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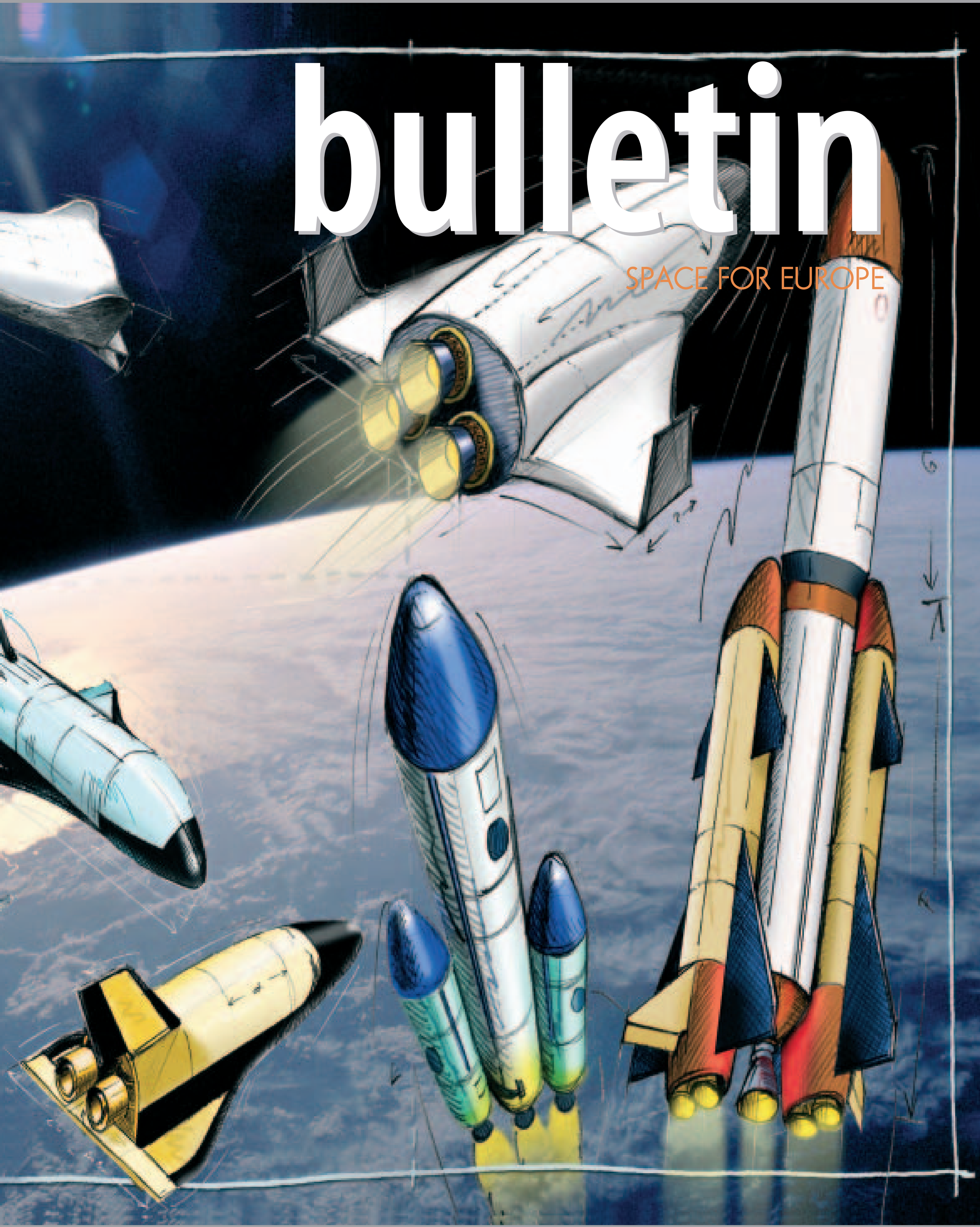

SPACE FOR EUROPE

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 Organisation for the Development and Construction of Space Vehicle Launchers (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, co-operation 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:

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(b) by elaborating and implementing activities and programmes in the space field;
(c) by co-ordinating 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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ESRIN, Frascati, Italy.

Chairman of the Council: Sigmar Wittig

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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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(b) en élaborant et en mettant en oeuvre des activités et des programmes dans le domaine spatial;
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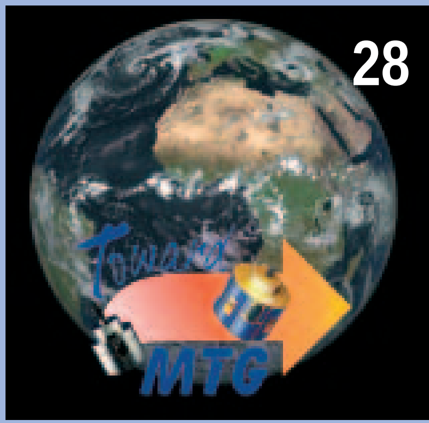
Cover: Next-generation European launchers – see page

The Ariane-5 ECA Heavy-Lift Launcher



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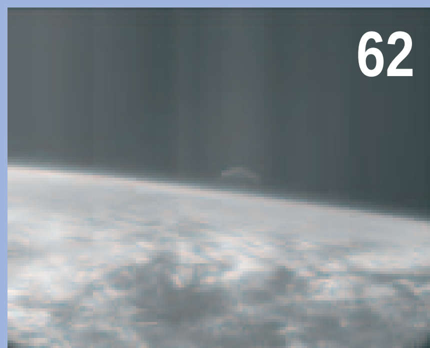

Rosetta: ESA's Comet Chaser Already Making its Mark

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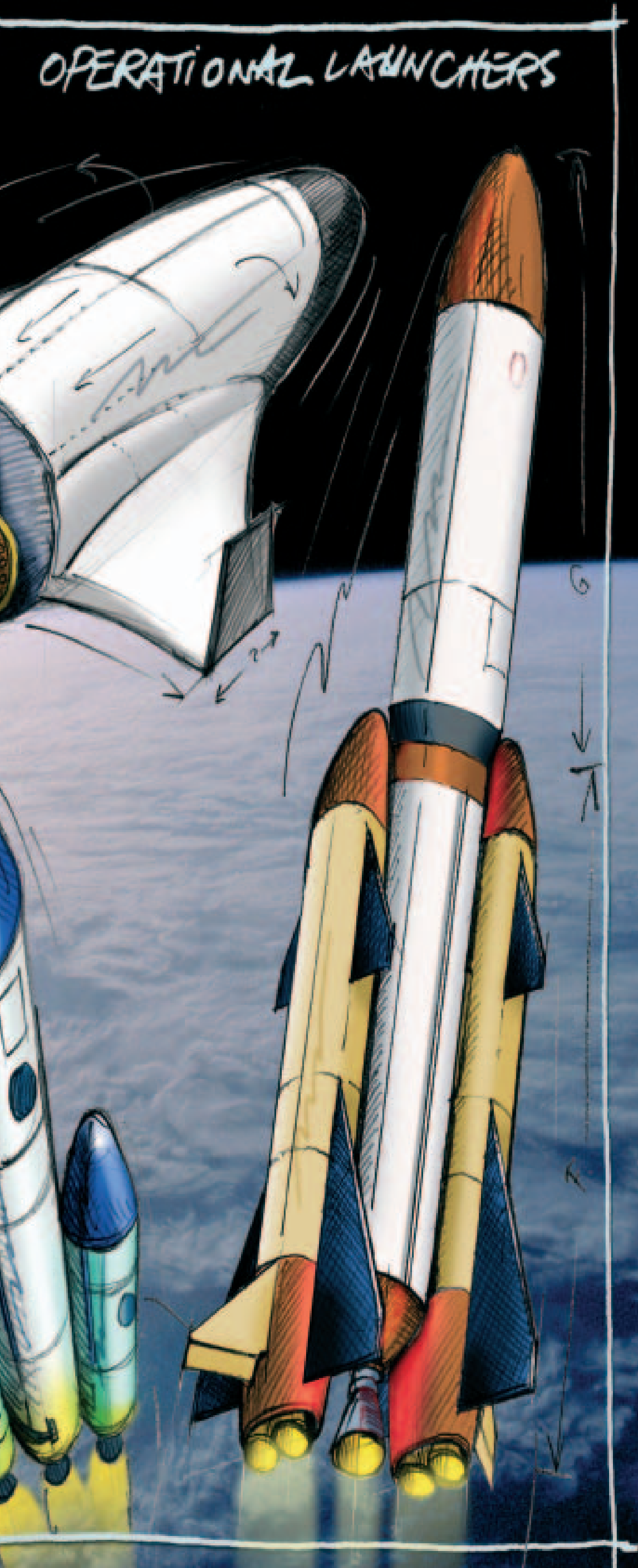
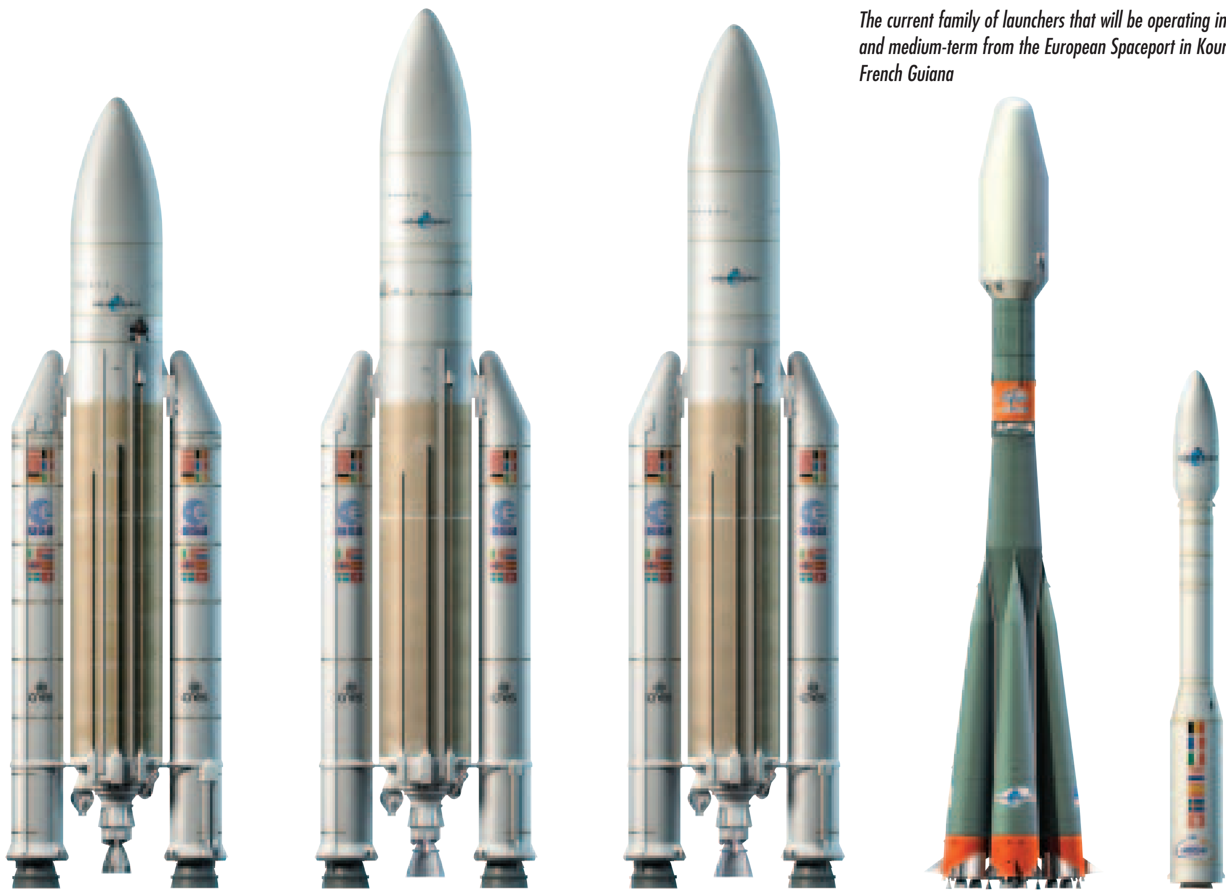


Jürgen Ackermann, Jérôme Breteau,
Jens Kauffmann, Guy Ramusat
& Giorgio Tumino
Future Launchers Preparatory Programme,
Directorate of Launchers, ESA, Paris

The Future Launchers Preparatory Programme (FLPP) was approved by the last ESA Ministerial Council and began in February 2004, ending a long period without a programme dedicated to future launchers at the European level. The aim is to prepare the Next Generation Launcher to be operational around 2020. System studies and technology activities therefore need to be conducted, including ground and in-flight tests, to foster new technologies capable of providing high performance and reliability, together with low life-cycle costs. The final choice between an expendable or reusable type of launch vehicle will be made on the basis of proven technological readiness and consolidated cost and risk assessments.

Programmatics

The Agency's Future Launchers Preparatory Programme was initiated in February 2004 with the aim of preparing for the development of Europe's Next-Generation Launcher (NGL). The FLPP is designed to strengthen European industry's innovative technology competences and foster progress in the launcher field in order to safeguard Europe's guaranteed access to space in the longer term. The choice for the best Earth-to-orbit launch system architecture is essentially between an advanced expendable launcher and a fully or partially reusable vehicle. The final decision will be made on the basis of competitive launch cost and market requirements, such as expected commercial payloads and the European institutional mission needs stemming, for



The current family of launchers that will be operating in the near- and medium-term from the European Spaceport in Kourou, French Guiana

instance, from the new ESA space exploration programme and the implementation of European Union policy concerning environment, security and defence.

It is essential for Europe to retain its autonomous, affordable and competitive access to space both now and in the future. The near-term needs are covered by the European launcher workhorse Ariane-5, to be complemented in the near future by the Vega small launch vehicle and operation of the Russian Soyuz launcher also from Kourou. Looking further ahead, however, Europe must already begin to prepare the programmatic and technical ground in order to be able to undertake the development of an NGL a decade from now.

Among the various solutions promising affordable access to space, Reusable Launch Vehicles (RLVs) offer the potential for major cost reductions well beyond those provided by on-going improvements to Expendable Launch Vehicles (ELVs). Before being able to make a sound choice between an ELV and an RLV for the Next Generation Launcher, a number of critical reusability-related technologies need to be developed and demonstrated, as well as acquiring RLV system-level expertise. Before finally deciding on the NGL's development, there is a need for sufficient maturity of system and technology competencies to assess the associated costs and risks.

Industrial Policy

It was decided at the outset to grant all NGL-related activities within FLPP to an industrial prime contractor, and EADS and Finmeccanica have therefore created a new company, provisionally called 'NGL Prime Co'.

The industrial work at system and technology level began at the end of 2004, with a comprehensive road map of activities that will provide, step by step, the results needed for the decision on the NGL to be taken at the end of the decade.

The industrial activities in 2005 encompass RLV system concept studies together with the preparation of on-ground demonstrations for various structure and propulsion subsystems, as well as the progressive implementation of in-flight demonstrations with testbeds and experimental vehicles.

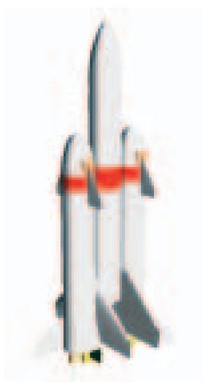
In its first two years, the FLPP programme is concentrating on assessing the attractiveness of reusability from the launcher affordability and robustness standpoints. Decisive progress has to be made, however, with respect to current technology to achieve a robust, low-cost, reusable system. The system requirements, overall development logic and technological demonstrations required to design and build such a demanding vehicle are going to be assessed, focusing on the most critical areas, like propulsion, materials and structures, aerothermodynamics, vehicle health management and avionics. These new technologies will be able to foster new system concepts. In addition, Europe plans to develop and operate hypersonic experimental vehicles for flight demonstrations, when deemed necessary to overcome technology barriers, study critical flight phases and assess reusability.

A cornerstone of the European launchers strategy is optimum use of available resources. Therefore on the one hand a harmonisation of all European activities for future launchers has been initiated, and on the other the FLPP will permit the progressive restructuring of the European industrial landscape in preparation for a future cost-effective NGL development and exploitation programme. From the start, a number of cooperative activities in the RLV field have been identified, not least with Russia.

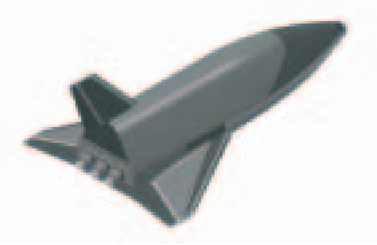
System Studies

There is already a solid base of experience and technology in Europe for the design of ELVs, which is being exploited to establish the system-level capabilities needed to assess the risks inherent in developing and operating RLVs. One of the main goals of the FLPP studies is to assess the attractiveness of launcher reusability by comparing the economic features of the best RLV options accessible for Europe with the possible ELV solutions on the basis of comparable Technology Readiness Level (TRL).

The system work will have to accomplish multiple objectives. RLV system design concepts will be developed to allow quantification of performance, flexibility of operations, reliability, cost and safety. On the basis of these concepts, a number of system-level trade-offs dealing with such aspects as propellant combinations, stage arrangements, launch modes and return-flight options will be performed. A further task will be to elaborate guidelines and well-quantified objectives for the RLV technology developments in order to be able to monitor their coherence and feed the results into the vehicle concept studies. The objectives for the in-flight and on-ground experiments and demonstrations will also be derived from the system needs. At a later stage, i.e. during FLPP Period-2, system studies of expendable NGL concepts will be started, leading to a thorough trade-off between the ELV and RLV concepts. This important decision will be largely based on the final mission specification, but will also rely on the results of critical-technology validation tests.


LFBB concept (Courtesy of DLR)

FLPP Period-1 is characterised by a focused approach, aiming at the selection of one preferred RLV concept for each of two preliminary ‘reference missions’. The availability of results from a number of previous national and European RLV studies, such as ESA’s Future European Space Transportation Investigation Programme (FESTIP, 1995-1998), allow FLPP to focus just on what are seen as the currently most promising concepts, namely:


Sub-orbital concept (Courtesy of DLR)

- semi-reusable concepts using a Liquid Fly-Back Booster (LFBB) or Reusable First Stage (RFS)
- sub-orbital concepts
- fully reusable Two Stage To Orbit (TSTO) concepts.

Considerable experience in the analysis of these options already exists in Europe. Aside from FESTIP, other studies have been performed in recent years in France (e.g. SYS RLV) and Germany (e.g. ASTRA) on concepts belonging to these categories and their results will also be exploited in the FLPP system activities. The semi-reusable RLV concepts are an attractive area for potential cooperation with Russia, where joint activities on the analysis of reusable liquid stages will be considered.

Single Stage To Orbit (SSTO) concepts and air-breathing ascent propulsion systems (e.g. Scramjet) will not be addressed as they do not meet the technology-maturity requirements.

In-flight Experimentation

For any RLV development effort, in-flight


TSTO concept (Courtesy of CNES)

The European Heritage Regarding RLVs

Several system studies were conducted during the 1980s to investigate possible concepts for a European RLV, both at ESA level (FLS, WLC, RRL, FESTIP, as well as the Hermes Programme which included some RLV-related technologies and facilities) and at national level (Hotol, Sanger, Taranis, Star-H, WLC, STS 2000, FLS and RRL).

In 1998, ESA flew the Atmospheric Re-entry Demonstrator (ARD) capsule, which provided valuable information on atmospheric re-entry.

