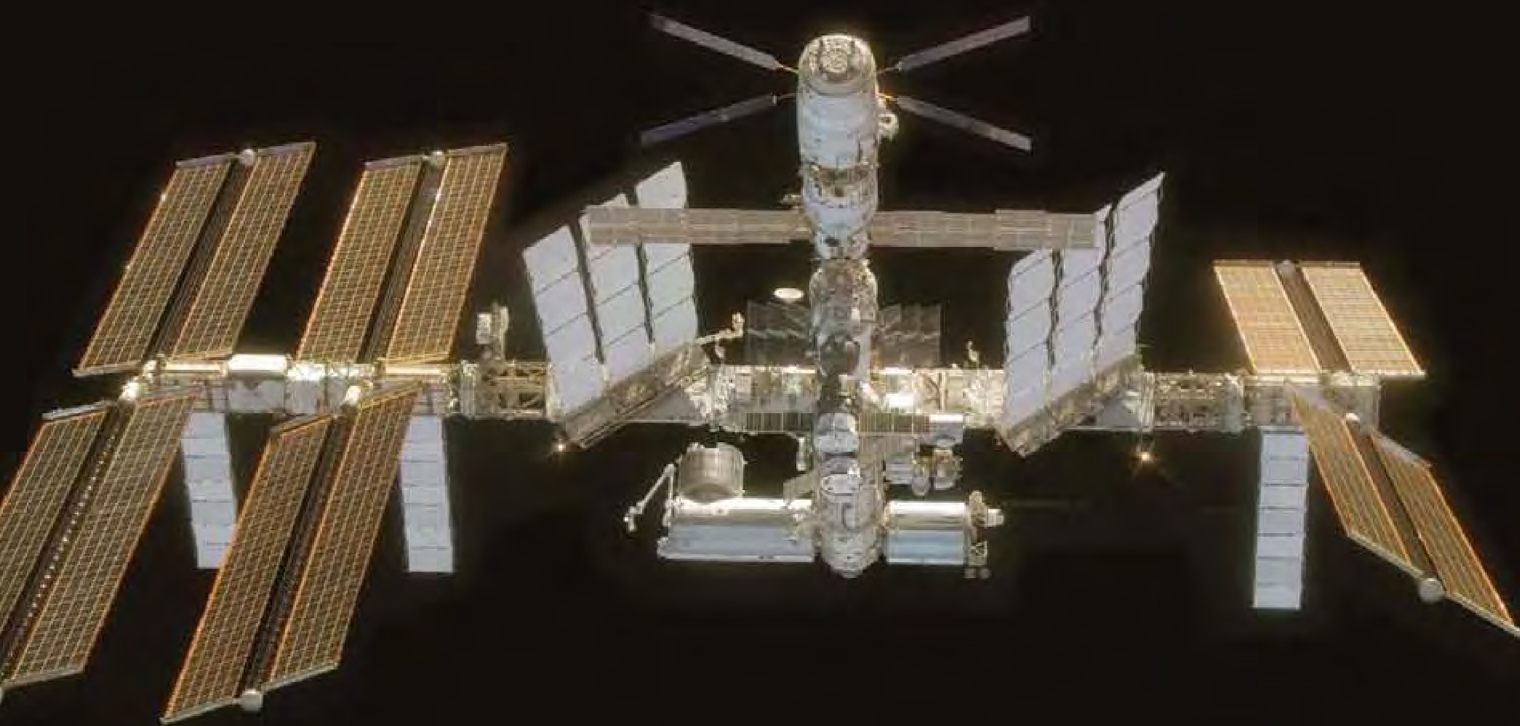
The first phase of space exploration is now over. During this phase, we learned to fly in space, to live and work there, but always remaining safely close to Earth. In parallel, our robotic proxies have reached out and conducted an initial, but no less fascinating, exploration of more distant planets, including Mars, which remains the ultimate destination for a human mission.

We are on the edge of a second phase that promises to be much more rewarding as we build on the accomplishments and the experience gained previously, in order to go farther than low Earth orbit and to do much more.

This next phase will be characterised by a number of important players with similar capabilities, a second wave of innovation linked to space exploration, an accrued attention paid to economic factors and, possibly, by the emergence of private enterprise in human spaceflight and exploration. Because this second phase aims at a sustained effort in space exploration, cooperation will be even more important and will occur probably at global level.

With this in mind, 14 space agencies worldwide have produced an important document called 'Global Exploration Strategy: a framework for coordination'.

*The ISS as seen from Space Shuttle* Discovery *in June 2008 after the addition of the Japanese Kibo module (lower centre near ESA's Columbus). ESA's ATV* Jules Verne *is at the top, recognised by its familiar diagonal cross of solar panels (NASA)*



With a significant contribution from Europe through ESA and four national space agencies (ASI, BNSC, CNES and DLR), this document lays down the common vision and objectives by possibly all space agencies involved or interested in space exploration.

It also provides for a mechanism of coordination and for multiplying the opportunity for cooperation. The first element of this mechanism is an International Space Exploration Coordination Group (ISECG) that is meant to implement, with the support of a Secretariat, the strategic vision contained in the document. The experience and the tradition of working together that we have gained in the ISS will come in very useful as we plan to pool our resources for a robust and sustained space exploration effort.

## Europe's Role in Human Spaceflight

Europe has secured an important role in the ISS partnership and has lived up to its commitments brilliantly. We should credit the European industry in developing and manufacturing the space hardware that has been working flawlessly since the first day of installation and ever since. Columbus, ATV, Node-2 and many other elements have gained for Europe the respect and compliments from all international partners. Special credit goes to past ESA Directors of human spaceflight

activities, Jörg Feustel-Büechl, who had for such a long time skilfully managed the ESA ISS programme, and Daniel Sacotte, under whose mandate all the major European elements were launched and successfully commissioned.

Through the participation in the ISS endeavour, ESA has been able to gain an important experience in human spaceflight. The European Astronaut Corps is a valuable asset for Europe, not only for the individual European countries, but also for our international partners as the recent positive performances of our astronauts have shown.

In May and June this year, over 9000 European men and women, from all ESA Member States, enthusiastically responded to ESA's call for a new class of astronauts. They are the proof that human spaceflight is not only a highly technical and innovation-rich activity, but also can still make people dream. They represent not only the individual wish to accomplish something exceptional like becoming an astronaut, but also the desire to see Europe playing a visible role in the future space exploration.

Europe cannot afford to remain at the margin of what is bound to be one of the great undertakings of this century. Expanding human presence in the Universe, namely on the Moon and later on Mars, will positively mark humankind and our societies. This great challenge will be a source of inspiration and of mutual understanding as we cooperate to reach a goal unattainable by any nation on its own. Resolving the engineering and logistic issues of sustained surface operations, with the requirements in term of mobility, energy and life support systems, will boost research and innovation in fields that are also vital to the well being of millions of men and women on Earth.

## Themes For the Future

Space exploration will also be a great diplomatic and geopolitical opportunity where the relative influence will be as important as the capabilities each player can display. Additionally it is likely that only those nations that participate and contribute to a significant level in space exploration will have a real say in a possible evolution of the current international principles regulating the use of outer space.

The main themes that ESA will be presenting to the Ministers of ESA Member States, in the ESA Ministerial Council in Den Haag in November 2008, are:

- building on the investments made in the past and the resulting industrial know-how and human capital;
- contributing to a knowledge-based economy and social growth in Europe;
- stimulating innovation and research;
- fostering European geopolitical role and inspiring our citizens, and
- providing a unifying and very visible example of a world-class European programme.

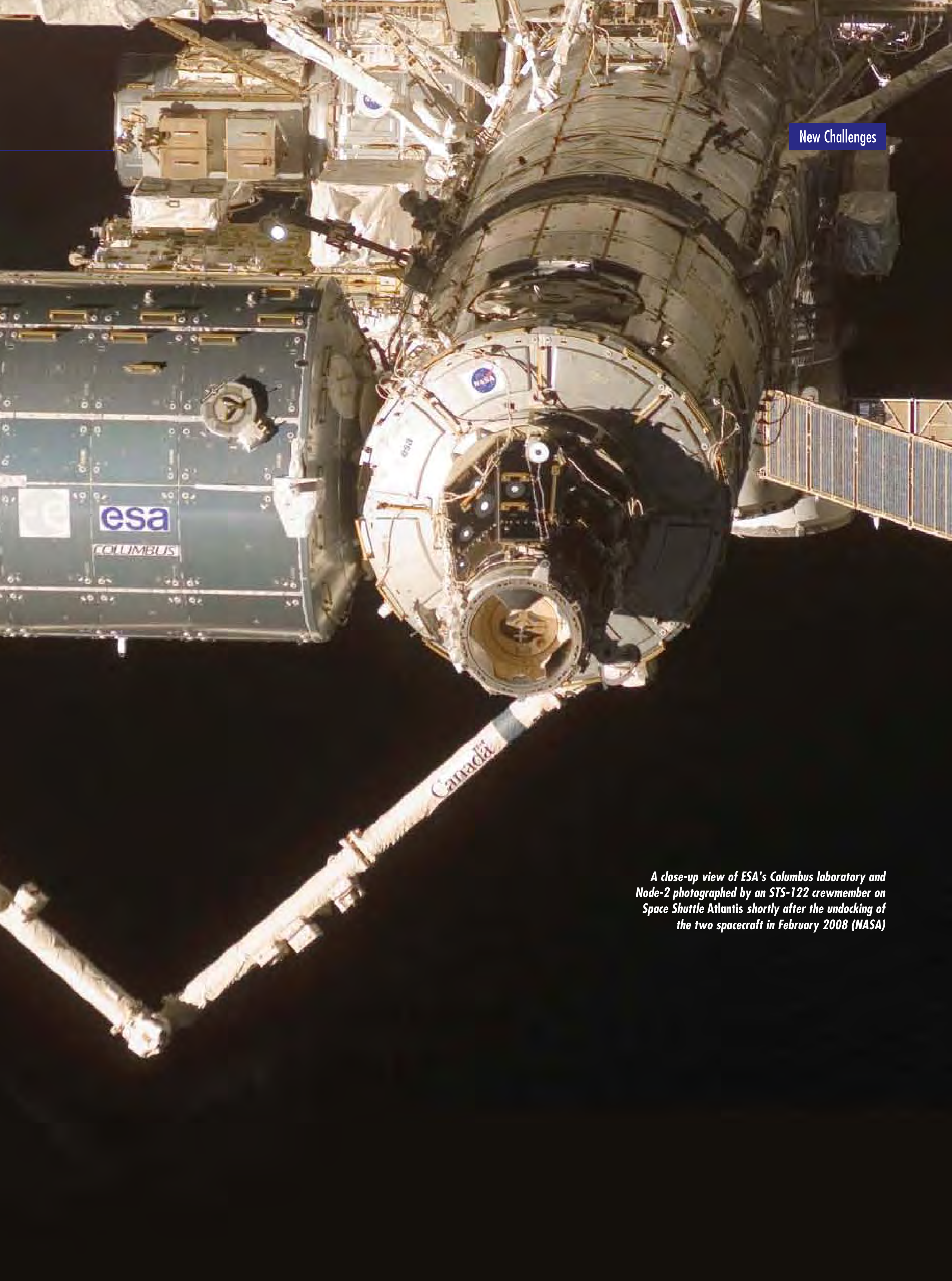
These are ambitious but affordable proposals regarding its future role in the global endeavour of space exploration.

European decision-makers demonstrated vision and inspiration when they backed the Aurora programme, first in 2001 as a preparatory programme and subsequently in 2005 as a fully fledged programme. These decisions have given Europe the required leverage, credibility and framework to be recognised, together with the recent successful missions, as a credible and important partner in space exploration.

The ExoMars mission in 2013 is not only a European flagship mission, but also a key element of the international effort to better understand and characterise Mars in preparation of future human missions. The work conducted on architectures, generic exploration technologies, life-support systems and, in particular, on a Mars Sample Return mission concept has reinforced this role for ESA and Europe.

## Autonomy and Cooperation

We need to keep this direction and at the same time consider a step forward to enhance our role and increase our autonomy, both to reinforce partnerships and to better serve European interests.




*A close-up view of ESA's Columbus laboratory and Node-2 photographed by an STS-122 crewmember on Space Shuttle* Atlantis *shortly after the undocking of the two spacecraft in February 2008 (NASA)*

*ESA astronaut Hans Schlegel seen during his spacewalk on the STS-122 mission to install Columbus. (Right) ESA's ATV Jules Verne seen in flight before docking with the ISS in April 2008 (NASA)*

‘Autonomy for enhanced cooperation’ is how we like to refer to it. Increasing European capabilities for the reasons described will eventually result in a more robust and sustainable global space exploration effort.

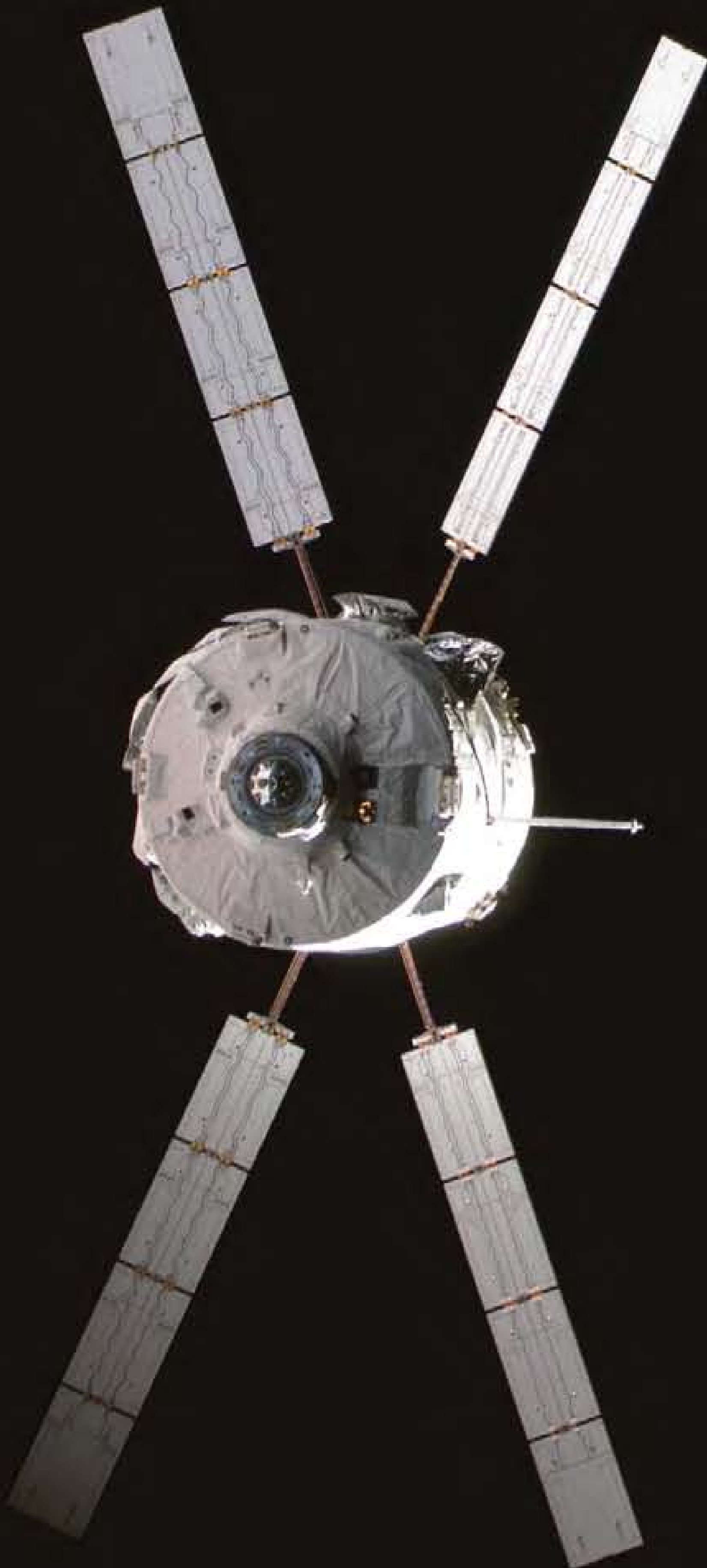
Only one element will allow Europe to make this leap and reach a higher status among spacefaring nations, and this unique element is an autonomous capability in space transportation and its further evolution.

## The Next Logical Evolution

The ATV’s capabilities are a great help to overall ISS logistics and a pride for Europe, ESA and our industry. We have the duty to build on this accomplishment, to continue down the path of a European capability that would return cargo initially and to prepare for its next logical evolution.

Industry has already been working on similar concepts. Today it seems that there is also a convergence among key players in the institutional European space landscape. Our successes have boosted our confidence and provided us with a capital of credibility that will evaporate if we wait too long. The international context is favourable as space exploration is top on the agenda of most of the space agencies worldwide.

We need to seize this opportunity and in the next months lay down the foundations for European programmes that will determine our role and positioning in the decades to come, and that will probably define our contribution to one of the biggest enterprises that humankind will undertake this century - taking humans to the surface of a distant world.



# Space Tourism

## ESA's View on Private Suborbital Spaceflights

Artist's impression of a commercial spaceport (Virgin Galactic)



*Andrés Gálvez & Géraldine Naja-Corbin*
General Studies Programme, Institutional Matters and Strategic Studies Office, ESA HQ, Paris, France

***Suborbital spaceflights offering opportunities to 'touch' space and experience 'weightlessness' are creating substantial public interest. These developments are closely related to ESA's core business, and we are observing them with interest.***

## What Do We Mean by 'Space Tourism'?

There are different possible definitions of 'space tourism'. Here we use the term to mean suborbital flights by privately funded and/or privately operated vehicles and the associated technology development driven by the space tourism market.

## Current Context

Activities linked to space tourism have been gaining momentum and we have seen some remarkable achievements during the last few years, such as the flight of *SpaceShipOne*. There is large public interest in human suborbital flights, and the figures of prospective paying customers quoted in recent market surveys show that space tourism offers the potential for sustained progress similar to what happened in the


*Today, students and scientists can experience 'weightlessness' while flying on modified aircraft for microgravity research*

early days of aviation. Suborbital flight vehicles, designed for use over and over again, could gradually bring down the costs, as the technology and the operational approach become more mature.

The cost for individuals to fly on a manned suborbital spaceflight was initially projected at about US$ 200 000 with over 200 private persons having made an advance payment to fly on *SpaceShipTwo* in the case of Virgin Galactic. This is expected subsequently to drop to about US$ 50 000 with roughly 16 000 passengers interested to fly in 2021, according to the 'Space Tourism Market Study' conducted in 2002 by FUTRON, a US-based space consultancy firm.

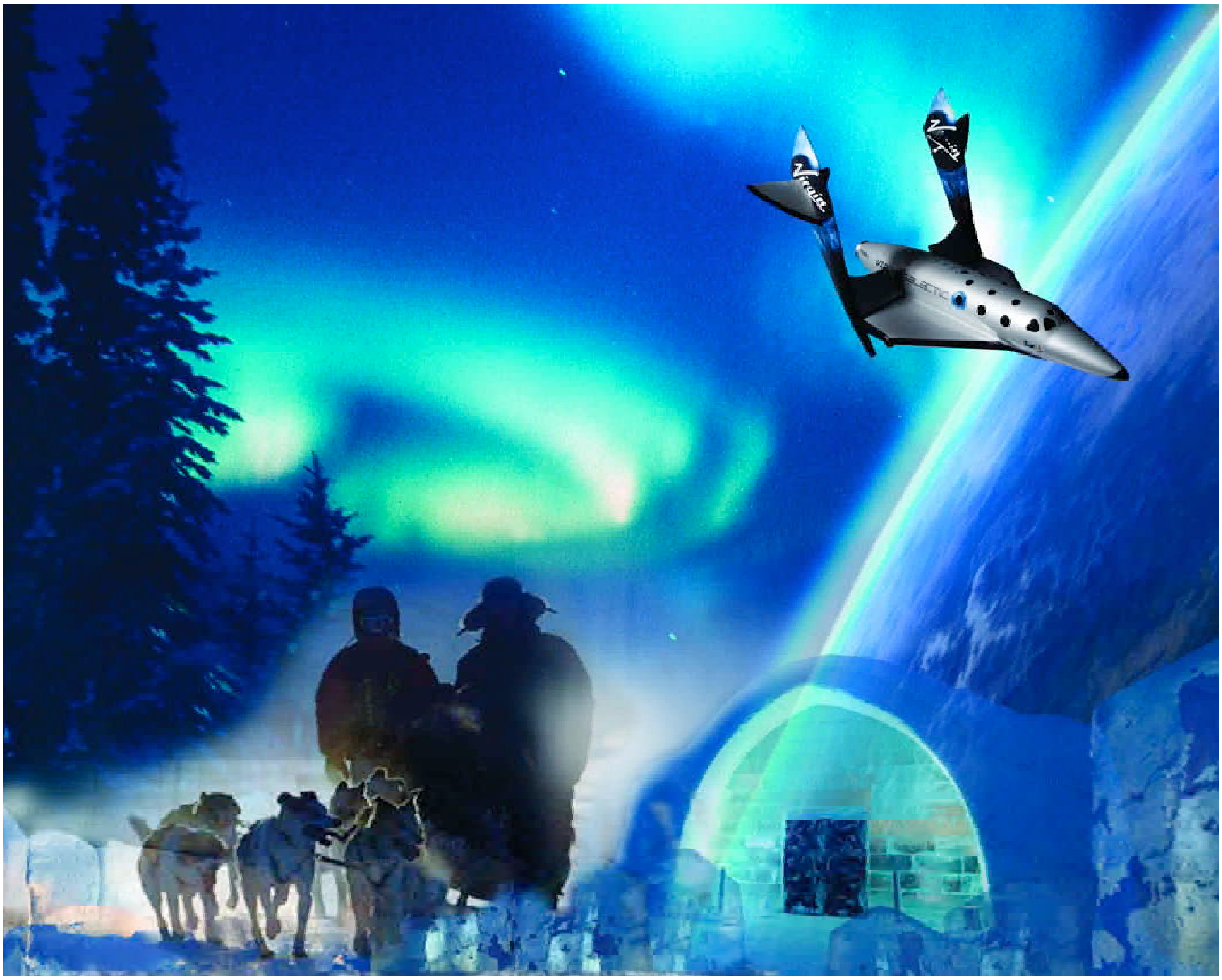
These developments might have deep and significant implications for space activities as a whole. Being at the heart of Europe's space activities, ESA is expected to have a position on space tourism, and needs to have a coordinated and corporate approach with respect to these activities.

## A Position on Space Tourism

To provide a better understanding of this emerging industry, several assessments have been carried out by ESA over the last four years. For instance, ESA has coordinated and participated in a European Commission FP-6 funded study on the development of commercial high-altitude flight. On 7 November 2007, ESA's General Studies Programme presented the results of its 'Study of European privately funded vehicles for commercial human spaceflight' at ESTEC in The Netherlands; the study was aimed to understand the dynamics of specific European space tourism ventures.

As a follow-up, an internal ESA Working Group was set up with the goal of making recommendations based on

*SpaceShipOne seen making its historic suborbital flight in June 2004 (Virgin Galactic)*



*A publicity poster concept for Spaceport Sweden, a company that plans to make Kiruna the primary European spaceport for personal suborbital spaceflight and space tourism. It is a cooperation between the Swedish Space Corporation, the Jukkasjärvi Icehotel, LFV Group and Kiruna's business-development company Progressum (Spaceport Sweden)*

these studies; their work was endorsed by all ESA Directors on 14 April. The International Academy of Astronautics' 'First Symposium on Private Human Access to Space' in May 2008 provided the opportunity to present these conclusions to a wider external audience.

## Different Dimensions of Space Tourism Relating to ESA Activities

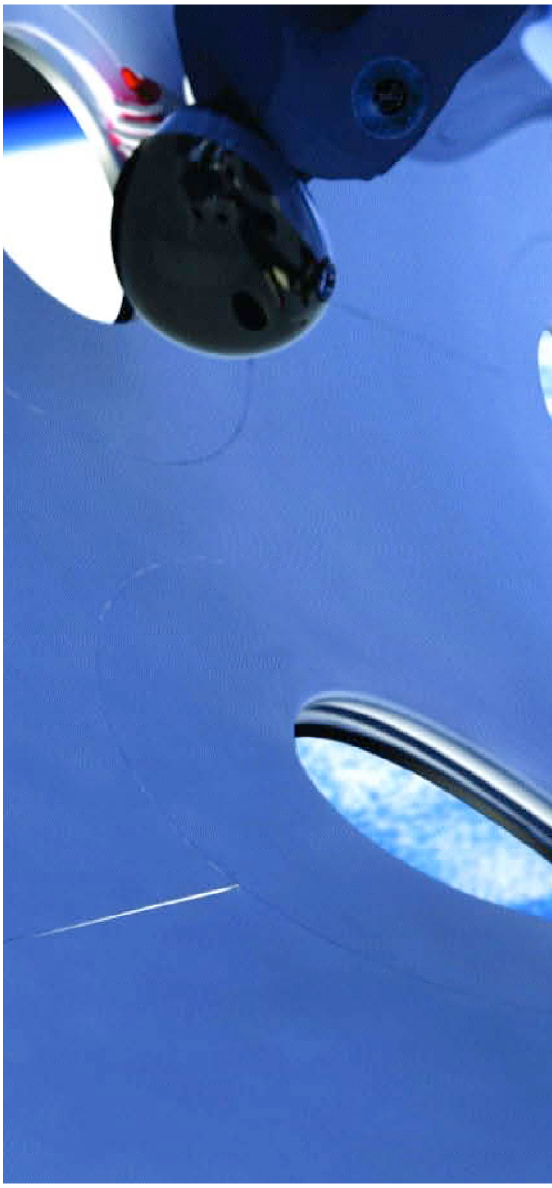
There are many different aspects linked to space tourism that may have an impact on ESA. The major features of such relationships are:

***Technology and operations***

The growth of space tourism would encompass significant new developments in aerospace technologies, and bring an aeronautics perspective to space technology development and operations, in particular concerning the aspects of reusability and routine processes associated to the high flight rates. So far, it has been demonstrated that suborbital flight at around 100 km can be successfully carried out a few times in a row with a prototype vehicle. The real challenge will be to have a vehicle that allows flying many missions, with associated operations, in a profitable way. This achievement would have a significant impact in the space sector. In the aeronautics sector, if successful, such development could lead in the long term to high-speed vehicle concepts, with the potential to reduce drastically the duration of long-distance flights.

***Commercialisation and partnership development***

Space tourism efforts are also related to the ultimate goals of human spaceflight programmes, i.e. enabling routine human access to space and the preparation of the long-term, sustained



*Subordinal Flight is an EADS Astrium concept for a takeoff and one-stage journey into space for up to five people. Beginning with a 45-minute cruise to an altitude of 12 km, rocket propulsion takes over from the jet engines and the space plane is boosted in almost vertical attitude for 80 seconds to ascend to over 100 km (EADS)*

human exploration of the Solar System. In this sense there is also a link between space tourism activities and exploration programmes, even if the end-objectives and requirements are completely different.

There is thus an interest in supporting the emergence of private business in the context of human spaceflight. In the longer term, and based on technologies developed in the frame of institutional programmes, privately developed and operated infrastructure elements derived from space tourism undertakings could one day become building blocks of a open space exploration scenario.

***Legal aspects and regulatory framework***

The challenges for space tourism are not only technical ones. Especially in the European context, there are important aspects to be addressed from a legal standpoint.

Space tourism will be carried out substantially in the airspace of a given country and therefore, it will be subject to the local legal framework – which might be different from country to country. It is therefore essential that the civil aviation regulatory authorities of the countries concerned and the competent agencies of the European Union are at the forefront of the setting up of a regulatory framework for space tourism adapted to the European scenario.

ESA must also consider other legal matters. Space tourism will certainly have a significant influence on aerospace

*Artist's impression of future space travellers enjoying the 'weightless' environment (Virgin Galactic)*

industry, in view of the opportunities it may create, but also of the competition it may foster. In order to support the emergence of new European capabilities without distorting such competition, ESA should carefully define the boundaries of any space tourism support activities in line with the ESA Convention.

Finally, since in the longer term space tourism should involve traveling in space, some rules of space law may also find application for space tourism; in particular, the notion of 'launching state(s)', through its administrative national agency designated for carrying out space activities, will have a role to play in exercising jurisdiction and control over that activity.

***Communication aspects and visibility of space activities***

The development of a larger space tourism market and potentially a larger number of citizens experiencing spaceflight will have an impact on the visibility and perception of human spaceflight/exploration in the general public. ESA will have to consider such development in its communication strategy. On one hand, the aim should be to take advantage of such additional outreach activity for the benefit of the space sector; on the other, ESA should use its communication tools to explain the differences in technical complexity, requirements and ambitions of space tourism and those of 'classical' human spaceflight and exploration activities.

## Guidelines of ESA's Position on Space Tourism

Considering the balance between the potential advantages of space tourism (high visibility of space, additional development efforts of space technologies, increased appeal for science and technology education, creation of new commercial markets, etc.) and its potential risks or drawbacks (environmental aspects, safety issues, exclusiveness of an activity aimed initially at a small minority of the population), ESA is taking a position of cautious interest and informed support, with the following guidelines:

1. ESA should monitor the relevant technology activities and assess whether spin-ins and spin-offs could be envisaged for/from European space programmes.
2. While avoiding interfering in the development of a fully competitive market, ESA should further reflect on possible partnership with European ventures or support actions, based on mutual interest and demonstrated technical and commercial maturity, without nevertheless exposing ESA to any liabilities related to business exploitation. To this end, legal schemes should be defined to allow for such activities, as allowed within the principles laid out in the ESA Convention.
3. Provision of services by ESA in the domain of human spaceflight, in particular 'astronaut training', i.e. provision of expertise for developing dedicated training programmes and/or facilities for specific tourist flight opportunities, and 'space medicine', i.e. provision of expertise to develop dedicated medical preparation programmes of space tourists, should also be explored for mutual benefit, making available ESA's competences under conditions to be defined.
4. ESA should contribute in the development of a regulatory frame for space tourism in Europe, involving both civil aviation regulatory authorities and competent bodies from the EC, aiming also at a 'more level playing field' for all parties around the world, and supporting the interests of European industry.
5. ESA should facilitate the free flow of ideas among all interested European parties, e.g. by establishing a platform for voluntary information exchange.

## Summary

ESA recognises the private sector's efforts both in the achievement of suborbital flights and in the associated technological development. We intend to show this recognition by helping provide the necessary environment for this industry to flourish, for example by assisting in the setting up of legal frameworks for operation across Europe, involving civil aviation authorities and other relevant bodies in debate.

Private developers of space tourism could also gain by collaborating with ESA on areas of recognised ESA expertise such as astronaut training and space medicine, as part of their efforts to ensure thorough preparation programmes for space tourists and safe flight experiences.

These areas of expertise should be considered on top of the vast wealth of already developed and maturing technology, plus ideas that are still undergoing investigation and experiment. In order to facilitate the free flow of ideas among all interested European players, ESA intends to help establish a platform for voluntary information exchange and interdisciplinary discussion. Some pilot experiences and intense debates taking place in the frame of the GSP study last year were already very positive and inspiring.

While ESA must be careful not to interfere in a fully competitive market, its experience, achievements to date, eye for opportunity and bold vision of space utilisation should make a valuable contribution to this exciting new phase of human endeavour. esa

*Artist impression of a futuristic commercial spaceport (Virgin Galactic)*

# Hands-on Activities in Education

European students, taking part in an ESA Microgravity Research Campaign, are seen here floating in 'zero g' during a parabolic flight in an Airbus A300 aircraft

# Motivating Young Europeans for a Future in Space

*F. Emma, R. Walker, H. Page & R. Reinhard*
Education Office, Directorate of Legal Affairs and External Relations, ESTEC, Noordwijk, The Netherlands

*J. Ventura-Traveset*
Communication & Education Office, Directorate of Legal Affairs and External Relations, ESAC, Villafranca, Spain

***The purpose of ESA's Education Office is to motivate young people to study science and technology and, in particular, to ensure a qualified workforce for ESA and the European space sector in the future.***

## Introduction

The Education Office supports student 'hands-on' activities including the design, development, integration, testing, launching and operations of small satellites such as CubeSats and CanSats, and the provision of payloads on satellites, sounding rockets, stratospheric balloons and parabolic flights. Many thousands of European students have taken part in the various projects facilitated by the Education Office in the 10 years of its existence (1998–2008).

## History

The ESA Education Office was set up in 1998 by René Oosterlinck, then Head of Legal Affairs, Procedures, Rules and Organisational Matters, with former ESA astronaut Wubbo Ockels as its Head. Since September 2007, the office


The Express satellite is launched on 27 October 2005 by a Cosmos rocket from Plesetsk in Russia

has been headed by Francesco Emma. The office now has three units: the Policy and Coordination Unit, the Education Projects Activities Unit and the European Space Astronomy Centre (ESAC) unit located at Villafranca near Madrid. The latter is integrated within the ESAC Communication & Education Office.

For many years, concerns have been voiced in Europe about the growing indifference of students towards scientific and technology disciplines. During the Lisbon conference in 2000, the European Council devised a strategy to help reduce the scarcity of human capital in the European Science, Engineering and Technology (SET) domain.

The Education Office, while serving the general needs of Europe, particularly focuses its efforts in increasing the skills and knowledge of youngsters with regard to space. The overall strategy is to target students aged between 6 and 28 years. Its hands-on activities, involving both suborbital experiments and satellite projects, offer practical experience to undergraduate and postgraduate university students.

## Student Educational Satellites

A number of small satellites have been, or are being, developed with the support of the ESA Education Office.

### *Express*

Express was a box-shaped (60 x 60 x 70 cm) microsatellite with a launch mass of 62 kg, including as passengers three ‘picosatellites’ (CubeSats) of 1 kg each and their associated deployment system. Express was built entirely by student teams, taking in only 18 months from start to launch. The Education Office provided networking facilities that:

- enabled the student teams to exchange information and discuss technical issues, solutions and schedule;
- identified a suitable launch opportunity and covered the launch cost;
- provided technical and management coordination;
- organised and sponsored regular

workshops at ESTEC where the student teams agreed on their interfaces and could get advice from experts;
– managed the integration and testing of the satellite including the provision of the test facilities; and
– managed the launch campaign.

Express was launched on 27 October 2005 by a Cosmos rocket from the Plesetsk Cosmodrome in northern Russia into a Sun-synchronous, circular orbit at 686 km altitude. Unfortunately, due to a failure in the electrical power subsystem, the satellite batteries could not be recharged and the satellite shut down after 12.5 hours of normal operation. Nevertheless, in many respects, Express was a success. Of the 19 subsystems, 12 operated successfully, five could not be tested because the mission ended prematurely, and only two failed. Valuable lessons were learned during the development, integration, testing and operational phases of the project, with the malfunction itself being the most valuable lesson. The media impact was enormous, with an estimated 100 million viewers watching the launch of Express on TV.

*Artist's impression of Express in orbit*

***European Student Earth Orbiter (ESEO)***

ESEO is a 110 kg microsatellite currently due for launch into a geostationary transfer orbit (GTO) as an auxiliary payload in 2011. To achieve its mission objectives, ESEO will carry a narrow-angle camera for taking images of Earth. Four charged particle detectors measure the total radiation dose received at different locations outside and inside the satellite, a Langmuir probe on a 40 cm deployable pole measures the instantaneous radiation, and a series of dedicated memory chips indicate the effects of radiation on the satellite's electronics. ESEO will also test technologies in orbit, for example, thin film solar cells mounted on deployable solar panels, a reaction wheel, a thrust vector system with a carbon-fibre nozzle, and a star tracker developed by students that will be space-qualified for later use on the European Student Moon Orbiter (ESMO).

The box-shaped (70 x 70 x 80 cm) satellite has four deployable, Sun-tracking solar panels. The attitude determination system comprises two Sun sensors, a three-axis magnetometer, a three-axis gyroscope and a star tracker. The attitude control system comprises a single-axis reaction wheel, four nitrogen cold-gas attitude thrusters and a main thruster for orbit control. This main thruster is used at the end of the mission for lowering the perigee in order to ensure reentry due to atmospheric drag within 25 years, thus complying with the European space debris Code of Conduct. Mission lifetime is not expected to exceed one month, considering the harsh energetic particle environment in the radiation belts in GTO and the fact that student teams can generally only afford commercial-off-the-shelf electronic components.

*Making final adjustments to the Express student satellite at ESTEC, The Netherlands, in September 2005*

A low Earth orbit (LEO) mission is currently being considered as an alternative to the baseline GTO option because of the reduced launch cost. Should this be retained the deployable solar arrays, the main thruster and most of the nitrogen would not be needed. This, together with a few additional minor savings, would result in a reduced launch mass of 80 kg. A launch on the VERTA 1 qualification flight (VERTA is the Vega Research and Technology Accompaniment programme) into a Sun-synchronous, circular orbit at 700 km altitude is

*Top, Russian technicians lower YES2 onto the Foton-M3 spacecraft using a roof-mounted crane at the Baikonur Cosmodrome in Kazakhstan. Above, Foton-M3 is then placed inside the Soyuz rocket fairing, seen here alongside the Soyuz booster inside the Integration Building at Baikonur in September 2007*

currently being explored, along with commercial launch opportunities.

The ESEO project Phase-B2 (consolidation of preliminary design) is due to begin in September 2008 and for the first time it will be implemented with a prime contractor to perform the system engineering, and coordinate and guide the subsystem work of the students. The current GTO orbit will be compared, during the Invitation-to-Tender process, with a possible LEO mission.

***European Student Moon Orbiter (ESMO)***

ESMO is a mini-satellite mission to be designed, developed, built, tested and operated by students. Its objectives are to prepare the next generation of lunar explorers, image the Moon from lunar orbit for public outreach, and conduct niche science/technology experiments related to future lunar exploration. Some 300 students from 29 universities in 12 countries are currently participating in the project.

In order to achieve these objectives, a miniaturised payload would perform measurements in lunar orbit over a six-month period. The core payload is a 2.5 kg narrow angle camera for optical imaging of specific locations on the lunar surface upon request from schools, and a 9 kg subsatellite, called Lunette, for global gravity field mapping via accurate ranging of the subsatellite from the main spacecraft. Lunette would be deployed in a near-circular polar orbit at 100 km altitude. Possible alternative scientific payloads under definition are a biological experiment to characterise the effects of the lunar environment on living cells, and a passive microwave radiometer to measure the temperature of the lunar regolith a few metres below the surface.

The box-shaped (85 x 85 x 62 cm) ESMO mini-satellite has a launch mass of 250 kg. Electrical power (110 W) is provided by body-mounted gallium arsenide solar cells. The attitude and control system comprises two star trackers, four Sun sensors, two Inertial Measurement Units, four reaction wheels and eight cold-gas thrusters. Downlink (8 kb/s Moon-Earth) and uplink (4 kb/s Earth-Moon) communications are in the S-band. The ground stations at Malindi (10 m dish), Weilheim (15 or 30 m) and ESAC (15 m) will be used during the mission, supplemented by additional coverage from Perth and Kourou in the early GTO phase.

ESMO will be launched into GTO from Kourou in 2012, flying as a secondary payload by using the Ariane Structure for Auxiliary Payloads (ASAP) adapter on Ariane-5 or Soyuz. Over a period of three months, an on-board liquid bipropellant propulsion system will be used to transfer the spacecraft from GTO to its operational lunar orbit via the Sun-Earth L1 Lagrange point.

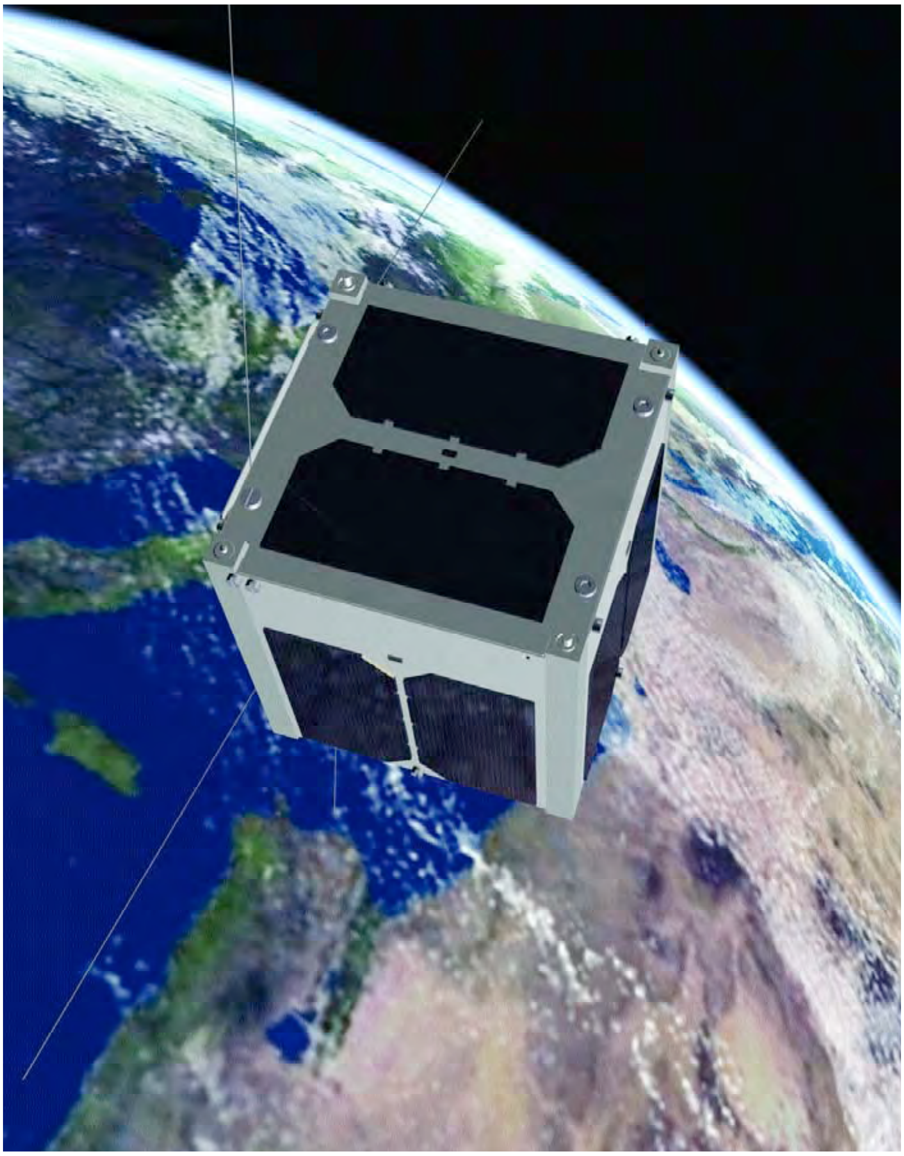
The project successfully completed a one-year Phase-A Feasibility Study and passed its Phase-A Review at a workshop in ESTEC in December 2007. The ESMO Phase-B/C/D/E1 contract is due to start at the beginning of 2009, following the same contractual set-up established for ESEO.

***Second Young Engineers' Satellite (YES-2)***

YES-2 was one student experiment on board a Russian Foton-M3 spherical capsule. The Foton carried a microgravity payload of 600 kg, provided mostly by research institutes and European industry under the management of the Directorate of Human Spaceflight (D/HSF). YES2 had the objective of demonstrating the 'Space Mail' concept for the first time, by returning a capsule (with payload) safely to Earth using a tether-assisted, deorbiting manoeuvre instead of a conventional retro-rocket propulsion system.

YES2 was built and tested by university students from all over Europe under the supervision of the Education Office and the industrial prime contractor Delta-Utec. The flight hardware installed on top of Foton-M3 had three components:

– the Foton-located YES2 Deployer (FLOYD), 21.7 kg, accommodating a 31.7 km-long, 0.5 mm-thick, non-conductive tether;
– the Mechanical and data Acquisition and Support System (MASS), 7.9kg;
– Fotino, a small spherical capsule (5.6 kg, diameter 40 cm), equipped with a heat shield to survive reentry. Inside Fotino there were thermocouples, thermistors, pressure sensors, accelerometers, gyroscopes, and a magnetometer to measure relevant physical parameters during reentry, a GPS receiver to determine its location, a parachute to ensure a soft landing and an ARGOS beacon to locate Fotino on the ground after landing. As there was no telemetry from Fotino to FLOYD or to the ground, so all data was stored on board Fotino and only be retrieved if Fotino was found after landing.



*Artist's impression of a Cubesat in orbit*

Foton-M3 was launched on 14 September 2007 by a Soyuz launcher from Baikonur. YES2 tether deployment started on 25 September. During the operation of YES2, the summary telemetry data obtained from Foton-M3 through the Russian ground station network indicated that the tether only partially deployed to a total length of 8.5 km. Subsequent thorough analysis of raw telemetry data showed instead that the tether was fully deployed. USSTRATCOM radar tracking data and Foton-M3 accelerometer data confirmed this result which was initially not evident because of a failure in the optical detectors sensing the deployment of the tether. This failure also caused a release of the Fotino capsule with a higher than planned speed acting against the direction of orbital motion. This caused the Fotino capsule to reenter the atmosphere at slightly steeper angle than planned. It has been

*Used in the REXUS programme, the Improved Orion M112 is an unguided solid-propellant single-stage rocket, launched from Kiruna in Sweden*

estimated that Fotino may have landed about 800 km short of the expected landing area, perhaps in the Aral Sea, which could explain the failure of the ARGOS beacon to send a signal acknowledging the landing.

The hands-on educational objectives of the project exceeded expectations. Some 450 students participated in the YES2 project from over 50 universities throughout the project lifecycle with about 120 students from five university centres of excellence involved in the later build and test phases of the engineering and flight models, when the implementation approached that of ESA space project standards.

Due to its innovative nature and large student involvement, the experiment received a high level of public outreach in various media, including TV, internet, newspapers and magazines in Europe and internationally. This was well complemented by a comprehensive, regularly updated project mini-website on the ESA Education web portal and a more informal student website. Amateur observers in Alaska and Antarctica also attempted to image the tether in orbit, but unfortunately local weather conditions prevented these efforts.

***CubeSats***

A CubeSat is a fully operable picosatellite for educational purposes which measures 10 x 10 x 10 cm, weighs up to 1 kg and uses Commercial Off-The-Shelf electronic components. The CubeSat standard was defined in 1999 by Stanford University and California Polytechnic State University. CubeSats can be built for €50 000–€100 000, plus €25 000–€50 000 for the launch. This price, compared to larger satellites and their associated higher launch costs, has made CubeSats a viable option for universities across the world.

Apart from the standard satellite subsystems (power, telecommunications, attitude determination and control, on-board data handling and storage) most CubeSats carry one or two scientific instruments or a technology demonstration payload. The telecommunications power is of course very limited and so CubeSats can only have a reasonable downlink data rate (9.6 kb/s) up to about 800 km orbital altitude.

On 28 May 2007, René Oosterlinck (then ESA Director of Legal Affairs and External Relations) and Antonio Fabrizi (Director of Launchers) signed an agreement to include an educational payload on the maiden flight of Vega, ESA's new small launch vehicle which is currently under development. This educational payload consists of nine CubeSats with two back-up CubeSats that can replace the primary satellites should they not be ready in time.

To support the selection of the CubeSats for Vega, a workshop was organised by the Education Office on 22–24 January 2008. The workshop at ESTEC was the first of its kind at a European level and brought together almost all of the European CubeSat teams for the first time. There are now 35 teams developing CubeSats in ESA Member States and Cooperating States.

*The BEXUS balloon gondola sitting on its transport vehicle with the stratospheric balloon in the background. The balloon has a total volume of 10 000 m3 and grows to a diameter of 40 m when the maximum altitude is reached*

***Global Educational Network for Satellite Operations (GENSO)***

As a complementary hands-on activity to CubeSats, GENSO is a planned network of over 100 small ground stations that is intended to provide global, near-continuous coverage of educational satellites in LEO. The network is being implemented under the auspices of the International Space Education Board (ISEB) with CNES, CSA, ESA, JAXA and NASA as member space agencies.

At present, a university typically builds a small satellite (e.g. a CubeSat) and launches it into low Earth orbit. It also builds, or already has available, a ground station to track the satellite and facilitate uplink/downlink telecommunications.

The period of a low Earth orbit is typically about 90 minutes, but the duration of a satellite pass over the ground station is very short and varies from approximately 10 minutes in the best case to no coverage at all for most of the orbits. When supporting only one satellite project, the ground station is not in operation 97% of the time. This is highly inefficient and often, despite on-board data storage capability, a limiting factor in mission return.

Moreover, there are sometimes mission critical operations requiring uninterrupted coverage for several hours. In the worst-case scenario, if there is an on-board emergency, there is no immediate access to the satellite. However, the situation would dramatically improve if the satellite could be tracked by other ground stations along its ground track.

During a workshop at the University of Aalborg in November 2007, a successful proof of concept was demonstrated when an Authentication Server in Austria was connected to the Ground Station Server (GSS) and the Mission Control Client (MCC) applications installed on the Aalborg ground station. Japanese and American hardware drivers were configured to control the ground station hardware, and telemetry was received from four student satellites – the passes were scheduled, the satellites tracked from horizon to horizon, the radio set and corrected for Doppler, and data decoded.

Since then, the GSS application has been installed in three further ground stations in the UK, California and Japan to run tests for tracking satellites and automatically scheduling passes. A GENSO detailed design review will take place at ESTEC in September 2008, closing out the Alpha software development phase. Thereafter, the Beta Phase will begin, involving a number of tests at some 20 ground stations during 2009, and ending with the Critical Design Review in September 2009. GENSO is expected to be fully operational by mid-2010.

## Other Hands-on Projects

***Rocket/Balloon Experiments for University Students (REXUS/BEXUS)***

REXUS and BEXUS are five-year programmes providing Swedish and German university students with the opportunity to launch educational experiments on sounding rockets and stratospheric balloons. Three cycles are envisaged during these programmes, each beginning with a Call for Experiment Proposals and ending with


Operated by Novespace, ESA uses the Airbus A300 'Zero-G' for its parabolic flight campaigns (Novespace)

the launches. A cycle comprises two rocket launches and two balloon launches. All launches are managed by Eurolaunch and take place from Esrange, near Kiruna, in northern Sweden. On each launch, half of the payload resources are available to Swedish students, the other half to German students. The flights are funded by the Swedish National Space Board (SNSB) and the Deutsches Zentrum für Luft- und Raumfahrt (DLR).

For their share of the payloads, SNSB has decided to invite students from all ESA Member States to participate in the REXUS and BEXUS campaigns. To this end, SNSB has asked the ESA Education Office to make European-wide announcements for the two annual opportunities, select the experiments, manage the interface between the selected experiment teams from European universities and SNSB and Eurolaunch/Esrange, and cover the expenses of European students to attend all of the associated activities (workshops, training week, reviews and launch campaign).

In the REXUS campaign, a spin-stabilised, solid-propellant, single-stage rocket with an 'Improved Orion' motor is used, reaching an altitude of 90–100 km. The total available mass for student experiments is about 30 kg. BEXUS uses a 12SF helium balloon from Zodiac (France), which can carry a student experiment mass of 40 kg to a ceiling of 35 km. The floating phase at ceiling altitudes can last up to four hours. The first REXUS and BEXUS flights with eight European student experiments selected by the Education Office will take place in March 2009 and October 2008, respectively.

***Stratospheric Platform Experiment (STRAPLEX)***

STRAPLEX is a collaboration between the University of Porto and ESA which began in 2005. It involves balloons that are launched from Évora in Portugal and can reach an altitude of 34 km with a payload mass of 4.5 kg. Since the end of 2005, four qualification flights have been successfully completed. The last one of these, on 2 May 2008, included for the first time a lightweight (0.5 kg) transponder. On 22 October 2006, two experiments – a radiation measurement system from the University of Valencia and an accelerometer from a Dutch school – were flown successfully and STRAPLEX is now fully operational. For this year's campaign, six experiments were selected, two from universities in Spain and Portugal, which will be flown at the end of July, and four from high schools in the UK, Belgium and Sweden (2), which will be flown in September.

***Student parabolic flight experiments: Fly Your Thesis!***

Parabolic flights were proposed by ESA to foster university student interest in microgravity research all over Europe. The Student Parabolic Flight Campaign (SPFC) was the first hands-on activity offered by ESA, staring in 1994. The last full ESA student campaign was held in 2006.

After 2006, the whole ESA Parabolic Flight programme was subject to a thorough review, and several managerial and safety recommendations were made for future campaigns. Following these recommendations and specific interactions between the ESA Education Office and the Directorate of Human Spaceflight, a new programme concept called 'Fly Your Thesis! An Astronaut experience' has been agreed for 2008/2009. The following aspects are especially emphasised:

– Academic: the experiment work must be an integral part of the student's syllabus. This can be through a Master thesis, a PhD thesis, a research programme or any form of project supported by the applicant's university.
– Scientific: the quality of the scientific proposals will be reviewed by a high-level Board panel, including experts from ESA and ELGRA (the European Low Gravity Research Association).
– Outreach: the ESA Education Office, in close coordination with the ESA Communication and Knowledge Department, will stress the outreach/communication aspects to foster interest in Europe for science, ESA activities and microgravity research.

A new call for student experiments has been launched in June 2008, for a preliminary selection of about 20 university teams in September 2008. These will come from all over Europe and consist typically of two to four students, together with an endorsing professor, appointed as the Experiment Principal Coordinator.

These teams will work on a detailed microgravity scientific experiment proposal, with the support of an ELGRA mentor. The teams will present their projects to a Review Board through a dedicated workshop at ESTEC in December 2008. This Board will then select the best three or four teams that will eventually fly their thesis in 2009. ESA is also assessing the possibility for all preliminary selected teams to visit the ESA European Astronaut Centre facilities in Germany.

The final three/four teams will design and build their experiment rack in the first half of 2009, assisted by qualified professionals and their ELGRA mentor. The cost of the manufacture will be partly supported by the ESA Education Office. The experiments will then be fully integrated within ESA's 51st Microgravity Research Campaign (MRC) for two weeks in fall 2009 in Bordeaux, France. Here, they will experience three flights, each of 30 parabolas, one parabola lasting 20 seconds. This will allow the selected teams to be in contact with experienced professional scientific teams from across Europe.

It is also intended that some of the best teams not finally selected for the flights will be invited to perform some microgravity research using ESA's microgravity and hypergravity facilities (e.g. the Large Diameter Centrifuge) at ESTEC. This is currently under assessment and considered an important complementary aspect of the new programme.

***CanSats***

A CanSat is a 'satellite' accommodated within the volume and shape of a regular soft drink can. The CanSat concept was introduced in 1998 by Professor Robert Twiggs from Stanford University. Just like a real satellite, a CanSat consists of a 'bus' and a payload. The bus comprises the structure (the aluminium soft drink can, antenna, circuit board), power (battery), telecommunications (transmitter), on-board computer and the recovery system (parachute). The payload may consist of sensors for measuring accelerations, the ambient air temperature, pressure and humidity, a differential GPS, a camera (pictures or video), attitude determination sensors or a mini-rover.

A CanSat is launched by an amateur rocket to an altitude of 500–4000 m. After release from the rocket at apogee, a parachute or parafoil opens and 5–20 minutes later the CanSat makes a soft landing. The drop time, during which it transmits telemetry, is comparable to the horizon-to-horizon pass of a satellite in low Earth orbit. Their advantages are that they can be built at very low cost, typically under €1000 and can be proposed, designed, built, tested and launched in six to nine months.

The building of a CanSat usually involves participation in a competition for university and high school students. Such competitions are organised regularly in different parts of the world. The competitions are in two categories: the standard CanSats (370 g) and the 'Open Class' (over 1 kg), which often includes a mini-rover. In Europe, CanSat competitions are being held in The Netherlands, France and Spain. The Education Office has organised some CanSat activities in the past and has been requested to organise a European-wide competition.

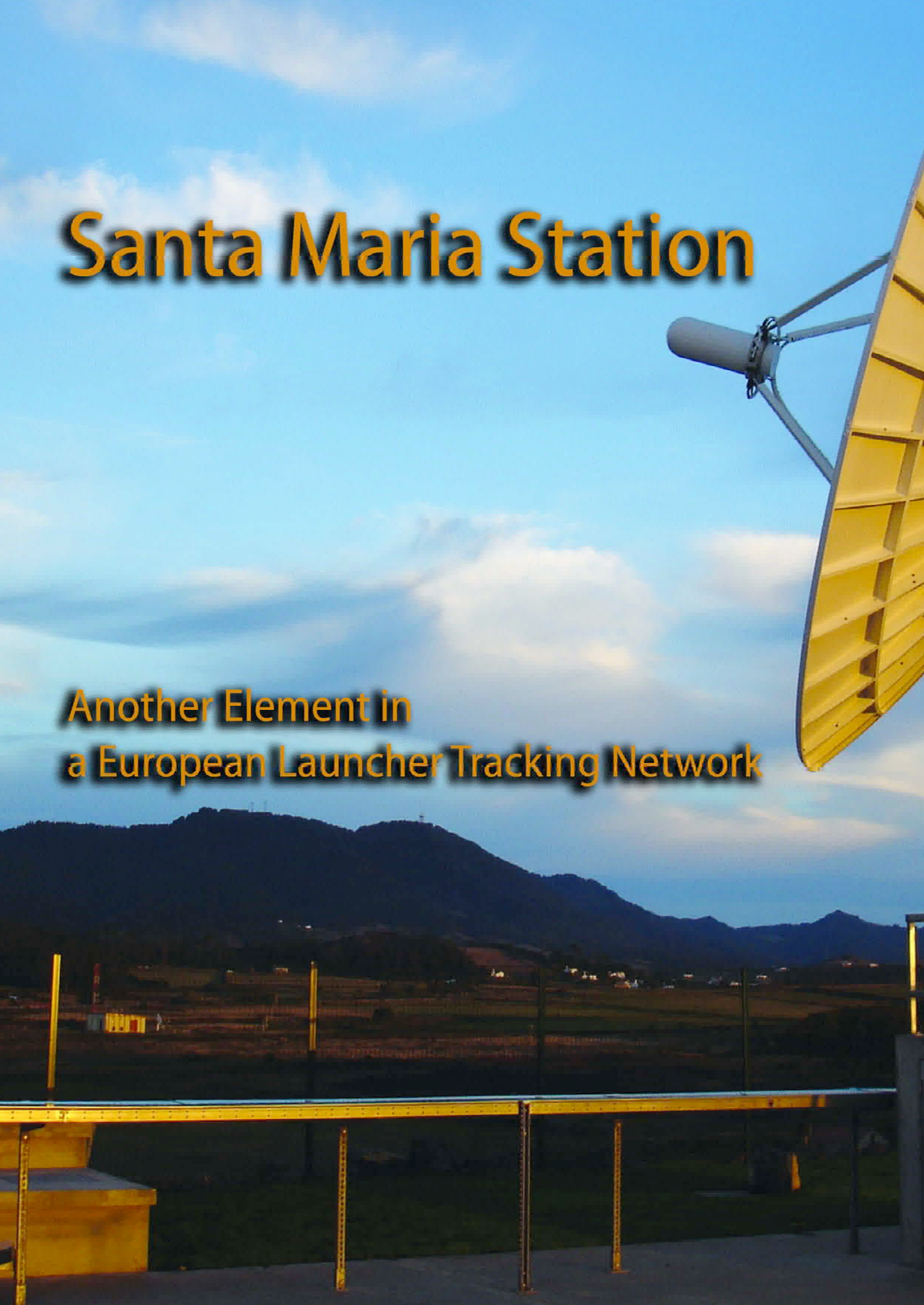
*A typical 'Cansat' (Univ. of Wurzburg)*

## Conclusions

Up to 10 000 European students have been involved in the various hands-on activities announced, managed and funded by the ESA Education Office. They have been able to visit ESTEC and participate in workshops, project reviews, integration and test campaigns. They have prepared the required documentation according to semi-professional standards and participated in communication and outreach activities. They have benefited from the support by ESTEC staff on these projects and from discussions with these experts. Throughout all these processes they have met fellow students from other European countries, learned how to work successfully as a team, and established valuable contacts at ESTEC and in the space industry. Several hundred Masters and PhD theses have resulted from these projects, and the active involvement in one of the projects of the Education Office has often been the first step towards a successful career in space.