The Agency's Future Launchers Technologies Programme (FLTP) was approved in 1999 with the objectives of confirming the interest of launcher reusability under realistic assumptions, and of identifying, developing and validating the required technologies. The unbalanced participation in the programme by Member States and the consequent problems with implementing procedures resulted in the FLTP being put on hold.

Several programmes were, however, set up in Europe, both at national level (e.g. Astra, Prora and Prepha, as well as vehicle concept studies like Boomerang, Astral, USV and Everest) and ESA level (X-38/CRV), to foster the development of some of the technologies required for future reusable space transportation systems.

Moreover, some specific RLV technologies are still being developed within the ESA Technology Research Programme (TRP) and General Support Technology Programme (GSTP).

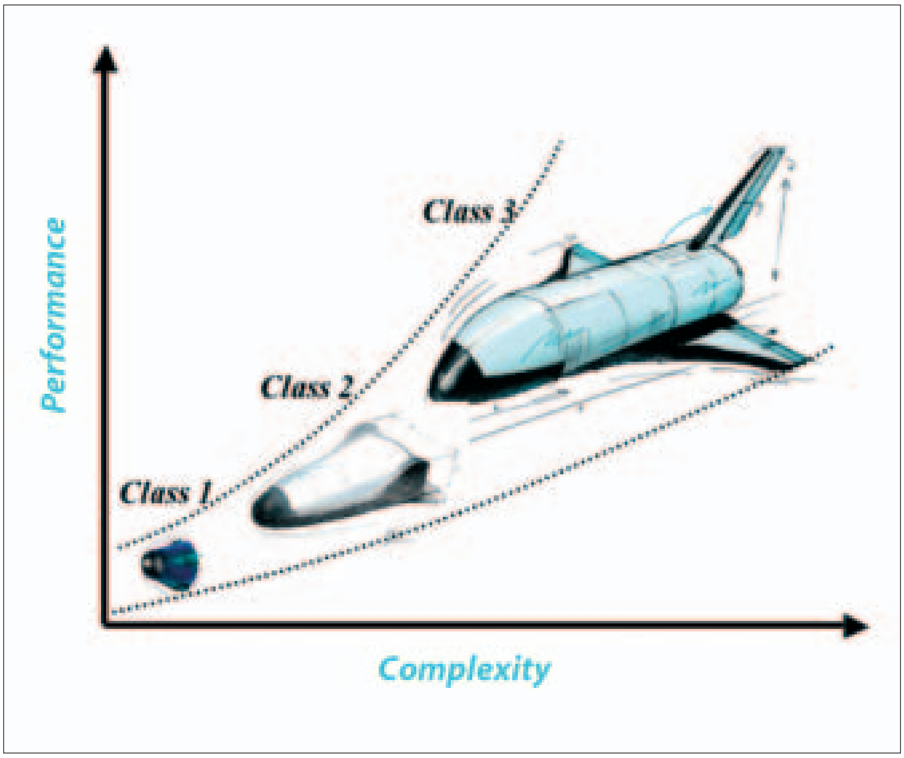
experimentation is indispensable both for validating system and technology performance models, as well as for gathering the first operational experience. Past experience with experimental vehicles shows that a step-by-step flight-demonstration approach allows one to limit the risks with a progressive investment effort, especially for the most technically challenging developments.

The various European studies and projects conducted to date involving in-flight experimentation have been evaluated in the frame of an ESA 'harmonisation' study, resulting in the identification of three distinct in-flight experimentation levels, or classes of vehicles:

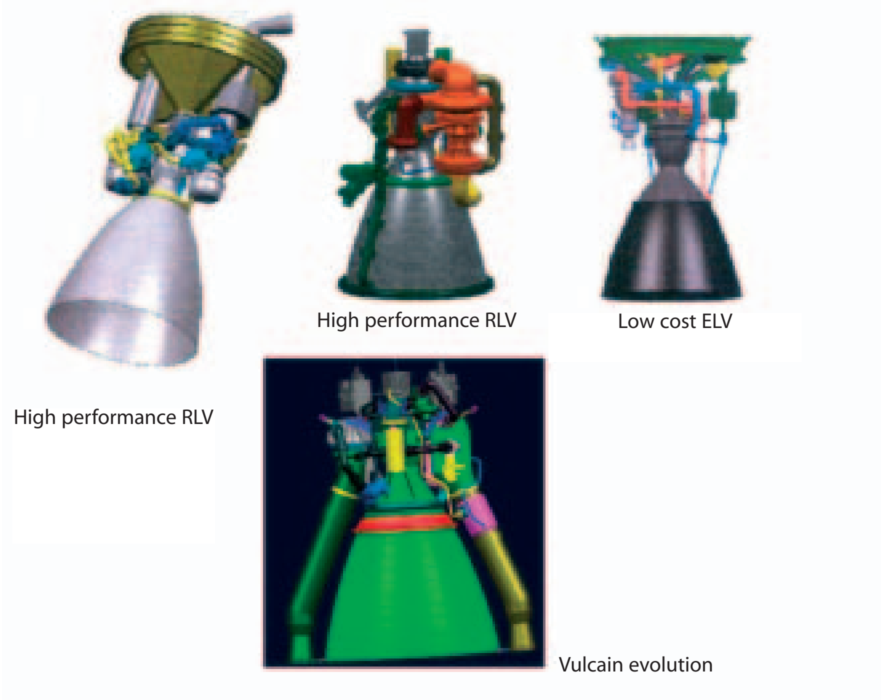
Class-1: *'Flying Test Beds'*, focusing on design-tool validation and dedicated to a single discipline, and thus not concept or system representative.

Class-2: 'Intermediate Experimental Vehicles', focusing on the integration at system level of key technologies, such as vehicle thermal-protection and health-management system components and flight controllability by means of aerodynamic control surfaces.

Class-3: 'Experimental Vehicles', aiming at validation of a combination of technologies and system-design capabilities, such as shape representativeness, fully integrated thermal-protection systems, guidance, navigation and control, vehicle health-management systems, reusability and operations.



An approach taking into account these three classes of vehicles has been adopted for the FLPP in order to reduce the development risks. Considering the existing planned development schedule for a series of Class-1 type vehicles (e.g. EXPERT, PHOENIX-1, etc.), it was deemed appropriate for FLPP to focus on Class-2 and Class-3 and so the industrial system team has been tasked in Period-1 to:
- define an optimised long-term in-flight experimentation strategy
- select the most promising Class-2 Intermediate Experimental Vehicle (IXV) and perform a consolidation



Concepts for potential engines for Reusable or Expendable Launch Vehicles (Courtesy of SNECMA Moteurs)

(Phase-A type) study of the proposed concept as part of the short-term in-flight experimentation strategy
- identify promising Class-3 vehicle concepts, such as Reuse-X, reflecting on among other things specific propulsion system requirements.

The concepts selected will be further investigated during the second part of FLPP Period-1.

Bringing together the ESA programme and currently running national initiatives is clearly the best means of ensuring that in-flight experimentation really takes place in Europe and that a true technological return on the investments made is created for Member States. Given Russia's considerable experience in this field, its cooperation will also be considered with a view to reducing demonstration risks and the associated costs.

Propulsion

The main propulsion system's technical complexity and interaction with the overall performance and operational capabilities of an ELV or RLV gives propulsion a key role in launcher development and makes its operational implementation a major challenge. Today, operational experience with RLV rocket engines is still rather limited. The US Space Shuttle and the Russian Energia/Buran vehicles rely on the only flight-proven reusable (or robust) rocket engines, and their experiences have shown how technically demanding the reusability requirement really is. This is why the initiation of development in Europe of high-performance reusable rocket engines is an ambitious challenge that will have to be carefully responded to within FLPP. Success within the schedule foreseen will rely on existing European industrial and national-agency know-how and the fact that the key players of the European propulsion industry are members of the NGL Joint Propulsion Team defining the future engines.

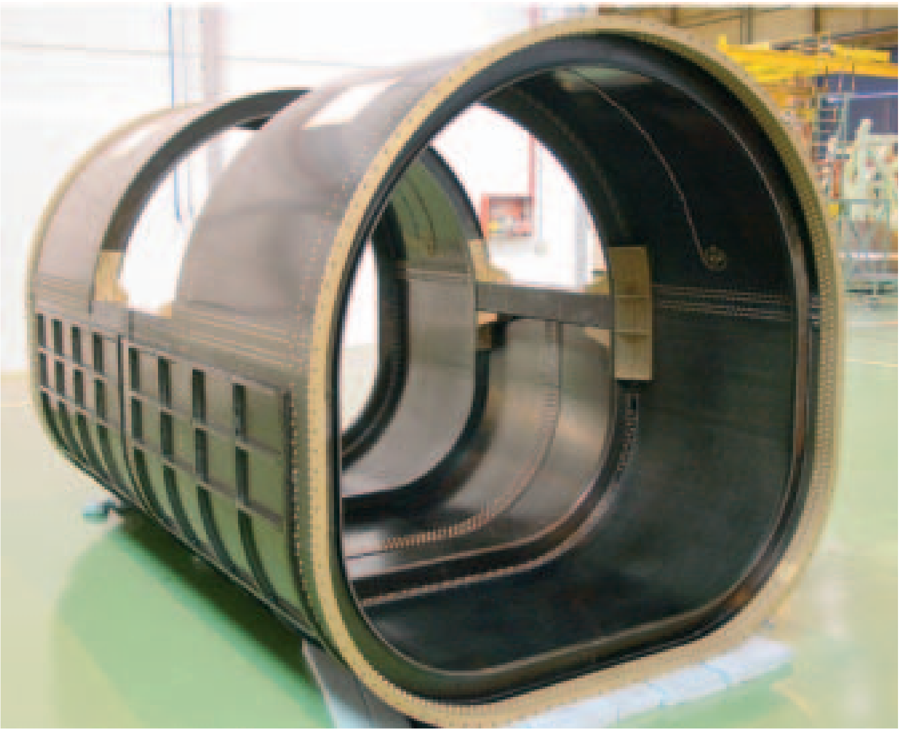
Basically, the propulsion activities in FLPP Period-1 include two parallel and interdependent sets of system and technology activities aiming at achieving appropriate technology-readiness levels for identified critical technologies. At system level, the studies and tradeoffs on propulsion cycles and architectures (gas generator, staged combustion, full-flow staged combustion), high-performance propellants (LOx-LH_2 and hydrocarbons), and requirements definition and design-method elaboration are being closely coordinated with the parallel launcher system studies. At technology level, activities on already identified critical technologies are in progress for major components such as turbo pumps, valves, health-monitoring systems, nozzles, thrust chambers and pre-burners. All of these activities involve representative testing at technology, component or subsystem level. A set of activities designed to improve solid-propulsion cost efficiency and combustion characteristics is also included in FLPP Period-1.

During FLPP Period-2, the technology-demonstration activities will be continued with increasingly representative scales of hardware. All key engine technologies will be test-proven with component and/or engine-level demonstrators before the final development decision for the Next Generation Launcher is taken.

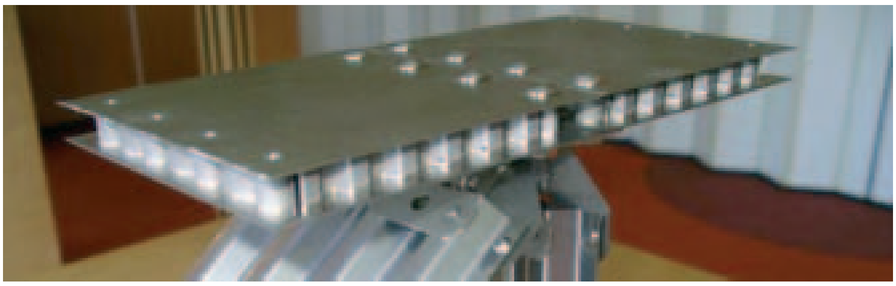
Risk management is a cornerstone of the FLPP propulsion activities due to the close interaction of the system-design activities with the convergence process at the propulsion system and technology levels.

Materials and Structures

A technology-development effort on structures and materials is included in the FLPP themes to distil a burgeoning array of advanced structural concepts down to those that are close enough to maturity for application in fully or partially reusable launch vehicles and should provide the best performance at an affordable cost. Major challenges include reducing overall structural mass, increasing structural margins for robustness, reusable containment of cryogenic hydrogen and oxygen propellants, reusable thermal-protection system, significantly reducing operational costs for inspection and re-validation of structures and sustainability, all of which must be addressed in close cooperation with the other themes of the programme.



CFRP intertank subscale demonstrator structure for a future reusable launcher, including an embedded fibre-optic health monitoring system (Courtesy EADS-CASA and Contraves Space)



Reusable rudder metallic structure building-block element (Courtesy of Dutch Space)

To be economically viable, the stages of an RLV must be able to withstand repeatedly the harsh environmental conditions encountered during all phases of the mission. All elements contributing to the dry mass of the vehicle (e.g. primary structures, engines, tanks, thermal-protection systems, etc.) must be cost effective and as light as possible in order to give each stage the structural index compatible with high robustness.

Improving the performance and reducing the cost of RLV primary structures largely relies on identifying and developing innovative reusable structural concepts and architectures, adequate advanced materials and manufacturing processes, and refined analytical techniques allowing reduced vehicle dry mass together with low operating costs. The various structural subsystems of a typical RLV will be subjected to complex loadings and temperature conditions, leading to severe thermo-mechanical gradients. The structures that carry loads from one part of the launcher to another must have good reliability, availability and maintainability and require as little maintenance, repair and overhaul as possible, which can partly be achieved through the use of 'structural health monitoring systems'. One approach is to use CFRP structures with fibre-optic sensors embedded at critical locations within the matrix and other innovative sensors attached to the structure's surface.

Propellant tanks form a large part of the vehicle's structure and dominate the airframe design effort, influencing as a consequence the aerodynamic and thermal aspects of the vehicle's configuration. The design and manufacture of large reusable cryogenic propellant tanks are very complex, be they metallic or composite structures. The fact that RLVs ascend into orbit full of cryogenic propellant and return with almost empty tanks presents particular thermal and structural challenges. Mastering the fabrication of reusable, high-volumetric-efficiency, cryogenic propellant tanks is therefore one of the key technologies for RLV development.

The FLPP will also address the development of an advanced, reusable thermal-protection system and load-carrying hot-structure subsystems. These will both protect the vehicle airframe from the thermal loads imposed by the high temperatures reached and the harsh environments encountered at several points during ascent and re-entry, and contribute to its external aerodynamic shape. The programme will begin to overcome the hurdles of developing reusable metallic and ceramic structures dedicated to large-area applications at elevated temperature. The thermal protection must not only be lightweight and cost-effective, but also durable, involving minimum maintenance or repair.

Conclusion

The Future Launchers Preparatory Programme will leverage existing European technology investments in the field of reusable concepts based on the large efforts made over the last 15 years with funding from ESA and national agencies. The challenge in the FLPP technology effort will be to define, design, analyse, build and test, either on the ground or in flight, various representative demonstrators validating the requirements defined in the FLPP system studies. This proactive demonstrator policy will foster rapid technology maturation, focusing on concrete targets such as the experimental vehicle (IXV) dedicated to reentry technologies. As a system-concept-driven technology programme, the FLPP combines innovation with addressing future market needs. r

The Ariane-5 ECA Heavy-Lift Launcher

Lift-off of the Ariane-5 ECA for its qualification flight L 521 from the European Spaceport in French Guiana

Uwe L. Berkes
Ariane Project Department, Directorate of Launchers, ESA, Paris

Ariane-5 ECA made a flawless qualification flight on 12 February 2005, heralding this version of the launcher's readiness to enter the launch-services market. This major step forward was the result of more than two years of very intense efforts within the framework of the Ariane Recovery Plan, endorsed by the ESA Council on Ministerial Level in May 2003, after the failure of the ECA version's maiden flight in December 2002. The recovery involved ESA, CNES, Arianespace and European Industry in a consolidated effort to establish this launcher as the European launch-services 'workhorse' for many years to come.

Introduction

ESA's Ariane Development Programme is funded by 14 Participating States. Ariane-5 has been launched 21 times to date from the European Spaceport (CSG) in Kourou, French Guiana, with four of those launches dedicated to the flight-qualification of the various versions. The commercial flights are prepared and operated by Arianespace, which orders the production launchers from European Industry.

As the new heavy-lift version of the Ariane-5 family, Ariane-5 ECA provides a 35% increase in payload performance compared with the baseline Ariane-5 G version. It is optimized and qualified for dual-launch missions to Geostationary Transfer Orbit (GTO), but specific adaptations are foreseen to make it flexible enough for other specific launch missions and orbits other than GTO.

The need for a larger version of the Ariane-5 launcher was identified in the 1990s, when market forecasts revealed that the launch-services market would have to cope with larger satellites. The Ariane philosophy today is to provide cost-efficient double-launch opportunities and so to follow the predicted market evolution a more powerful version had to be considered. The birth of Ariane-5 ECA has been the result of development activities conducted within the framework of two programmes: the Ariane-5 Evolution Programme, and the Ariane-5 Plus Programme. The aim of the former was to improve the performance of the launcher's lower composite, consisting of the boosters, the central EPC stage (Etage Principal Cryotechnique), and the Vulcain main engine. The latter concentrated on the development of new upper stages, of which the ESC-A (Etage Superieur Cryotechnique A) has become the upper-stage of Ariane-5 ECA.

The launch of Ariane-5 ECA as seen from the tracking station at CSG

The Ariane-5 Recovery Plan

Following the failure of the maiden Ariane-5 ECA flight, a Recovery Plan was proposed by the ESA Director General and subsequently adopted at the Council Meeting at Ministerial Level in May 2003. This Ariane-5 Recovery Plan was intended to:
- Re-establish the qualification status of the Ariane-5 ECA version.
- Provide Arianespace with the capability to manage its current backlog of commercial missions with the ‘gap-filler’ Ariane-5 G+ during 2004 and qualification of the ‘back-up’ Ariane-5 GS version.
- Ensure the European institutional missions, and in particular the ESA missions through the EGAS Ariane-5 Programme.

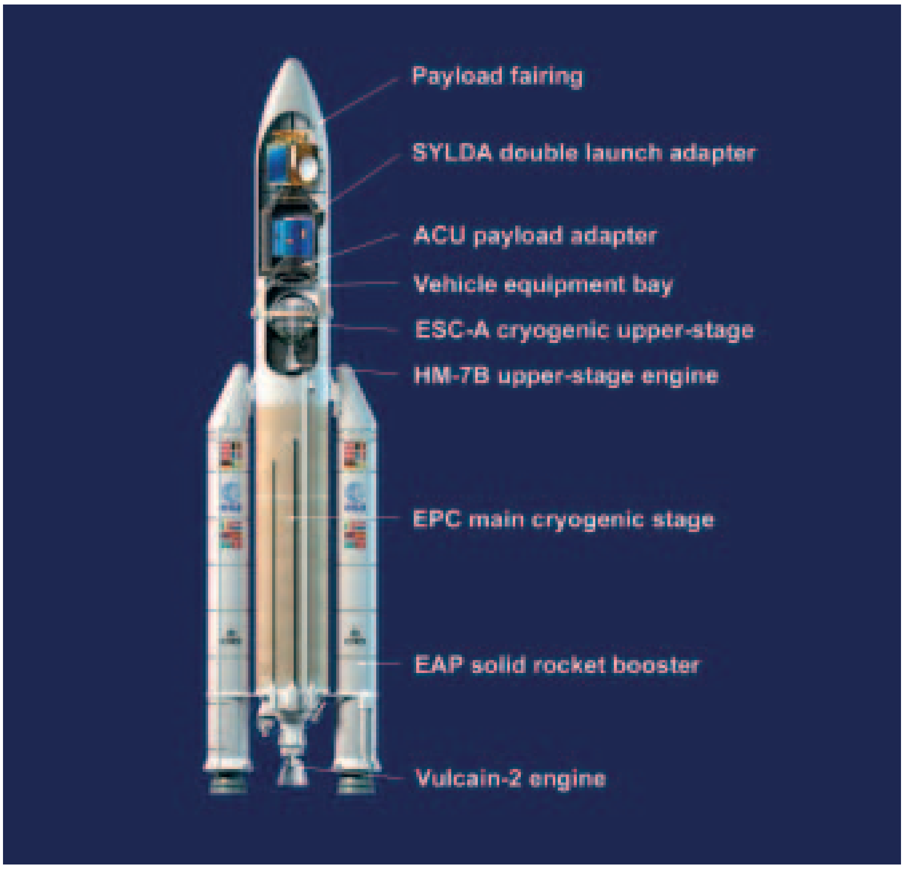
To this end, the Recovery Plan consisted of a scenario based on establishing the Ariane-5 ECA version as the ‘workhorse’ for Arianespace, and back-up scenarios for each milestone of the baseline scenario. In the baseline scenario, the following development activities were identified:
- Consolidation of the Vulcain 2 engine.
- Consolidation of the ESC-A upper stage.
- Qualification flight of the Ariane-5 ECA version (flight L521)
- Restarting of the production of new generic launchers (Ariane-5 GS)
- Qualification of the EPS upper stage for a re-start capability for the launch of ATV and qualification of the related Ariane-5 ES-ATV.