# Santa Maria Station

## Another Element in a European Launcher Tracking Network



The antenna and view of the Montes das Flores area from the Santa Maria station

*Gerhard Billig & Boris Smeds*
Directorate of Operations and Infrastructure, ESOC, Darmstadt, Germany

*Pier Michele Roviera*
Directorate of Launchers, ESA HQ, Paris, France

*J. Pedro V. Poiares Baptista*
Directorate of Technical and Quality Management, ESTEC, Noordwijk, The Netherlands

***The Santa Maria station, also known as 'Montes das Flores' (Hill of Flowers), is located on the Portuguese island of Santa Maria, in the Azores. Santa Maria is one of ESA's first tracking stations with launcher tracking capability, used to receive real-time telemetry from launches from ESA's Spaceport in Kourou, French Guiana.***

## Introduction

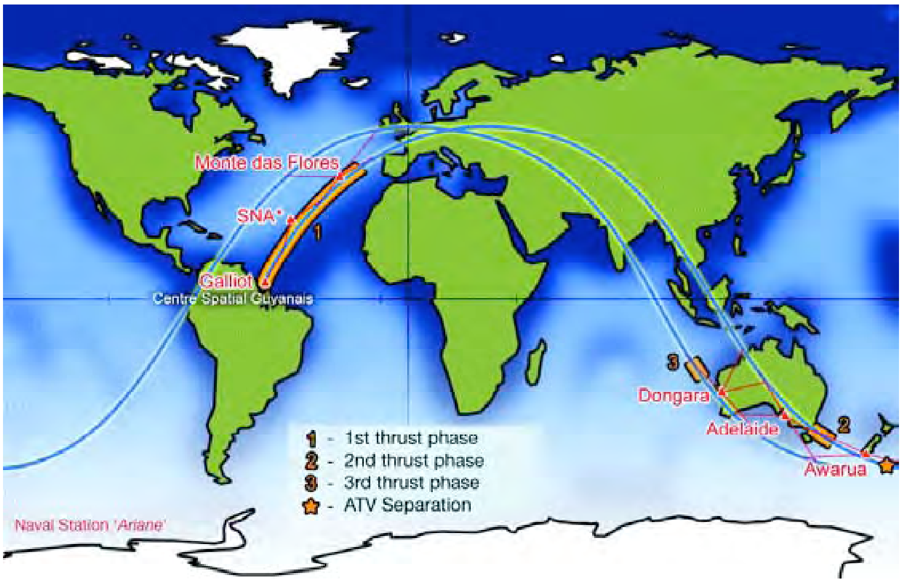
During any Ariane launch, the reception of vehicle data via telemetry is essential for several reasons, for example to provide information for the launch vehicle specialists and the customers and, of course, flight safety. Overall, more than 1500 parameters are measured from the launch vehicle and recorded throughout the flight.

All these data are received through a specific network of ground stations, historically called 'the Ariane network'. This is composed of several facilities, fully or partially dedicated to launch vehicle telemetry reception, and developed by the ESA Ariane programmes and operated by the French space agency CNES/Guiana Space Centre (CSG). The Ariane network is tailored for the most common Ariane trajectory (the geostationary transfer orbit, GTO), therefore its stations are based near the equatorial plane: Galliot station (Kourou), Natal (Brazil), Ascension Island in the South Atlantic Ocean (UK), Libreville (Gabon) and Malindi (Kenya).

For some specific missions, with trajectories other than GTO, additional facilities must be set up. For long ballistic or steady-state flight phases, it is possible to use on-board data recorders to cover the reception 'holes' between one ground station and the next. However, for some key phases, for example engine start/shut-off and stages or payload separations, real-time data reception is mandatory. This means that specific receiving facilities must be positioned in the right geographical locations.

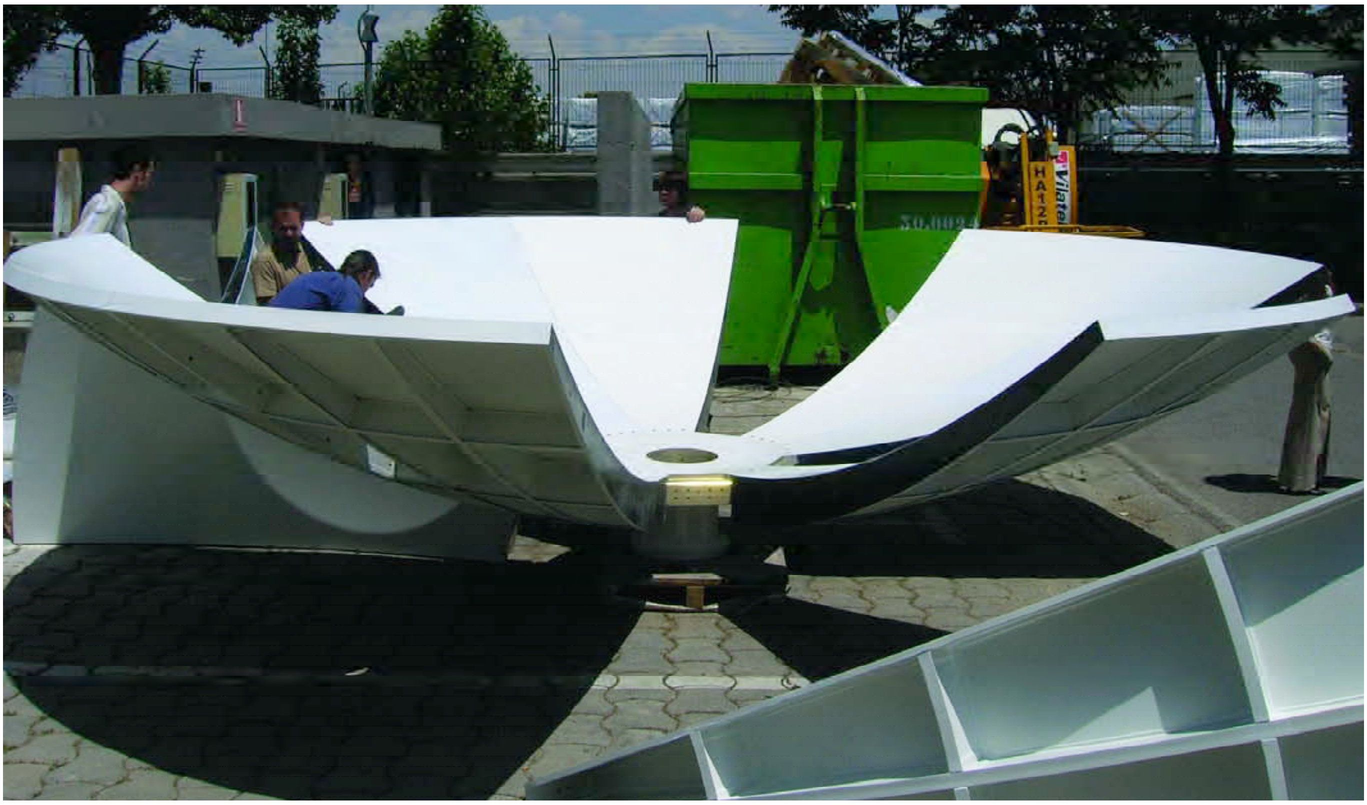
One of these 'exotic' missions is the launch of ESA's Automated Transfer Vehicle (ATV), such as the flight of *Jules Verne* that took place in March this year. This type of launch needed an inclined trajectory (about 50 degrees). From the very first Ariane/ATV mission analyses several years ago, it seemed evident that after the loss of signal from the Kourou station, the existing Ariane equatorial network was of no use and that a specific network had to be set up.

In the same period, Portugal joined ESA as a Member State, and this opened the discussions to investigate the possibility for setting up a telemetry reception site in the Azores islands, for inclined trajectories such as the ATV ones. The first site surveys were made jointly by ESA and CNES experts in 2003. The Santa Maria Island, the southernmost of the archipelago, turned out to be the best location, even if from a logistical point of view this solution was less easy than the main island of




ATV trajectory and ground station coverage

The site for the new ground station in 2006, with concrete platform, access road, power supply and lightning protection



*The antenna dish under construction at Indra Espacio in Spain*

São Miguel. Thanks to a very fruitful cooperation between ESA, CNES and local authorities (the regional government of the Azores and the Town Hall of Vila do Porto), some possible sites were identified on the island. One of these, in the 'Monte das Flores' area, 5 km from Vila do Porto, was selected.

## Ground Station Build-up

When the ESOC involvement started, the site for the new ground station was already selected, and the infrastructure was prepared to temporarily host a portable containerised station. It consisted of a concrete platform, lightning protection, an access road and connection to the public power supply.

In July 2006, ESA awarded a contract to Carlo Gavazzi Space SpA to develop the new ground station in Santa Maria. The telemetry-receiving system (called the TM kit) had already been developed by the company and was in use at different equatorial ground stations to track Ariane-5 launchers. The new development called for an equipment shelter to house the new installation, and a new antenna system to receive the Ariane-5 telemetry. Indra Espacio S.A. was selected as supplier of the antenna. In addition the contract included the remotely controlled calibration tower equipment.

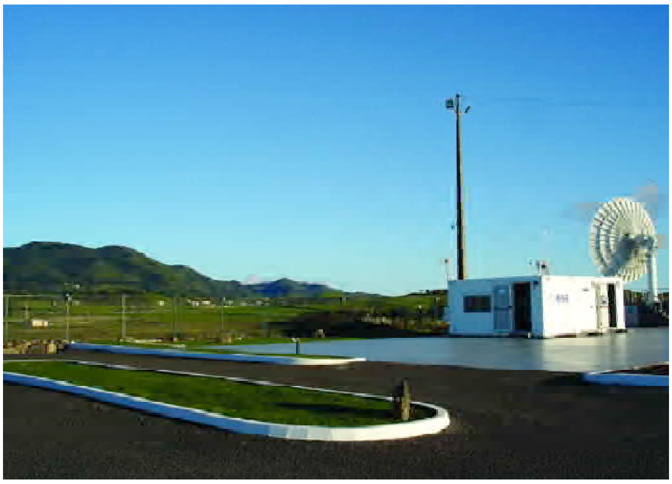
One key design parameter for the antenna is to autotrack an S-band telemetry signal with a received flux between –109 and –75 dBm/m$^2$, and to receive the Ariane-5 telemetry at a data rate of 1 Mb/s. For this a 5.5 m parabolic reflector made of carbon fibre sectors was selected with a newly developed prime focus feed.

Normally, satellites transmit on one frequency and the autotrack systems are also designed for one frequency. The Ariane-5 telemetry is transmitted simultaneously on two different frequencies from two antennas mounted on opposite sides of the spinning rocket. In this way at least one of the frequencies will be seen from the ground station.

This required the development of an 'autotrack' system that automatically selects the best signal to steer the antenna during the pass. Autotrack is the capability of an antenna to autonomously follow a target once acquired. This capability is crucial for launcher tracking, because the pointing predictions may not be as accurate as for satellites in well-known orbits.

As an extra option, an X-band feed with a dichroic reflector could be added to have the possibility to use the antenna to receive Earth observation satellite data in X-band. The antenna uses an X-Y mount to avoid problems when following targets at high elevation near zenith. There are still two points that the antenna cannot easily cover, but they are located at the horizon in a direction where the rocket is not expected to appear.

The design also had to consider the possible interference from nearby UMTS transmitters that had been found in radio frequency interference measurements



*Views (left) inside the power generator plant, and (right) the completed station*

made at Santa Maria. The UMTS frequency was outside the nominal Ariane-5 frequency band, but close enough to cause disturbance if not using input filters for the required attenuation of the UMTS signals (UMTS, or Universal Mobile Telecommunications Service, is a mobile computer and cell phone network standard).

In May 2007, the equipment shelters with the Ariane-5 telemetry kit and the calibration tower equipment were installed at Santa Maria. At the same time the antenna system was assembled and partly tested at the factory in Madrid. Performance tests in the factory were limited since there was no access to a calibration tower and there was a lot of domestic radio interference in the urban area.

In August 2007, the antenna was shipped to Santa Maria for installation and continued testing and commissioning. From October, the station was used for training and preparation by the operations team, in parallel with the final engineering verifications and then the final autotrack tests with an aircraft in January 2008.

## Infrastructure

Since the plan changed to host the station permanently, the infrastructure needed to be adapted. From the Azores Regional Government, a power plant was supplied, providing fully autonomous electrical power to the station by means of diesel generators and Uninterruptible Power Supplies. The design process was in close collaboration with ESA. Furthermore, a site security system, a fence and a telecom system was installed to adequately support the permanent installation.

Inauguration of the complete ground station took place in January 2008, integrating the station into the ESA Tracking Network.

## Validation

The majority of the validation tests was done the same as for satellite ground stations. Some of the requirements, however, made extra tests necessary, mainly the tracking and the end-to-end data flow tests. End-to-end data flow tests with the

*The Portuguese Minister of Science, Technology and Higher Education, Prof. José Mariano Gago (left) shakes hands with Gaele Winters, ESA's Director of Operations and Infrastructure, with Carlos Cézar, President of the Autonomous Region of the Azores, and José Contente (right), Regional Secretary for Housing and Infrastructure at the formal inauguration of Santa Maria station, 17 January 2008*

customer took place between the ground station and CSG directly. These tests comprised all aspects of data exchange: extracted launcher telemetry, orbital predictions as well as telemetry recording.

***Autotrack test campaign using an aircraft***
The launcher, as seen from the ground station, appears to have a much higher angular velocity than a satellite. This is mainly because the launcher is much closer when over Santa Maria, around 200 km compared to roughly 800 km for a satellite in a low-Earth orbit.

Obviously testing of the autotrack function was highly desirable, both for the ESOC team as well as for CNES/CSG, but this was not possible using satellites as is normally done for tracking stations. The solution was to downscale the geometry by a factor of about 100 and to replace the target with an aircraft carrying representative transmitters.

The equipment was installed in a 10-seat twin-propeller aircraft, with one antenna in the front window and one in the back, both radiating to the lefthand side on the two different frequencies. For flight regulations, both antennas had to be mounted inside, but the two different locations made it possible to see at least one antenna from the station. This was also a good test case for the frequency diversity function.

The pilots flew exactly along a path, defined by GPS coordinates, at a given speed, simulating both passes of the rocket over the ground station. The test was performed successfully in January 2008, and the results confirmed the theoretical analysis and local measurements already performed earlier. With this, the antenna was fully validated and technically in a state to support the launch.

Seen after the ATV launch, the full Santa Maria team including support (top, from left): Paulo Rocha, Ricardo Conde, Ricardo Mourao, Diego Rodriguez, Maite Arza, Herve Tailame, Boris Smeds, Aage Riise, (front) Robert Launer, Gerhard Billig

## Operational Preparation

The operations performed for launcher tracking are somewhat different than those for satellite tracking, but the preparations for satellite support at ESOC formed a solid baseline for this new type of support. The operations team, composed of the maintenance and operations contractor consortium Edisoft/Segma/Global EDA and ESOC engineers, underwent an intense training session by CNES at CSG in 2007, to understand the specifics and the elements of operation during a launch support.

***Operational qualification***
The Santa Maria ground station was part of the Ariane-5 launcher tracking network for the ATV *Jules Verne* launch. Operational qualification of that whole network was performed in January 2008. The Santa Maria station took part in this, when all the elements occurring during a normal launch countdown and the launch support were exercised. In addition to this, station-dedicated operational and performance tests were performed, as also done for satellite launch supports. This mainly covered contingency situations, which the team had to respond to, also under time

pressure. By mid-February, all preparations were finalised and the station was ready for launch.

***Launch campaign***

The launch campaign started 10 days before launch. Now the tests again comprised the whole station network and were mainly focused on the smooth work-together of all the involved entities. This culminated with the Repetition Generale, which was a simulation of the full launch countdown and launch chronology.

***Launch countdown and launch support***

As the support to Ariane-5 for ATV takes longer than for a normal mission (1.5 orbits), also the countdown phase is longer. The station team was required to be on post 10 hours before lift-off. All the preparations and tests went nominally; everything was 'green' for the launch. Lift-off took place at 05:03 CET in the night of 9 March 2008. Twelve minutes later, the Santa Maria station received the signal of the rocket and telemetry provision to CSG started. The whole pass went smoothly. The rocket could even be seen visually during its thrust phase.

All the other stations also received the signal flawlessly and the separation of ATV finally took place over New Zealand. Half an orbit later, the rocket was again tracked by Santa Maria. Again, the new station and its team worked perfectly. The mission ended successfully after the deorbit burn, again monitored over New Zealand.

## Outlook

The Santa Maria station is being upgraded with X-band (8 GHz band) receive capability to allow reception of Earth observation satellite payload data. For this, a dichroic sub-reflector will be put in front of the S-band feed, only reflecting the X-band signals into the X-band feed located on the main reflector. The station will support the MARISS and CLEANSEANET initiatives when it is not required for launcher tracking. esa

### ESA tracking stations

The ESA tracking stations network - ESTRACK - is a worldwide system of ground stations providing links between satellites in orbit and ESA's European Space Operations Centre in Germany. The core ESTRACK network comprises 13 terminals sited at nine stations in six countries.

The essential task of all ESA tracking stations is to communicate with our missions, up-linking commands and down-linking scientific data and spacecraft status information. ESTRACK stations also gather radiometric data to help mission controllers know the location, trajectory and velocity of their spacecraft.

ESTRACK stations provide additional services, including searching for and acquiring newly launched spacecraft, autotracking, frequency and timing control using atomic clocks and gathering atmospheric and weather data. Some stations are also equipped with GPS receivers connected to our GPS Tracking and Data Analysis Facility at ESOC, enabling highly precise orbit and geophysical calculations.

Each ESTRACK station hosts one or more terminals, each of which comprises an antenna and its associated signal processing equipment. Stations can support multiple missions and ESTRACK also shares resources with other agencies and satellite operators.

### ESTRACK Core Network

Kourou (French Guiana), Maspalomas, Villafranca and Cebreros (Spain), Redu (Belgium), Santa Maria (Portugal), Kiruna (Sweden) and Perth and New Norcia (Australia). The ESA Perth ground station, located in Western Australia, is being upgraded to receive launcher telemetry.

Maspalomas

Villafranca

Perth

Kiruna

## ESA Deep Space Network

ESTRACK's new 35 m stations at New Norcia (Deep Space Antenna 1, DSA 1) and Cebreros (DSA 2) form the European Deep Space Network.

The new stations provide the improved range, radio technology and data rates required by current and next-generation exploratory missions such as Mars Express, Venus Express, Rosetta and BepiColombo.

*Cebreros*

## ESTRACK Augmented Network

The ESTRACK system also includes terminals operated by external organisations on ESA's behalf:

1. MAL-1 in Malindi (Kenya)
2. SG-3 in Svalbard (Norway)
3. AGO-1 in Santiago (Chile)

Additional stations are used in some cases, including Alaska, Dongara and Weilheim (used most recently for Cluster).

*Svalbard*

## CNES/CSG Ariane network

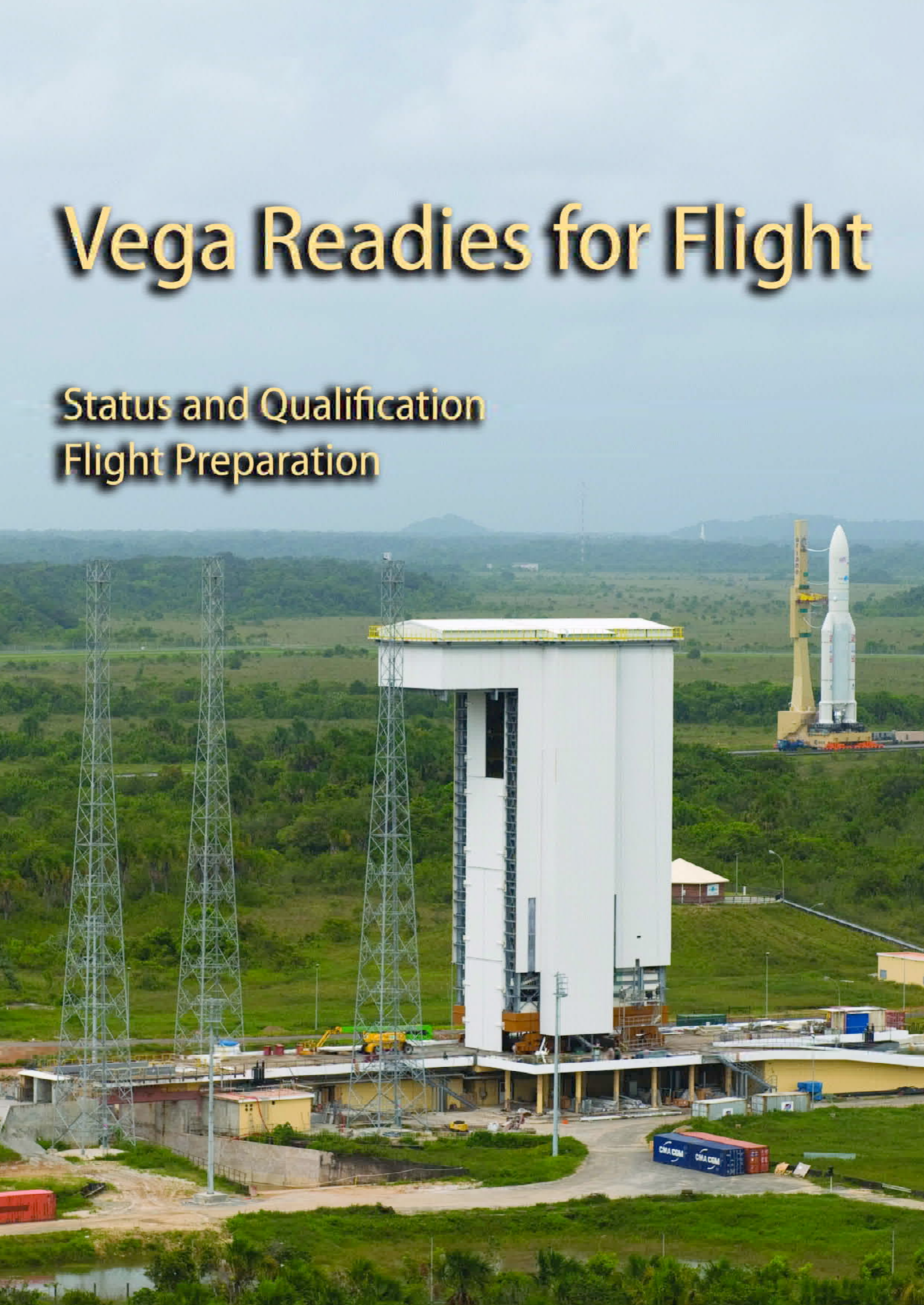
In order to cover the entire length of an Ariane's trajectory when launched from Kourou, CNES/CSG uses a network of downrange stations whose antennas relay signals to CSG as the launch progresses.

The network consists of the following stations: Galliot (Kourou), Natal (Brazil) Ascension Island (UK), Libreville (Gabon) and Malindi (Kenya), and now Santa Maria in the Azores.

*Natal, Brazil*

# Vega Readies for Flight

## Status and Qualification Flight Preparation



The former ELA-1 Ariane-1 launch pad at Kourou has been transformed for Vega. The Mobile Gantry is in place and the site almost complete. In the background, an Ariane-5 is seen being moved to its launch site ELA-3

*Stefano Bianchi, Renato Lafranconi & Michel Bonnet*
Vega Programme, Directorate of Launchers, ESRIN, Frascati, Italy

***A key element of the European launcher strategy for access to space, the Vega small launcher is being preparing for its maiden flight in November 2009.***

The development of Vega passed major milestones in 2007 and 2008, providing essential results in terms of test data and design consolidation. These will lead to the Qualification Flight from Europe's Spaceport in French Guiana at the end of 2009. This will be an important step in the implementation of the European strategy in the launcher sector and the guarantee of access to space for Europe, as endorsed by the ESA Ministerial Council in 2003.

The exploitation of this new ESA developed launcher will widen the range of launch services offered by launchers developed and produced by European industry and will improve launch flexibility by providing a more adapted response for a wide range of European institutional space missions, as well as an optimised family of launchers to serve commercial market needs.

## The Vega and VERTA Programmes

The Vega launch system, currently developed by ESA, has an essential role within the family of launchers that will be operated by Arianespace at the European Spaceport in French Guiana (Centre Spatial Guyanais, CSG). It will complement the European Ariane and the Russian Soyuz: Ariane is optimised for larger spacecraft and missions to Geostationary Transfer Orbit (GTO) as well as Earth gravity escape missions, while Soyuz is suitable for medium satellites in GTO and heavy satellites in Low Earth Orbit (LEO).

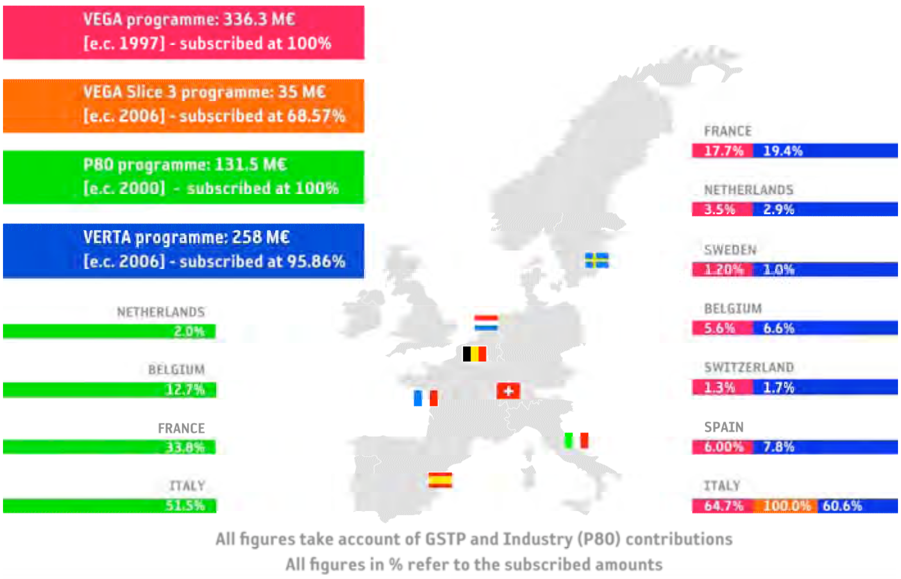
Vega is a four-stage launch vehicle designed to cover a wide range of small satellite missions in LEO. The main system requirements, in terms of payload mass and dimensions as well as mission range, were driven by the market projection showing a broad need of different missions as follows:

- Reference: 1500 kg in polar circular 700 km orbit,
- Mission range: inclination 5° to sun-synchronous orbit, LEO and small-to-medium payload mass range, from micro and mini-satellites up to 2.5-tonne satellites.

In 2010–15, the addressable market consists of five to seven satellites a year with a mass greater than 250 kg and compatible with the Vega reference capability. This fully consolidates the planned launch rate of two launches per year as a minimum.

The Vega programme is composed of three ESA optional programmes (the Small Launcher programme, the P80 demonstrator programme and an additional programme slice, decided at the end of 2007) organised into three projects: the launch vehicle, the P80 (first stage solid-rocket motor) and the ground segment.

The Vega launch system includes also the dedicated launcher infrastructure at CSG and the worldwide ground station network necessary to launch a payload and to place it into the required orbit, respecting the specified environment for the payload, the safety and operational constraints.




*Participation in the Vega and VERTA programmes*

In order to prepare the exploitation phase, the Vega Research and Technology Accompaniment (VERTA) programme, including the launch services for five ESA missions, was decided by the participating states at the ESA Ministerial Council in December 2005. This programme has the objective

*ESA's family of launchers: Vega, Soyuz, Ariane-5 and Ariane-5 ECA*

to enlarge the qualification domain, sustaining its reliability, demonstrating its flexibility through various missions and enhancing its affordability for future customers.

The Vega and VERTA programmes are funded by the following participating states: Belgium, France, Italy, The Netherlands, Switzerland, Spain and Sweden.

The programme is managed by an Integrated Project Team composed of staff from ESA, the Italian space agency ASI and the French space agency CNES, based at ESRIN in Frascati, Italy, for the launch vehicle and ground segment, and at CNES-DLA in Evry, France, for the P80 demonstrator.

The industrial organisation is based on a prime contractor for each project: ELV (I) for the launch vehicle, AVIO (I) with delegation to Europropulsion (I/F) for the P80 demonstrator, and Vitrociset (I) for the ground segment.

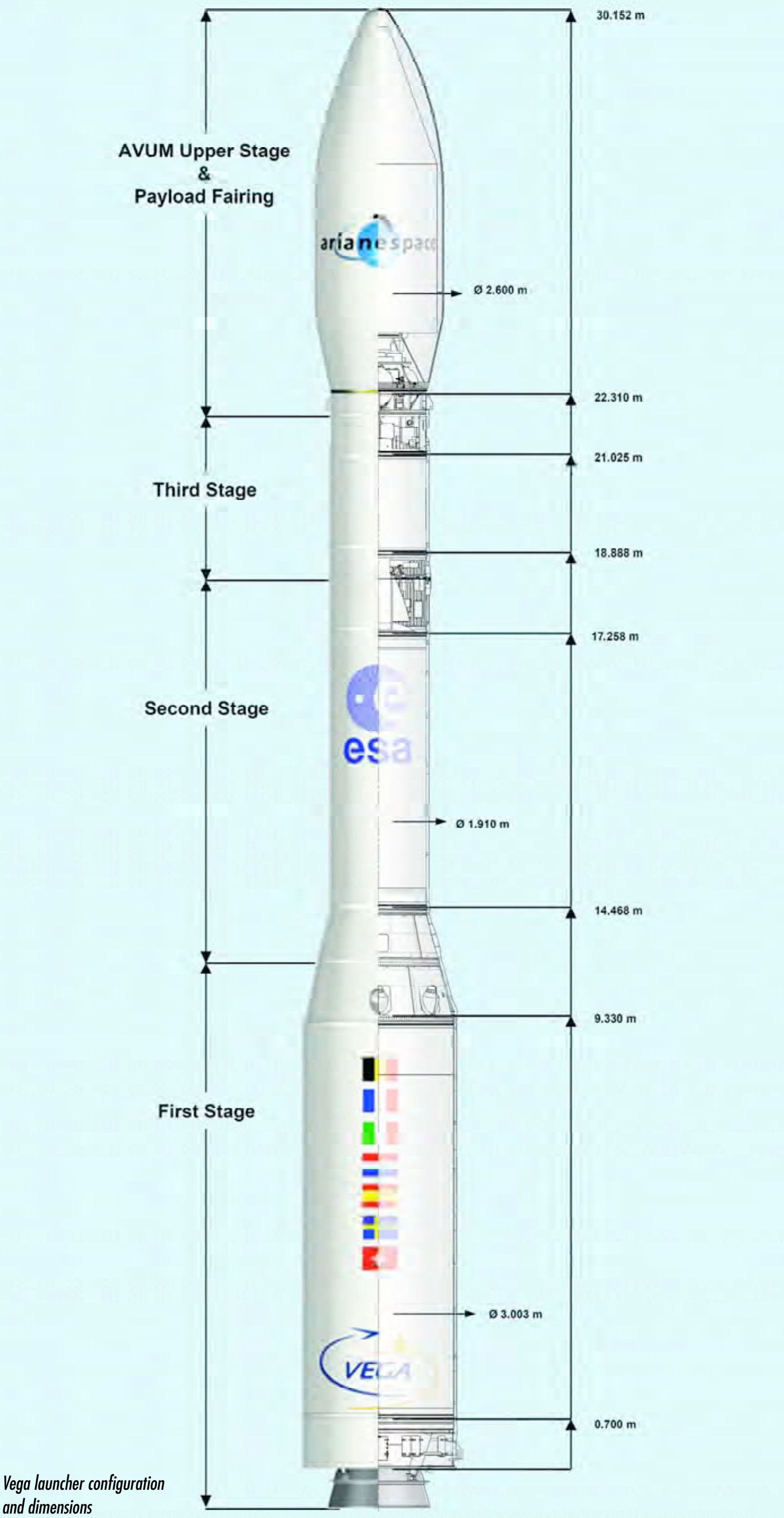
## The Vega Launcher

The Vega launcher is a single-body vehicle composed of three solid-rocket motor (SRM) stages (P80, Zefiro-23 and Zefiro-9), a liquid-propulsion upper stage (Attitude Vernier Upper Module, AVUM) and a fairing. At lift-off, the launcher is 30.2 m high and weighs 139 tonnes.

To minimise risks and costs, the development has been based on a mix of well-proven technologies, benefiting from synergy with Ariane-5 development and with new technologies aimed at reaching low recurring cost objectives. The choice of solid-rocket motors was driven mainly by demonstrated high reliability on Ariane programmes and by low development and recurrent costs.

The three solid-propellant stages perform the main ascent phase while the fourth stage compensates for the solid-propulsion performance scattering, circularises the orbit and executes the de-orbiting manoeuvres.

The diameter of the first stage has been set to 3 m in order to exploit fully the synergies with already existing Ariane facilities for casting and




*Vega launcher configuration and dimensions*

*The P80 firing tests at the the Booster Test Stand at the Centre Spatial Guyanais in December 2007*

integration. The P80 is the largest monolithic solid-rocket motor with a filament winding CFRP motor case ever developed in the world.

The fourth stage (AVUM) includes a bipropellant (NTO/UDMH) liquid-propulsion system (LPS) that provides the necessary velocity changes for reaching the final launcher orbit, and a monopropellant (hydrazine) Roll and Attitude Control System (fulfilling the main functions of roll control during flight, attitude control during coasting phases, attitude recovery during second-stage separation, payload pointing manoeuvre and orbit control for the collision avoidance manoeuvre).

The Upper Composite, composed by the payload adapter, the payload and the fairing is mated on the top of the fourth stage.

In a single launch configuration, Vega provides a minimum volume allocated to the payload consisting of a cylindrical volume of 2.35 m diameter and 3.5 m height plus a frustum volume of 2.8 m height.

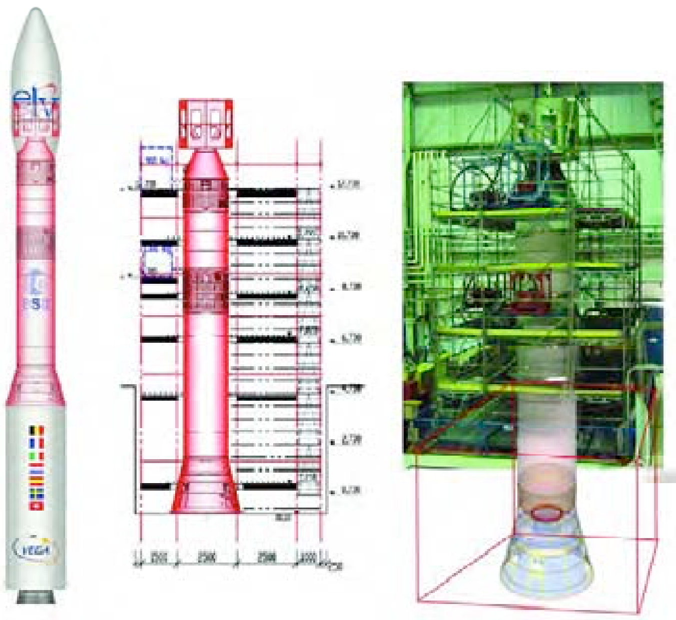
Avionics functions are distributed among hardware items and onboard software. They are split into three subsystems:

– the guidance, navigation and control subsystem, grouping all acquisition and execution means, data processing and data communication needed by the flight control function (during pre-launch and flight mission phases);
– the electrical safeguard subsystem, consisting of all the equipment for power generation, reception, processing and transmission to ground needed by the safety functions;
– the telemetry subsystem, including all the means to acquire and process the telemetry monitoring functions, and transmit to the ground.

In order to reduce as much as possible the development and recurring costs, the Vega avionics system is based on the use of existing hardware and/or components from Ariane and other ESA programmes. As an example, the Vega onboard computer (OBC) is based on existing blocks and components from ESA satellite programmes.

## The Ground Segment

As with Ariane-4, the Vega launcher is assembled and tested on its launch pad. The launcher preparation takes place inside a Mobile Gantry, housing all the Ground Support Equipment needed to assemble and check the launcher, which is moved back a few hours before the launch.



*Characterisation of launch vehicle bending modes and structural damping at IABG in Germany (ELV)*

The former Ariane-1 platform (bunker) is being refurbished and upgraded for Vega. The launch pad itself is equipped with several pipe networks which fulfil the different functions required, e.g. pressurisation, cooling, ventilation, flushing and propellants loading.

The Upper Composite assembly and checks will be done inside the payload integration facilities at CSG (Ensemble de Préparation des Charges Utiles, EPCU).

The Vega Control Bench facilities will be located in the Centre De Lancement (Launch Centre) No. 3 (next to that for Ariane-5).

| | P80 | Z23 | Z9 |
|---|---|---|---|
| Overall length (mm) | 10 791 | 7585 | 3953 |
| Outer diameter (mm) | 3003 | 1904 | 1907 |
| Propellant mass (kg) | 87 733 23 | 823 10 | 570 |
| Inert mass (kg) | 7030 | 1951 | 915 |
| Burn time (s) | 110 | 77 | 118 |
| Vacuum specific impulse (s) | 280 | 288 | 296 |
| Nozzle expansion ratio 16 | 27 | 72.5 | |

*SRM nominal characteristics and performances*

| Characteristics and performances | |
|---|---|
| AVUM stage dry mass (kg) | 615 |
| Propellant loading (kg) | 577 |
| Pressuring (GHe) gas loading (kg) | 4.1 |
| Main engine thrust (N) | 2450 |
| LPS total impulse (kN s) | 1634 |
| Restart capability | 5 |

*AVUM nominal characteristics and performances*

## Vega Development Status

***Launch vehicle***

System activities in 2007 were devoted to the consolidation of the launch system design in the frame of the Vega System Critical Design Review activities, allowing the start the qualification loop activities in December.

In parallel, the development activities at equipment and subsystem levels have allowed the completion of most of the critical design reviews. For some of the elements, like the fairing, the inter-stage 0/1, the ignition and separation pyrochains, the AVUM structure, the On-Board Computer and the safety units, Qualification Reviews have already been performed.

Testing activities have been very intense too. The Upper Composite Mechanical model (UCMEC) underwent vibration and acoustic testing at the ESTEC Test Centre from summer 2006 until the beginning of October. The third and fourth stage separation and fairing horizontal separation system (HSS) tests have been performed, in EADS-CASA facilities in Spain, in December 2006 and February 2007 respectively. During November 2007, the characterisation of the launch vehicle bending modes and structural damping was carried out at IABG (D) with the integration of all the launch vehicle subassemblies except the first stage (P80 plus inter-stage 0/1).

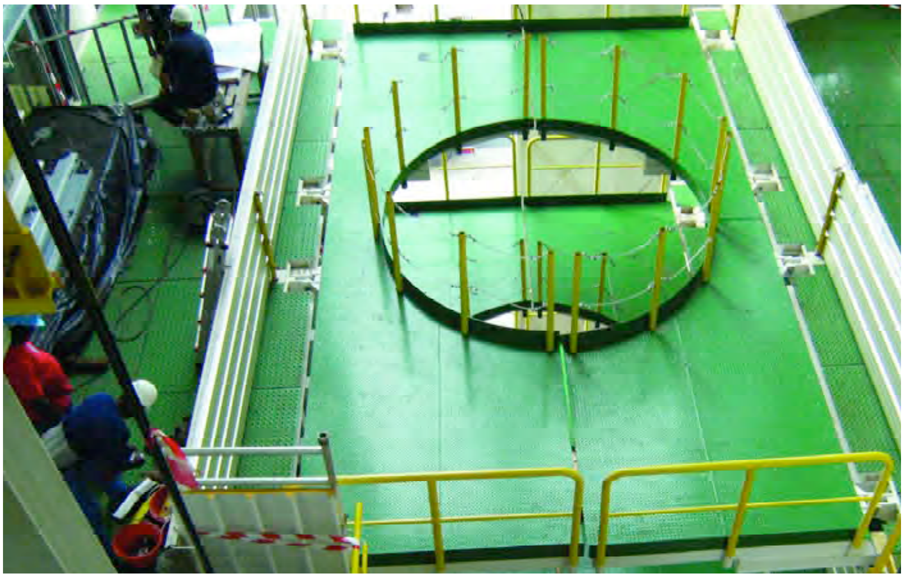
The Vega Upper Composite electromagnetic compatibility tests were completed successfully in Colleferro (I) during summer 2007, and in INTA (E) for the final part of the conducted and radiated susceptibility tests at the end of 2007/early 2008.

The qualification of the avionics has made significant steps ahead with the set up of the 'hardware in the loop' facility, now nearly finished, and the completion of the first validation campaigns of the safeguard subsystem (SAS) and communication subsystem.

The P80 solid-rocket motor – the first stage – successfully completed its qualification firing test in December 2007, one year after the test-firing of the development model, confirming the predicted performances and behaviour. Due to its size, the P80 firing tests are performed at the Booster Test Stand (Bâtiment d'Essais des Accélérateurs à Poudre, BEAP) at CSG.

A few months later, in March 2008, at the Italian Air Force Salto di Quirra Range (Sardinia), the Zefiro-23 solid-rocket motor – the second stage – also completed its functional qualification with a successful second test-firing.

The qualification firing test of the Zefiro-9 solid-rocket motor took place in March 2007, but failed with the ejection of the nozzle after 35 seconds of operating time. An inquiry board was put in place, and pointed some weaknesses in the design of the nozzle and in manufacturing quality on some of its components. Intense work was made by Avio teams in order to recover the situation, with a complete material characterisation campaign (in particular of the carbon-phenolic (C-Ph) materials used in the insulators of the carbon-carbon nozzle throat, operating at up to 2000°C), redesign of the nozzle, and improvement in the manufacturing process and then quality of the C-Ph



Mobile Gantry integration activities in CSG (Vitrociset)

insulators. Most of these improvements were applied on the nozzle of the Zefiro-23 qualification model and the nozzle expertise after its successful firing test confirmed the soundness of the modifications.

Taking advantage of the schedule shift because of the redesign of the Zefiro-9 nozzle, the project decided to increase the Zefiro-9 performance with an overloading of propellant (by 560 kg), allowing and improvement in launcher payload capability of more than 60 kg. Following a review of the impact at motor and system levels, the implementation of this modification was endorsed through the System Critical Design Review.

Because of these significant changes in the third-stage motor configuration (now named Zefiro-9A), two firing tests are still needed to demonstrate the qualification. They are scheduled in October 2008 and February 2009.

Not only do solid-rocket motor firing tests verify the correct overall behaviour of the Vega motors and demonstrate that the ballistic performances comply with the system requirements, but they also contribute to the Thrust Vector Control (TVC) subsystems qualification as well. Large amplitude movements of the TVC system were executed during the P80 and Zefiro tests, simulating worst-case manoeuvres, and the performance was satisfactory.

For the liquid-propulsion subsystem – the fourth-stage main engine – derived from the Ukrainian RD-869 engine (Yuzhnoye) has already successfully undergone several test campaigns with two qualification models. The firing test at subsystems level (complete liquid propulsion subsystem in the flight configuration) is under preparation at the P2 test stand in Lampoldshausen (D) and the test campaign will start in summer 2008. This will be the final step to demonstrate the liquid-propulsion system suitability for the Qualification Flight. The manufac-turing, assembly and integration of the units for the Qualification Flight have already started, according to their qualification status.

The focus in 2008 on the launch vehicle side will be the closure of the major actions resulting from the development activities and reviews, the completion of all the qualification reviews at equipment and subsystem levels and the acceptance of the flight units, as well as of course the preparation of the ground qualification review of the launch system, scheduled to start in the first quarter of 2009, and the preparation for the maiden flight.

***Ground Segment***

The Vega ground segment has entered in its final phase with the completion of the detailed design of the various subsystems (mechanical, fluid and control centre).

At CSG, the civil works of refurbishment of the bunker and integration of the Mobile Gantry main structure have been completed as well as the installation of equipments for heating, ventilation and air conditioning. The launch table has been integrated in its position, and will be soon completed with the upper and lower pallets. The umbilical mast is being erected in the launch area, in parallel with the integration of piping for fluid installation.

Fluid panels factory acceptance has been completed in Europe and they will be shipped to Kourou and connected to the networks on the launch pad.

The Vega Control Centre (CCV), fully developed and tested at the ground segment prime contractor premises with a first release of software, has been shipped to the launch site. This release will be used to start the ground segment integrated tests phase. Further releases are foreseen to cover late changes.

The next important milestone for the Vega ground segment is the Test Readiness Review for the integrated test phase under the responsibility of the industrial prime contractor and closely followed by ESA/IPT with a dedicated team on site. The closure of this test phase will allow pronouncing the technical qualification of the Vega ground segment.

***Launch System***

Activities at launch system level are now focused at the preparation of the Combined Test Campaign. This will be the major step of the launch system development, being the first time that the launcher (a representative mock-up) and the ground segment will meet together.

These tests will allow the validation of all processes, from the delivery of subassemblies in Europe, their transportation to Kourou, storage, integration on the launch table and the final preparation of the launch vehicle as for flight, which includes the propellant loading and the validation of the countdown phase.

A dedicated Integrated Operations Team has been set up to manage this Combined Test Campaign, taking advantage of the cooperation between the different players and securing at the same time the continuity of technical competences through the different phases of realisation and validation of products up to the integration and launch campaigns. Specialists from industrial contractors, support services and the future operator Arianespace are involved under the coordination of the Vega Integrated Project Team.

After completion of the combined tests and Ground Qualification Review, the Flight Readiness Review will enable the start of the Qualification Flight campaign that will complete the preparation for the maiden flight. The Launch Readiness Review will give the green light for the maiden flight, and this will be followed by a detailed exploitation of the flight results and by the Flight Qualification Review.

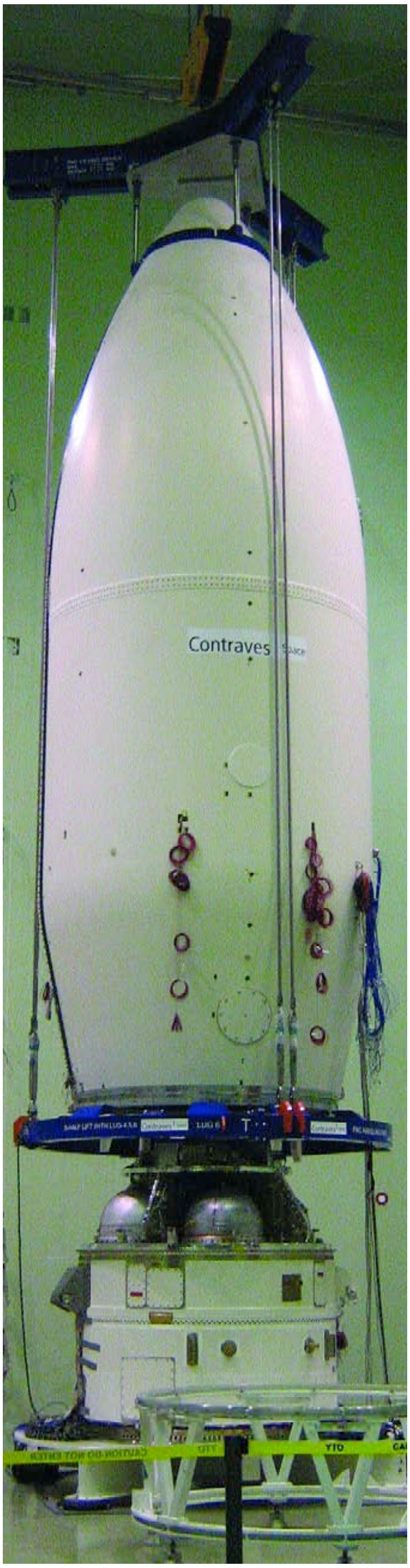
### *The Qualification Flight*

The mission for the Qualification Flight has been defined to take into account different targets: mitigation of risks inherent to the first flight, representativeness of the mission within the flight qualification domain, compliance with ground/flight safety and programmatic constraints.

In particular, due to the larger uncertainties in a first flight, specific constraints are introduced to limit the risks safetywise. Hence the payload mass has been reduced for this flight.

The main passenger of the maiden flight is the LARES experiment developed by ASI. This is a satellite laser-ranging experiment, completely passive with no sensors or on-board electronics. The main scientific objective of the LARES mission is the measurement of the dragging of inertial frame due to Earth's angular momentum (or 'Lense-Thirring effect') and a high precision test of Earth's gravitomagnetic field. Gravitomagnetic field and inertial frame drag are predictions of Einstein's theory of General Relativity.

The secondary payloads of the maiden flight are educational microsatellites.




*AVUM and fairing at ESTEC for upper-composite mechanical tests (ELV)*

## From Development to Exploitation

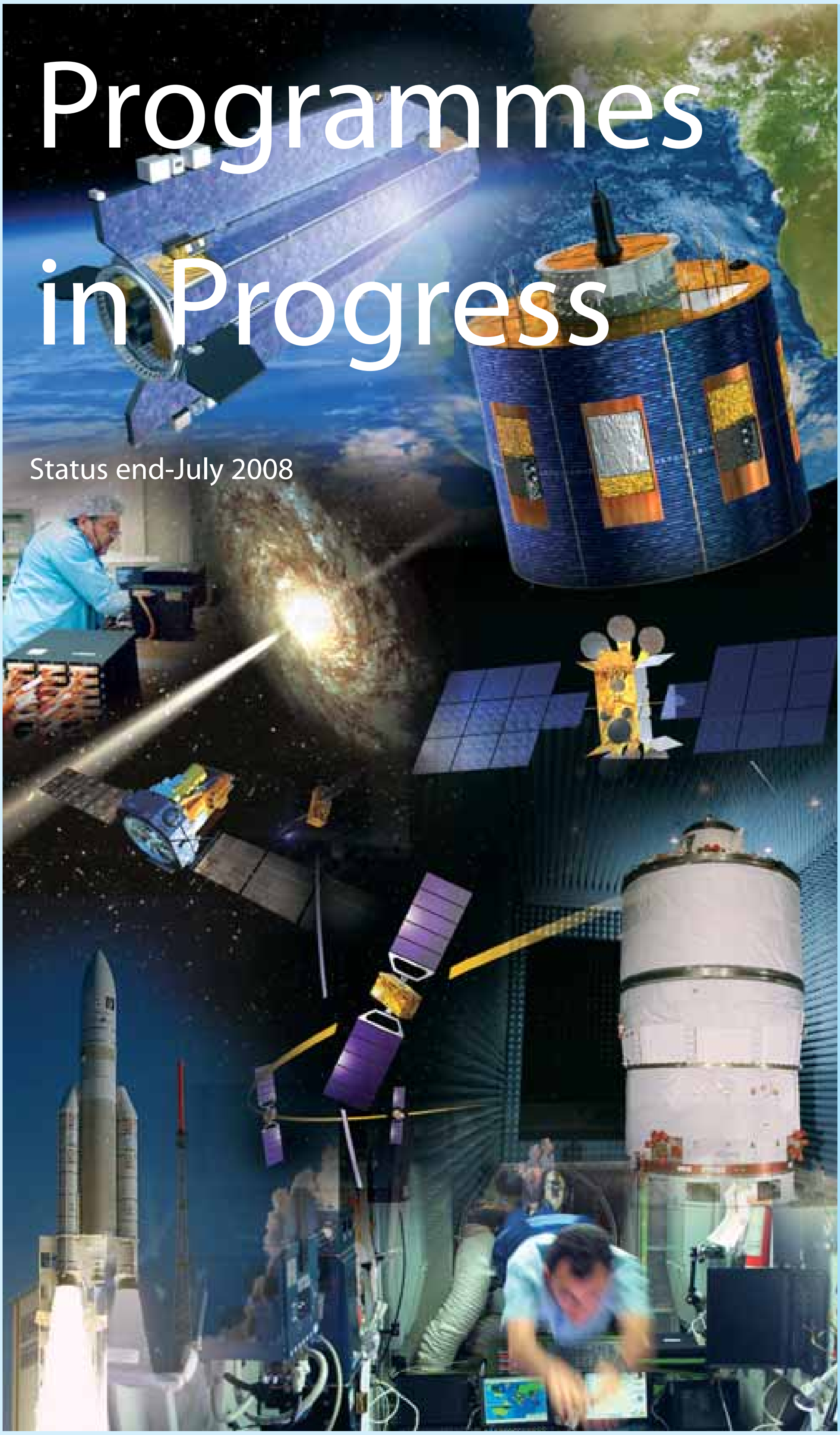
For a smooth transition between development and exploitation, the VERTA programme will undertake five flexibility demonstration flights, primarily for ESA user missions. Different ESA user mission candidates are already identified for these five launches:

- ADM-Aeolus Earth observation mission, weighing around 1400 kg, to be placed in a sun-synchronous orbit at about 400 km altitude;
- SWARM Earth observation mission, comprising a constellation of three satellites in near-polar orbits, between 450 and 550 km altitude;
- LISA Pathfinder science mission, weighing about 1900 kg, with an operational orbit around the first Earth-Sun Lagrange point (L1) after a transfer trajectory from a low Earth parking orbit;
- Proba-3, a formation-flying cluster of two mini-satellites, with a highly elliptical final orbit;
- ESA IXV demonstrator for re-entry applications, weighing around 1850 kg, to be de-orbited by the Vega upper stage before starting its re-entry phase at 120 km altitude.

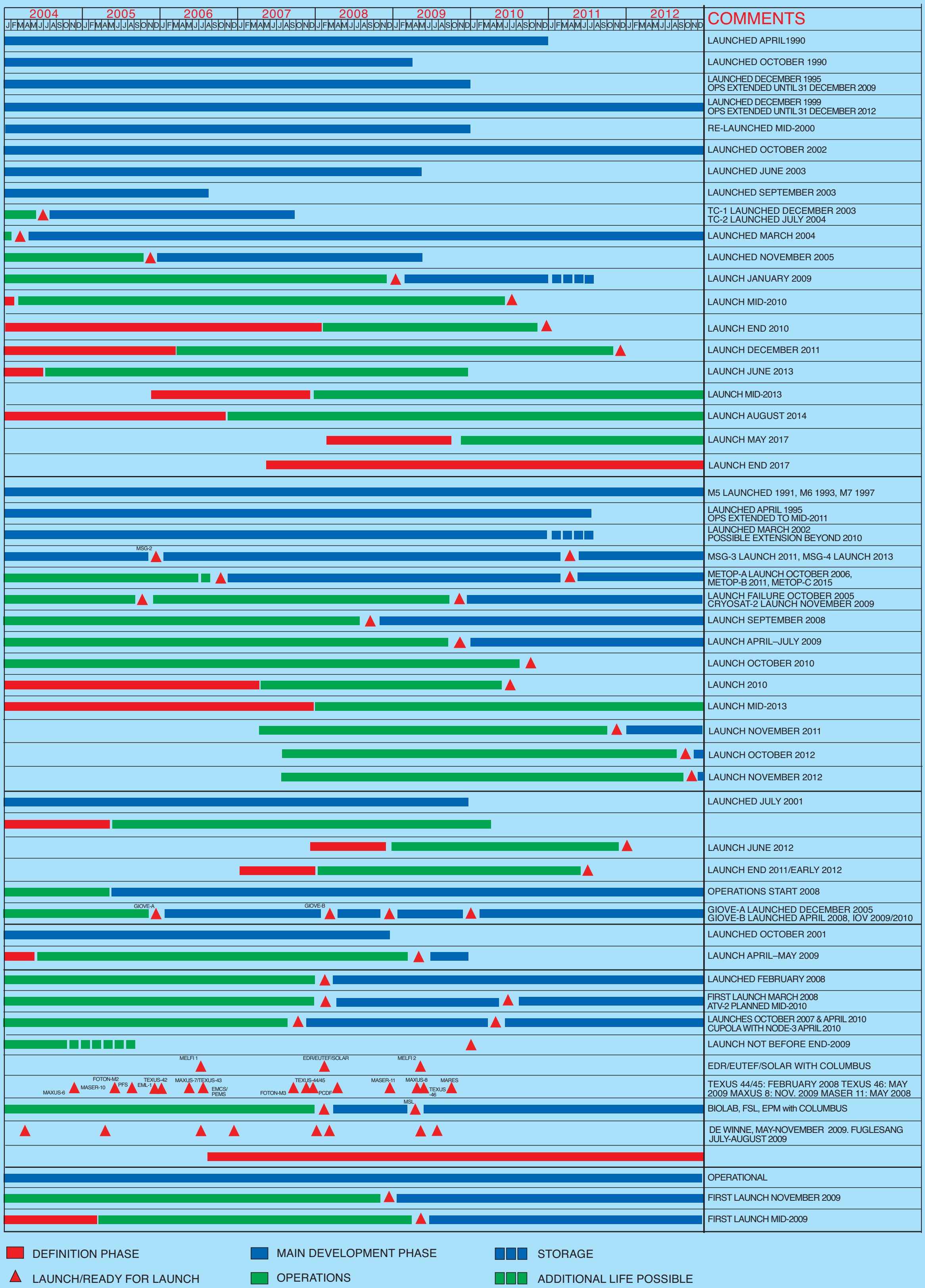
For the first VERTA flight, scheduled six months after the maiden flight, ESA will issue an international Announcement of Opportunity (AO). The response to the AO will be assessed by ESA, with the participation of Arianespace, and building upon such an assessment, in a second step, a Call(s) for Proposals will be published, and the payload(s) for the first VERTA flight will be selected.