Closure of these activities in 2004/5 was the major objective, in order to be able to proceed with the Ariane-5 ECA qualification flight, to launch the three Ariane-5 G+ launchers, and to initiate the qualification and production processes for the Ariane-5 GS launcher.

Ariane-5 ECA was launched for the first time on 11 December 2002, but this maiden flight failed due to a malfunction in the new Vulcain-2 main engine. A Recovery Plan was endorsed by the ESA Ministerial Council in May 2003 to allow the improvements to be made that resulted in the successful L521 qualification flight on 12 February 2005.

Ariane-5 ECA

The Ariane-5 ECA vehicle stands 50.5 metres tall in double-launch configuration with the long fairing installed on top. It weighs 780 tons at lift-off and delivers a maximum thrust of 13 000 kiloNewtons. The launcher consists of a lower- and an upper-composite. The lower-composite is made up of the central EPC stage (Etage Principal Cryotechnique) with the new Vulcain-2 engine, and the two EAP solid-rocket boosters (Etage d’Acceleration à Poudre) attached laterally to the central



The main elements of the Ariane-5 ECA launcher stage. The upper-composite consists of the Ariane-5 ESC-A (Etage Superieur Cryotechnique A) upper-stage with its HM-7B engine, the Vehicle Equipment Bay (VEB), the ACU payload adapters (Adaptateur Charge Utile) and the payload fairing. For double launches, the upper satellite is installed on the SYLDA (Système de Lancement Double Ariane).

The EPC central stage

The EPC central stage (Etage Principal Cryotechnique) is 31 metres long and has a diameter of 5.4 metres. It weighs 188 tons, 173 tons of which is propellant (148 tons of LOX and 25 tons of LH_2). The EPC is powered by the new Vulcain-2 engine, which provides 20% more thrust than its predecessor. The Vulcain-2 is ignited from the start to work for a maximum of 540 seconds prior to separation of the ESC-A upper-stage.

The Vulcain-2 main engine

Vulcain-2 is a new engine based on the Vulcain-1 of the generic Ariane-5 model. The new engine provides more thrust – 1350 kN compared with the 1100 kN of Vulcain-1 – and forms the basis of the launcher's central stage in its evolution configuration. The engine and in particular its nozzle extension have undergone major reworking in the past two years in implementing recommendations from the technical-review commissions to reach qualification status, involving in particular:

- Reduction of nozzle-extension wall temperature.
- Mechanical reinforcement of the upper nozzle-extension section.
- Assessment of fatigue behaviour of the exhaust-gas torus.
- Assessment of Vulcain-2 aerodynamic loads on the nozzle extension and shortening of the latter to reduce excitation.
- Increasing the number of circumferential mechanical stiffeners to improve the lower-end ovalisation behaviour.

The Vulcain-2 engine and its major modifications after completion of the reworking activities conducted in the framework of the Ariane Recovery Plan

The analyses have been accompanied by extensive development tests under the most extreme conditions, and have been verified by appropriate qualification tests on the P5 (DLR-Lampoldshausen) and P50 (SNECMA-Vernon) test-stands. A further series of tests has been performed using a specially developed Load Simulation Device (LSD) on the P5 test-stand. This device, consisting of a tight skirt around the nozzle extension, allowed near-flight conditions to be simulated, with a vacuum level of 200 mbar and the introduction of ovalisation loads (70 tons), whilst the engine performed a hot run under maximum load conditions.

The solid-rocket boosters

Attached to the central stage are the two EAP solid-rocket boosters, each of which weighs 280 tons, including 240 tons of propellant. The boosters are 31.6 metres high and have a diameter of 3 metres. The maximum thrust from each booster in vacuum is 7080 kN and they operate for 140 seconds. They are ignited 7 seconds after initiation of the Vulcain-2 engine start-up sequence and provide 90% of the lift-off thrust. The EAPs are of the evolution type, with the top segment of

Time	Event
$T_0 - 7s$	Start of the ignition sequence for the Vulcain-2 engine
T_0	Ignition of the solid-rocket boosters and lift-off
$T_0 + 65s$	Maximum dynamic pressure
$T_0 + 140s$	Extinction and separation of the solid-rocket boosters
$T_0 + 188s$	Separation of the payload fairing
$T_0 + 530s$	Extinction of Vulcain-2 engine and separation of the EPC
$T_0 + 535s$	Ignition of ESC-A upper-stage HM-7B engine
$T_0 + 1480s$	Extinction of the upper-stage engine and entry into a ballistic phase prior to separation of the first of the payloads in GTO

each booster carrying an extra 2 tonnes of solid propellant to generate a higher lift-off thrust.

The ESC-A upper stage

The upper composite of the Ariane-5 ECA launcher uses the newly developed ESC-A upper stage. Its LOX tank and HM-7B engine are heritage items from the Ariane-4 H10 cryogenic third stage. The LH_2 tank, however, is a new design using elements from the Ariane-5 main stage (EPC). The stage's wet mass is 19 tons with 14.6 tons of propellant (LOX and LH_2), which provides a maximum of 970 seconds of propelled flight. The 5.4 metre diameter of ESC-A corresponds to that of the central main stage. The HM-7B cryogenic engine provides a thrust of 65 kN in vacuum, with a specific impulse of 447 seconds. A launcher attitude-control system and roll-control system are installed with the ESC-A stage.

The Vehicle Equipment Bay

The Vehicle Equipment Bay (VEB) is a cylindrical, 5.4 metre diameter, carbon-fibre structure installed on top of the central stage. It houses the electrical equipment and the guidance, navigation and inertia platforms to control the launcher.

The fairing, SYLDA double-launch structure and payload adapters

The payload on top of the Ariane-5

The Ariane-5 launcher family

launcher is protected by a payload fairing during the atmospheric flight phases. It is a lightweight carbon-sandwich structure and is produced in three lengths to accommodate different sizes of payloads. The fairing length may be further increased in height by adding cylindrical sections (Adaptateur Cylindrique, or ACY).

The so-called SYLDA (Système de Lancement Double Ariane) is installed underneath the fairing in double-launch configuration. One passenger payload is installed inside the SYLDA, and the other sits on top of it. The SYLDA too is available in various lengths to accommodate satellites of different sizes.

Payload adapters (Adaptateur Charge Utile, or ACU) with various diameters are available to mount the payloads to the 3936 mm interfaces of the upper stage and of the SYLDA.

Ariane-5 ECA Launch Sequence

The launching of Ariane-5 ECA follows the sequence defined since the first Ariane-5 launches, with the timing of the various events depending on the number and masses of the satellites onboard, their intended orbital parameters, and the associated payload insertion criteria. The accompanying table shows a typical sequence for an Ariane-5 ECA launch to Geostationary Transfer Orbit (GTO).

The Ariane-5 Launcher Family

Ariane-5 ECA is supplemented by two further models of Ariane-5, which are presently in the qualification process and whose qualification flights are foreseen in 2005 and 2006, namely:

– Ariane-5 GS, and
– Ariane-5 ES-ATV.

Ariane-5 GS

The GS version of the launcher is based on the Ariane-5 Generic launcher, with the Vulcain-1 engine and elements of the lower composite based on the evolution configuration. The re-partitioning of the LOX and LH_2 propellants in the central stage (EPC) has been carefully matched to the specific mixture ratio of the Vulcain-1 engine. This GS version has been introduced as a backup to the ECA version and will be produced in only limited numbers.

Ariane-5 ES-ATV

The ES-ATV version has been introduced specifically to allow for the launch of the ATV (Automated Transfer Vehicle) to the International Space Station (ISS), in a 51.6 degree, low-Earth orbit (LEO). It can deliver a 20 ton payload to this orbit using a ‘bi-boost’ strategy. Ariane-5 ES is based on the evolution-type lower composite with the Vulcain-2 engine. The upper-stage is the EPS from the generic Ariane-5 launcher, qualified for three ignitions, two for the in-orbit insertion of the ATV, and a further boost for the de-orbiting of the upper stage.

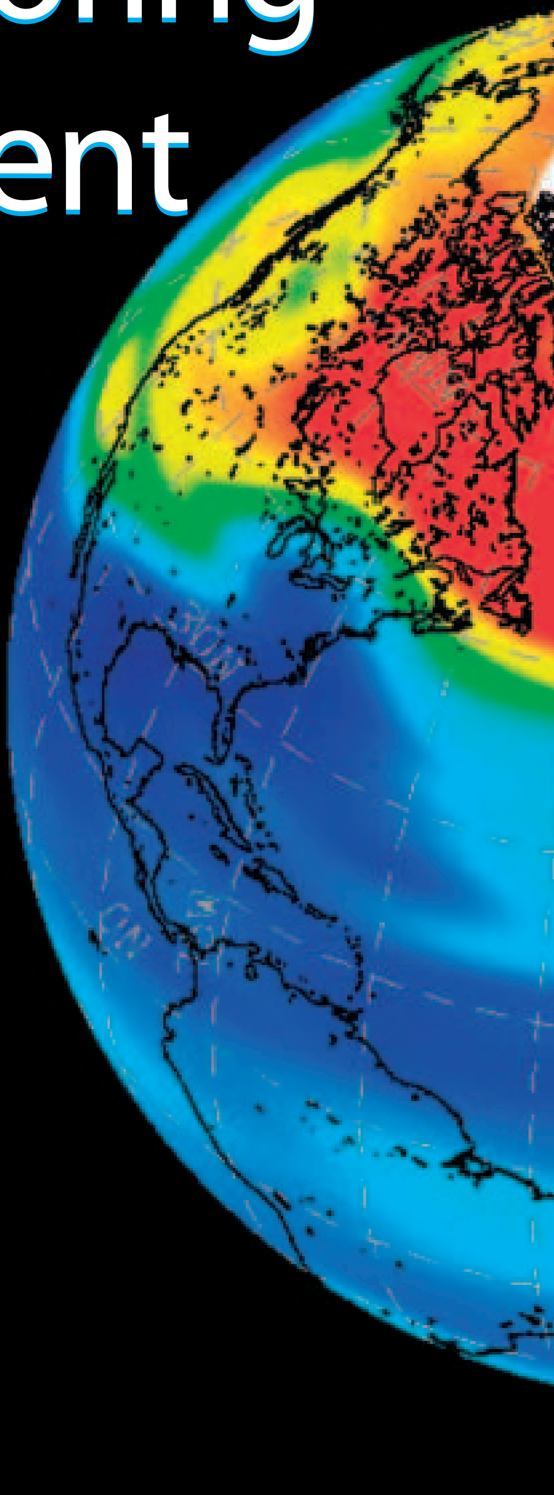
Conclusion

Having now successfully completed its initial qualification flight, Ariane-5 ECA will make at least one more flight in 2005, together with the first flight of the new Ariane-5 GS. The first qualification flight of the Ariane-5 ES-ATV carrying ‘Jules Verne’ is currently expected to take place in mid-2006.

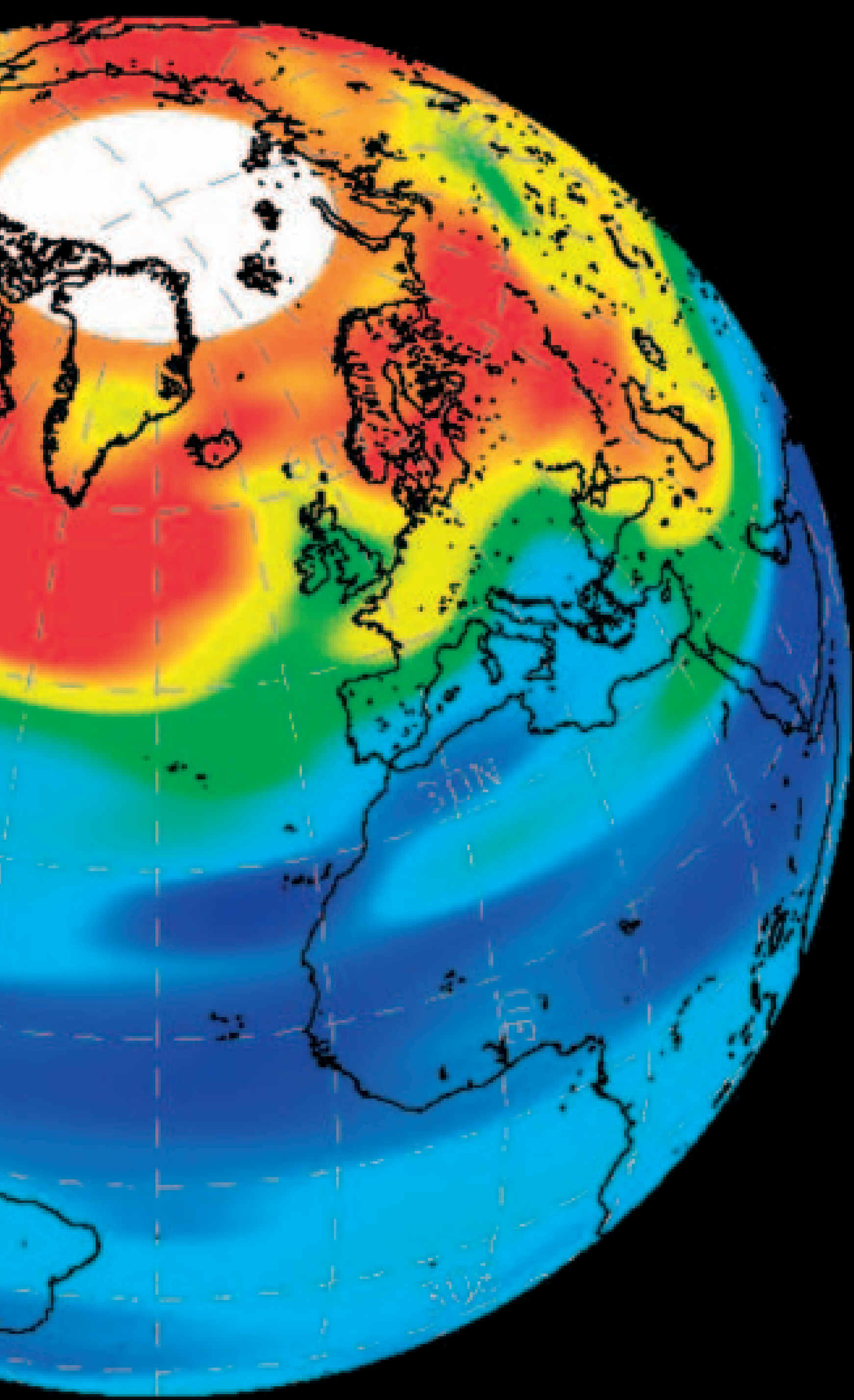
It is foreseen to stabilise the Ariane operating frequency at six launches per year, the majority of which will be Ariane-5 ECA flights. Consolidation of this version of the launcher as the European launch-services ‘workhorse’ for the coming years has been and remains a major programme objective. r

Global Monitoring for Environment and Security

– Europe's next space initiative takes shape



The ozone hole over the Earth's Northern Hemisphere in January 2002, based on measurements made by ESA's Envisat satellite (courtesy of DLR)



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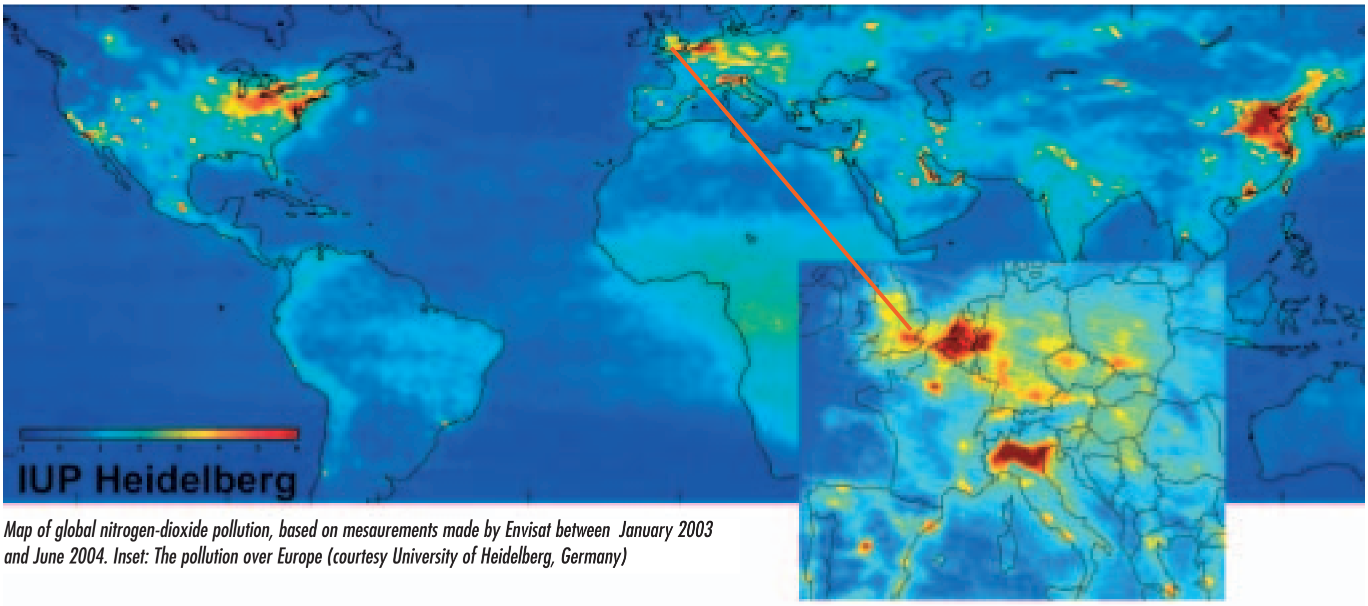
At the first Space Council in November 2004, Global Monitoring for Environment and Security (GMES) was proclaimed as the next flagship initiative for space in Europe, after Galileo. This underlines that GMES has come a long way since its beginnings in 1998. Initially conceived as a relatively loosely coordinated forum for cooperation among space agencies, GMES today stands on firm ground. The European Commission has assumed political leadership for GMES, and the European Union's policy priorities have been confirmed. A strong user base has been built up through numerous GMES projects funded since 2001 by ESA and the Commission. Currently ESA is preparing, with its Member States, a firm proposal for the 2005 Ministerial Council to start building up the space infrastructure necessary to sustain operational GMES services in the long term.

Why GMES ?

At their 2001 Summit in Gothenburg, the EU Heads of State and Government requested that: *"the Community contribute to establishing by 2008 a European capacity for global monitoring for environment and security (GMES)"*.

GMES serves two main policy requirements for Europe in terms of the need for geo-spatial information services. Firstly, it provides independent access to information for policy and decision makers to advance European and national agendas related to environment and security. Secondly, it federates European contributions to the international Global Earth Observation System of Systems,



Map of global nitrogen-dioxide pollution, based on mesaurements made by Envisat between January 2003 and June 2004. Inset: The pollution over Europe (courtesy University of Heidelberg, Germany)

GEOSS, which was established at the Third Earth-Observation Summit in Brussels in February 2005.

Europe's Independent Access to Global Information

Access to information has strategic value for the development of nations and regions. GMES will contribute to Europe's ability to fulfil its role as a global player. This entails the capacity to have independent access to reliable and timely information on the status and evolution of the Earth's environment at all scales, from global to regional and local. GMES must also ensure long-term, continuous monitoring based on space and in-situ observations on a time-scale of at least decades.

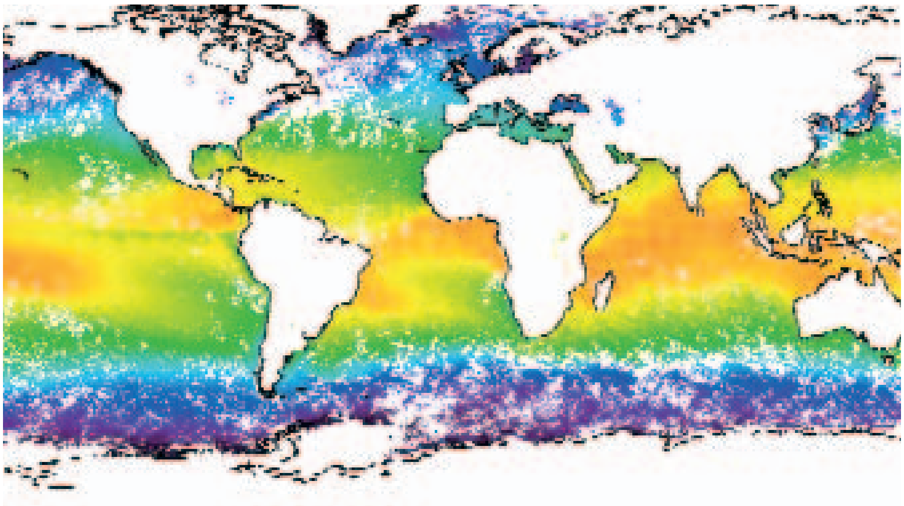
Through GMES, Europe is now in the process of capitalising on its strengths by better coordinating its observation capacities, hence providing continuity of services to support the implementation of EU policies. These include policies in the domains of environment, agriculture, regional development, fisheries, transport, humanitarian aid and external relations, as well as the Common Foreign and Security Policy and the European Security and Defence Policy.

GEOSS, the Global System of Systems

The need for better-integrated observations has been recognised by different governments as a major pre-requisite to understanding global issues such as climate change and to tackling them appropriately at the political level. To advance the integration of these measurements, then US Secretary of State Colin Powell hosted the first Earth Observation Summit in Washington DC in July 2003. This was followed by intermediate and concluding Summits hosted by Japan's Prime Minister Junichiro Koizumi in Tokyo in April 2004 and EU Commissioners Verheugen and Potocnik in Brussels in February 2005. A 10-Year Implementation Plan for a Global Earth Observation System of Systems, GEOSS, was adopted during the Brussels Summit, which asks for closer cooperation among the 60 governments and 40 international organisations that constitute GEO today. Nine 'Societal Benefit Areas' have been identified as the focus for the implementation of the 10-Year Plan: in short, disasters, health, energy, climate change, water, weather, coastal and marine ecosystems, desertification and biodiversity. The 10-Year Plan identifies 2-, 6- and 10-year targets in terms of observational capabilities for the nine areas and indicates their benefits to society.

Statements made by European governments and the European Commission have

The Third Earth Observation Summit in Brussels in February 2005, at which the GEOSS 10-Year Implementation Plan was adopted



Variation in sea-surface temperature between March 2003 and March 2004, based on measurements made by Envisat

repeatedly underlined the intention to provide the European contribution to GEOSS via GMES. This will not include the totality of GMES, but rather those elements that are deemed appropriate to be shared at international level. Likewise, GMES will also act as recipient of data and information from external sources for the benefit of European users.

Through GMES, Europe has established intellectual leadership in developing a holistic space and in-situ based observation system coupled with Earth system prediction models which is driven by policy needs identified by government authorities. Indeed, the GEOSS 10-Year Plan has taken advantage of GMES, translating some of Europe's challenges to the global scale. In addition, a number of countries are establishing national systems, which serve their policy priorities. Examples are the USA, Japan, India, China or Morocco.

IEOS – The US Equivalent of GMES

The United States is developing the Integrated Earth Observation System, IEOS. A Strategic Plan for IEOS has been established over the past two years, which addresses the same nine societal benefit areas as GEOSS, hence allowing coherence between both systems from the outset. The Strategic Plan identifies six priority areas from the nine GEOSS domains that are to be tackled in the near-term. These are: data management, disaster warning, global land observations, sea-level observations, national drought information, and air-quality forecasts.

The IEOS Strategic Plan was developed by 17 federal agencies that are part of the Interagency Working Group on Earth Observation, IWGEO. It reports to the National Science and Technology Council's Committee on Environment and Natural Resources, which advises the office of President George W. Bush on science and technology issues.

The Content of GMES

The overall GMES architecture comprises four major elements, as outlined in the EC Communication on GMES. These are services, space observations, in-situ observations, and data integration and information management. The establishment of a policy and regulatory framework, as well as the setting up of an institutional structure to govern, finance and operate GMES as a whole, are also required. They are dealt with in the GMES Programme Office at the working level, and by the GMES Advisory Committee at Member State level.

From EU Policy Priorities to the GMES Space Component

The definition of the GMES Space Component is based on a number of steps, such as: (i) the identification of EU policy priorities and the respective users within the EC and the EU/ESA Member States; (ii) the implementation of GMES service projects responding to these policy needs, such as those funded by the EC and ESA over the past years; (iii) the retrieval of service requirements and space-observation requirements; and (iv) the identification of gaps in the continued provision of Earth Observation data for European policies, after analysing the current and planned EO missions of ESA, EU/ESA Member States, Eumetsat and third-party operators. The GMES 'Sentinel' missions are defined as an output of these steps.

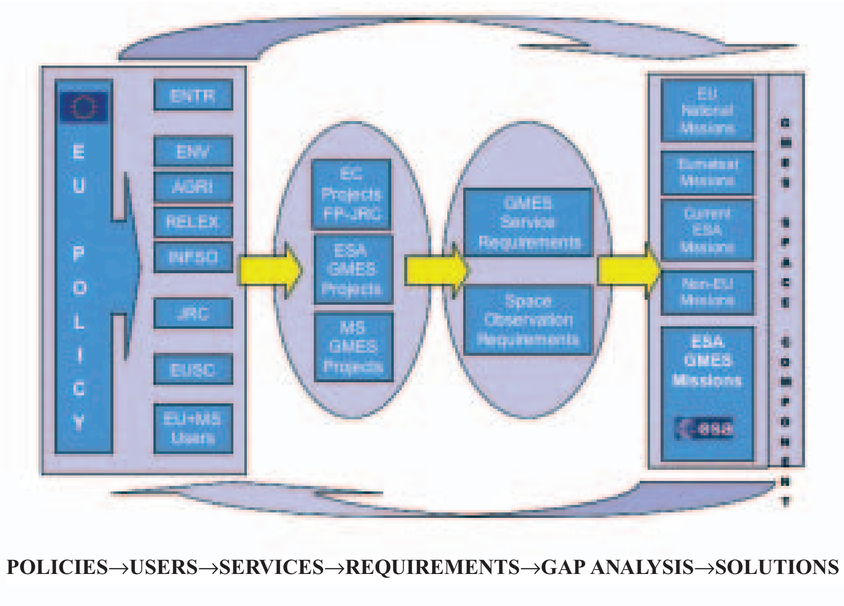
Gathering requirements from these users has been a highly structured process conducted with their active participation. Within the framework of current GMES projects, the process has been based on policy review, traced down to the nature and scope of responsibilities of legally mandated organisations under the identified policies, followed by an assessment of their requirements for information as well as the nature of their working practices and applicable standards that place constraints to be met within such organisations.

Data gaps are expected to occur in the near future. ERS-2 and Spot-4 have already exceeded their nominal lifetimes in 2002, Envisat and Spot-5 have a nominal end-of-life in 2007, and the ETM imaging sensor on Landsat-7 has already failed a few years ago.

Observation requirements for satellite instruments have been derived and the satellite elements aggregated into the definition of the space component of GMES, which is made up of components from ESA, Eumetsat and ESA/EU Member States.

Who Are the GMES Users?

GMES is user driven and responds directly to user requirements. In particular cases, requirements can come from users sufficiently expert in remote-sensing technologies. This is the case, for example, for the European Environment Agency requiring Landsat TM-class observations for operational updates to the Corine land-cover database, and for users involved in programmes such as Global Land Cover 2000 (GLC2000) where there is a direct, demonstrated and endorsed requirement



Analysis of the GMES space component based on EU policy priorities

for continuity of MERIS/vegetation-type measurements.

In other cases, users have only recently been exposed to GMES services through dedicated GMES projects funded by ESA, the EC or Member States. The users comprise European, national and local-government level organisations, and include environmental agencies, civil protection and safety agencies, city councils, coastguards, geological surveys, meteorological offices, fishery-management authorities, transport authorities, development and aid agencies, river-basin authorities, port authorities and health departments.

A recent survey identified some 330 organisations as users of currently running GMES service projects. As these are organisations at European, national and regional level, they have a multiplier effect in terms of the numbers of citizens benefiting from this information. For example, the European Environment Agency is using and redistributing satellite-based Corine land-cover maps of the European territory at 1:50 000 scale to national environmental organisations for further use and distribution.

GMES Initial Services

The GMES Advisory Council has endorsed a number of GMES Initial Services, which require immediate attention in terms of data provision and service development. They have been derived from on-going GMES projects, and they satisfy EU policy priorities that are described in different documents. The identified GMES Initial Services cover:

– Marine and coastal environment monitoring (including pollution, oil spills)
– Risk management (floods and forest fires)
– Risk management (subsidence and landslides)
– Air-pollution monitoring (local to regional scales)
– European water-quality monitoring
– European land-use / land-cover state and changes monitoring
– Forest monitoring
– Food security – early-warning systems
– Global-change monitoring
– Maritime security (marine transport, coastal-area surveillance, ice monitoring)
– Humanitarian-aid support.

All of these services are set to progressively enter the operational stage from 2010 onwards, provided that Earth-observation data are continuously available to users.

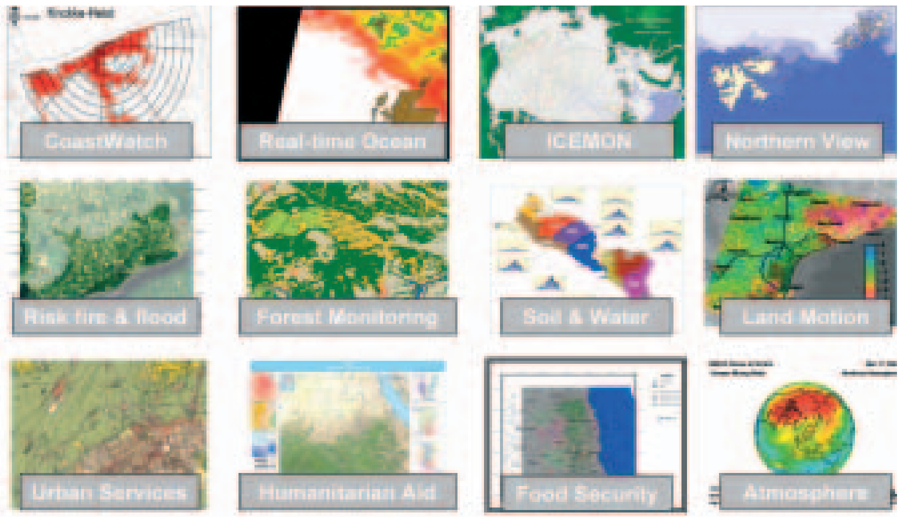
GMES Pilot Services

Among the Initial Services that the EC has identified are a limited number of early GMES pilot services to which it would give priority for operational implementation by 2008. These are:

– Emergency management
– Land monitoring
– Ocean monitoring.

It is planned to establish a fourth pilot service on atmospheric chemistry is in a second stage.

The EC will engage in an intense user-consultation process through a series of three workshops at the end of 2005 in order



The 12 ESA GMES Service Element projects subscribed to at the ESA Ministerial Council in Edinburgh in 2001

to consolidate and update existing user requirements, develop an action plan for 2006-2008, and define criteria for the sustainability of the three GMES pilot services.

The ESA GMES Space-Component Programme Proposal for the 2005 Ministerial Conference

The ESA programme currently being negotiated with Member States in preparation for the 2005 Ministerial Council concentrates on the *GMES space component*, which comprises the space segment and the associated ground segment, including access to national, Eumetsat and third-party missions.

In this context, it is worth recalling that ESA, several ESA Member States and Eumetsat are funding a number of Earth-observation satellite programmes, which should become an integrated part of the overall architecture of the GMES space component. ESA has duly taken account of these missions and has designed the proposed satellite missions – the 'Sentinels' – in a complementary manner.

The following missions are candidates for contributions to GMES:

National
- Spot-5 (operating)
- TerraSAR-X (1 satellite, launch 2006)
- Cosmo Skymed (3 satellites, launches 2007, 2008, 2009)
- Radarsat-2 (1 satellite, launch 2006); C-band constellation (tbc)
- Pleiades (2 satellites, launches 2008, 2009)
- Other national missions (tbc).

Eumetsat
- Jason-2 (with CNES, 1 satellite, launch 2006)
- MSG (4 satellites, launches from 2002); MTG (launch 2015, tbc)
- MetOp (3 satellites, launches from 2006); Post-EPS (launch 2019, tbc).

Privately funded or third-party missions
- DMC-UK (constellation of satellites, launches from 2003)
- RapidEye (5 satellites, launch 2007).

The architecture of the GMES Space Component is designed in such a way that a certain degree of dual-use capability can be achieved. This involves investments in the space segment, ground segment and information and service dissemination element. Details of security-related aspects will be defined during 2006-2007 and proposed in a later phase (post-2008) of the GMES Space-Component Programme.

Flight models of MSG-2 and MSG-3 in the clean room at Alcatel Space in Cannes (F)

GMES Sentinels

The following five members of the Sentinel family have been identified as core elements of the GMES Space Component:

Sentinel-1	a radar imaging mission with interferometric capability
Sentinel-2	a multispectral optical imaging mission
Sentinel-3	an ocean and global-land surface monitoring mission with altimeters and wide swath, low-to medium resolution radio-meters
Sentinel-4, -5	two families of atmo-spheric chemistry missions, on geostationary (Sentinel 4) and low Earth orbit (Sentinel-5) spacecraft.

GMES-1, the First GMES Mission

The core element of the ESA programme proposal for the 2005 Ministerial Conference includes the development of a first GMES mission, GMES-1, planned for launch in 2010/11. This mission's definition is driven by three factors. Firstly, as mentioned above gaps in data will occur in the 2009-2011 time frame. Secondly, no definitive financial commitments are expected from the EC before 2007. And thirdly, the developments must be the basis for a robust and affordable operational system, incorporating sufficient flexibility and modularity to allow for the anticipated evolution that will occur throughout the extended lifetime of the system.

The GMES-1 mission will satisfy the most urgent data needs by combining selected instruments on one spacecraft, the design of which will allow for future payload growth. The envisaged instrument package forms a coherent set of instruments, sharing similar constraints in terms of orbit requirements. It is anticipated that the instruments developed for GMES-1 will also be used on the future operational series of GMES satellites.

Aimed at addressing the observational needs of Sentinel-1 and -3, as a starting point GMES-1 will include a C-band imaging radar capable of continuing the interferometric and ocean/ice/land measurements of ERS and Envisat, as well as an ocean-colour instrument providing continuity of MERIS-type measurements. An infrared instrument for fire monitoring will also be included to demonstrate its capabilities. The option of embarking an infrared radiometer (AATSR-type SST instrument) or a radar altimeter will also be investigated early in the programme.

GMES Ground Segment

The GMES ground segment related to space data comprises tasking, telecommand and tele-control, acquisition, archiving, processing up to appropriate product level and distribution of Earth-observation data according to GMES service needs. It includes the payload ground segment, flight-operations segment as well as access to historical data. The payload ground segment is based on existing national and commercial facilities in a fully distributed approach. In addition, access to and integration of Earth-observation data from Eumetsat, national and third-party missions are provided to users via the GMES ground segment.

GMES Service Portfolio Extension

GMES services must serve many diverse user communities in Europe and worldwide, continuously integrate new techniques and research advances from many different fields, exploit spatial and non-spatial data from a multitude of different sources including newly available satellite data, and evolve to deliver new forecasting, prediction and early-warning capabilities. The service extension will contribute to bringing the current GMES services to full operational status and to developing new Earth-observation-based GMES services. It is understood that this element is to be funded through (future) European Commission budgets as part of the joint implementation of GMES by the Commission and ESA.

GMES Operations

The operation of the GMES space component covers the space, ground and service segments. The different GMES missions (Sentinels, Eumetsat, national) and their related ground segments will be operated by different entities, with ESA ensuring the integrity and coordination of the GMES space component.

The operating entities for the GMES Sentinel family will emerge over the next years in parallel with an agreement on the governance of GMES as a whole.

Cooperation with the European Commission

GMES has, from the outset, been a cooperative effort involving all major stakeholders in Europe. Over the past years, the Commission and ESA have cooperated on GMES on behalf of their respective Member States. Investments so far have focused on the consolidation of the GMES user base and the provision of initial services. ESA and the Commission have each provided some 100 MEuro for the development of services based on EC and EU/ESA Member State priorities. In 2004, the ESA Member States have approved an additional 40 MEuro for preparatory studies of the GMES space component.

The GMES Advisory Council and GMES Programme Office lead the GMES process. The GMES Advisory Council is chaired by the European Commission (DG Environment, to underline the user-driven aspect of GMES). The GMES Programme Office is co-led by the Commission and ESA.

The model of shared responsibility has been a successful means to continuously move GMES forward. It has led to the consolidation of a significant user base across Europe and has raised the political awareness in the EC and the EU and ESA Member States. On the international scale, GMES has been portrayed as a model for establishing the Global Earth Observation System of Systems, GEOSS.

Taking these considerations into account, and making use of existing co-ordination and consultation mechanisms, ESA continues to closely coordinate the definition of the GMES space component with the EC and the EU/ESA Member States using existing mechanisms, such as the GMES Advisory Council for the definition of the GMES Space-Component Programme.