# Programmes in Progress

Status end-July 2008



| Programme | PROJECT |
|---|---|
| SCIENCE & ROBOTIC EXPLORATION PROGRAMME | HUBBLE |
| | ULYSSES |
| | SOHO |
| | XMM-NEWTON |
| | CLUSTER |
| | INTEGRAL |
| | MARS EXPRESS |
| | SMART-1 |
| | DOUBLE STAR |
| | ROSETTA |
| | VENUS EXPRESS |
| | HERSCHEL/PLANCK |
| | LISA PATHFINDER |
| | MICROSCOPE |
| | GAIA |
| | JWST |
| | EXOMARS |
| | BEPICOLOMBO |
| | SOLAR ORBITER |
| | LISA |
| EARTH OBSERVATION PROGRAMME | METEOSAT-5/6/7 |
| | ERS-2 |
| | ENVISAT |
| | MSG |
| | METOP |
| | CRYOSAT |
| | GOCE |
| | SMOS |
| | ADM-AEOLUS |
| | SWARM |
| | EARTHCARE |
| | SENTINEL-1 |
| | SENTINEL-2 |
| | SENTINEL-3 |
| COMMS./NAV. PROGRAMME | ARTEMIS |
| | ALPHABUS |
| | ALPHASAT |
| | SMALL GEO SAT. |
| | GNSS-1/EGNOS |
| | GALILEO |
| TECHNOL. PROG. | PROBA-1 |
| | PROBA-2 |
| HUMAN SPACEFLIGHT PROGRAMME | COLUMBUS |
| | ATV |
| | NODE-2 & -3 & CUPOLA |
| | ERA |
| | ISS BARTER & UTIL. PREP. |
| | EMIR/ELIPS |
| | MFC |
| | ASTRONAUT FLT. |
| | AURORA CORE |
| LAUNCHER PROG. | ARIANE-5 |
| | VEGA |
| | SOYUZ AT CSG |


2004
2005
2006
2007
2008
2009
2010
2011
2012
COMMENTS
LAUNCHED APRIL1990
LAUNCHED OCTOBER 1990
LAUNCHED DECEMBER 1995
OPS EXTENDED UNTIL 31 DECEMBER 2009
LAUNCHED DECEMBER 1999
OPS EXTENDED UNTIL 31 DECEMBER 2012
RE-LAUNCHED MID-2000
LAUNCHED OCTOBER 2002
LAUNCHED JUNE 2003
LAUNCHED SEPTEMBER 2003
TC-1 LAUNCHED DECEMBER 2003
TC-2 LAUNCHED JULY 2004
LAUNCHED MARCH 2004
LAUNCHED NOVEMBER 2005
LAUNCH JANUARY 2009
LAUNCH MID-2010
LAUNCH END 2010
LAUNCH DECEMBER 2011
LAUNCH JUNE 2013
LAUNCH MID-2013
LAUNCH AUGUST 2014
LAUNCH MAY 2017
LAUNCH END 2017
M5 LAUNCHED 1991, M6 1993, M7 1997
LAUNCHED APRIL 1995
OPS EXTENDED TO MID-2011
LAUNCHED MARCH 2002
POSSIBLE EXTENSION BEYOND 2010
MSG-2
MSG-3 LAUNCH 2011, MSG-4 LAUNCH 2013
METOP-A LAUNCH OCTOBER 2006,
METOP-B 2011, METOP-C 2015
LAUNCH FAILURE OCTOBER 2005
CRYOSAT-2 LAUNCH NOVEMBER 2009
LAUNCH SEPTEMBER 2008
LAUNCH APRIL–JULY 2009
LAUNCH OCTOBER 2010
LAUNCH 2010
LAUNCH MID-2013
LAUNCH NOVEMBER 2011
LAUNCH OCTOBER 2012
LAUNCH NOVEMBER 2012
LAUNCHED JULY 2001
LAUNCH JUNE 2012
LAUNCH END 2011/EARLY 2012
OPERATIONS START 2008
GIOVE-A
GIOVE-B
GIOVE-A LAUNCHED DECEMBER 2005
GIOVE-B LAUNCHED APRIL 2008, IOV 2009/2010
LAUNCHED OCTOBER 2001
LAUNCH APRIL–MAY 2009
LAUNCHED FEBRUARY 2008
FIRST LAUNCH MARCH 2008
ATV-2 PLANNED MID-2010
LAUNCHES OCTOBER 2007 & APRIL 2010
CUPOLA WITH NODE-3 APRIL 2010
LAUNCH NOT BEFORE END-2009
MELFI 1
EDR/EUTEF/SOLAR
MELFI 2
EDR/EUTEF/SOLAR WITH COLUMBUS
MAXUS-6
MASER-10
FOTON-M2
PFS
EML-1
TEXUS-42
MAXUS-7/TEXUS-43
EMCS/PEMS
FOTON-M3
TEXUS-44/45
PCDF
MASER-11
MAXUS-8
TEXUS 46
MARES
TEXUS 44/45: FEBRUARY 2008 TEXUS 46: MAY 2009 MAXUS 8: NOV. 2009 MASER 11: MAY 2008
MSL
BIOLAB, FSL, EPM with COLUMBUS
DE WINNE, MAY-NOVEMBER 2009. FUGLESANG JULY-AUGUST 2009
OPERATIONAL
FIRST LAUNCH NOVEMBER 2009
FIRST LAUNCH MID-2009
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
STORAGE
LAUNCH/READY FOR LAUNCH
OPERATIONS
ADDITIONAL LIFE POSSIBLE

# Ulysses

Since the failure of the X-band EPC/TWTA in January, numerous attempts to re-establish an X-band downlink have been made without success. Despite this, an S-band science mission is still ongoing at the time of writing. At the end of May, the S-band downlink had deteriorated because of the increasing distance between the spacecraft and Earth to the point that playback of recorded data could no longer be supported and only spacecraft data received in real-time during a tracking pass are now able to be acquired.

Without the heating effect of the X-band TWTA, the temperature in a portion of the hydrazine pipe-work in the lower spacecraft section continues to decrease. Since the pipe-work temperature drops when the S-band transmitter is on, tracking passes of only a few hours' duration are now scheduled. In addition, fuel is being moved every two hours through the short length of cold pipe-work where freezing is likely to occur by simultaneously firing two opposing thrusters. As a result of these and other operational measures, the projected mission end date of 1 July 2008 was reached without the hydrazine freezing. Spacecraft operations and science data acquisition will continue using the same strategy until freezing occurs.

An international workshop focusing on the contributions of Ulysses to the network of space missions that are collectively exploring the Sun and heliosphere as an integrated system was held on the island of Kefalonia, Greece, on 6–9 May, followed by a press conference highlighting the legacy of Ulysses in Paris on 16 June.

# SOHO

SOHO has just discovered its 1500th comet, making it more successful than any other comet discoverer throughout history. Not bad for a spacecraft that was designed as a solar physics mission! The small faint Kreutz-group comet was discovered on 25 June by US-based veteran comet-hunter and amateur astronomer Rob Matson.

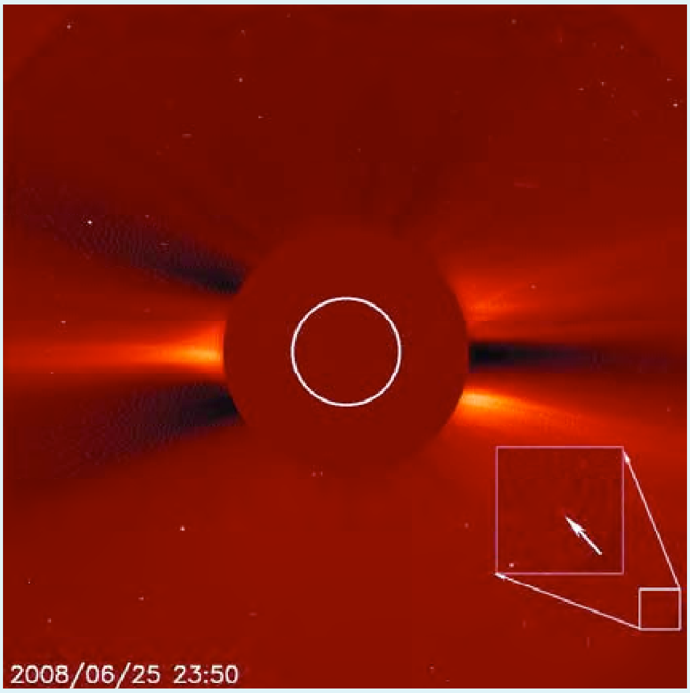
Roughly 85% of the SOHO discoveries, including this one, are fragments from a once-great comet that split apart in a death plunge around the Sun, probably many centuries ago. The fragments are known as the Kreutz group and now pass within 1.5 million kilometres of the Sun's surface when they return from deep space. Of course, SOHO itself does not make the detections; that task falls to an open group of highly skilled volunteers who scan the data as soon as it is downloaded to Earth (usually within 15 minutes after it is taken). Enthusiasts from all over the world look at each individual image for a tiny moving speck that could be a comet. When someone believes they have found one, they submit their results to the SOHO team where the findings are checked before submitting them to the Minor Planet Center, where the comet is catalogued and has its orbit calculated.

# Cassini-Huygens

The nominal four-year mission of Cassini-Huygens came to an end on 30 June 2008. However, the journey around Saturn will continue for at least another two years following the recent approval by NASA of the Cassini Equinox Mission. This mission will address discoveries and new questions raised by Cassini-Huygens and will continue exploring two of its most intriguing targets: Titan (26 targeted flybys planned) and Enceladus (6 flybys planned).

# XMM-Newton

All the stars, galaxies and gases observable in the Universe account for less than a half of all the atoms (baryons) the Universe is made of. Scientists have predicted that the 'missing' matter exists in the form of low-density gas that fills vast spaces between galaxies forming a web-like structure. The 'missing' matter would have a high temperature and so it would primarily emit low-energy X-rays. But its very low density made observation extremely difficult. XMM-Newton's observations of a pair of galaxy clusters, Abell 222 and Abell 223, situated at a distance of 2300 million light-years from Earth, detected a bridge of hot gas connecting the two clusters. The hot gas in this bridge or filament is probably the hottest




*SOHO's record-breaking comet discovery was made on 25 June 2008. Images of this small faint object were captured by the Large Angle and Spectrometric Coronograph (LASCO), one of SOHO's 12 instruments on board (ESA/NASA)* and densest part of the diffuse gas in the cosmic web.

About 330 scientists participated in the 'The X-ray Universe 2008' symposium in Granada (E), on 27–30 May 2008 and opened by ESA's Director of Science and Robotic Exploration, Prof. David Southwood. A smooth and professional organisation of the conference contributed significantly to the overall success of the symposium and to the good impression made on all participants. The conference was exceptionally interesting from the scientific viewpoint reflecting the mature state of the scientific return from XMM-Newton.

## Cluster

From 25 April to 30 May, a 'tilting campaign' was performed, in which the spin axis of Spacecraft 3 was tilted by 45 degrees relative to the other spacecraft to allow electromagnetic waves and electric fields to be measured in three dimensions. Throughout the campaign, platform and payload temperatures remained within the forecast range.

The periodic magnetic activity, or substorms, at Jupiter and Earth was compared using Galileo and Cluster data respectively, by Kronberg *et al.* in the *Journal of Geophysical Research.* The paper highlighted striking similarities, suggesting that the same cyclic mechanism of loading and unloading affects both magnetospheres. A special issue of the *Journal of Geophysical Research* has been published containing 32 papers on Cluster and Double Star's most recent results.

## Double Star

Observations made by a unique constellation of Double Star TC-2 (at 10 Earth radii), Cluster (at 14–16 Earth radii), GOES-10 and the LANL spacecraft (near 6.6 Earth radii) have allowed Sergeev *et al* to study the details of three reconnection events located unusually close to Earth (10–12 Earth radii).

The period August–September is critical since it was at this time last year that contact with Double Star was lost. The reason was most likely due to very high spacecraft temperatures and minimal solar array power. Because of the low power, instrument operations will be suspended from 15 July to 15 September. If the situation improves during that time, the instruments (FGM and PEACE) will still be able to operate via direct command from the Chinese Operations Centre.

## Mars Express

The PFS instrument has studied seasonal, diurnal, and spatial variations of methane in the Martian atmosphere. The so-called methane mixing ratio shows a slow decrease from northern spring to southern summer. The change is extremely small, but can still be clearly observed.

Data from OMEGA and PFS have been used to study the evolution of the water vapour concentration over the Hellas basin as a function of the seasonal cycle. The data show an abrupt enhancement of the water vapour column density on a timescale of three days. Such an increase is not predicted by models, and was also occasionally observed by Mars Global Surveyor over the Hellas basin during previous martian years at the same season; however, its origin is not yet understood.

The first article to be fully based on data from three Mars Express experiments was accepted for publication in June 2008. This study suggests that the crustal magnetic fields, when they happen to be organised in 'cusp-like' structures, can trigger the aurorae observed.

## Rosetta

The Rosetta spacecraft has spent the last three months in passive cruise model, while the ground segment finalised preparations for the active payload checkout (PC8) and interference campaign in July 2008, and the subsequent flyby of asteroid (2867) Steins, for which the navigation started on 4 August 2008.

Asteroid (2867) Steins was discovered by N.S. Chernykh on 4 November 1969 at the

*The High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft has returned images of Echus Chasma, one of the largest water source regions on the Red Planet. Echus Chasma is the source region of Kasei Valles that extends 3000 km to the north. This image was taken on 25 September 2005, centred on 1° North and 278° East, with a resolution of about 17 m/pixel. The dark material shows a network of light-coloured, incised valleys that look similar to drainage networks known on Earth. It is still debated whether the valleys originate from precipitation, groundwater springs or liquid or magma flows on the surface (ESA/ DLR/FU Berlin)*

Crimean Observatory, Nauchnyj, Ukraine. It was provisionally designated as 1969VC and later numbered, and named after the astronomer K.A. Steins. It is an asteroid of the Main Belt with an eccentricity of 0.145 and a perihelion distance of 2.019 AU. (2867) Steins is believed to be an E-type asteroid, which is characteristic of iron-poor or iron-free silicates. It has an irregular shape with an average diameter of about 4.6 km and an albedo of 0.45 ± 0.10 derived from polarimetric data. Its rotational period was recently determined also from observations obtained with the OSIRIS camera system on board Rosetta. From the light curve obtained a rotational period of 6.052 ± 0.007 hrs was derived.

The flyby of this asteroid has been scheduled from 4 August to 5 October 2008 with closest approach on 5 September 2008, 18:37 UTC, when the asteroid is at a heliocentric distance of 2.14 AU and a geocentric distance of 2.41 AU. The targeted minimum flyby distance is 800 km and the relative flyby velocity is 8.62 km/s. A flyby strategy was selected that will allow continuous observation of the asteroid before, during and after closest approach. Rosetta will pass the asteroid on the sunward side approaching from low phase angle, going through phase angle zero, and entering high phase angles after closest approach. The planning activities for the asteroid flyby phase have been completed and detailed scheduling is now proceeding. By the end of June 2008, Rosetta was 285 million km (1.9 AU) away from the Sun and 211 million km (1.41 AU) from Earth.

## Venus Express

The airglow of the hydroxyl molecule has been detected in the upper atmosphere of Venus for the first time. This will improve the understanding of the chemical processes and is useful for tracing the dynamics in this region.

A first-ever surface temperature distribution map of the southern hemisphere has been compiled. New data have shown a surprisingly variable concentration of sulphur dioxide in the upper atmosphere. This has led to a renewed discussion on the case of present volcanism on Venus.

The clouds on Venus, which exist in a layer extending between 45 and 70 km above the surface, move rapidly. These clouds are mainly composed of micrometre-sized droplets of sulphuric acid and other aerosols, the origin of which is unknown.

The Venus Monitoring Camera (VMC) on board Venus Express has been observing the top of the cloud layer in visible, near-infrared and ultraviolet wavelengths. Ultraviolet observations have shown a wealth of new details including a variety of markings created by variable concentrations of different aerosols located at the top of the cloud layer. The shape of the clouds on Venus changes dramatically from the equator to the pole. At low latitudes, the cloud shape is spotty and fragmented, a consequence of a vigorous convective movement powered by the radiation of the sun heating the atmosphere itself.

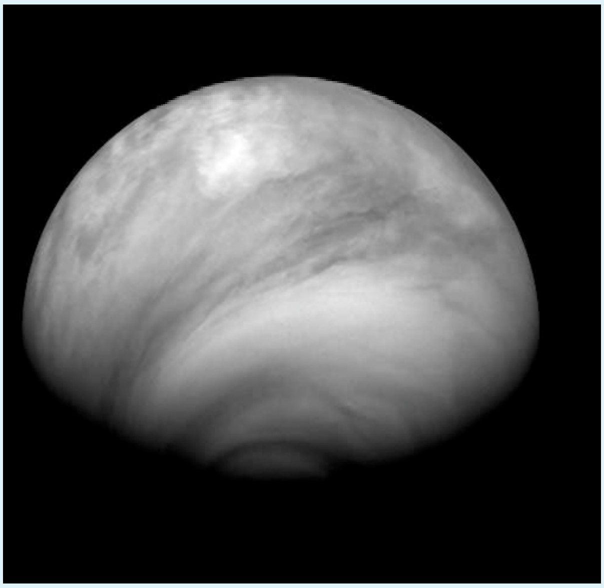
## COROT

COROT has now been in orbit for more than one and a half years. During this time, more than 30 000 stars have been observed during unprecedented long (and uninterrupted) periods of up to 150 days.

A characteristic of the COROT mission is that since the observing periods are so long, by the time the data has been acquired by the co-investigators, the Sun is in the part of the sky which the spacecraft has just observed, making the follow-up observations from the ground (necessary to confirm any planet candidates) impossible during a further six months. This causes a serious bottleneck in the follow-up process. Therefore, there is a significant delay in the presentation of scientific results. It is expected that this will be alleviated in about six months when the first data will become public.

Nevertheless, seven extrasolar planets have been confirmed, and about 30 more high-priority candidates are currently being followed up. About 10 papers in refereed journals are published or submitted. All of these potential planets are similar to Jupiter in our Solar System. A re-evaluation of all hitherto observed fields is under way, as the software for planetary detection is continuously being refined, in order to search for smaller planets.

The first asteroseismological signatures, at a level similar to those previously only detected in the Sun, have been detected in a solar-type star. The results have been submitted to scientific journals.



*An ultraviolet VMC image of Venus from 30 000 km. The south pole is at the bottom, while equator is at the top. The bright lace visible on top of the darker cloud deck is made of freshly formed droplets of sulphuric acid. At mid latitudes, the convective clouds make way for more streaks, indicating that the flow is basically laminar in this part of the atmosphere. At high latitudes, the cloud structure appears as a dense, almost featureless haze forming some a 'polar cap' on Venus. The dark, circular feature visible at the lowest part of the image is one of the dark streaks usually present in the polar region, indicating atmospheric parcels spiralling towards the pole (ESA/MPS/DLR/IDA)*

# Herschel/Planck

Both spacecraft are in the final stages of the flight acceptance testing and have completed a set of major milestones.

The main highlight of the Herschel flight model test campaign was the completion of the mechanical test campaign (sine vibration test and the acoustic noise testing). The satellite is now undergoing the final functional and performance verification before the thermal vacuum and thermal balance test later this year. All the functional testing that needed to be completed before and after the mechanical test campaign have also been carried out, including the system validation test where the satellite is operated by the mission control centre in ESOC. A first electromagnetic compatibility test has been carried out, measuring the radiated emission of the operational satellite in the large anechoic chamber in ESTEC, showing the expected very low emission level of the satellite, a key input to the demonstration that the satellite will not disturb the very sensitive detectors of the scientific instruments in orbit.

The Planck flight model satellite is undergoing its last big environmental test before flight, the thermal balance and thermal vacuum test in the test chamber at CSL in Liege (B). During the two-month long test, the performance of the scientific instruments under orbit like cryogenic conditions will be verified. This includes cooldown of the system with the three cooler stages of Planck with the lowest temperature of 0.1K being reached at the HFI bolometers. The test started with the satellite in the chamber in mid June to functionally test the satellite. One of these tests was the science operations validation test with the satellite being operated by the control centre in ESOC, simulating five operational days in orbit and processing the data coming from the satellite through the complete ground segment, including the data-processing centres of the two scientific instruments.

Overall, the test activities of the last months were carried out on time, leading to readiness of both satellites for launch just before the end of the year.

# LISA Pathfinder

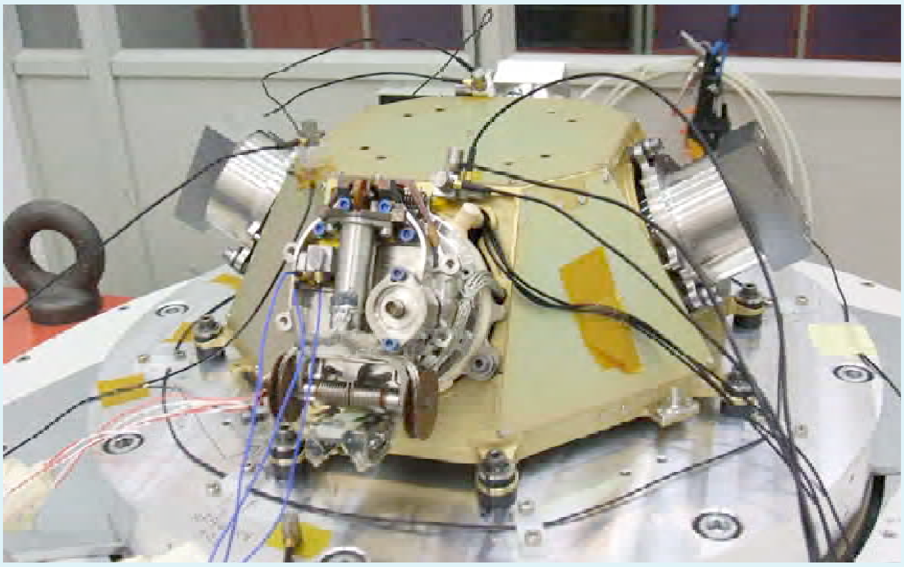
The LISA Pathfinder development is in progress despite a delay in the schedule. The main engineering activities are related to finalising the spacecraft design, in preparation for the spacecraft CDR to be held in the autumn. All subsystems have already had their own subsystem CDRs and many equipment suppliers have delivered electrical units and some their Flight Models. The science module FM structure that was damaged during the static test has been repaired and will be used in the summer together with the propulsion module structure for a combined acoustic and separation test. A new FM structure has been

*Planck fine-balancing test at ESTEC inside the Large Space Simulation facility* built in parallel by Oerlikon Space (CH) to be used for flight. The on-board software development is proceeding. The versions 2.0 and 2.1 are being used by the Drag Free Attitude Control (DFAC) team in Astrium GmbH and by Astrium Ltd for their testing. These two test set-ups (Real-time Test Benches) will proceed in parallel initially with electrical units and later with flight units until spacecraft FM integration.

The two European micropropulsion technologies (needle indium thrusters and slit caesium thrusters) continue their challenging development to prove the readiness of the technologies. Especially in slit technology, substantial steps have been made towards a final validation of the technology, expected by the end of the year. The technology that will not be selected for flight will be held as a back-up.

Concerning the LTP, after completion of the system CDR, the work is focused on the critical subsystems, e.g. caging mechanism, electrode housing and Data Management Unit software. All the LTP Electrical Models (ELM) have been built and delivered to Astrium GmbH for the Real-time Test Bench and all electronics FM units are expected to be delivered by the end of the year.

The launch is expected to take place at the end of 2010.



*Slit FEEP thruster cluster development model for LISA Pathfinder under vibration test at ALTA (I)*

# Microscope

The T-Sage payload development is progressing on schedule.

In the micropropulsion area, an ESA/CNES status review was held end April 2008. At the Microscope Steering Committee meeting, held in May 2008, it was recognised that a decision could not made then on the thruster technology to be adopted for Microscope. It was requested to define objective criteria that will permit the choice between FEEP and cold-gas micropropulsions and to make sure that the corresponding tests required to demonstrate fulfilment of these criteria are properly planned. In the meantime CNES will pursue a Phase B of the cold-gas mission configuration to obtain the same level of definition as for the FEEP-based mission for which Phase B has been completed already.

*Telescope integration to the Herschel spacecraft*

# Gaia

Contract negotiations with the prime contractor Astrium SAS (F), for the conversion of the C/D ceiling price, are almost completed. The contract should be signed within the third quarter of 2008.

The equipment procurement has continued and only few non-flight items remain to be subcontracted. At unit level, only two PDRs are still to be held. As a consequence the CDR's process has started.

The release of the manufacturing drawings for the production of the optical bench (Torus) is progressing almost nominally. The first segment has been manufactured.

The implementation of the science ground segment moves ahead as well. The second meeting of the Steering Committee of the Data Process and Analysis Consortium (DPAC) has taken place.

# JWST

After successfully passing the mission PDR and the Non-Advocate Review, the James Webb Space Telescope was formally approved at the NASA programme management council meeting.

Integration activities on the Near Infrared Spectrograph (NIRSpec) development model are progressing, with the cryogenic harness already routed on the optical bench and the structural-thermal assemblies integrated. The instrument control electronic and control S/W passed successfully their CDR and the optical performance at ambient of the Integral Field Unit Qualification is within specification. The measurements of flight candidate detector chips are ongoing. Intensive work with breadboard models continues for the cryo-mechanism's grating and prism mount and for the refocus mechanism mirror. The instrument CDR board meeting is now planned for December 2008.

The first cryo-test campaign of the Mid Infrared Instrument (MIRI) Verification Model was successfully completed. Following the successful delivery of the telescope simulator, final cryo performance test is now due to start in August. The imager qualification review was passed successfully. The MIRI schedule has been recovered by modifying the manufacturing sequence of the grating and filter wheel mechanisms; the first units delivered will now be used for integration in the instrument flight model.

The launcher Interface Control Document issue 1.0 was released in June by Arianespace. Improvement of cleanliness control of the launcher environment, using Herschel/Planck as test case, is also ongoing.

# BepiColombo

The mission Tiger Team has been tasked to define a mission based on a launch with Ariane-5 in order to accommodate the severe mass increase. The extra launch capacity will also be used to provide design robustness for critical areas, e.g. for adequate radiator margin and for a temperature decrease on solar arrays and mechanisms. On that basis, the system design is now being reiterated. The PDR has been pushed back by one year and as a consequence, the launch is foreseen in August 2014. The SPC has been informed of the BepiColombo situation and of the order of magnitude of the cost impact. In view of the overall impact on the scientific programme, the SPC was asked to vote for cancellation of the BepiColombo project, however, the required 2/3 majority was not reached. Therefore the project team should propose a workable solution by the November SPC.

The schedule for the Instrument Preliminary Design Reviews (IPDR) has been adjusted to the actual project programme taking into account the individual payload status, and priorities for the near-term workplan were agreed with the Principal Investigators. The first IPDR started in March 2008, and the last design reviews should be completed in Autumn 2008. Interfaces for both instruments are being consolidated in close cooperation with the spacecraft prime contractor team. The BELA experiment definition is progressing with an optimised laser transmitter subsystem. The MIXS mirror optics module has completed the first design phase and the experiment configuration is being consolidated.

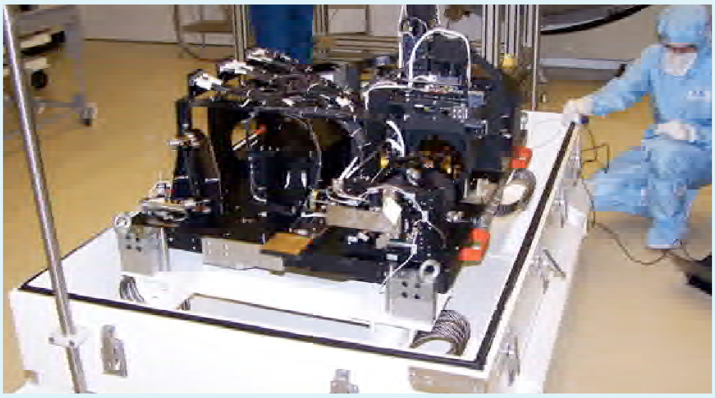
Work in Japan on the Mercury Magnetospheric Orbiter (MMO) is continuing in the C/D phase.

# Solar Orbiter

The Solar Orbiter Definition Phase (Phase B1) is being performed by an industrial team led by Astrium Ltd (UK) and including Astrium GmbH (D) and Thales Alenia Italy. It will culminate in Autumn 2009 with a System Requirements Review. Design trade-offs are addressing all major subsystems and the spacecraft heat shield upon which the survival of the spacecraft will depend when it gets close to the sun. The spacecraft baseline design relies heavily on the re-use of technology and equipment from the BepiColombo project.

The instrument proposals received from Europe and the United States in response to the Solar Orbiter Payload Announcement of Opportunity released in October 2007 have been subjected to a scientific and technical evaluation by both ESA and NASA. The spacecraft definition will now be adjusted to take into account the detailed payload complement as selected.

In parallel, technology development activities are advancing the readiness level of several key elements. The Heat Rejecting Entrance Window breadboard has been submitted to a full qualification testing sequence. A commercially available visible light detector has been characterised and submitted to total-dose radiation testing, to be followed later by proton testing. Investigations into the possibility of space qualifying a liquid crystal polariser have been started.



*MIRI Telescope Simulator after delivery to RAL (UK) (MIRI European Consortium)*

# LISA

The Mission Formulation contract started in January 2005 with Astrium GmbH has produced a solid mission baseline design and has analysed in detail a few alternative designs aimed at reducing complexity and cost. Recent discussions with NASA have led to the concrete possibility of ESA assuming the LISA mission leadership, thanks to the fundamental preparation performed in the framework of the LISA Pathfinder mission. This implies that ESA will be responsible for the LISA mission performance and eventually for the mission success.

The scope of the work that has been carried out by Astrium so far was mainly concentrated on the payload design. In the forthcoming extension, it will be extended to the overall system and mission, encompassing initiation of an end to end performance simulation, apportionment and iterations on the performances required by the various subsystems, in relation with the CTP technology development activities, consolidation of the system design and interface requirements. This will allow to progress with NASA on respective roles and responsibilities and the mission to reach the required level of maturity for the Cosmic Vision L1 mission selection planned for the end of 2009.

# ExoMars

Phase B2 work progressed well during this period with the entire industrial team being kick-off and a contract for the Phase B2 and Advanced C/D activities signed in June. The Advanced C/D activities are proceeding well, with the issue of several ITTs to start schedule critical procurements and to build up the industrial team.

On the international cooperation side, an ESA/NASA Letter of Agreement for cooperation on ExoMars was signed as well as the ExoMars and Phobos-Grunt cooperation agreement for cooperation with Russia.

The Instrument Multilateral Agreement for the ExoMars payloads was approved by the HME Programme Board and now awaits signature by the Lead Funding Agencies that will be delayed until the results of the ESA Ministerial Council in November 2008. The ExoMars Programme Proposal was reviewed several times in this period and is essentially in its final form pending last inputs related to the overall programme costs expected in September-October.

*Enhanced ExoMars Rover*


*GOCE in flight configuration at ESTEC*

## AKARI

The AKARI project has been reviewed by JAXA, who supported the implementation of the Post-Helium (i.e. warm) Phase observations for an interval of three years. Post-Helium phase observations offer imaging and spectroscopy in the 2–5 micrometre wavelength range. The routine phase started with guaranteed time observations on 1 June. The ESA and JAXA Call for Proposals for open time observations, issued in May, closed in July with 40 proposals received in total. Further to peer review, open time observations are expected to start in mid October.

The AKARI pointed observation data archive was opened for general community use on 7 March. The data being made available at this time are those taken in the Large Area Surveys and in the guaranteed time programmes, which were archived before March 2007 for internal use, and all Director's Time and Calibration observations, including data taken in the Performance Verification phase. AKARI cold-phase open time observations will be in the public domain in September 2008. New versions of the data reduction pipelines and associated user documentation have been released in June by the AKARI User Support teams.

ESA pointing reconstruction data have been delivered to ISAS for inclusion in the survey catalogues generation software. The catalogues are planned to be released for internal use in September 2008 and one year later for public use.

## GOCE

The investigation into the cause of a Breeze-M upper-stage rocket failure that led to the temporary halt of Rockot launches – thus delaying the launch of GOCE – concluded that the failure was linked to pipework being stressed in long-duration burns not foreseen for launches into low Earth orbit. Following confirmation of the flight-worthiness of the Breeze upper stage for Rockot, a new launch date in September was agreed by all parties.

The activities required to cope with the new launch date included the selection of new optimal orbit injection parameters. As a consequence, GOCE will be launched into a dusk-dawn orbit, which will allow science operations to remain unaffected by eclipses until end of March 2009. Moreover, the presently low solar activity has offered the opportunity to lower the satellite injection altitude by 10 km, which in turn improves the gravity gradient signal strength and reduces the time needed to decay to the target altitude for the first measurement phase. Finally, changing from a dawn-dusk orbit to a dusk-dawn orbit has required the reconfiguration of some platform and payload elements, notably the mounting location of star cameras and GPS antennas, and an update of the on-board application software. The formal consent to ship the satellite to the launch site was given on 18 July.

On the ground segment side, the main activities have been the rehearsal of all Payload Data Ground Segment operations and the preparations for the final Low Earth Orbit Phase and commissioning phase simulations. Additionally, a slightly updated version of the Level 1 to Level 2 processing facility has been accepted. With the conclusion of these activities the ground segment is ready for launch.

## CryoSat

The satellite is fully integrated except for one delayed subsystem. Nevertheless, system level testing is proceeding with engineering model equipment as a substitute. However, a delay in the satellite's environmental test campaign is required and consequently the start of the campaign (requiring transport of the satellite from Astrium Friedrichshafen to IABG Munich) has been formally moved from mid-July 2008 to mid-September 2008.

Following the successful System Validation Test (SVT) in March 2008, which tested the compatibility of the command and control centre at ESOC with the satellite, a complementary SVT has been planned for September 2008. Additional compatibility testing has been performed with the 'RF-suitcase', which demonstrated the compatibility of the satellite telecommand and telemetry physical radio-frequency links with a reference ground station. Testing of the interfaces between the different elements of the ground segment has also continued.

During April, a further measurement campaign in the CryoVex series was completed very successfully. The calibration, validation and retrieval team is now working on processing the results.

## SMOS

With the satellite AIT programme finished, SMOS is being prepared for storage, with some remaining activities to be performed towards the end of the year (final software uploading, third system validation test, second adaptor fit check). In the meantime, the satellite qualification review is conducted under CNES lead.In parallel, the finalisation of launcher-related documentation is taking place, to be reviewed at the final mission analysis meeting scheduled for October 2008 in Moscow.

Delivery and integration testing of the ground segment elements is taking place in the ground segment overall validation. While most functions are available as needed, the final operational processors to be installed are still under development. However, intermediate deliveries allow reasonably representative test scenarios to be run.

A rehearsal of the validation campaign took place in Spring with the University of Helsinki's Skyvan aircraft, equipped with real and synthetic aperture radiometers, an infrared camera, and GPS reflectometry instrumentation. This exercised all logistics, procedures, data processing and interpretation in order to make sure everything works for the real validation campaign after launch.

# ADM-Aeolus

Investigations could show that the anomaly found during the laser vacuum test in April 2008 was due to particles on the surface of one of the optical elements in the laser Master Oscillator that led to laser-induced damage of the optical coating. The particles were released by an adhesive bond near the component. An updated manufacturing procedure will be applied to prevent release of particles in the future.

To reduce the risk of further anomalies that could delay the qualification of the laser it was decided to perform a comprehensive review of the laser design margins and performance predictions and identify weaknesses in the baseline configuration, if any. This review, with experts from the industrial consortium, ESA and external independent consultants, took place in May and June 2008.

On the basis of existing vacuum test data and performance predictions the review came to the conclusion that the required thermo-elastic stability improvements of the Master Oscillator have been achieved, as the result of the extensive modifications that were implemented in the Master Oscillator. It pointed out, however, that further improvements of the beam stability in the amplifier and harmonic section are necessary. Also, the robustness of some optical elements against laser-induced damage should be increased by implementing new state-of-the-art coatings.

The parallel activities of performing of the repairs in the Master Oscillator, improving the beam stability of the amplifier and harmonic section, and replacing some of the optical elements by upgraded ones have been initiated. The laser qualification programme will be resumed once these modifications are in place. In addition, some back-up solutions are being prepared in case these measures do not prove fully successful.

The system tests at satellite platform level are making good progress. An advanced version of the satellite application software is currently under test and the formal qualification review of the application software is foreseen in July 2008.

# Swarm

The Critical Design Review (CDR) of the structure was successful. This paves the way for the manufacturing and assembly of the satellite structural model due to be tested during the first quarter of next year within the test facility of IABG at Ottobrunn. The recovery plan initiated last quarter for the development of the optical bench in carbon fibre is completed. The structural model of the optical bench will be tested early September this year.

The CDR of the Electrical Field Instrument (EFI) is ongoing. The engineering models of the EFI instrument and the digital processing unit of the Scalar magnetometer are ready for an electrical compatibility test with the satellite. The ground segment activities for the development of the payload data and the flight operations system are on track with a Preliminary Design Review (PDR) scheduled in September.

The next major step for the Swarm programme during the next quarter will be the consolidation of the satellite design at unit/instrument level with the completion of the unit level CDR.

*Swarm's new CFRP STM optical bench with the Vector Fluxgate Magnetometer sensor head assembled on the right side of the picture (EADS Astrium GmbH)*

# MetOp

**MetOp-A**

MetOp-A continues to perform excellently in-orbit. Investigations on the HRPT anomaly on MetOp-A revealed the unanticipated sensitivity of the power gallium-arsenide field effect transistors. Pending the results of the investigation and eventual corrective action, procurement of replacement transistors, less sensitive to heavy ions, is under way. The replacement transistors would be integrated on the MetOp-B and MetOp-C HRPTs. The transistors have successfully passed their heavy ion radiation test.

On 1 July, the Eumetsat Council has decided to abandon the LRPT services on the Eumetsat Polar System (EPS), which means that the LRPT on board the MetOp spacecraft will remain switched off.

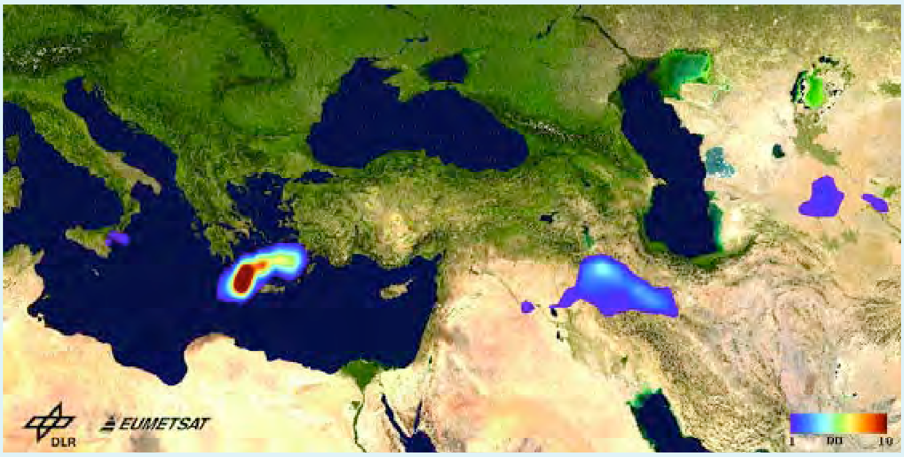
**MetOp-B and MetOp-C**

Although the MetOp Payload Modules, PLM-1 and PLM-3, are in long-term storage, there are still some residual AIT activities to be performed that require dismounting of some instruments for repair, recalibration and/or alignment. The MetOp Service Modules are kept in storage at Astrium Toulouse, waiting for the restart of AIT activities in 2009 for a planned MetOp-B launch in 2011.

# Meteosat

**Meteosat 8/MSG-1**

Investigations into the uncommanded orbit change of the Meteosat-8 spacecraft are still ongoing. The most likely cause for the observed anomaly would be the loss of two




*On 10 May 2008, the volcano Etna erupted on Sicily. The Global Ozone Monitoring Experiment 2 (GOME-2) on MetOp-A measured the resulting sulphur dioxide $SO_2$ plume, which reached an altitude of 12 km. The data were evaluated by scientists at DLR (Eumetsat/DLR)*

thermal frames, on the side of the radial thrusters. With the satellite spinning at 100 rpm, the centrifugal forces experienced on these frames are about 17g. The thermal and dynamic behaviour of the satellite fit with this assumption. The satellite experiences larger thermal gradients during eclipse nights, however all parameters remain in the nominal area. The performance of the imaging service has not suffered and is still excellent.

On 2 April 2008, Meteosat-8 started a drift from 3.4° West to 9.5° East, in preparation for the new Rapid Scan Service (RSS), and arrived there on 28 April. The MSG Rapid Scan Service was declared operational on 13 May 2008, with new MSG Level 1.5 Image Product Effective Radiance Definition being applied. The MSG RSS is a follow-on to the Meteosat-6 RSS (terminated 8 January 2007).

**Meteosat-9/MSG-2**

Meteosat-9 is Eumetsat's nominal operational satellite at 0º longitude, with Meteosat-8 as its back-up. Satellite and instruments performance are excellent.

**MSG-3 and MSG-4**

Both MSG-3 and MSG-4 are in intermediate storage in the Thales Alenia Space Cannes, awaiting the restart of the AIT campaign begin 2010, to prepare MSG-3 for its launch, currently foreseen for early 2011. MSG-4 is still awaiting its completion of the MSG-4 Pre-Storage Review. The MSG-4 launch is planned not earlier than 2013.

## Sentinel-1

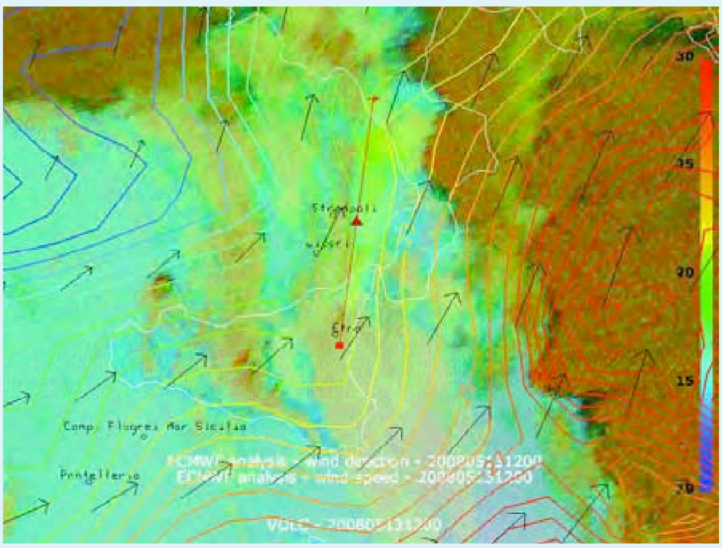
The Phase B2 is approaching its conclusion with the Preliminary Design Review. The Data Package was delivered on 25 April, the main presentation was held on 9 May at ESTEC (attended also by external experts from DLR, CSA, CNES, CDTI) and the PDR Board was held on 4 July at ESTEC.

The PDR was successful pending the resolution, within next October, of a limited number of issues. The procurement of equipments has progressed and only about a dozen equipments remain to be assigned. For the equipments to be procured in a coordinated fashion among the three Sentinels, good progress has been achieved following a commonly agreed among the three Sentinel prime contractors. The negotiation of the conversion of the ceiling price for the Phase C/D is progressing in parallel.

## Sentinel-2

Following prime contract signature for the delivery of the first satellite model between ESA and Astrium GmbH on 17 April 2008, the satellite and payload instrument system level trade-offs have been completed allowing the generation of consolidated specifications. Phase B2 procurement activities are intensifying (about 60 procurement actions), and several equipment manufacturers have now joined the industrial prime and core team consortium (e.g. for the GPS receiver, instrument optical filters). The first equipment PDR for instrument SWIR detectors has been held. Activities related to image quality monitoring and the definition of prototype processor algorithms has been initiated by CNES in support to the Sentinel-2 project team.

The 'Sentinel-2 Payload Instrument PDR' and the 'Sentinel-2 System PDR' will take place in two incremental steps from September to November 2008.



*The movement of the $SO_2$ cloud from Etna over the Mediterranean Sea towards the Middle East and up to Iran can also be followed with Meteosat-9 in this composite RGB/IR image, taken on 13 May 2008, 12:00 UTC with ECMWF winds at 200 hPa (Eumetsat/ECMWF)*

## Sentinel-3

Following the signature between ESA and the Sentinel-3 prime (Thales Alenia Space – France) of the Phase B2-C-D-E1 Contract on 14 April, the finalisation and signature of the lower level contracts between the prime and the other core team partners is on going, aiming to have most of them completed before the summer holidays break. All activities have been proceeding in the meantime through PATPs.

The execution of the procurement tasks through competitive Invitations To Tender (ITTs) is proceeding in all fields and it still represents the main effort in this phase of the programme. Roughly 100 procurement contracts have to be placed, 18 have been concluded and another 25 are under negotiation. All the ITTs related to flight hardware have been issued and their completion is expected in the coming quarter.

On the technical side, the satellite baseline configuration to be presented at the PDR including the launcher interfaces, has been completed. At instrument level, the Ocean and Launcher Colour Instrument (OLCI) and the Radar Altimeter (SRAL) consolidation are proceeding nominally. On OLCI, due to the advanced status of development, the PDR of the Video Acquisition Module is already ongoing, as well as the preparation of the OLCI S/S breadboarding activities. On SRAL the design activities during this period focused on the replacement of several obsolete or non-European components, present in the original design inherited from previous projects. Alternative design solutions are being assessed through unit breadboards. On the Microwave Radiometer, the design of the switch assembly for calibration and redundancy has evolved and a consolidation is expected within the next month.

Finally the Sea and Land Surface Temperature Instrument is undergoing an overall consolidation of the thermomechanical design of the instrument is ongoing, aiming to optimise the working temperature while reducing the overall instrument mass.

The first major programme review is the satellite PDR, planned to start in August 2008 and the agreed list of PDR documents is under preparation. Also the preparation of the five lower level PDRs (platform and instrument) planned in the forthcoming months is on going.

## EarthCARE

The EarthCARE contractual and technical baseline documentation was finalised in preparation for the signature of the industrial contract with Astrium GmbH. Contract signature took place at the Berlin Air Show on 27 May in the presence of the German Chancellor Angela Merkel.

Early Phase B activities are continuing with the goal of consolidating system trade-offs at base platform and instrument level prior to the System Requirements Review scheduled for later this year.

The participation of ESA's partner agency JAXA, which is responsible for the delivery of the EarthCARE Cloud Profiling Radar, has been formally approved in Japan and the JAXA project team was officially instated on 1 July.

Activities are in progress in the project's Joint Mission Advisory Group to establish a way forward for the collaborative European/Japanese development of level 2 algorithms which will allow full exploitation of the synergy between the four instruments of the EarthCARE payload.

## Alphabus/Alphasat

The Critical Design Review for the generic Alphabus platform was successfully completed with a final Board close-out meeting in April. In parallel, a detailed definition of the specific adaptations required for the protoflight platform, to ensure compatibility with the first flight application (Alphasat), has been satisfactorily concluded and manufacturing of the flight structure has been authorised.

In the Alphasat programme, the detailed definition of the challenging operational payload required for the Inmarsat I-XL continues. The main reflector and feed configuration has been frozen and the associated subcontracts begun. The Alphasat payload and satellite PDR is scheduled for September.

The development of the four Technology Demonstration Payloads, to be provided by ESA for the Alphasat satellite, is under way. These include an optical communications terminal, a Q-V Band experiment, an advanced star tracker and an environments and effects facility.

**Vega**

Flight Model manufacturing activities started. The Z23 Inert Motor Case Thermal Protection manufacturing was completed as well as the InterStage Qualification Model. The structure was sent for static tests to be performed in July. In parallel, test activities are proceeding with Z9 firing test scheduled in September. An updated plan was issued with a launch date in November 2009.

**Soyuz at CSG**

The Mobile Gantry Steering board took place on 3 April 2008. The Critical Design Review of the Soyuz Launch System ground segment took place from 8 April to 16 May and the relevant Steering Board closed the review on the 20 June 2008.
The arrival of the first shipment of Russian equipment in French Guiana is expected by the end of July, in parallel with the arrival of a precursor team of 40 Russian specialists.

**FLPP**

The IXV System Requirement Review was successfully completed. Wind tunnel test campaign started and has already shown promising results on the stability of the IXV in transonic phase.

The Expander Demonstrator test campaign

with M2R engine has been completed with a total of more than 4500 s cumulated hot-firing test duration demonstrated on the Vinci engine.

In Main Stage Propulsion activity, the post-test review of LOx/LH2 coupled test was held on 21 May. The subscale demonstrator accumulated 450 s hot-firing test time, where main combustion chamber and pre-burner pressures reached respectively more than 160 bars, and 220 bars and it enabled also to characterise different injectors in a wide operating domain. These tests constitute a first major step towards the high-thrust engine.
A first set of cryogenic upper-stage technologies has been selected; technology development and validation plans are being worked out.

# ARTA

The ARTA Programme, part of ESA's Ariane-5 Development Programme, is aimed at the continuous verification of the qualification status of the Ariane-5 launch system, checking the current production and qualifying required modifications to the launcher design before they enter service.

The ARTA 4 MPS (Moteur Propergol Solide) test-firing took place on 5 April at the BEAP (Banc d'Essais des Accélérateurs à Poudre) in Guiana Space Centre, Kourou, French Guiana. Initial analysis of the data shows that performance was in line with predictions. An in-depth analysis has started now to evaluate the results with respect to the specific objectives of the test: verification of current production stability, efficiency of pressure oscillation reduction device, simplification of manufacturing process, behaviour of new products to solve current obsolescence, etc.

The main goal of this ARTA test was to verify the qualification status of the current MPS solid rocket booster production with respect to potential manufacturing process drifts. This was the fourth test of an MPS since the beginning of the Ariane-5 ARTA programme and the eleventh since the start of the Ariane 5 Development Programme. The next MPS ARTA test is expected in about two years from now.

*The ARTA 4 MPS test-firing on 5 April at the Guiana Space Centre, Kourou*

# Human Spaceflight, Microgravity and Exploration

**International Space Station**
The Expedition 17 crew, aboard Soyuz TMA-12, successfully docked with the ISS on 10 April 2008.

ESA's Automated Transfer Vehicle, ATV *Jules Verne*, was used for the first time on 25 April to raise the orbit of the ISS. A 740-second burn of the ATV's main engines successfully lifted the altitude of the 280-tonne ISS by around 4.5 km to a height of 342 km above Earth's surface. The reboost set up the ISS for the arrival of Space Shuttle *Discovery* (launched 31 May) on the STS-124 mission that delivered the Japanese 'Kibo' (Hope) laboratory.

On 19 June, ATV *Jules Verne* was used to reboost the ISS for the second time. The reboost consumed about 400 kg of propellant on board *Jules Verne*. The ATV *Jules Verne* was also used for the first time to successfully transfer about 280 kg of the Russian UDMH (unsymmetrical dimethylhydrazine) propellant fuel and 530 kg of nitrogen tetroxide (which provides a source of oxygen so that the fuel can ignite and burn in orbit) to the Russian-built Zarya module's propulsion tanks.

The on-orbit commissioning of ESA's Columbus laboratory payloads continued over the last few months. The Biolab facility commissioning was completed, the Fluid Science Laboratory is in the final stage of facility commissioning, the European Drawer Rack including the Protein Crystallisation Diagnostics Facility have been successfully commissioned, and the European Physiology Modules have been largely commissioned with the exception of few minor steps at instrument level.

**Space Infrastructure Development and Exploitation**

*Infrastructure Development*
The Study on a Columbus external platform capability for small payloads (SPERO) and a EuTEF-2 Feasibility Study are ongoing with industry.

*ATV Production*
The ATV-2 integration progressed well. The ATV-3 equipment was released for procurement with a few exceptions following the ATV Production Readiness Review on

*An original 19th century luxury edition of Jules Verne's book 'De la Terre à la Lune' and two of his handwritten manuscripts were among the cargo to arrive at the ISS when ATV Jules Verne docked last April. The Expedition 17 crew, Greg Chamitoff, Oleg Kononenko and Sergei Volkov, are seen here retrieving the book and manuscripts from the ATV's cargo hold to mark the occasion of July's ISS Heads of Agencies meeting in Paris. (NASA)*

17 April 2008. The ATV-2 launch is now scheduled for the second quarter of 2010. The ATV rack design was optimised and qualification tests were running without any problems. The formal transition process between ATV development and ATV production has been started both at ESA and on the industry side.

*Operations*
The Columbus laboratory operations continued without problems on the system side. All ATV *Jules Verne* systems continued to operate nominally. Most of the remaining docked phase activities were carried out in June. In addition to the propellant, over 80 litres of water were successfully transferred from the ATV to the Russian segment. In addition, two of the empty ATV water tanks have been used to collect ISS condensation water following anomalies in the ISS condensate collection system.

Discussions are taking place on the ATV undocking date. To allow reentry at night, a date of 29 September is currently targeted. The target undock date will be early September to make way for the docking of the next Progress.

**Utilisation**
The first Biolab experiment, WAICO Run#1 (studying the waving and coiling behaviour of Arabidopsis roots), has been completed; and the for experiment reactors with the zero-g plants have been returned to Earth for detailed laboratory analysis.

The first Fluid Science Laboratory experiment, GEOFLOW (studying the thermally-driven and magnetic field driven geophysical flows) is on board and is expected to begin immediately after the final optical checkout of FSL at the end of July, with an exhaustive science programme until end 2008.

The European Drawer Rack, including the Protein Crystallisation Diagnostics Facility (PCDF), are now ready for the start of the four-month protein science programme of the first PCDF experiments which will be uploaded on the next Shuttle flight (ULF-2) to ISS.

The first three sessions of the 3D space neurophysiology experiment has been successfully performed. The preparations for the SOLO nutrition experiment are completed and it is ready for execution by the end of the ongoing mission increment.

The European Technology Exposure Facility (EuTEF) science and technology programme is progressing well; all nine instruments are continuously delivering science data according to their experiment protocols. The SOLAR payload and instruments have been performing the first three sun observation cycles. Currently a communication link failure is under investigation.

The Cell Wall Resist Wall experiment of JAXA has been completed in ESA's European Modular Cultivation System (EMCS) and the plant samples returned to ground on the Shuttle. Exhaustive ground tests are ongoing to secure the full EMCS facility performance for ESA's next experiment, GENARA, which will study the existence of gravity-regulated genes in Arabidopsis plants. The ANITA

*Mounted on Columbus, SOLAR is seen here in front of the Shuttle Atlantis, showing the movement bracket holding the scientific instruments (NASA)* instrument still runs operationally in Destiny and continues to deliver invaluable cabin air constituents data.

ESA's complementary experimental programme in the Russian ISS segment is nominally progressing with five experiments in respiration (NOA-1/-2), radiation (Altcriss, Matroshka-2B) and technology (GTS-2).

The MASER-11 sounding rocket flight was successfully performed at Esrange (Sweden) on 15 May, with a set of four extraordinary applied research experiments with novel instrumentation on board. This accomplishment proves again this invaluable mission asset for the European science community.

The 48th ESA A300 Parabolic Flight Campaign was successfully performed in March with a focus on fundamental and applied research in heat and mass transfer. The next flight campaign is already under preparation for Autumn 2008.

**Astronauts**

On 19 May, ESA began its search for new astronauts, calling for applications from talented individuals who wish to join the European Astronaut Corps. At the close of the application phase, ESA received 8413 completed applications. The Astronaut Selection Team, based at the European Astronaut Centre (EAC) in Cologne, Germany, now have the challenging task to select the best applicants. Those who make it through this first screening step will be invited in the next weeks to the first round of psychological tests in Hamburg.

*ESA Medical Operations for long-duration missions*

The successful Columbus mission signals the beginning of a long-term European presence in space. Columbus is a place for European astronauts to live and work on a regular basis, protected from the harsh environment of space. As such, there is a corresponding dedicated team of experienced medical and health professionals in the ESA Crew Medical Support Office (CMSO) working to support European astronauts. The CMSO team consists of physicians, engineers, exercise specialists, medical experts in nutrition, radiation, psychology and physiotherapy, information technology experts and project managers, all focused on providing the best possible care for European astronaut health. The CMSO team is a significant contributing partner of the Integrated Medical Group (IMG) that comprises representatives from all five international partner agencies.

*The MASER-11 rocket roll-out on 15 May 2008*

ESA astronauts will have more opportunities to participate in long-duration missions now that Columbus is an integrated part of ISS. Hence, the CMSO is constantly engaged to help optimize their health before a mission, reduce as much as possible the deleterious physiological effects of being in space during a mission, and maximise a rehabilitation and health programme after a mission to return the ESA astronaut back to optimal health as quickly as possible. CMSO works closely with both the US and Russian space agencies to combine efforts and use most effectively the resources to provide this support.