Implementation Approach

The approach proposed has to be compatible with the fact that no definitive financial commitments will be available from user entities, represented through the European Commission, before 2007. The second programme imperative is to anticipate potential data gaps that might occur in the period 2008-2012, particularly in:

– the C-band radar imaging and interferometric capability
– Landsat-Spot type data
– wide-swath radiometer data.

The implementation of the GMES Space-Component Programme is proposed to take place in two segments:

– Segment-1 covering the period 2006 2012, and
– Segment-2 covering the period 2008 2013.

Segment-1 will be funded through the ESA Optional Programme, while Segment-2 is expected to be co-financed with the European Commission according to a financing model to be agreed in 2007.

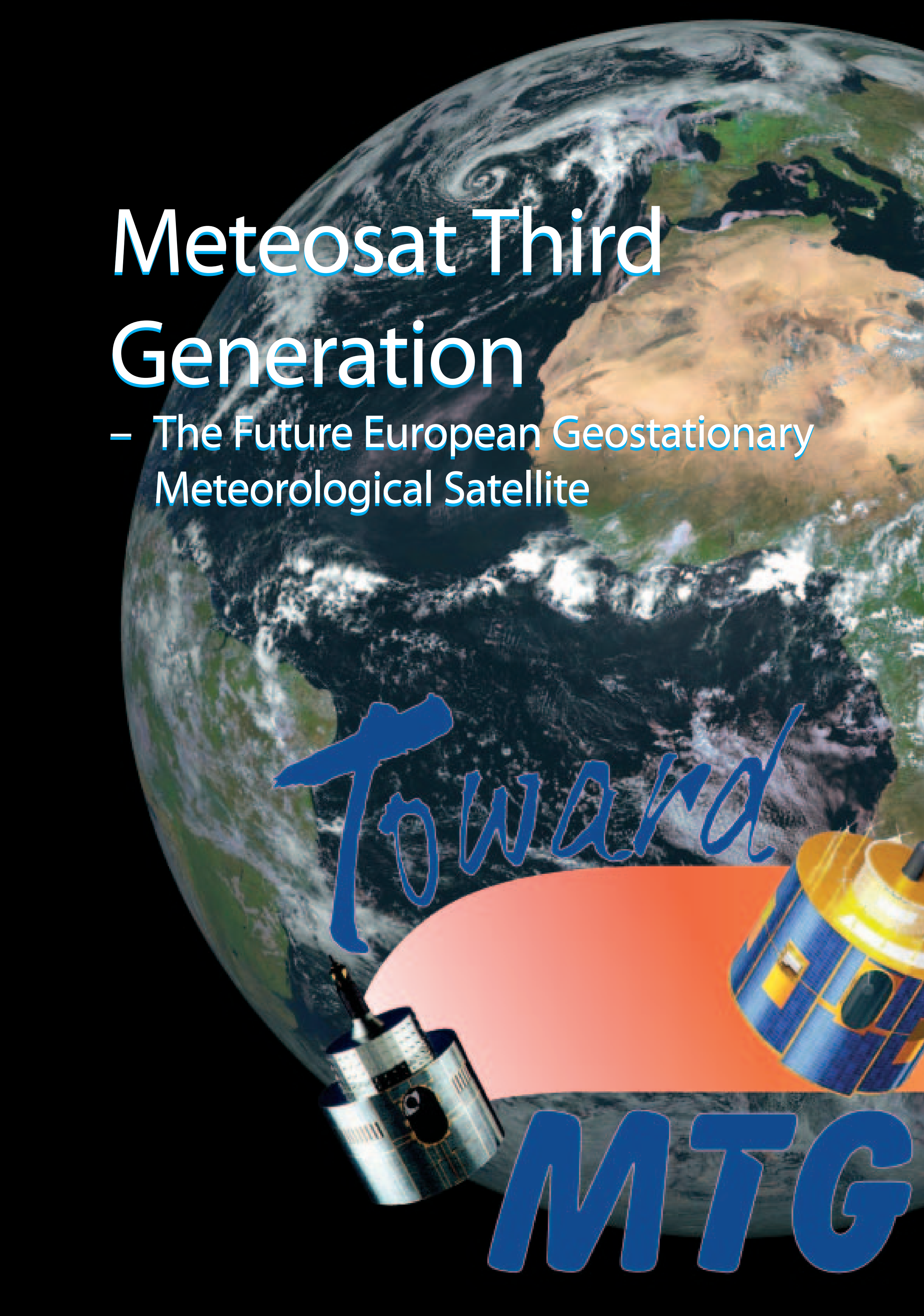
Outlook

Data continuity over a period of decades is a key requirement for operational services. In order to prepare for the full implementation of GMES, the ESA Space-Component Programme assures data continuity for critical satellite observations from 2010/2011 onwards. The Ministerial Conference will be a decisive event, in particular for ESA, to ensure that GMES continues to move forward.

Only a well-funded and strongly implemented GMES can serve the ambitious goal of Europe becoming one of the most dynamic knowledge-based societies in the World. Furthermore, GMES has provided intellectual leadership in establishing the Global Earth Observation System of Systems, GEOSS. It is important that Europe continues to support this leadership through action, thus providing a favourable platform for Europe’s industry, institutions, organisations and scientists to maintain a leading edge in preserving the global environment and ensuring security to Europe’s citizens and people everywhere. r

Meteosat Third Generation

– The Future European Geostationary Meteorological Satellite



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Today, the Meteosat geostationary meteorological satellites play a key role in providing continuous atmospheric observations both for weather forecasting and for monitoring a wide variety of environmental phenomena. Following the successful commissioning of the first satellite in the Meteosat Second Generation (MSG) series, Eumetsat and ESA are already actively planning the next European operational geostationary meteorological satellite system in the form of the Meteosat Third Generation (MTG). Being considered for launch in 2015, MTG will revolutionise weather forecasting and environmental monitoring as we now know them, by providing a very significant improvement over the capabilities of the current Meteosats.

The second generation of Meteosat satellites is expected to provide operational services at least until 2015. However, when one considers the time needed for the definition phases of new space systems, their typical development cycles, and the approval process for such complex programmes, it is already time to start planning for follow-up geostationary missions.

Some time ago, therefore, Eumetsat established a User Consultation Process aimed at capturing the foreseeable high-level user/service needs and priorities of its customers for the 2015 – 2025 time frame. This process has led to a preliminary definition of objectives for the European MTG geostationary satellite system, which currently consists of a total of five candidate observation missions selected for feasibility studies at system level under ESA contract.

The overall mission will be implemented using the same ESA/Eumetsat cooperation scheme that has been successfully exploited for both the MSG and MetOp satellite series. ESA will be the development and funding agency for both the basic technologies and the first satellite of the MTG system, and will also be the overall procurement agent for all MTG satellites. Eumetsat will define the requirements for each mission and be responsible for the overall programme. Eumetsat will also fund and develop the ground segment, as well as all operations and follow-on satellites.

The Candidate Observation Missions

Following the consolidation of user requirements and assessment of observing techniques, five candidate observation missions for MTG were proposed:

- Three distinct imaging missions dedicated to operational meteorology, with the emphasis on 'nowcasting' and very-short-term forecasting:
  - a High-Resolution Fast Imagery (HRFI) mission, based on enhancement of the MSG High-Resolution Imagery mission
  - a Full-Disk High-Spectral-resolution Imagery (FDHSI) mission, as the successor to the MSG SEVIRI instrument
  - a Lightning Imagery (LI) mission.

- Two atmospheric-sounding missions:
  - an Infrared Sounding (IRS) mission focusing on operational meteorology, with potential relevance to atmospheric chemistry applications
  - a UV/Visible Sounding (UVS) mission dedicated to atmospheric chemistry.

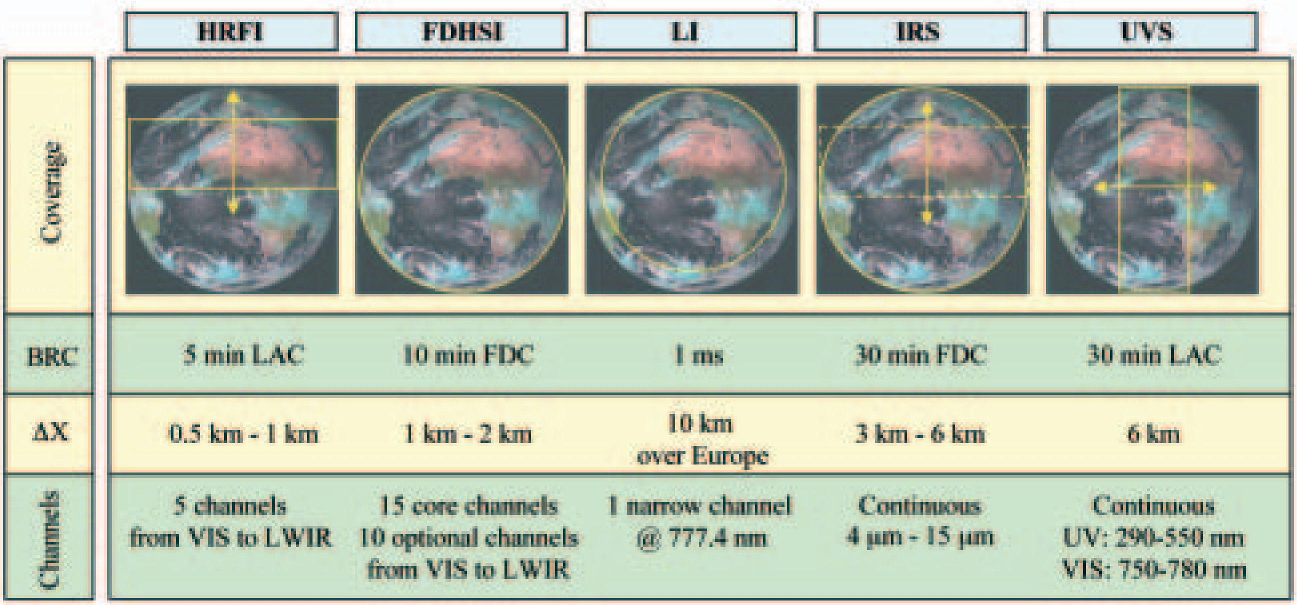
Complementing the observational missions, the MTG Programme will also support:
- a data-collection mission
- a Level-2 product-extraction mission
- an external data-collection mission.

High-Resolution Fast Imagery mission

The HRFI mission expands the MSG High Resolution Visible (HRV) mission in the spectral domain. The emphasis is on high temporal (5 min) and spatial (0.5 - 1.0 km) resolution requirements, for a limited number (five) of spectral channels. The coverage is limited to selectable fractions of the full Earth disk, with a coverage equivalent to one-third of the full disk (18º E/W x 6º N/S) referred to as Local Area Coverage (LAC). The LAC can be variably placed over the Earth.

The main objective of the HRFI mission is to support nowcasting and very-short-range forecasting of convection, and its relationship to the 'fast' component of the hydrological cycle. This will be achieved through observations of cloud patterns, their horizontal movement, the vertical

Main characteristics of the MTG observation mission



BRC: Baseline Repeat Cycle FDC: Full Disk Coverage LAC: Local Area Coverage (18° x 6°) ΔX: Spatial resolution UV: ultraviolet VIS: visible LWIR: longwave infrared development of clouds, and the microphysical properties at cloud top. A second objective of the HRFI mission is to complement the MTG Full-Disk High-Spectral-resolution Imagery and the Infrared Sounding missions, by providing more detailed, 'targeted' observations over selected regions where active weather patterns are developing.

Full-Disk High-Spectral-resolution Imagery mission

The FDHSI mission is an evolution of the MSG SEVIRI full-disk mission, featuring high radiometric performances in a larger number of spectral channels and full Earth-disk coverage. It is also more demanding on temporal and spatial resolution than the MSG SEVIRI mission, and has a core set of 15 channels and 10 optional channels located in the visible and infrared parts of the spectrum. The main objectives are to support:

– nowcasting and very-short-term forecasting
– Numerical Weather Prediction at regional and global scales
– climate monitoring.

The FDHSI mission will cover the full Earth's disk, with a 10 minute repeat cycle and a 1 to 2 km spatial resolution for the solar and infrared channels, respectively.

A single multi-channel imager operated in an optimised sequence of full-disk and LAC coverage will support both the FDHSI and HRFI missions.

Lightning Imagery mission

The LI mission is designed for the continuous mapping, day and night, of lightning discharges into a geostationary orbit. Detection on a geostationary Earth-disk basis and real-time observation of the total lightning-flash activity represent valuable improvements for all operational applications. The sensor will be capable of detecting all forms of lightning with a high spatial resolution and detection efficiency. Since the data will be distributed in real time, it will be an invaluable tool to aid weather forecasters in detecting severe storms in time to give advance warning to the public. The LI mission will also support atmospheric-chemistry applications, as lightning plays a significant role in generating nitrous oxides. The natural nitrous-oxide budget is currently a matter of great uncertainty, and long-term observations of one of its sources will prove valuable as the research develops.

The observation technique selected is based on the detection of the strongest lightning emission feature within the cloud-top optical spectra produced by the neutral oxygen line at 777.4 nm.

Infrared Sounding mission

The primary objective of the IRS mission is to support Numerical Weather Prediction (NWP) on regional and global scales, through the provision of:

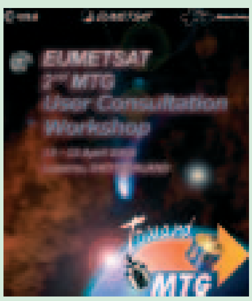
– Atmospheric Motion Vectors (AMV) with higher vertical resolution in clear air, to be extracted from the tracking of three-dimensional water-vapour patterns
– more frequent information on temperature and water-vapour profiles.

The full-disk AMV capability has the highest priority for global NWP, as this geostationary observing technique is unique for the extraction of three-dimensional wind fields in clear air. Infrared soundings with high vertical, horizontal, vertical/spectral resolution and temporal sampling of a fraction of an hour will also greatly enhance the National Meteorological Services' (NMS) ability to initialise regional NWP models with more realistic information on temperature and moisture. The high temporal frequency achieved from geostationary orbit will increase the likelihood of getting clear-sky soundings over dynamically important regions such as the North Atlantic. This will enable regional and global NWP models to better identify areas of rapidly developing atmospheric instability responsible for vertical motion, convection, and precipitation development.

Current MTG Status

Meteosat Third Generation is an Eumetsat/ESA collaborative mission with the first satellite planned for launch in 2015. MTG preparatory activities started at the end of 2000, following the decision by Eumetsat's Council to proceed with a Post-MSG User Consultation Process. A joint work plan between ESA and Eumetsat has been established to consolidate the mission requirements and demonstrate the mission's feasibility.

The Eumetsat-led process aiming at capturing the needs of users for the 2015-2025 timeframe has been completed and presented at the first User Consultation Workshop in November 2001. Five candidate observation missions resulted from the user-consultation initiative. High priority has been given to the continuation of the MSG imagery missions, but with significantly improved performance. Lightning imagery and atmospheric sounding will complete the MTG mission and offer the operational meteorology community an outstanding tool for weather forecasting.



Since September 2004, the MTG mission has been the subject of two parallel ESA system studies led by Alcatel Space and EADS Astrium GmbH, respectively. The preliminary findings have been presented at the second User Consultation Workshop in April 2005.

The secondary objective of the IRS mission is to support, together with the UV/Visible Sounding mission, chemical weather and air-quality applications. IRS will provide dramatic improvements over current sounder data and products, including better spectral resolution, faster geographical coverage, and improved spatial resolution.

A high-spectral-resolution infrared spectrometer has been selected as the most efficient instrument to fulfil the mission requirements. Two possible concepts, namely a Fourier Transform Spectrometer and a Dispersive Spectrometer, are currently under investigation.

UV/Visible Sounding mission

Long-term observations have shown that the composition of the Earth's atmosphere is changing. A human influence is clearly discernible and in some cases firmly established. The change in atmospheric composition induces changes in climate, UV exposure and air quality. It therefore has important, often adverse, consequences for human health and safety, eco-system balance and socio-economic conditions. To understand, predict and control environ-mental change is one of the main challenges of the 21st century.

UV/Visible Sounding measurements could contribute substantially in these areas, and thus support the following primary applications:

- air-quality monitoring and forecasting
- detection and surveillance of unpredictable pollution clouds and plumes
- control of air-polluting emissions
- UV radiation monitoring and forecasting
- numerical modelling and weather forecasting.

Mission Implementation

Candidate system concepts for the implementation of the MTG mission are being defined and assessed in the framework of two parallel MTG System Architecture Studies, carried out by industrial consortia led by Alcatel Space and EADS Astrium GmbH.

The dramatic improvement in performance compared with the previous generations of Meteosat is made possible by the use of a three-axis-stabilised rather than a spin-stabilised platform, allowing a much higher duty cycle for observing the Earth.

To minimise the risks inherent in the development of the payload complement, and also to allow a flexible approach to the MTG system's operational deployment, two satellites supporting the imagery and the sounding missions, respectively, are being considered. The high availability required for the provision of operational meteorological satellite services implies the need for backup satellites in orbit. The MTG mission lifetime of 15 years will therefore require up to 8 satellites (4 nominal and 4 backup), each with a lifetime of 7.5 years.

Besides the definition of the system concepts, the ongoing studies will produce initial estimates of the overall system development costs and assess the critical technologies requiring specific pre-developments. The results of the studies will be jointly used by ESA and Eumetsat to consolidate the MTG mission and technical requirements at the MTG Mission Definition Review to take place in the first quarter of 2006. The selected concepts and the relevant requirements will then be used as inputs for the detailed feasibility studies at Phase-A level to be initiated in late 2006.

Planning Timeline

Based upon Eumetsat maintaining an 'in-orbit backup satellite' philosophy and hence MTG-1 replacing MSG-3, then with a nominal lifetime of 7 years for each MSG satellite, the first component of the MTG space segment needs to be launch-ready in 2015.

Eumetsat and ESA are conducting joint preparatory activities for the definition of the MTG mission, with the following planning assumptions for feasibility studies, design and development:

• 2004-2005
Pre-Phase-A studies conducted with ESA based upon the high-level user needs and priorities established in 2000-2003 through the post-MSG user consultation process.

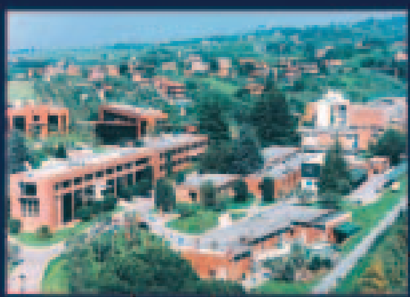
• 2006-2007
MTG Phase-A studies for selected mission concepts, with approval processes for coordinated ESA and Eumetsat MTG preparatory programmes.

• 2008-2009
Phase-B activities under coordinated Eumetsat and ESA Preparatory Programmes, with approval processes for coordinated MTG development programmes.