**Exploration**

*Core Element*

In the European Aurora space exploration programme, the Core element is meant to 'define, implement, and where possible/ useful, demonstrate capabilities and/or technologies to support a European long-term plan for robotic and human exploration', whose ultimate goal is a human mission to Mars.

To prepare for this ultimate goal, ESA envisages a series of intermediate steps, similar to its international partners, such as technology developments and technology-driven precursor and exploration missions. ESA intends to make the Core programme a source of key technologies and capabilities that can support Europe's ambition for an enhanced role in the upcoming human exploration endeavours.

*CSTS*

The situation in the crew transportation field has evolved considerably in the last weeks. On the Russian side, the work under the Crew Space Transportation System (CSTS) Preparatory Programme has focused on the further definition of the concept selected for the crew transportation vehicle.

In the meantime, with the support of European industry involved in CSTS, ESA has evaluated alternative options for a crew transportation system based on the Ariane-5 launcher and a stepped approach, with the first element being a cargo return capability from the ISS.

A programme proposal for the development of a new crew transportation system is being prepared by ESA. The proposal would aim to establish a European level of autonomy in the strategic field of human access to space, while positioning Europe for a more effective cooperation with the international partners.

In Brief

# Astronaut Applications from all ESA Member States

ESA began its search for new astronauts on 19 May this year, calling for applications from talented individuals who wish to join the European Astronaut Corps.

Out of almost 10 000 individuals who registered to begin the application process, 8413 aspiring astronauts provided the required medical certificate and finalised their online application forms. This qualified them for the next step in the selection process.

The Astronaut Selection Team, based at the European Astronaut Centre (EAC) in Cologne, Germany, now has the challenging task of selecting the best applicants. Those who make it through this first selection receive a letter inviting them to participate in the next stage – the psychological testing.

*"We now have a large number of highly qualified applicants. I am confident that we will find the outstanding individuals we are looking for. This will be ensured by the next selection steps, starting with a first round of psychological testing," said Michel Tognini, Head of EAC.*

*These tests aim to identify the psychological and technical skills of the applicants, who will be tested in different fields including visual memory and psychomotor aptitude.*

*"I am very pleased that we have received so many applications stemming from all our 17 ESA Member States,"* said Simonetta Di Pippo, ESA's Director of Human Spaceflight. *"This shows that the strong commitment for Human Spaceflight and Exploration, which ESA and its Member States demonstrated in holding the first astronaut selection after more than 15 years, is met by an equally strong interest from European citizens."*

Most of the applications were received from France (22.1%) and Germany (21.4%) followed by Italy (11.0%), the United Kingdom (9.8%) and Spain (9.4%). 18% of the total of applications were submitted by women. esa

*ESA astronaut recruitment campaign 2008*

| Country | No. of applicants | % of total | Men | Women |
|---|---|---|---|---|
| Austria | 210 | 2.5% | | |
| Belgium | 253 | 3.0% | | |
| Denmark | 35 | 0.4% | | |
| Finland | 336 | 4.0% | | |
| France | 1860 | 22.1% | | |
| Germany | 1798 | 21.4% | | |
| Greece | 159 | 1.9% | | |
| Ireland | 128 | 1.5% | | |
| Italy | 927 | 11.0% | | |
| Luxembourg | 14 | 0.2% | | |
| Netherlands | 203 | 2.4% | | |
| Norway | 74 | 0.9% | | |
| Portugal | 210 | 2.5% | | |
| Spain | 789 | 9.4% | | |
| Sweden | 172 | 2.0% | | |
| Switzerland | 351 | 4.2% | | |
| United Kingdom | 822 | 9.8% | | |
| Other | 72 | 0.9% | | |
| **Total** | **8413** | **100.0%** | **7111** | **1302** |

# ESA Astronaut Selections

*The first ESA astronauts selected: Nicollier, Merbold, Ockels and Malerba*

*DLR's first astronauts were chosen for the German-sponsored Spacelab D-1 mission on board the Shuttle. Left, Reinhard Furrer, and right, Ernst Messerschmid. ESA's Wubbo Ockels (centre) completed the European part of the crew*

*Five more candidates were chosen by DLR in 1987. The group is seen here with original German astronaut Ulf Merbold: from left, Ulrich Walter, Gerhard Thiele, Merbold, Renate Brümmer, Hans Schlegel and Heike Walpot*

ESA started its first astronaut selection in 1977, finding four European Payload Specialist candidates for the first Spacelab mission. This stemmed from the agreement in 1973 between ESA and NASA to supply the Spacelab, a reusable science laboratory that would be carried in the Space Shuttle's cargo bay, in exchange for flight opportunities for European astronauts.

From this selection campaign, ESA chose its first astronauts: Claude Nicollier (CH), Wubbo Ockels (NL) and Ulf Merbold (D). Franco Malerba (I) was also chosen in this group, but later resigned for medical reasons (Malerba then joined ESA's Space Science Department at ESTEC, working on an ionospheric plasma physics experiment to be flown on Spacelab in 1983. Malerba eventually flew as the first Italian citizen in space on STS-46 in 1992, sponsored by the Italian space agency ASI.).

Merbold became the first ESA astronaut to fly on a Space Shuttle mission, the 10-day STS-9/Spacelab-1 flight in 1983. Not only was this the first flight of an ESA astronaut, it was the first flight of the European-built Spacelab and the first flight of a non-US citizen on the Shuttle.

In the 1980s, while ESA astronauts were taking part in Shuttle/Spacelab missions, several other European countries and Member States of ESA, began recruiting their own astronauts in national campaigns. Many of these nationally selected astronauts flew on Russian Soyuz missions to the Mir space station or on Space Shuttle missions as Payload Specialists.

The European Astronaut Centre (EAC) was founded in 1990 in response to ESA's many ongoing projects and studies that would eventually be realigned into Europe's contribution to the ISS including the Columbus orbital laboratory. EAC

*In May 1991, Belgium selected its five candidates for the 1992 ESA selection. Left to right, Werner Stessens, Frank De Winne, Marianne Merchez, Vladimir Pletser, Lucien Halleux*

*The second ESA astronaut group: clockwise from left, Christer Fuglesang, Thomas Reiter, Pedro Duque, Jean-Francois Clervoy, Marianne Merchez, Maurizio Cheli*

*In 1992, Clervoy and Cheli joined the NASA Group 14, to train as mission Specialists alongside Claude Nicollier*

*The newly formed European Astronaut Corps in 1998, with members joining from national space agencies, Umberto Guidoni (I), Jean-Pierre Haignere (F), Leopold Eyharts (F), Claudie Haignere (F), Paolo Nespoli (I), Reinhold Ewald (D) and Roberto Vittori (I)*

would increase the size of the European astronaut group and establish a centre of excellence in Europe for astronaut selection, training and medical support. By 1991, there were 19 European astronauts in total; however they were mostly members of the various national astronaut groups with only three belonging to ESA (Ockels, Merbold and Nicollier).

ESA organised a second astronaut selection in 1992 for the Hermes manned 'space plane' programme – since cancelled – and Columbus. First there was a national selection under the responsibility of each ESA Member State, and then each country had the opportunity to present up to five candidates to ESA for a final selection.

Some of the Member States, such as Germany, France, Austria and the United Kingdom, had proposed candidates from their previous national selections in the 1980s, but others decided to hold new national pre-selection campaigns applying the newly established ESA criteria.

More than 22 000 candidates applied, reflecting growing interest in Europe in human spaceflight. Out of these, around 5500 met the criteria to be taken into consideration. After a national psychological, medical and professional screening process, 59 candidates were identified for the final ESA selection.

Six candidates were selected, including only one previously selected national astronaut: Jean-Francois Clervoy, the first French member of the Corps. Also selected were Thomas Reiter (D), Maurizio Cheli (I), Maria Merchez (B), Christer Fuglesang (S) and Pedro Duque (E). M e rchez later resigned for personal reasons.

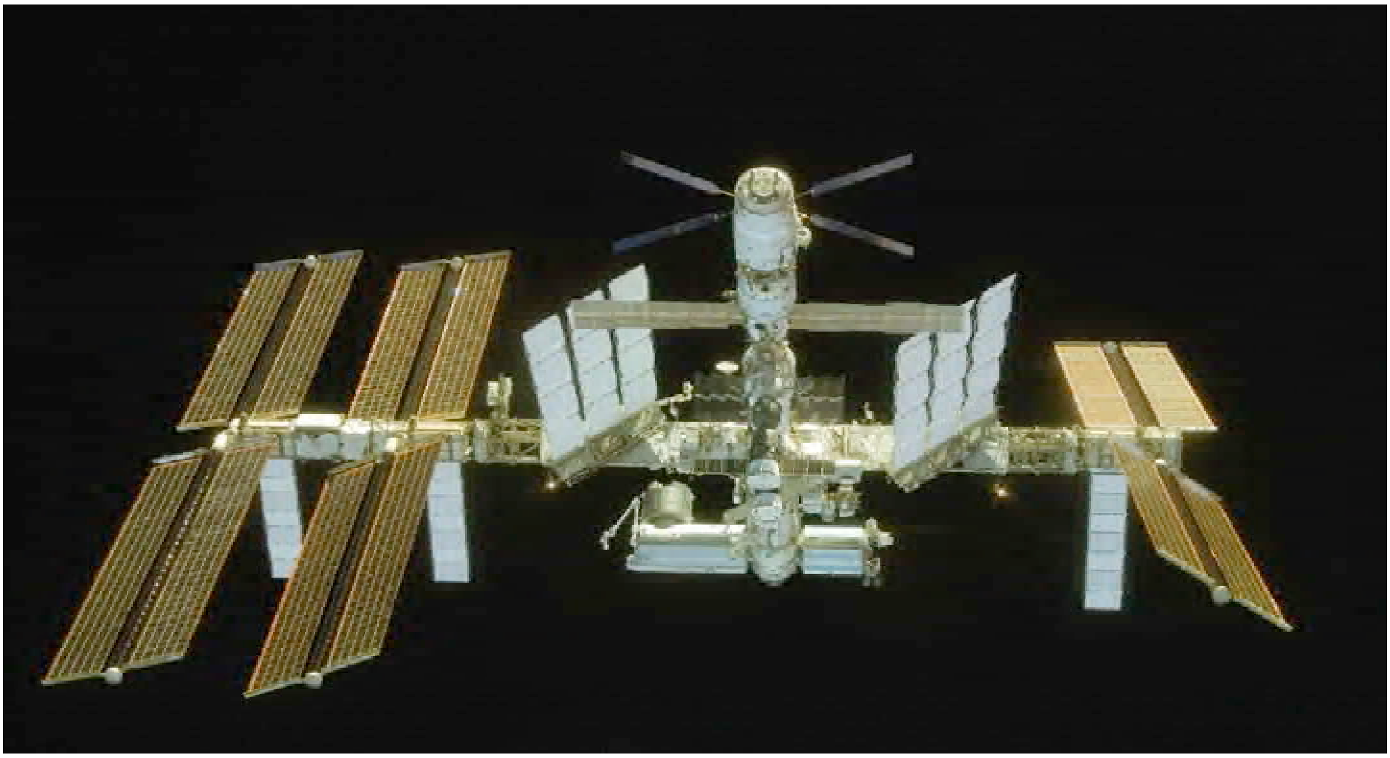
In the following six years, Europe would achieve many milestones in human spaceflight. In 1992, Merbold became the first ESA astronaut to undertake a second space mission (Spacelab IML-1, STS-42) and Claude Nicollier became the first European astronaut as a Mission Specialist on the Space Shuttle, taking over much more operational responsibilities than the Payload Specialists before.

In 1998, the European Member States decided to merge the national astronaut teams and to reinforce a European identity by forming a single 'European Astronaut Corps'. This process was concluded in 2002 when Philippe Perrin became the last member to join, bringing the Corps up to 16 astronauts (Perrin had been a CNES *spationaut* since 1996 and had flown as a Mission Specialist on STS-111 in 2002. After this flight he joined ESA to work on ATV. He left the European Astronaut Corps in 2004 before he could fly in space as an ESA astronaut.).

There are currently eight astronauts in the European Astronaut Corps. After the new selection campaign, four candidates will be chosen for training to be ready for a flight to the ISS from 2013 onwards. With the prospect of future human exploration missions to the Moon and Mars, another astronaut selection campaign could be carried out in 2014. esa

*The European Astronaut Corps in 2002, with Frank De Winne (B), Michel Tognini (F), Philippe Perrin (F) and André Kuipers (NL)*

# Refuelling in Orbit: *Jules Verne's* Premiere for Europe:



*The ISS as seen in June 2008, showing latest additions – Kibo, Columbus and ATV (NASA)*

ESA's ATV *Jules Verne* became the first western spacecraft to refuel another space infrastructure in orbit. On 17 June, Jules Verne was used for the first time to transfer in one step 811 kg of propellant to the International Space Station while the two vehicles orbited Earth at 28 000 km/h.

It took less than half an hour to automatically transfer about 280 kg of the Russian UDMH (unsymmetrical dimethyl-hydrazine) propellant fuel and 530 kg of nitrogen tetroxide to the International Space Station's (ISS) own Russian-built propulsion tanks.

Because of the toxic and explosive characteristics of the hydrazine, the transfer is done through dedicated pipes located outside the pressurised hulls of ATV and the ISS. The fuel lines run from the ATV, through the docking mechanism to the ISS's own plumbing.

The ISS crew was not involved in the refuelling operation – at the time they were busy preparing for a spacewalk scheduled for early July. The ATV was prepared for the refuelling operations by the ATV Control Centre in Toulouse. After the necessary verifications to ensure no leakage was present in the complete ATV piping system, Moscow Control Centre initiated the automatic refuelling procedure sequence, with the active support of the Engineering Support Team collocated in the Moscow Control Centre.

"We are impressed by this new achievement of Jules Verne ATV, which went without a hitch. And we really have to congratulate the teams of RSC Energia, Astrium and Thales Alenia Space for their years of efforts to integrate the Russian refuelling system in the ATV from the hardware and software point of view," said Massimo Cislaghi, ESA's leader of Engineering Support Team.

*"We have now successfully performed all the nominal operations of Jules Verne, such as the ISS attitude control, the ISS reboost, the gas transfer of air, the water transfer, the dry cargo and now the refuelling. Only undocking and re-entry remain, which we hope to do in September,"* said Hervé Côme, ESA's ATV Mission Director.

*"Europe has gained a new space capability which represents a new step towards human spaceflights and advanced exploration programmes. ATV is the only western vehicle able to refuel another spacecraft in complement to the Russian Progress,"* said Jean-François Clervoy, ESA astronaut and ATV senior advisor.

ATV *Jules Verne* has followed up its successful automatic docking on 3 April 2008 by achieving all its scheduled objectives - and much more. Astronauts on the ISS are discovering capabilities never planned for before its mission.

One of its empty tanks has successfully stored 110 litres of condensation water from the ISS.

Water retrieval in this way was not planned in ATV's original objectives. Five 22-litre water bags had been used to store this unwanted condensation water before transferring it into the ATV's empty spherical water tanks.

Since early April, the hatch has remained open between *Jules Verne* and the rest of the ISS, at times making the European spacecraft one of the centres of daily life for the crew and the ISS logistics activities. Crewmembers are using the extra 48 $m^3$ of space in the European supply vessel as a new area to sleep and wash instead of using the usual Crew Hygiene Station.

Answering a request from the ISS crew, ESA ATV managers authorised the use of *Jules Verne's* area by the astronauts for washing with their usual wet fabric towels and treated napkins. They also wash their hair with an alcohol-free rinseless shampoo.

*ISS resident crews can enjoy ATV's extra space*

Some crewmembers also enjoy *Jules Verne* as their sleeping quarters, given that the sound level of the ventilator fans and air circulation is relatively low. Although the ISS has two small crew cabins, each one is big enough to accommodate only one person. The third ISS crewmember can sleep anywhere in the ISS, including inside the ATV, just as long as they attach their sleeping bag to a wall!

*"The ATV's pressurised cabin offers the crew a large space, a lot of privacy and it also helps to keep the station air humidity level lower,"* said Hervé Côme, ESA's ATV Mission Director.

esa

# Second Flight for ESA Astronaut Christer Fuglesang

ESA astronaut Christer Fuglesang (S) has been assigned as a Mission Specialist on board the 11-day STS-128 mission, currently scheduled for launch with Space Shuttle *Atlantis* to the International Space Station (ISS) on 30 July 2009.

This will be Fuglesang's second flight after being a Mission Specialist on the 13-day STS-116 mission to the ISS in December 2006. For the STS-128 mission, Fuglesang will undertake two spacewalks as part of his mission responsibilities.

When he arrives at the ISS, he will again be meeting up with another ESA astronaut (this time Frank De Winne (B), who will be a member of the ISS Expedition Crew). In December 2006, ESA astronaut Thomas Reiter was on the ISS as the first ESA astronaut to be a member of an ISS Expedition Crew and returned with Fuglesang on the return leg of the STS-116 flight.

The STS-128 Shuttle Atlantis will transport a Multi-Purpose Logistics Module (MPLM) in its payload bay, which will carry science and storage racks to the ISS. MPLMs are Italian-built pressurised cargo containers that travel in the Shuttle's cargo bay.

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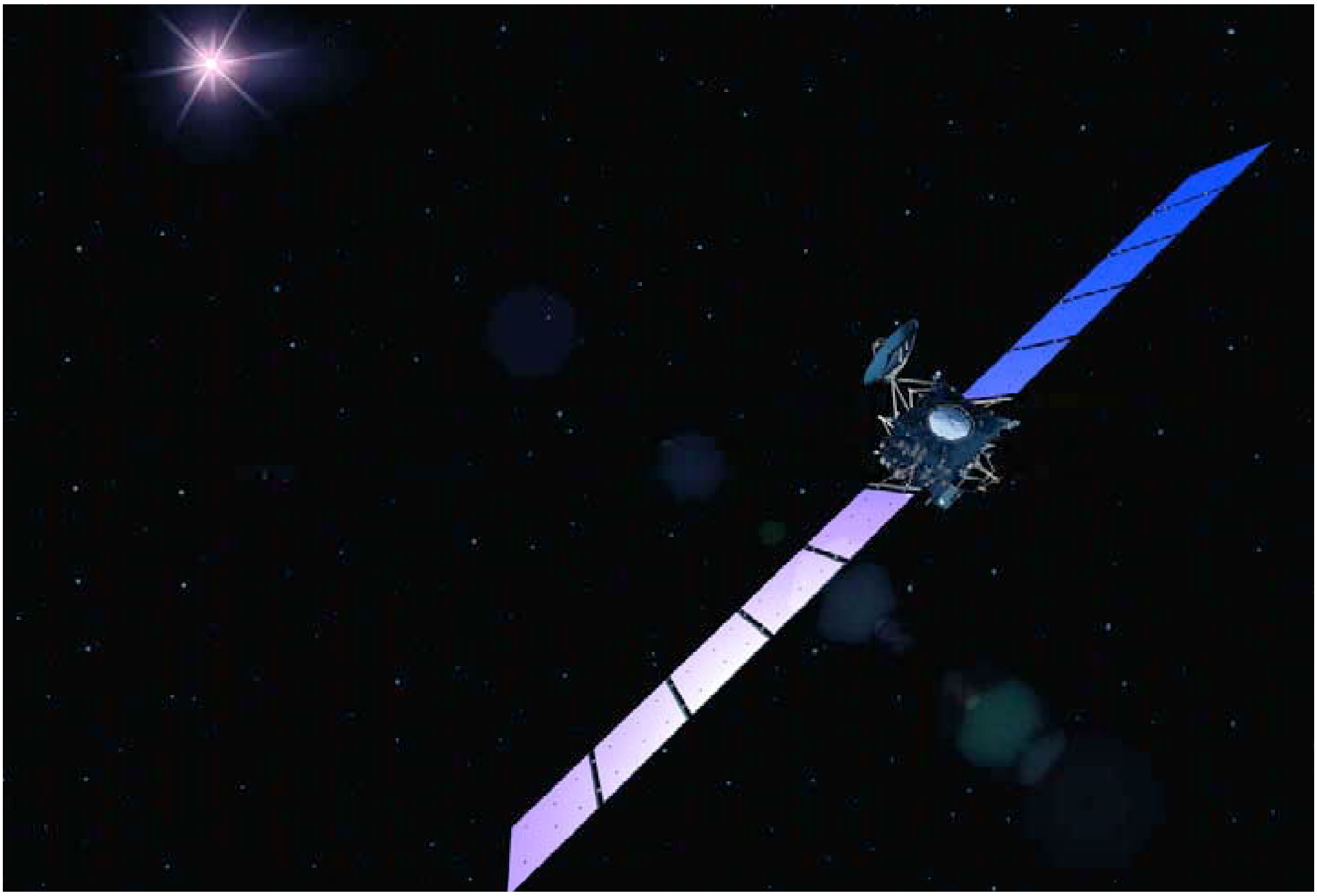
# Rosetta Wakes up for Asteroid Encounter



*ESA's Rosetta Spacecraft, now over 300 million km from the Sun*

ESA mission controllers woke the Rosetta spacecraft out of hibernation this July to prepare for its encounter with asteroid (2867) Steins on 5 September.

Launched in March 2004, ESA's comet chaser will study the relatively rare asteroid as it flies by on its way to Comet 67/P Churyumov-Gerasimenko. Rosetta will reach its final destination only in 2014, after travelling a total of about 6500 million km.

Rosetta has already swung by Earth twice and Mars once, performing gravity-assist manoeuvres to give it the necessary boost to continue on its journey. The third and last Earth swing-by is scheduled for November 2009. The spacecraft will also fly by two asteroids and study them on the way: (2867) Steins in September, and (21) Lutetia in June 2010.

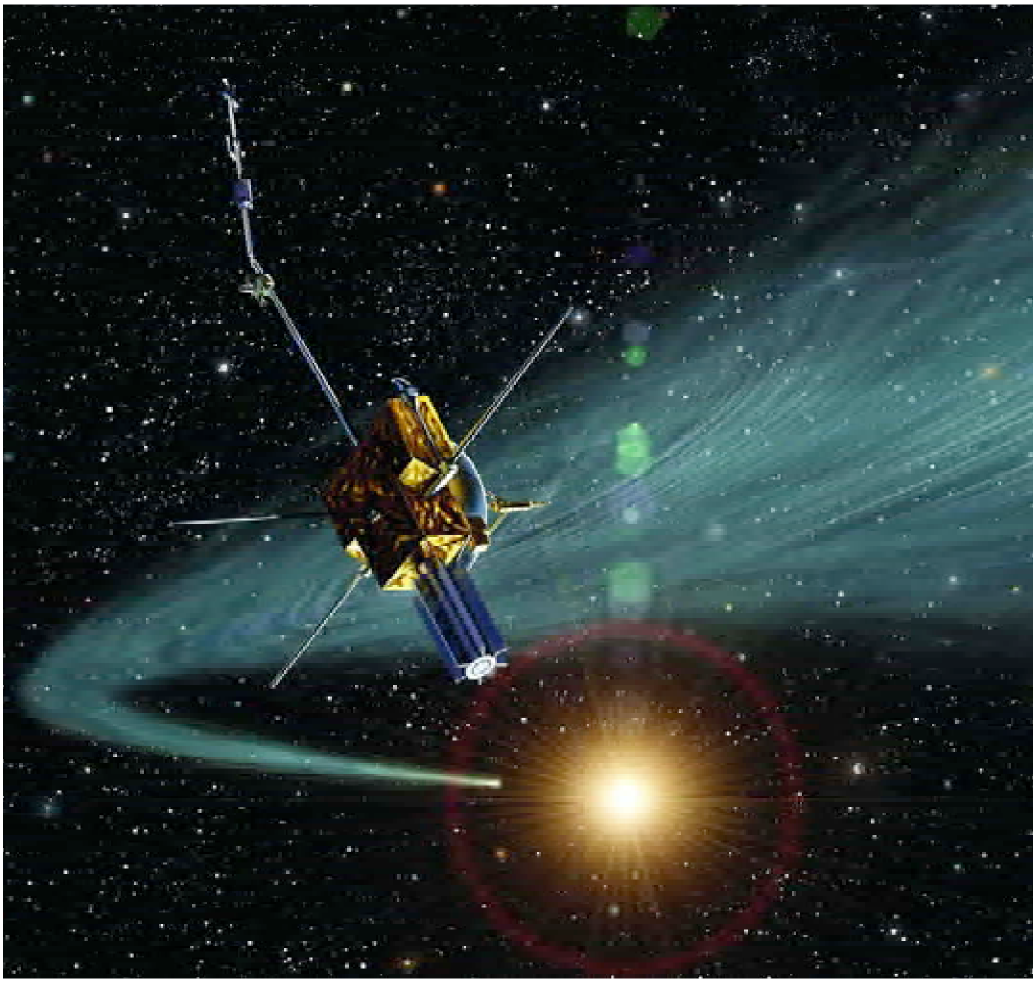
After its last planetary swing-by on 13 November last year, Rosetta headed towards the asteroid belt between the orbits of Mars and Jupiter. On 27 March 2008, the spacecraft switched to its near-Sun hibernation mode for a period of three months. During this phase, some subsystems were put into a dormant state to save power (as this is only the beginning of the mission's science phase).

Rosetta will pass within 800 km of (2867) Steins at 20:37 CEST on 5 September, at a relative speed of 8.6 km/s. This flyby is particularly exciting because it will push Rosetta to its design limits, due to the fast rotation of the spacecraft around the time of closest approach. This manoeuvre is necessary to ensure that the asteroid will stay in the field of view of the instruments. An in-flight simulation of the flyby was performed on 24 March 2008. The tests were successful, confirming the spacecraft's robustness.

In preparation for the flyby, all the instruments will be checked and tested in July. In August and early September, spacecraft operators will conduct an optical navigation campaign: Steins will be tracked by the on-board cameras and the observations will be used to refine the knowledge of its orbit which so far has only been derived from ground-based measurements.

Asteroids are samples of the Solar System's material at different stages of evolution, and studying them helps scientists understand the origin and evolution of Earth and of our planetary neighbourhood.

# Ulysses Mission Ends in July



*Artist's impression of Ulysses crossing the tail of Comet Hyakutake in 1996 (David A. Hardy)*

After over 17 years of operation, the joint ESA/NASA mission Ulysses officially concluded on 1 July this year. The spacecraft, which studied the Sun and its effect on the surrounding space for almost four times its expected lifespan, ceased to function because of the decline in power produced by its on-board generators.

Hurtling through space at an average speed of 56 000 km/h, Ulysses has travelled over 8600 million km. The longevity of the mission is testament to a creative team of NASA and ESA engineers who have risen to every challenge. As the power supply weakened over the years, so they came up with ingenious ways of conserving energy. This year, though, the power dwindled to the point where fuel would soon freeze in the spacecraft's pipelines.

Ulysses has forever changed the way scientists view the Sun and its effect on the surrounding space. Ulysses was the first mission to survey the environment in space above and below the poles of the Sun in the four dimensions of space and time.

*"Over almost two decades of science observations by Ulysses, we have learned a lot more than we expected about our star and the way it interacts with the space surrounding it,"* said Richard Marsden, ESA's Ulysses Project Scientist and Mission Manager.

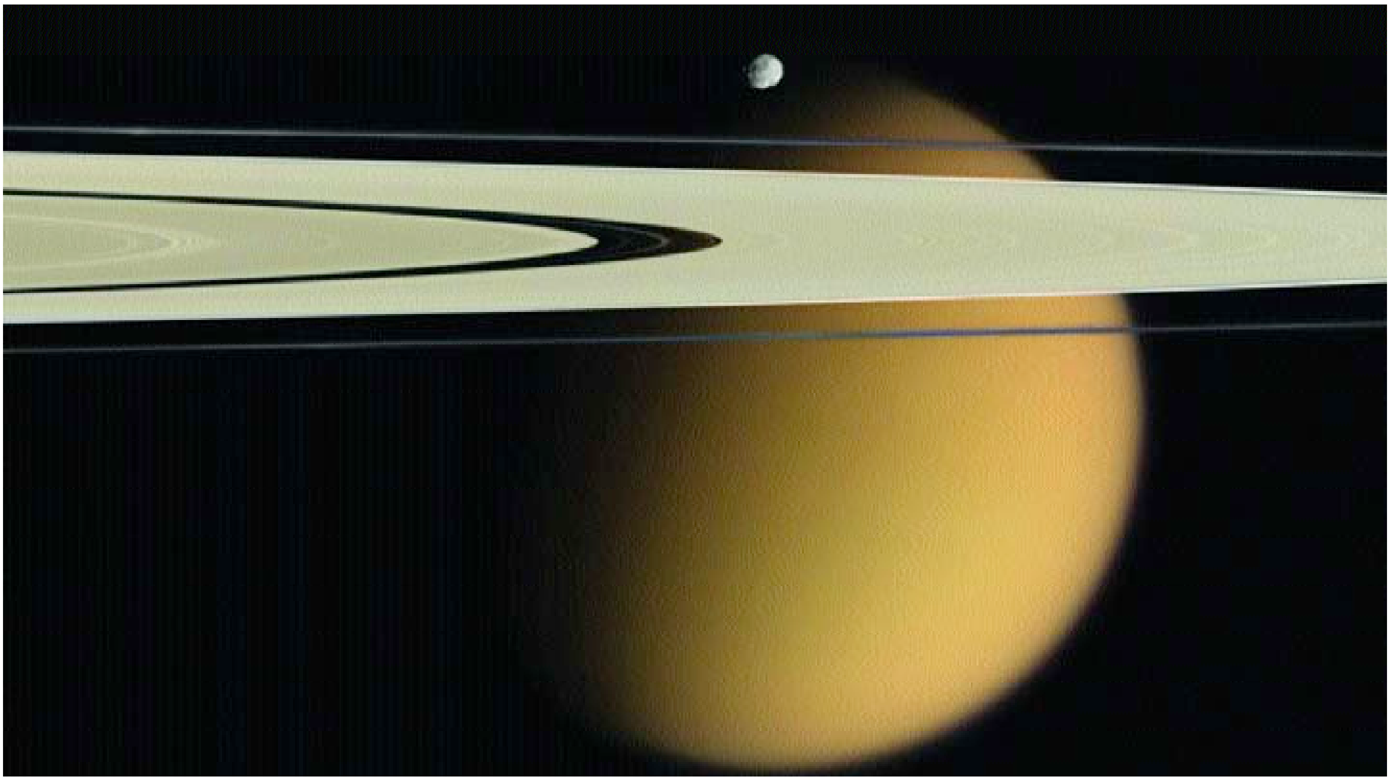
*"There will never be another mission like Ulysses. Many solar missions have appeared on the space scene in recent years, but Ulysses is still unique today. Its special point of view over the Sun's poles has never been covered by any later missions, making Ulysses's pioneering character still valid. This legendary spacecraft has served us extraordinarily well and it has certainly lived up to its mythical namesake's reputation."*

Ulysses showed that the Sun's magnetic field is carried into the Solar System in a more complicated manner than previously believed. Particles expelled by the Sun from low latitudes can climb up to high latitudes and vice versa, even unexpectedly finding their way down to planets. This is very important as regions of the Sun not previously considered as possible sources of hazardous particles for astronauts and satellites must now be carefully monitored.

Ulysses also detected and studied dust flowing into our Solar System from deep space and showed that it was 30 times more abundant than astronomers suspected. Perhaps most remarkably, the spacecraft detected helium atoms from deep space and confirmed that the Universe does not contain enough matter to eventually halt its expansion.

*"It is with enormous affection that we bid farewell to Ulysses. It has been a story of remarkable success and collaboration,"* added David Southwood, ESA's Director of Science and Robotic Exploration.

# Cassini Mission to Continue



*Titan, the resting place of ESA's Huygens probe, forms the backdrop to the rings of Saturn and the tiny moon Epimetheus, seen by Cassini in April 2006 (NASA/JPL/Space Science Institute)*

Operations of Cassini, part of the international NASA/ESA/ASI Cassini-Huygens mission, have been extended by two years. This historic mission's stunning discoveries and images have revolutionised our knowledge of Saturn and its moons.

More than 10 years after launch and almost four years after entering into orbit around Saturn, Cassini is a healthy and robust spacecraft. Three of its science instruments have minor ailments, but the impact on scientific observations is minimal. The spacecraft will have enough propellant left after the extended mission to potentially allow a third phase of operations.

Cassini's mission was originally scheduled to end in July 2008.

The recently announced two-year extension will include 60 additional orbits of Saturn and more flybys of its exotic moons. Data from the extended mission could lay the groundwork for possible new missions to Titan and Enceladus.

The Huygens probe successfully completed its part of the mission on 14 January 2005 when it successfully entered Titan's upper atmosphere and descended under parachute to the surface. The descent phase lasted around 2 hours 27 minutes with a further 1 hour 10 minutes on the surface. Throughout this period data was collected from all instruments providing a detailed picture of Titan's atmosphere and surface.

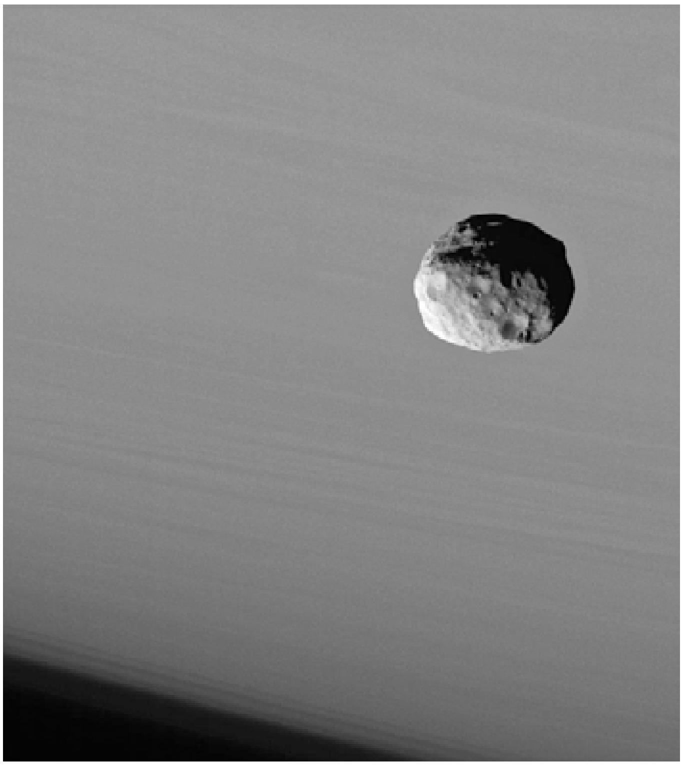
The Cassini-Huygens observations of Saturn's largest moon, Titan, have given scientists a glimpse of what Earth might have been like before life evolved. They now believe Titan possesses many parallels to Earth including lakes, rivers, channels, dunes, rain, snow, clouds, mountains and possibly volcanoes.

The Huygens landing site, which has already been observed a few times, will be further observed during the extended mission, in particular with the RADAR and VIMS instruments. Observations with these instruments, which at closest approach to Titan have a resolution of 300–500 m, will be used to look for temporal variability in this region.

Other activities for Cassini scientists will include monitoring seasons on Titan and Saturn, observing unique ring events, such as the 2009 equinox when the Sun will be in the plane of the rings, and exploring new places within Saturn's magnetosphere.

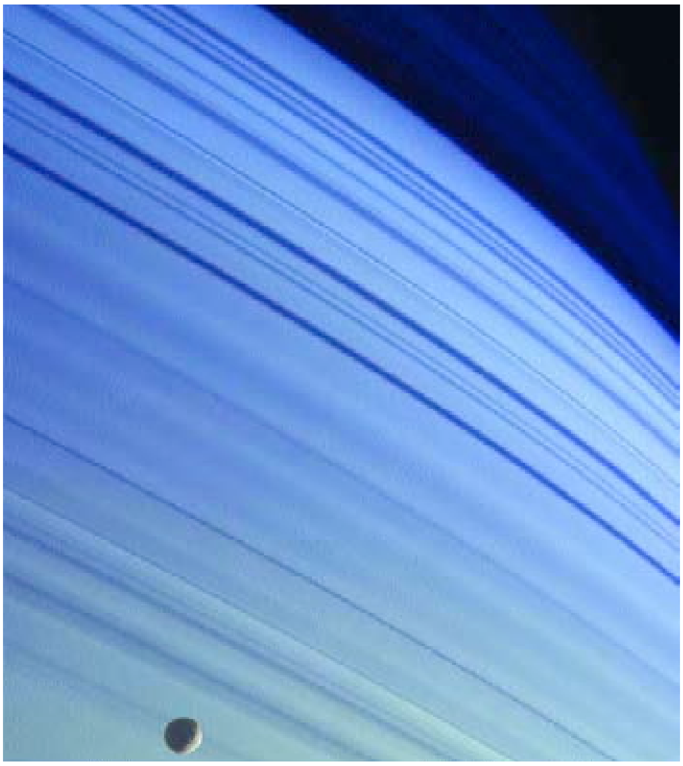
Based on findings from Cassini, scientists think liquid water may be just beneath the surface of Saturn's moon Enceladus. Cassini discovered geysers of water-ice jetting from its surface. These geysers shoot out to a distance three times the diameter of Enceladus and feed particles into Saturn's most expansive ring. This small moon, only one-tenth the size of Titan and one-seventh the size of Earth's moon, is a high-priority target for the extended mission.

# Cassini's Stunning Photo Album



*The tiny moon Janus backdropped by Saturn's cloudtops*

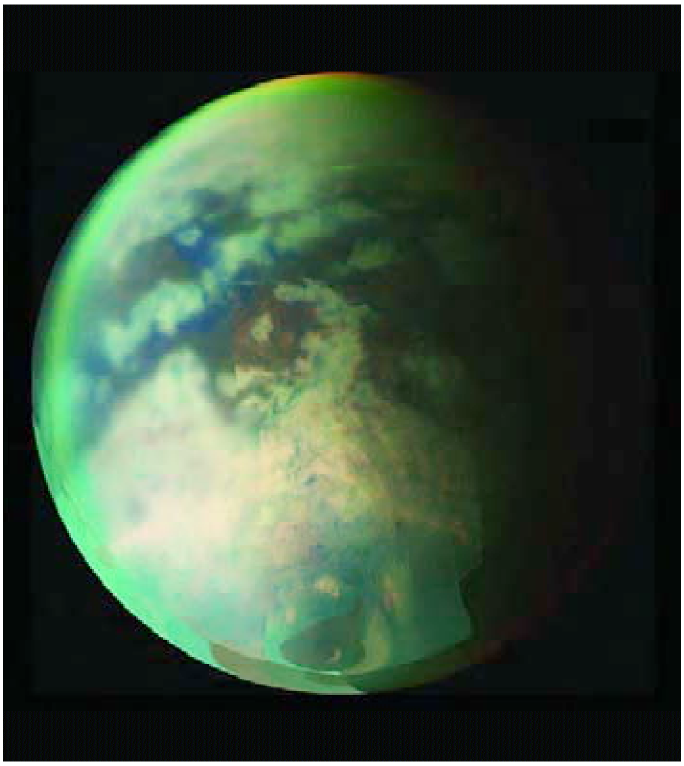
*The impact-pummeled Hyperion seen during a close approach in 2005*



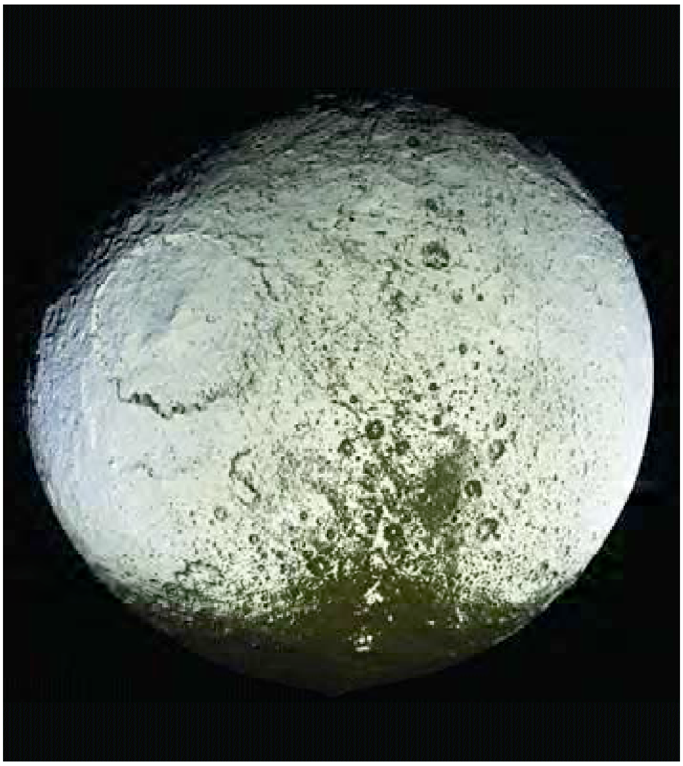
*A true-colour view of Saturn's northern latitudes with the moon Mimas in the forground*

*Saturn's rings and stormy cloud tops viewed with infrared filters in April 2007*

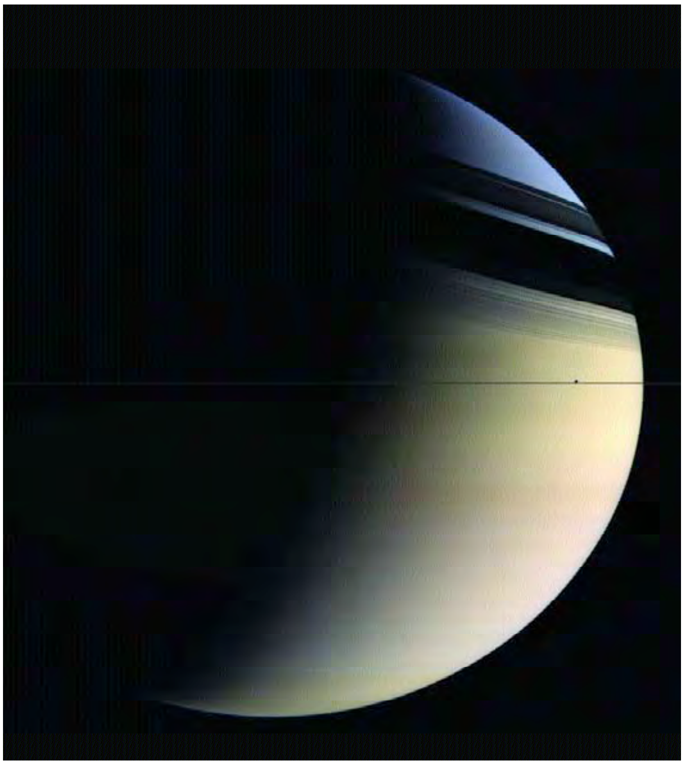
Cassini has returned data daily from Saturn's system for almost four years, taking nearly 140 000 images and gathering information during 62 revolutions around Saturn, 43 flybys of Titan and 12 close flybys of other icy moons. Here are just a few of the visual highlights from the last four years.



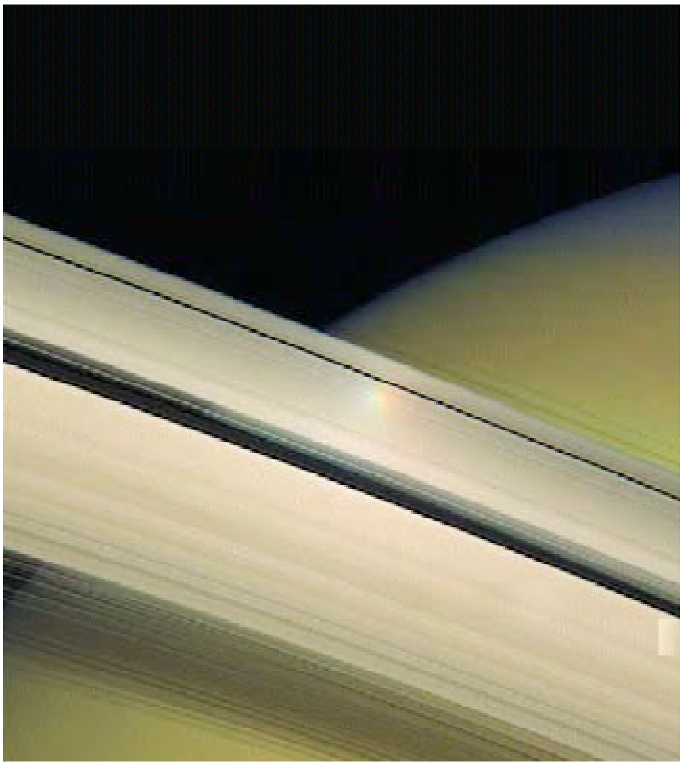
*A composite of several infrared images of Titan, showing land features beneath the clouds*



*The bright trailing hemisphere of Saturn's moon Iapetus*



*Taken with filters to approximate a human eyeview, this image shows Enceladus in the ring plane*

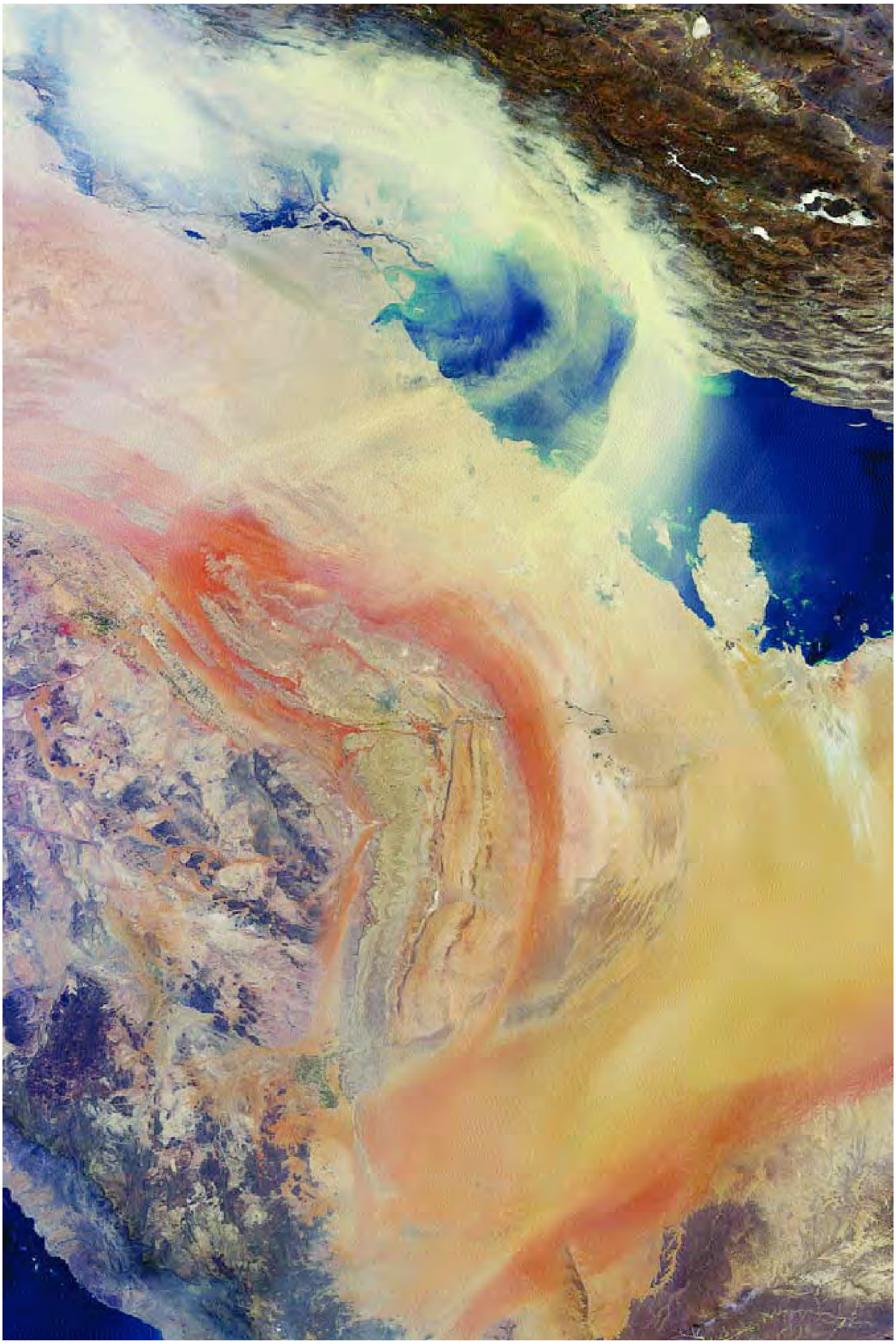


*Close-up of Saturn's sunlit rings, June 2007 (All images NASA/JPL/Space Science Institute)*

# Ariane-5 ECA Flight V183

*Ariane-5 ECA flight V183 lifted off from Europe's Spaceport in Kourou, French Guiana, at 00:05 CEST on 13 June, on its mission to place two telecommunications satellites into geostationary transfer orbit. The payload comprised Skynet 5C - which will deliver secure communication links for UK government and military users - and Turksat 3A - which will provide telecommunication services and direct TV broadcasting for Turkey, Europe, the Middle East, North Africa and Central Asia. This third launch of the year, followed by a fourth, V184 on 7 July, keeps Europe's Spaceport on target for the seven missions planned for 2008*

# Duststorm in Middle East



*Envisat captures sand and dust blowing northeast from the Arabian Peninsula across the Persian Gulf toward Iran (visible at image top). This image was acquired on 1 July 2008 by Envisat's Medium Resolution Imaging Spectrometer (MERIS) instrument while working in full-resolution mode to provide a spatial resolution of 1.2 km*

# Slovenia Signs Cooperation Agreement with ESA

An agreement on closer cooperation between ESA and Slovenia was signed on 28 May, by René Oosterlinck, ESA Director of Legal Affairs and External Relations, and Mojca Kucler Dolinar, the Slovenian Minister of Higher Education, Science and Technology.

In the ceremony at the Sneznik Castle (east of Ljubljana), the Prime Minister of Slovenia, Janez Janša, welcomed the ESA delegation and confirmed the support his Government is ready to give to this new agreement.

*René Oosterlinck (left), Mojca Kucler Dolinar and Prime Minister of Slovenia, Janez Janša (centre)*

In May 2006, a Slovenian delegation led by Mr Peterle (former Slovenian Prime Minister and currently a Member of the European Parliament) visited ESA's European Space Research & Technology Centre (ESTEC).

As a follow up, an ESA delegation went to Ljubljana in February 2007 to exchange information with the State Secretary in the Ministry of Higher Education, Mr Lesjak, and with many potential partners in the Josef Stefan Institute and with entrepreneurs in the Chamber of Commerce and Industry.

Slovenia is the second recent EU Member State to sign a Cooperation Agreement with ESA. Estonia did so in June 2007. The adoption of the European Space Policy by both ESA and the EU confirms the importance of ESA's space activities for EU Member States. Several other EU members have approached ESA with a request to participate in ESA's activities.

This Cooperation Agreement is a first step. It is expected that Slovenia will in a few years become a European Cooperating State, with an increased financial contribution to space activities.

# Czech Republic to Join ESA

The Agreement on the Czech Republic's accession to the ESA Convention was signed on 8 July in Prague, by Jean-Jacques Dordain, Director General of ESA, and Mirek Topolánek, Prime Minister of the Czech Republic.

The Czech Republic already has a strong tradition of space exploration. For example, Vladimir Remek of Czechoslovakia became the first European astronaut when he went into space in 1978.

Since the early 1990s, ESA has negotiated and concluded framework cooperation agreements with a number of central and eastern European countries. The Czech Republic signed such a Cooperation Agreement with ESA in 1996, requesting more specific collaboration.

In response, the ESA Council created the status of 'European Cooperating State' in March 2001. The ECS was a new status granted to European Union Member States wishing to accede to the ESA Convention. ESA concluded an ECS Agreement with the Czech Republic in November 2003; it entered into force with the signing of the PECS (Plan for European Cooperating States) Charter in November 2004.

During the first four-year period, the overall contribution to the PECS by the Czech Republic amounted to approximately €12 million. This Czech contribution goes towards projects that come under various ESA programmes: 50% on space science, 25% on space technology, 22% on Earth observation and 3% on navigation.

The Czech Republic is now embarking on the ratification procedure that will make it a formal ESA Member State by the end of the year.

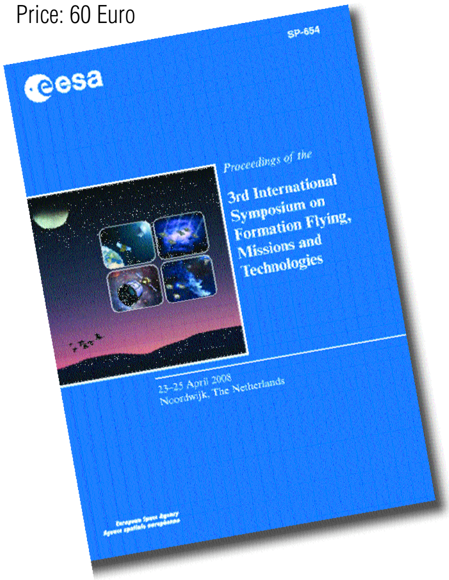
With the accession of the Czech Republic, ESA and its Member States are together extending the boundaries of space even further to take in new countries and new ambitions. Such ambitions are firmly rooted in forty years of success in space, thanks in particular to the continuous investment by ESA Member States and to the increasing cooperation between the European Community and ESA. The consensus reached by 29 European countries in support of the European Space Policy adopted in May last year also demonstrates that Europe and its citizens are prepared to play a stronger role in space.

# Publications

**The documents listed here have been issued since the last publications announcement in the ESA Bulletin. Requests for copies should be made in accordance with the Table and Order Form inside the back cover**

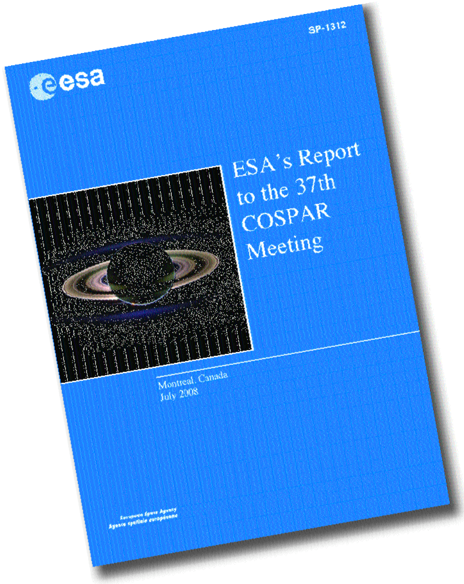
## ESA Special Publications

Proceedings of the 3rd International Symposium on Formation Flying, Missions and Technologies, 23-25 April 2008, Noordwijk, The Netherlands, (June 2008)
K. Fletcher (Ed.)
*ESA SP-654 // CD-Rom*
Price: 60 Euro




Proceedings of DASIA 2008 – Data Systems in Aerospace, 27–30 May 2008, Palma de Majorca, Spain, (August 2008)
L. Ouwehand (Ed.)
*ESA SP-656 // CD-Rom*
Price: 50 Euro

ESA's Report to the 37th COSPAR Meeting, July 2008, Montreal, Canada (May 2008)
K. Fletcher (Ed.)
*ESA SP-1312 // 176 pp*
Price: 40 Euro




## ESA Scientific & Technical Memoranda

Transport Coefficients of Argon Plasma with Electromagnetic Fields
D. Giordano & K. Fletcher (Eds.)
*ESA STR-254 // CD-Rom*
Price: 50 Euro

## Contractor Reports

Non Contact Measurements of Membranes – Summary Report (September 2007)
CLS, Belgium
*ESA CR(P)-4604 // 35 pp*
Price: 10 Euro

Study of the Potential of Sub-millimetre Wave Observations for Precipitation Retrieval – Final Report (June 2007)
CLS, Belgium
*ESA CR(P)-4605 // CD-Rom*
Price: 25 Euro

Establishment of Cirrus Cloud Mission and Instrument Requirements at Sub-Millimetre Wavelengths – Final Report (February 2007)
Sula Systems Ltd.
*ESA CR(P)-4606 // CD-Rom*
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ND SatCom, Germany
*ESA CR(P)-4607 // CD-Rom*
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Skyware Radio Systems GmbH, UK
*ESA CR(P)-4608 // CD-Rom*
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Alcatel Space, France
*ESA CR(P)-4609 // CD-Rom*
Price: 25 Euro

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Thales Alenia Space
*ESA CR(P)-4610 // CD-Rom*
Price: 25 Euro

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Trastec Scpa, Italy
*ESA CR(P)-4611 // CD-Rom*
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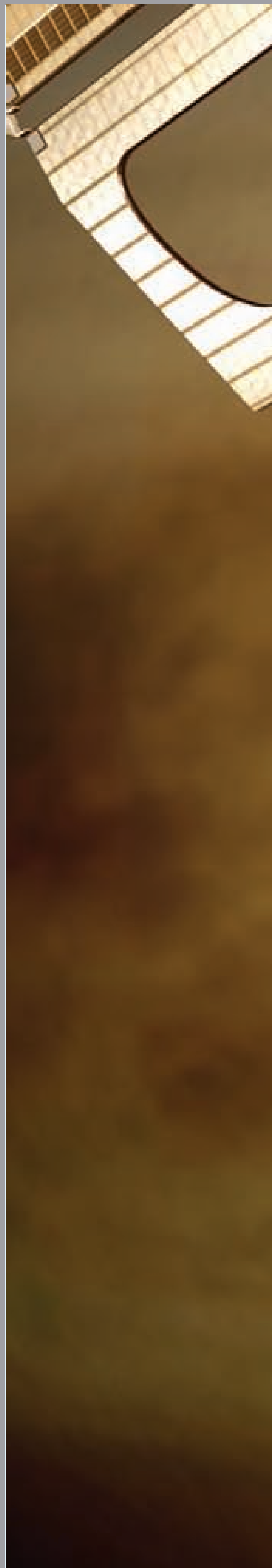

**European Space Agency**
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*ESA Communications*
ESTEC, PO Box 299, 2200 AG Noordwijk, The Netherlands
Tel: +31 71 565-3400 Fax: +31 71 565-5433
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