• 2009-2014
Development and on-ground testing of the MTG system. r

Precision Vineyard Management from Space

– From Bacchus to Eneide



ESA/ESRIN lies in the middle of the Frascati DOC wine-growing region, southeast of Rome. The right-hand image is an ERS multi-temporal satellite image of the Rome and Castelli Romani region. The second image is from an INTA aircraft multi-special-imaging overflight of the Frascati vineyard area (ESRIN entrance and surrounding vineyards) conducted in 2004, with 50 cm resolution

Simonetta Cheli & Luigi Fusco
ESA/ESRIN, Frascati, Italy

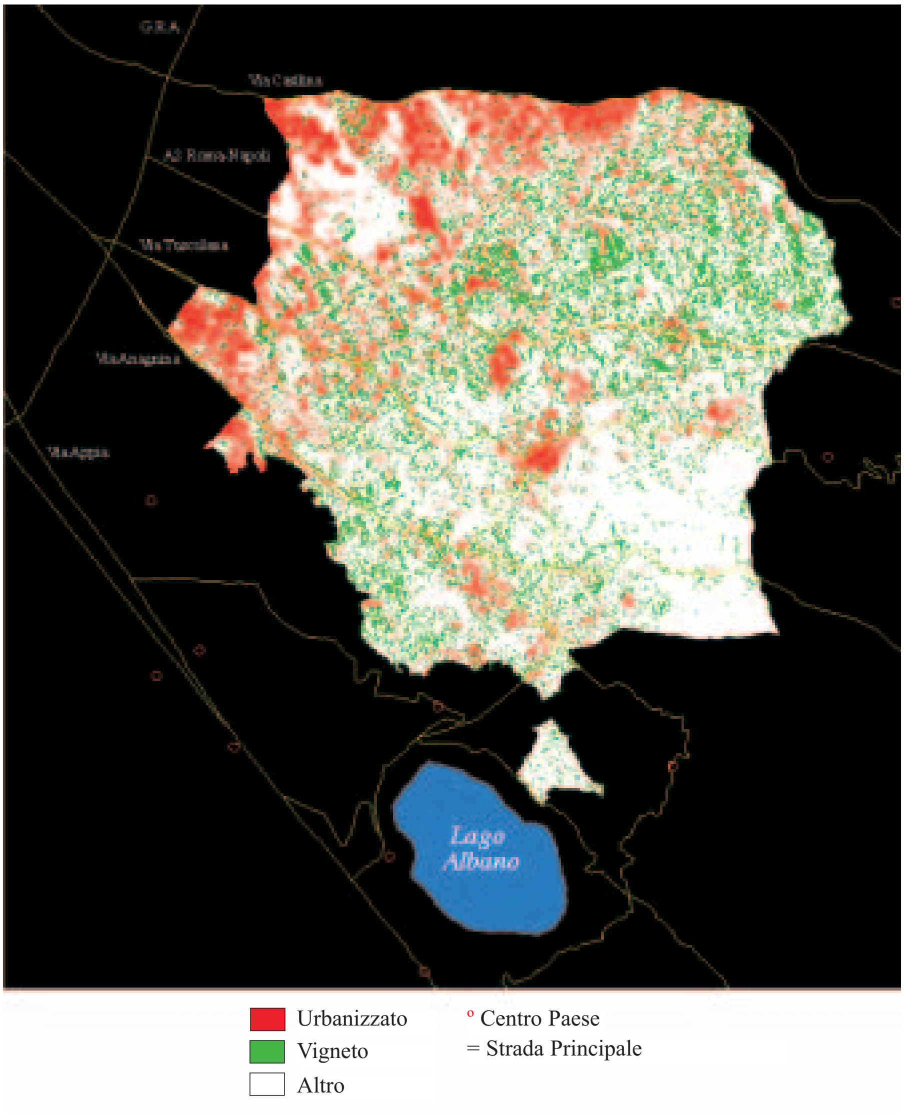
Stefano Sandrelli
Osservatorio Astronomico di Brera, Milan, Italy

In a highly competitive global market such as the wine business, consistent quality is a must, especially if Europe wants to maintain its position as world leader. It currently accounts for 55% of the world's vine-growing areas, 60% of wine production and 70% of exports.

In this very special sector of agriculture, technology and science play fundamental roles in all phases of activity, from the start of the vine-growing season, through the ripening of the grapes, to the bottling of the wine. The quality of the wine produced depends on many parameters, including the soil characteristics in the area, the weather and growth conditions during the season, the ability to monitor and control vine diseases, the degree of maturity of the grapes at harvest time, their grade, colour, organic acids, etc. during fermentation and, finally, the wine production techniques employed. In general, however, European vineyard managers still have little access to technical means or reliable systems to guide them in their decision-making.

Precision Farming in the Frascati area

Space technologies, particularly those associated with Earth Observation (EO), can help the wine-growing community in a number of technical areas. One of several initiatives promoting the use of EO in the wine sector has been 'Bacchus', a Research and Technological Development project started in 2003 (to be completed in 2005), funded by the European Community through its Fifth Framework Programme. The project is led by a consortium representing SMEs, institutes, public agencies and regulatory organisations from the main wine-producing regions of Spain, Italy, France and Portugal (see http://www.bacchus-project.com).



Assessment of the urban pressure exerted by Rome's growth on the Frascati DOC area: red = anthropic areas, green = potential vineyard area, as classified using a Landsat-4 TM dataset in 1986

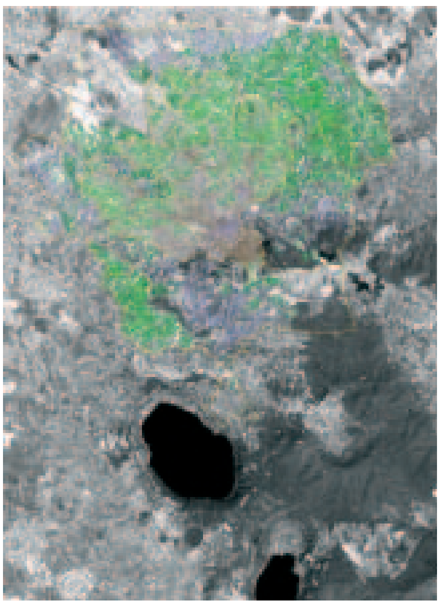
Bacchus's goal has been to demonstrate to regional vineyard regulatory bodies, vine quality-control bodies and wine producers how a comprehensive space-based solution can meet their information needs. Such a solution relies on the integration of very-high-resolution remote-sensing data gathered from space with other more traditional information available, for instance, in Geographical Information Systems (GISs). This Bacchus project environment has been used as a reference infrastructure for:

– defining new data-handling methods for improving current methodologies for vine area location, land parcel identification, and vineyard inventory making
– generating new land-management reference maps and experimenting with dedicated models for vineyard management.

Test sites in the participating countries have been selected for the trialing of pilot system(s) and for demonstrating the potential of this integrated approach to several interested parties in the wine business. In particular, the Frascati DOC (Denomination of Controlled Origin) wine region was been selected as one of the two Italian Bacchus test sites.

ESA's ESRIN establishment happens to lie right in the middlle of this important wine region southeast of Rome, which is partially in the volcanic Castelli Romani area. Since the start of the Earthnet Programme at the end of the 1970s, the Earth Observation team at ESRIN has had routine access to imagery from Landsat, ERS, Envisat and several other high-resolution EO missions. It has therefore accumulated a large archive of EO data and related information on the Frascati area, mainly to verify the quality of the ESRIN-generated EO products. Such data include a high-quality digital elevation model, for documenting the changes in local land use and environmental parameters over time. By using historical Landsat Thematic Mapper datasets, for example, it was possible in 1996 to assess the urban pressure of the city of Rome on the Frascati DOC area over the previous 10 years.

Comparison with the classification performed using images taken in 1996 shows that:

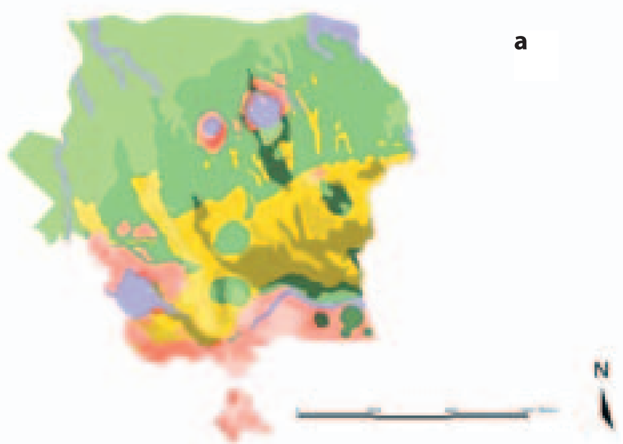


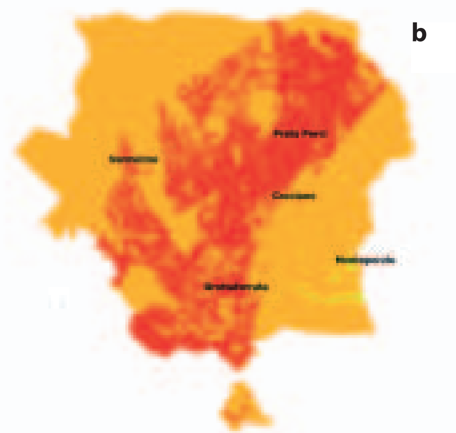
Composite of IRS (5 m resolution) and Quick Bird (0.61 m panchromatic, 2.4 m multi-spectal) satellite imagery covering the Frascati area. The yellow line identifies the boundaries of the community participating in the Frascati DOC region; the green lines delineate the Frascati DOC vineyards, and the blue lines the built-up areas in the region

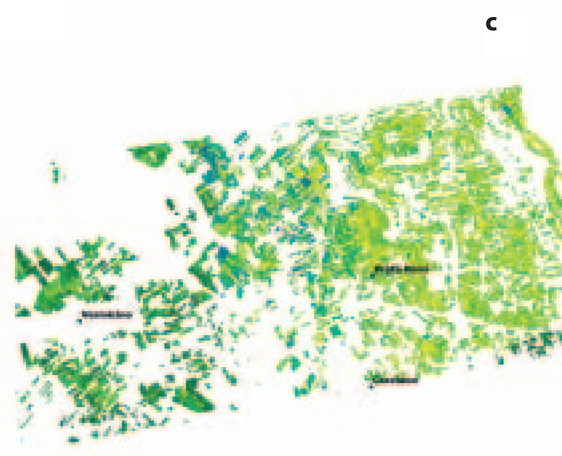
Urban	in '86: 14.59%	in '96: 15.70%	delta: +1.11%
Vineyard	in '86: 38.00%	in '96: 35.45%	delta: -2.55%
Other:	in '86: 47.40%	in '96: 48.85%	delta: +1.45%

This space-based assessment is in line with the changes defined in the land register for the Frascati DOC production.

The friendly spirit of cooperation between ESA/ESRIN, the local scientific institutions (in particular the University of Tor Vergata and the Consiglio Nazionale della Ricerca, Istituto Scienze Atmosfera e Clima) and the local authorities (in particular the Municipality of Frascati), all of whom have an interest in understanding and monitoring the evolution of the environment in this part of the world, has allowed a unique multidisciplinary knowledge base concerning farming in the Frascati area to be established. Integration of this knowledge into the enlarged Bacchus project partnership has led to the generation of very high-quality land-management information systems specifically tailored for the Frascati DOC area.







Examples of the geo-/bio-morphological and climatological information handled by the Frascati DOC Land Information Management System developed within the Bacchus project (courtesy of F. Comandini, CTDF and B. Rapi, CNR-IBIMET)

(a) Pedological map, integrating land use, terrain properties and geo-climate parameters

(b) Wine-growing suitability map for the Frascati region integrating various geo-morphological data and local climate information

(c) Estimate of 2004 grape production per vine in the Frascati DOC region for the area covered by the INTA overflight

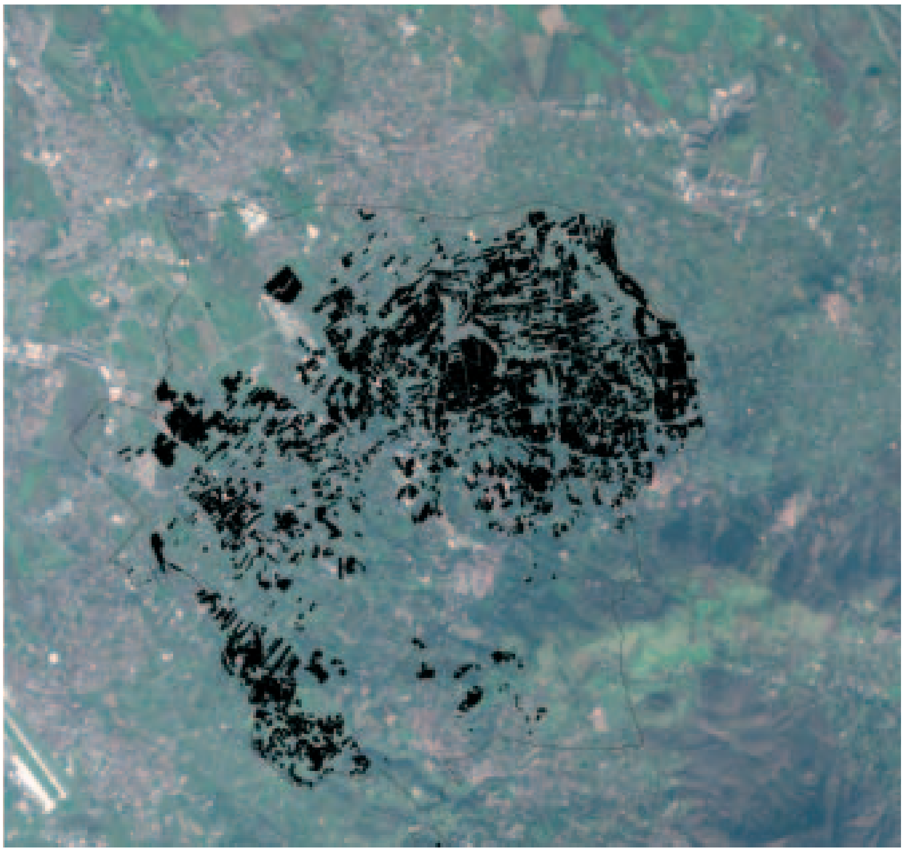
Results for the Frascati Test Site

The Bacchus project has taken advantage of recent progress in EO and ICT technologies, including:

– The availability of very-high-resolution imagery from space: IKONOS (since 2000) and QuickBird (since 2002) have been providing data with 80 cm and 60 cm resolution, respectively. European missions with similar capabilities, also at radar frequencies, will soon become available (e.g. Pleiades and Cosmo Skymed) and be able to support wine management applications.

– Good progress in web technology, especially for the handling of mapping services as part of the Open GIS consortium standardisation effort and the European INSPIRE initiative: the availability of web-GIS technology will make the dedicated geomatic services accessible via the Internet.

– Wireless communication: Significant progress has been made in the integration of wireless communication, for example to collect ground measurements or provide information



A Proba CHRIS image frame covering the Frascati DOC test area, supporting study of the phenology of the grape in the region by the University of Tor Vergata, CNR-ISAC and ESA/ESRIN). The black areas are all the vineyard parcels belonging to the Frascati DOC region

via portable devices. Vineyard managers view this technology with interest for supporting the wine traceability chain.

During the Bacchus project a number of dedicated tools have also been developed for:
- EO image data and GIS management, by the Spanish partner GEOSYS, to provide a friendly PC-based, end-user environment
- specific vineyard area high-resolution image classification and feature extraction, by the French partner CEMAGREF
- vineyard land analysis and management, by the Italian partner CNR-IBIMET. It provides models for vineyard area management and land-use potential for single vineyard parcels in terms of vine vigour, production potential and potential product quality.

Accurate knowledge of the local weather and climatic characteristics are of major importance for top wine-producing areas. The climate can have positive effects in that, for example, less frost may increase wine production, but also dramatic impacts in that it may also affect the annual timing of the main stages in grapevine development (bud break, flowering, veraison, maturation) or change the relationship between the vines and their parasites.

The hyperspectral view (18 bands and 18 m resolution) provided by the CHRIS instrument on ESA's Proba satellite, launched in October 2001, has the potential to yield additional information on vineyard 'phenology' - the link between grape health and ripening and local climate. This information can help significantly in adjusting viticulture and wine production to the potential climate changes that are believed to be on the way.

A few CHRIS images have already been acquired over the Frascati area for the Bacchus project. Co-registration of the images to a common geometry has proved to work satisfactorily and the new imagery has already been integrated into the Bacchus system.

ERS and Envisat radar imagery allows the ready retrieval of key information about observed vineyards, such as grape quality and surface parameters. The chronology of the cultivation practices in each vineyard can also be derived, which is a basis for gathering precise information about conditions within the land parcels in question.

In a side-study to Bacchus, carried out for a final-year dissertation at the University Tor Vergata, ERS-Envisat synthetic-aperture-radar (SAR) imagery was correlated with very-high-resolution QuickBird optical images to survey the approximately 1800 hectares of the Frascati DOC area. The integration of the SAR data into Bacchus has allowed the retrieval of radar scattering information for individual vineyard parcels. The study has shown that SAR data may also be useful for monitoring the development and ripening of the grapes, with a consistently sharp increase in backscattering detected during ploughing and harrowing in March and April. Strong correlations have also been observed between SAR back-scattering and the quantity of the grapes produced in a number of the parcels monitored.

The Eneide Mission and the VINO Experiment

Given that wine production can be studied from space, Valfredo Zolesi, Chairman of Kayser Italia SpA, began to think about the possibility of studying the behaviour of grapes directly in space. After all, he thought, the vine has been regarded historically as a companion to man, with archaeologists believing that wine-making can be traced all the way back to 5600 BC, and it would therefore be fascinating to think of vines now accompanying men and women on their space exploration travels too.

Such an opportunity was provided by the Soyuz 10S flight to the International Space Station (ISS), which included the Italian

The box that housed the vines for the VINO experiment on the ENEIDE mission

ESA astronaut Roberto Vittori. An experiment known as VINO (Vines in Near Orbits) was therefore rapidly prepared and financed by Kayser Italia, the vineyard associations of Tuscany, and the provincial authorities of Livorno. The Soyuz mission, named ENEIDE, was launched on 15 April 2005 from the Baikonur Cosmodrome and during his eight-day stay on the ISS Roberto Vittori conducted a programme of 21 experiments, including VINO.

VINO was the first attempt to study the growth and development of grape-vine cuttings in space. A few samples of rooted cuttings of Sassicaia, a high-quality grape variety grown at Tenuta San Guido in Bolgheri, in the Livorno area, were grafted and taken up to the Space Station. It was the first time that such a complex plant had been studied in space. Whilst in orbit, the samples were left to grow at ambient temperature inside a sealed container, to prevent possible bacterial contamination. Once back on Earth, the rooted Sassicaia cuttings were analysed to gauge what kinds of stresses they had undergone.

Fluid circulation was one of the most interesting aspects of the analyses, since the rooted cuttings were grafted and the nutrient fluids therefore had to deal with two different types of wood. The vines have since been replanted and in the coming weeks we will see how healthy they are and start to evaluate the effect of their trip into space on their reproduction and growth capabilities. When the plants are ready to bear grapes next season, more analyses will be performed …

The Wine Community Meets Space Technology

During his stay in space, Roberto Vittori participated by audio link in a novel workshop titled 'Space for Wine', organised by ESA/ESRIN in collaboration with the municipality of Frascati, the Strada dei Vini dei Castelli Romani (Wine Itinerary of the Roman Castles) and the Consorzio di Tutela Denominazione Frascati (Consortium for the protection of the Frascati designation of origin). The workshop was open to local, regional and national institutions and those involved in the wine business. The goal was to explain how the application of space technology and associated sciences could help the wine-growing community, and the ESA astronaut gave the participants a brief overview of the VINO experiment and its aims. The workshop presentations are available at:
http://www.esa.int/esaCP/SEMXD7NQS7E_Italy_0.html

The Effect of Global Change on Wine-Growing Regions

As already noted, climate change in the form of global warming can have negative as well as positive effects on vine-growing areas, with the most damaging impacts expected to occur in today's top wine-producing regions. A new WWF study echoes several other recent reports in suggesting that the Earth will warm by 2 degC (3.6 degF) above pre-industrial levels between 2026 and 2060, unless major steps are taken to reduce greenhouse-gas emissions. The need to change cultivars to cope with such climate changes could spell economic disaster for the Chianti or Chardonnay vineyards, but also for the Frascati DOC area.

On the other hand, two of the 'Space for Wine' presentations highlighted potential benefits:

– A. Castagnoli discussed how the influence of global change could represent an opportunity for some wine regions to use presently marginal areas for the production of higher quality wines in the future.
– M. Severini discussed how the vintage ratings of the Frascati DOC wine have increased over the last 20 years, showing how this may be correlated with a decrease in the number of frosts experienced per year in the Frascati region.

Another related issue is the earlier maturation of the grape crops in the years to come. On the basis of local long-term meteorological measurements, it is estimated that in 2050 the Frascati grapes will ripen about three weeks earlier than today. As regards the effect of a temperature increase on the evolution of insects, which may in turn affect quality grape production, the conclusion from modelling is that, fortunately, it will be minor, since the estimated warming is not sufficient to enable these insects to complete the fourth reproduction cycle before grape maturity.

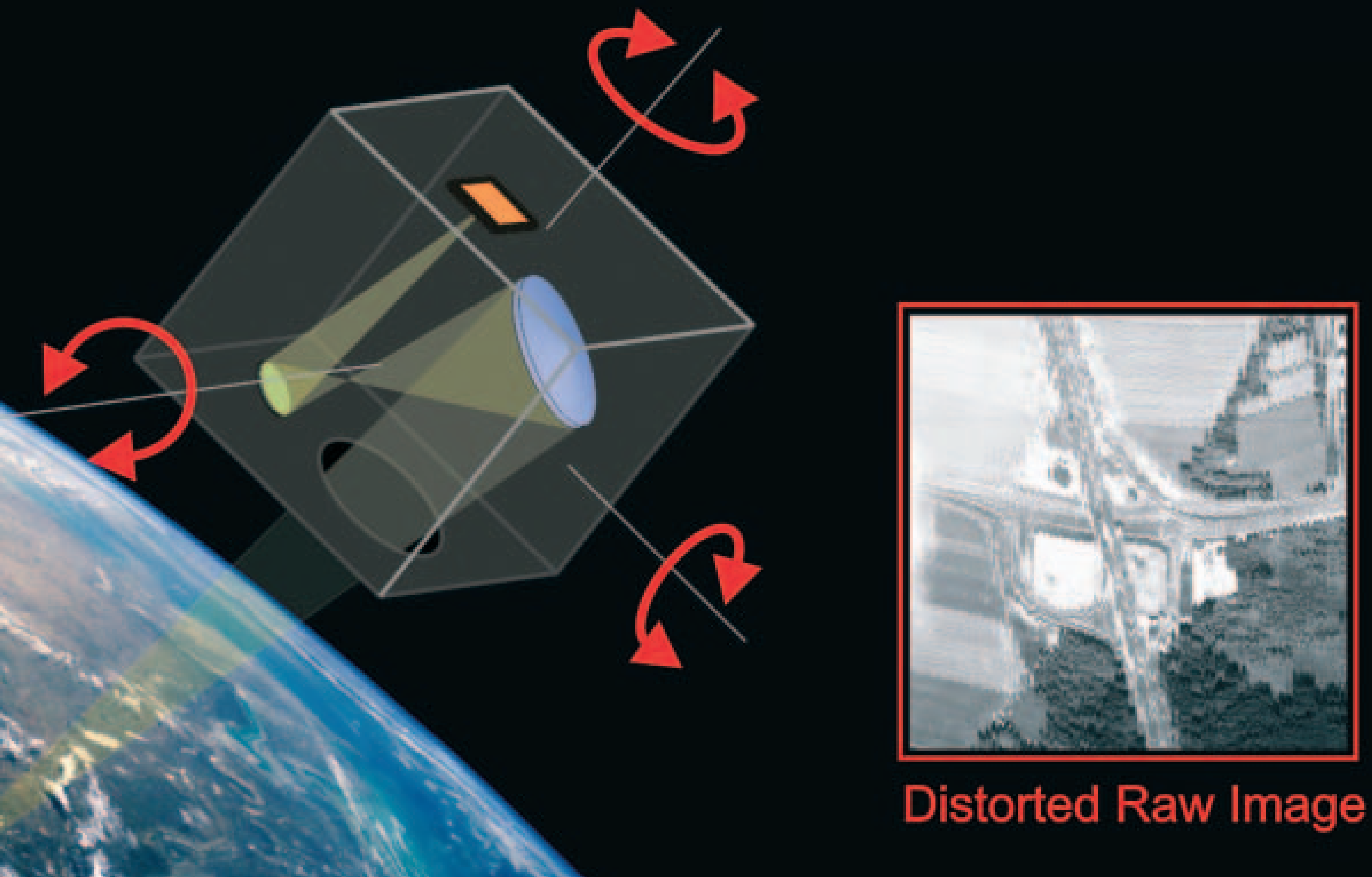
The Future of Vineyard Management

The various vineyard-management applications of Earth Observation data gathered from space which were presented at the 'Space for Wine' workshop clearly demonstrate the potential of space monitoring solutions for this highly specialised agricultural domain, at the local, regional, national and European level. This view was strongly confirmed by the representatives of the various institutions - Ministry of Agriculture, Regione Lazio and the wine sector - who participated in this unique workshop. The wine sector has clearly-identified operational requirements, and can definitely benefit from the recent and future environmental initiatives at European level, such as the GMES (Global Monitoring for Environment and Security) programme.

Acknowledgement

The authors wish to thank all of the participants in the 'Space for Wine' workshop, and especially those whose data have been used in the preparation of this article.

Clever Imaging with SmartScan



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Corrected Image

The cameras commonly used for Earth observation from satellites require high attitude stability during the image acquisition. For some types of cameras (high-resolution 'pushbroom' scanners in particular), instantaneous attitude changes of even less than one arcsecond result in significant image distortion and blurring. Especially problematic are the effects of high-frequency attitude variations originating from micro-shocks and vibrations produced by the momentum and reaction wheels, mechanically activated coolers, and steering and deployment mechanisms on board. The resulting high attitude-stability requirements for Earth-observation satellites are one of the main reasons for their complexity and high cost.

The novel SmartScan imaging concept, based on an opto-electronic system with no moving parts, offers the promise of high-quality imaging with only moderate satellite attitude stability. SmartScan uses real-time recording of the actual image motion in the focal plane of the camera during frame acquisition to correct the distortions in the image. Exceptional real-time performances with subpixel-accuracy image-motion measurement are provided by an innovative high-speed onboard opto-electronic correlation processor. SmartScan will therefore allow pushbroom scanners to be used for hyper-spectral imaging from satellites and other space platforms not primarily intended for imaging missions, such as micro- and nano-satellites with simplified attitude control, low-orbiting communications satellites, and manned space stations.

Imaging with Reduced Platform Attitude Stability

Stability of the camera's focal plane during the scanning motion of a remote-sensing imaging system is essential for good image quality. Satellite attitude perturbations disturb the imaging motion, which results in geometric distortions in the images obtained - with ground sampling every 1 metre, for example, a 0.3 arcsecond deviation corresponds to 1 pixel. Especially sensitive to this kind of disturbance are high-resolution pushbroom scanners which can, in principle, deliver a ground pixel resolution of less than 1 metre from a 700 km altitude orbit. Requirements on the satellite's attitude stability can be relaxed, however, if an appropriate correction to the distorted image can be performed on the ground.

Such a correction requires a real-time record of the image motion occurring in the camera's focal plane during the image's acquisition. With this so-called 'image-motion record', the relative position of every line and pixel can be calculated and a corrected image can easily be restored by standard 2D interpolation. To avoid degradation of the resolution after correction, the image motion needs to be recorded with subpixel accuracy.

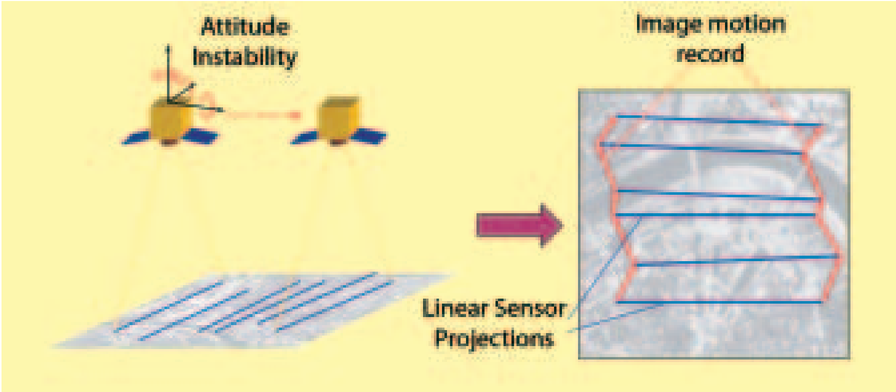
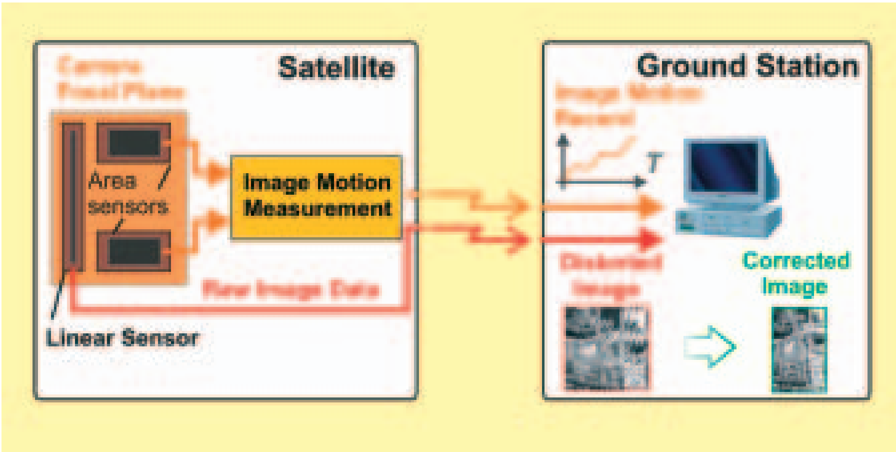


Image distortions due to satellite attitude instability while scanning with a linear image sensor



The basic elements of the SmartScan system

The Concept of Opto-Electronic Image Correction

State of the art solutions for camera image-motion measurement in aerial remote-sensing applications use high-bandwidth gyroscopes. Typically 100 times better accuracy is required, however, for satellite cameras due to their much higher operating altitude. The ideal place to measure the image motion is at the imaging instrument's focal plane, either using the image sensor itself or some auxiliary motion sensors. In the case of a pushbroom camera with one or more linear sensors (multi-spectral), at least two small auxiliary matrix image sensors installed in the focal plane of the camera are recommended. This allows in-situ measurement of all relevant image-motion distortions resulting from camera motion disturbances close to the primary image sensor. The resulting image-motion record data can be downlinked together with the primary linear sensor image data and used for posteriori image correction on the ground.

SmartScan Proof of Concept

The SmartScan concept was first proposed by the Technical University of Dresden in 1999. Between 1999 and 2002, three ESA/ESTEC-funded projects were undertaken to demonstrate the SmartScan system's feasibility and quantify the performance parameters of a spaceborne system. A follow-on system study in 2003/2004 investigated further performance improvements to SmartScan in terms of an opto-mechatronic solution, as well as further applications of the real-time image-motion tracking using optical correlators.

In the initial project (1999 – 2000), the feasibility of the system concept was proven using simulated images and a first hardware model of the optical Fourier processor. The second project (2000 – 2001) resulted in a hardware breadboard model of the SmartScan imaging system, includinges the optical processor and a smart camera, together with all necessary control and image-processing software. The model was tested with printed images on a laboratory satellite-motion simulator based on a five degree-of-freedom industrial robot. In the third project (2001 – 2002), the model was tested under flight conditions onboard a small turboprop aircraft.

The SmartScan system breadboard model includes a smart pushbroom camera and an optical processor. Standard video cameras have been used as matrix image sensors for the compact SmartScan camera due to project budget constraints, but this limits the maximum sampling frequency of the image-motion record to 30 Hz.

Image-Motion Measurement with 2D-Correlation

The spatial dynamics of imaging ‘windows’ can be analysed using feature- or area-based methods to derive image-motion information. Area-based methods have been proved to be much more robust, particularly for image data resulting from unstructured environment. The classical and most widely used approach is ‘area correlation’, which exploits the fundamental property location of the peak in the cross-correlation function of two images is gives directly the displacement vector of the image shift.

In the SmartScan configuration, each auxiliary matrix sensor acquires the sequence of 2D images in parallel with the linear-sensor exposure. The image shift between the moments of exposing neighbouring lines t_1 and t_2 is determined by 2D spatial correlation of the matrix sensor images. The image-motion record is then recalculated from the shift vectors by geometrical transformations.

Image-shift determination using the area-correlation method is extremely noise-resistant, gives sub-pixel accuracy and does not require any specific features in the image. As a drawback, the 2D computer correlation of the images requires a very large number of calculations. Taking into account the limitations of onboard data processing resources and the high sampling frequency required, it is not realistic either to produce the image-motion record by digital data processing onboard the satellite, or to transmit the matrix-sensors images to the ground station for further processing, due to the very high additional volume of data -the matrix sensors produce at least two 2D images for each line of the linear sensor image.

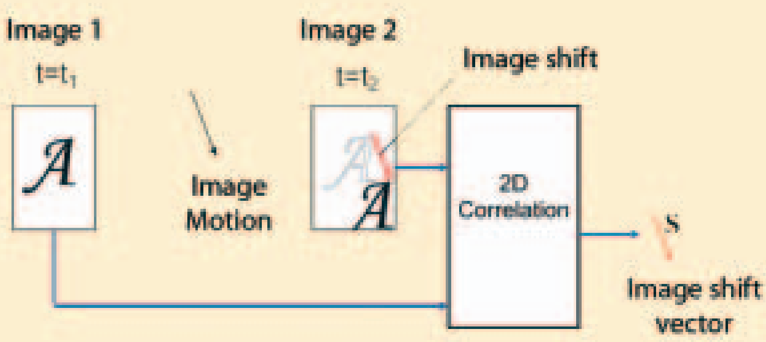


Image-shift determination with spatial 2D correlation

The optical-processor model consists of an optical unit and an electronic module. It processes two standard video signals from the camera’s matrix sensors and produces the real-time image-motion record. The optical unit uses standard video cameras as image sensors for the same reason as the camera. This limits the image processing rate to 30 optical Fourier transforms per second, or 15 correlations per second per optical Fourier processor (one correlation requires two Fourier transforms). To provide the required 60 correlations per second, two identical optical Fourier processors are operated in parallel and the image-processing rate for each of them has been doubled by the simultaneous processing of two image pairs.

The in-flight tests were performed using a small, single-engined aircraft (Cessna Grand Caravan) at the DLR (Deutsches Zentrum für Luft- und Raumfahrt) facilities in Oberpfaffenhofen near Munich. In addition to the complete breadboard model of SmartScan system, a portable PC and special control and image-processing software were installed in the plane. The camera was mounted in a special pod beneath the plane, and the other equipment was mounted in a special rack inside the cabin. An additional real-time data recorder was used to store all in-flight data (raw and operational) for follow-on laboratory evaluation.

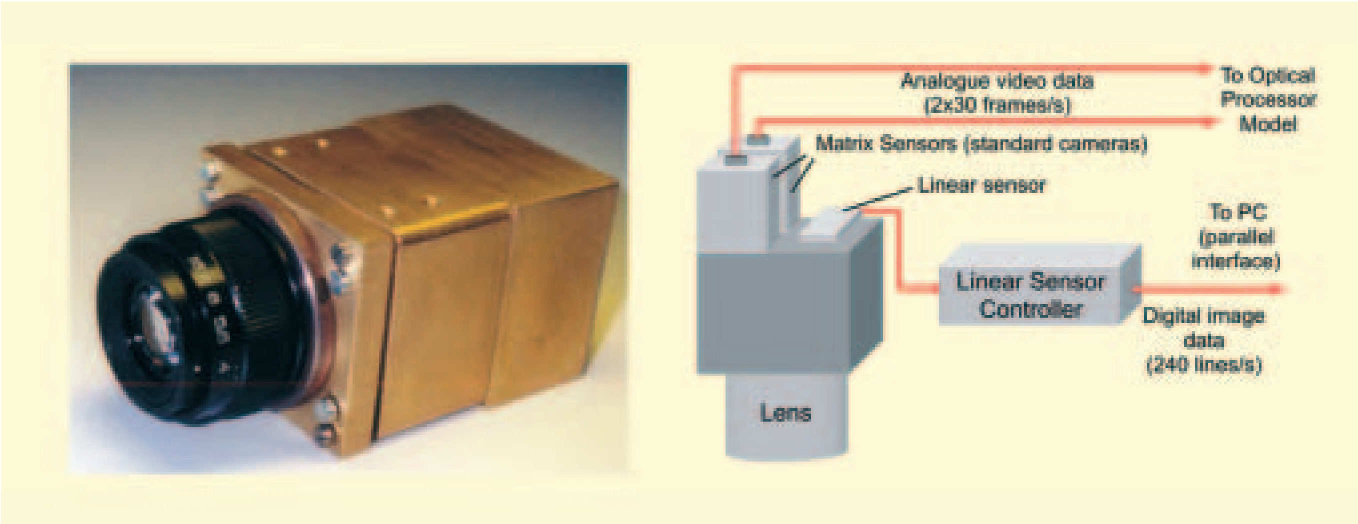
Two test flights were made, each lasting about an hour, during which a total of nine image acquisitions were performed. The altitude of the flights was approximately 2400 metres and the air speed 240 km/h (67 m/s), resulting in a ground pixel resolution of 0.45 m.

SmartScan Flight-Test Results

The linear-sensor images taken during the two test flights were considerably distorted due to variations in the aircraft’s attitude, engine vibration and changes in flight direction and velocity (see accompanying figure). The images were subsequently corrected based of the in-flight image-motion record, which gives the position of every line of the distorted image with respect to the first line. With this information, the coordinates of all the pixels of the distorted image with respect to the first line were calculated and the corrected pixel positions determined using a standard two-dimensional interpolation procedure.

A direct error determination for the image-motion record was not possible for these airborne tests, because no reference aircraft attitude and position data were available with the required accuracy. Instead, an extensive cross-data analysis with the recorded image-motion sequences was performed. The mean-square deviation for all nine imaging sessions was generally within 0.25 pixels, leading to the conclusion that the error in the image-motion record was also within 0.25 pixels.

Some residual distortions in the corrected images are mainly caused by unsuppressed residual vibration components from the camera mounting. A certain degree of smoothing of the

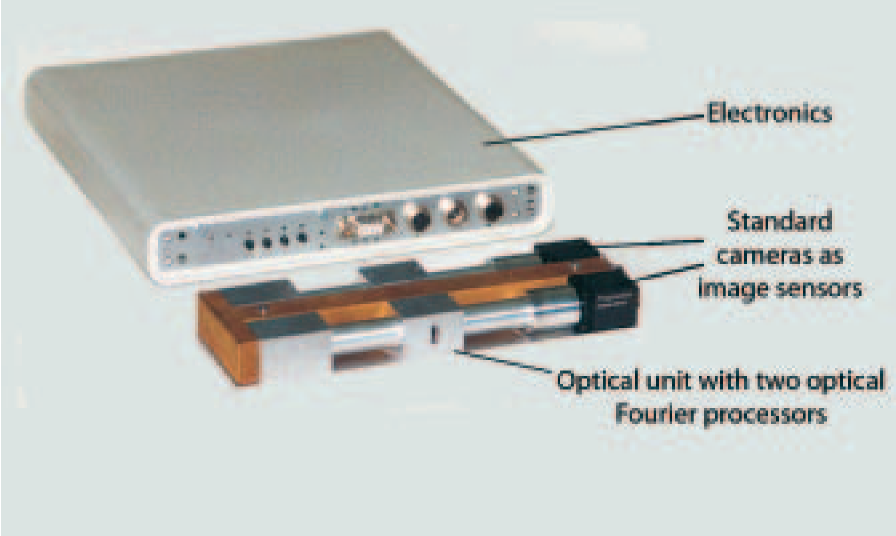


The breadboard model of the SmartScan pushbroom camera

Key performance parameters of the breadboarded SmartScan pushbroom camera

Focal length of the lens	75 mm
Linear sensor	Resolution: 2048 pixels in line
	Line rate: 240 lines per second
Auxiliary matrix sensors	Frame size: 640 x 480 pixels
	Frame rate: 30 frames per second
Angular resolution	187 µrad/pixel
Dimensions	110 x 58 x 50 mm^3
Mass	900 g

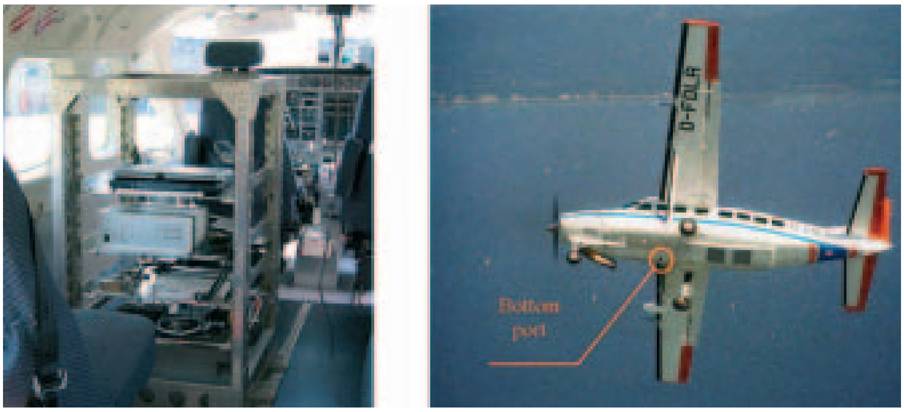
The SmartScan optical correlator breadboard model



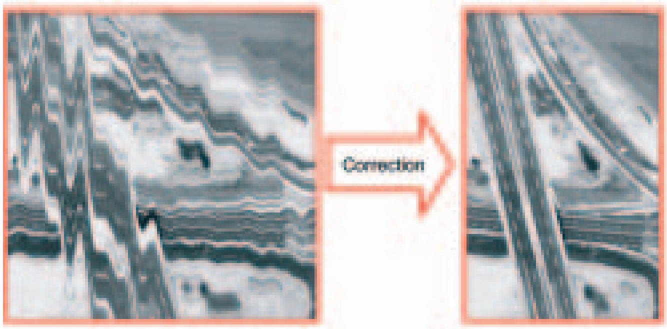
corrected image is caused by the interpolation procedure itself and (in some parts of the image) by a high local image-motion velocity due to high vibration amplitudes. These artifacts are associated with aircraft vibrations and motions, and will therefore not be present in satellite imagery.

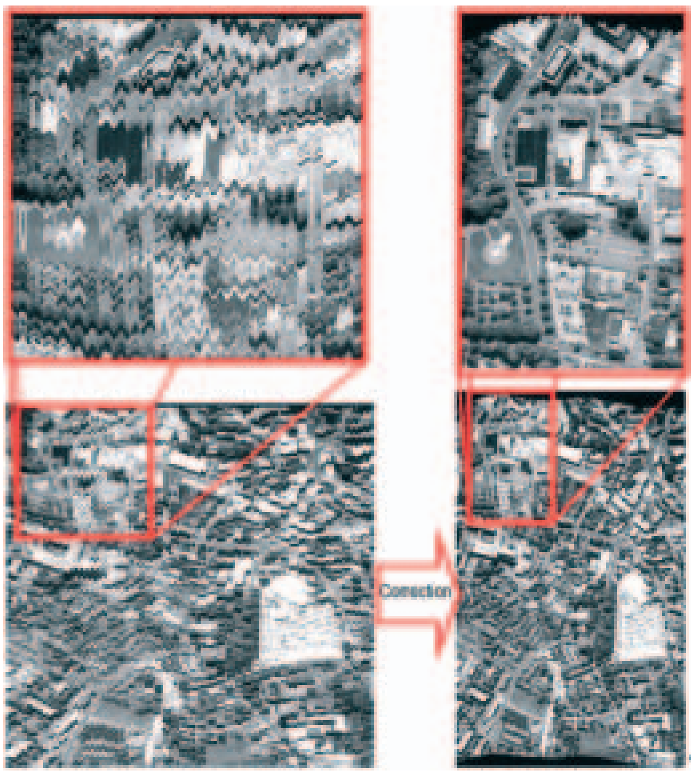
SmartScan's Performance for Spaceborne Remote Sensing

The image-processing rate of the breadboard optical processor model is currently limited to 60 correlations per second, due to the use of standard video cameras as image sensors. It is possible, however, with currently available off-the-shelf opto-electronic components to raise the performance of the optical processor to 32 000 correlations per second. This would allow the direct recording of the image position for every scan line without any interpolation. This is necessary for high-resolution imaging missions, which require extremely high line frequencies – up to 7000 lines per second for a low-Earth-orbiting satellite with 1 metre ground resolution. In principle, SmartScan will then be able to cope with any spacecraft angular velocity and acceleration during scanning, even making high-quality imaging from spinning satellites feasible without any sort of mechanical compensation device.



The SmartScan airborne flight-test configuration





Examples of SmartScan image correction on the basis of image-motion records

A high optical-processor performance also permits the image-motion record to be produced by tracking more than two image fragments, further improving its reliability and accuracy. Accuracy can be also improved by performing the correlation for a pair of images twice, once to determine the shift between the images coarsely and adjust their positions to reduce it before performing the second correlation.

The SmartScan concept using optical-correlator technology therefore offers unique opportunities for affordable spaceborne remote sensing.

Estimated performance of the full-scale SmartScan system

Sampling rate of imaging motion record	16000 samples/s for two-fragment tracking 6400 samples/s for five-fragment tracking 3200 samples/s for five-fragment tracking and double correlations (to improve accuracy)
Errors of the image motion record	$\sigma \leq 0.25$ pixel with single correlation $\sigma \leq 0.1$ pixel with double correlation
Dimensions and mass	Same as for optical processor + harness
Power consumption	within 12 W with full correlation rate within 5 W with 25% correlation rate

ARTES: The Future of Satellite Telecommunications

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Directorate of EU and Industrial Programmes,
ESA, Paris

Throughout its 30-year existence, ESA has played a key role by providing telecommunications infrastructures that have allowed the in-orbit validation, qualification and demonstration of equipment, technology and services. In the past, this has been achieved through the provision of dedicated satellites like OTS, Marecs, Olympus and Artemis, as well as by the implementation of piggy-back payloads on other ESA or commercial satellites. Today, due to the importance of satellite telecommunications, ESA continues to support this sector mainly through its ARTES – Advanced Research in Telecommunications – Programme.

Introduction

Satellite telecommunications has grown to be the most important commercial space application. In terms of business volume, industrial activity and employment generated, 'satcom' is by far the most important segment of the industry. The turnover generated in Europe from the space activity involves some 2 billion Euros in industrial contracts, and nearly 3 billion Euros in transponder leasing fees per year. In addition, the associated ground-segment activities and satellite-driven services generate a volume of business one order of magnitude greater than the space segment.

Telecommunications satellite knowhow, technologies and capabilities represent an important asset for Europe. There are important synergies between security/

Satellite telecommunications systems like AmerHis increase the connectivity

military and civil systems, and the critical technologies overlap. In the USA, the research and development in the security/military field allows the industry to transfer the resulting leadership edge into the civilian market.

Satellite telecommunications is vital to the continuity and viability of the European space industry. Not only the continued health of the communications industry depends on Europe's ability to design and build efficient and competitive telecommunications satellites, but also those of related industries such as launchers, where close to 90% of current business is generated by telecommunications-satellite launches, and of the ground-segment, applications and service providers.

Technical Content

The ARTES Programme was initiated in 1993 to maintain and improve the competitiveness of European and Canadian industry in this important segment of space applications. The activities supported by ESA address the needs of satellite operators, service providers and users in a very competitive market calling for continuous innovation in satellite telecommunications technology.

The main objectives of the Programme are to:

- define, assess and develop systems for advanced fixed, broadcast, multimedia and mobile communications, data relay, search and rescue, navigation, and aeronautical services
- promote the use of satellites, identifying and experimenting with new services to enlarge the field of satellite applications
- undertake experimental and technological missions identified as having good market potential.

Telecommunication Systems, Equipment and Techniques

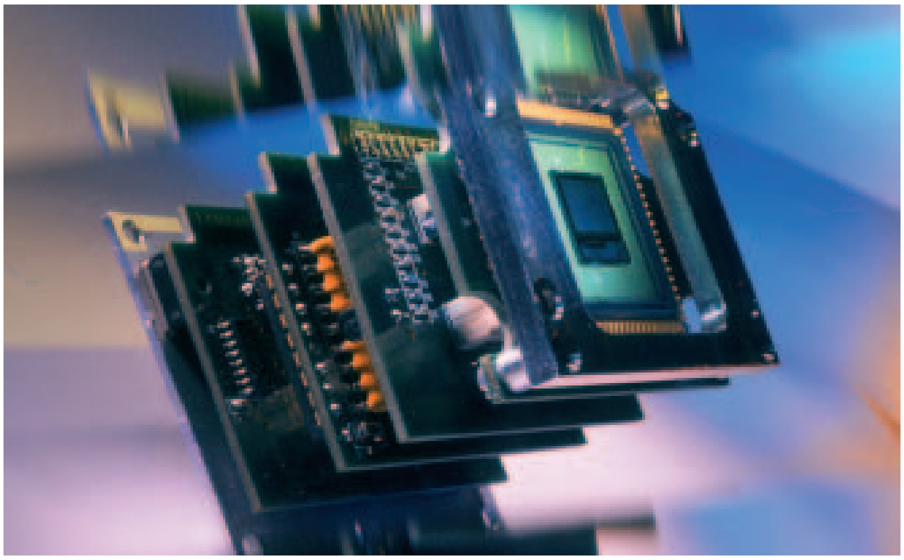
ESA's ARTES activities are focused on helping industry to enhance its competitiveness in the telecommunications market. This involves maintaining a well-structured and well-supported programme to improve the commercial and technological capabilities of the industry through the development of the state-of-the-art equipment, subsystems and systems required for each segment of the satellite telecommunications market.

Multimedia

The interactive broadband line of the multimedia programme element of ARTES is providing an important degree of support to European industry. Significant projects like Domino, Euroskyway and WeB/West are being developed to prepare for the emergence of a new generation of interactive satellite services.

A good example in this respect is the AmerHis system, developed under the Domino project and launched as a piggy-back payload onboard Hispasat's Amazonas satellite in August 2004. AmerHis is the first 'switchboard in space', providing connectivity between user terminals located at any point within the areas served by Amazonas. The innovative feature of AmerHis is the node-switching capability that it provides alongside the conventional satellite-transmission function.

The AmerHis payload: the first 'switchboard in space'



Developing microprocessor technology

Mobile
The mobility line has been dedicated to maintaining European capabilities in the design and implementation of mobile satellite systems. The Broadband Global Area Network system, developed for Inmarsat, will provide services for maritime, aeronautical and land-mobile applications. The AMETHYST project is defining an advanced mobile system concept and new payload architectures for mobile satellite systems. The Satellite Data Link System addresses the air-to-ground communications needs of civil aviation for air-traffic management.

Equipment
The technology and equipment line is providing significant support to European industry for the development of new concepts, as well as for upgrading existing designs to meet current market demands. Equipment prices have fallen over the last few years, emphasising the need for further reductions in recurring costs, implying further technology developments. Equipment items for existing satellite platforms are being updated and improved, and new payloads and ground equipment are being developed. Significant developments under this ARTES programme line include: Li-Ion batteries, a 400 N engine, smaller and cheaper frequency converters for the C-, Ku- and Ka- bands, and solid-state power amplifiers for the next-generation L- and S-band systems.

Applications

These activities relate to the needs of the users, which may be commercial or institutional bodies such as the European Union, government agencies, or other international organizations. The market forces normally address user needs but satellite-based solutions are often beyond the scope and capabilities, or even awareness, of many of the potential beneficiaries of satellite communication systems. There are many applications of satellite communications that can benefit user communities but first require demonstration and promotion. Therefore ESA has reinforced the Applications component of its Telecommunications Programme both to satisfy the needs of society and further develop the demand for satellite communications capacity, equipment and services.

Based on the experience acquired over the past years, three main lines are being followed:
– ‘Exploratory Applications’ and development of the associated technology.
– Deployment of pilot ‘Solution Projects’.
– Setting up of ad-hoc programmatic frameworks to support the operational phase.

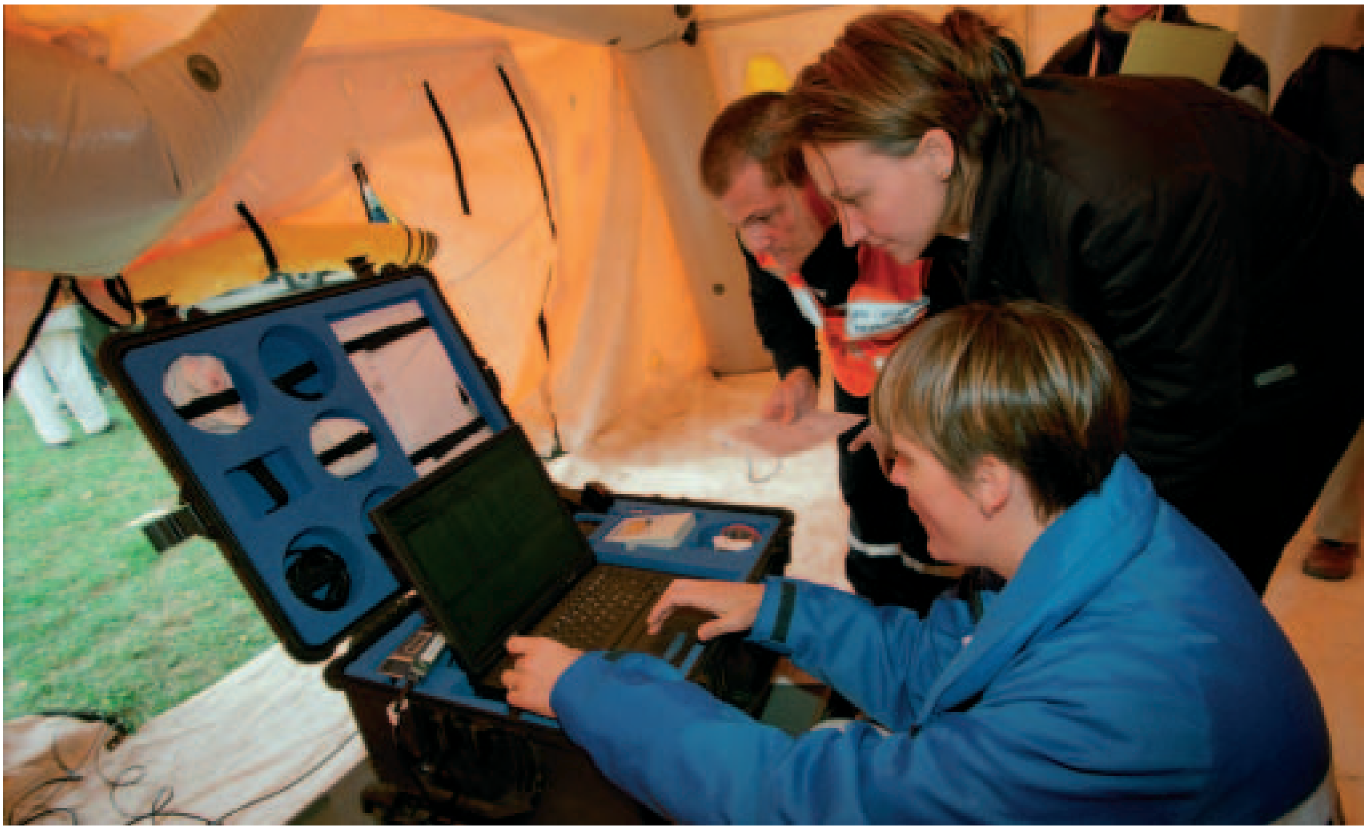
Exploratory applications
The traditional ‘exploratory applications’ activities play a crucial role in the generation and validation of new opportunities, and constitute the innovation engine for new applications in terms of new ideas, new entrants and seed opportunities. Due to the relatively high technical and operational risks involved, these activities are kept within small-scale projects until the concept is fully developed and validated.

Solution projects
This application line is designed to provide the financial and legal framework in which to execute, in partnership with the interested parties, a number of ‘solution projects’. The main goal is to set up fully functional systems, characterised by service requirements derived by the users, which can be easily extended in terms of scale and penetration, paving the way for sustainable services.

Ad-hoc programmatic frameworks
A specific legal framework is required to regulate the participation of user communities in the management and funding of the different phases of the projects, to guarantee compliance with regulations on competition and state aid for the pre-operational services, to verify the possibility of establishing synergies with regional/national/international development programmes with similar or complementary objectives, and to provide a stable and appropriate funding scheme for the operational phase.

User needs
The areas specifically identified for the development of applications are:
– Telemedicine
– Internet on Public Transport
– Broadband Access to Consumer Applications
– Interactive-TV Applications
– Location-Based Applications
– Automotive Applications
– Civil-Protection Applications
– Safety/Security Monitoring and Control
– Support to Development and Capacity Building.

Telemedicine at work



Connecting with the medical centre

Internet access on trains: connecting with the external world

Telemedicine: a test case
Telemedicine is an area that has been the subject of a number of applications activities in the past, and for which a specific, coordinated effort is required to move from the exploratory stage to the operational phase. Telemedicine represents an important opportunity in the field of satellite-based applications: the health sector recognizes that satellites can play a key role in several areas of telemedicine, and the large social benefits and immediate perception of the value of telemedicine by Europe's citizens makes it a priority for ESA in its application development strategy.

A range of opportunities for coordinated actions at European level has been identified and ESA's role in facilitating the development of telemedicine via satellite is well-recognised. Telemedicine via satellite will therefore be used as a test-case for the development of applications within the Agency's telecommunications activities. A strong link with the user community will be established to help ESA in defining priorities and mechanisms for the implementation phase.

Internet on trains: an exploratory application
The provision of Internet access on public transport has been explored. An encouraging demonstration conducted on European trains is paving the way for an envisaged 'solution project' in this domain.

Demonstration Missions

The in-orbit-demonstration component is a very important element of an overall telecommunications programme through its structuring effect on industry and its ability to focus efforts on a well-defined objective, despite all the associated mission considerations and constraints. Two lines of activity are being followed within the ESA Telecommunications Programme, the first dedicated to Alphabus/Alphasat, and the second addressing other opportunities including piggy-back and small-satellite missions.

AlphaBus/AlphaSat
The goal in developing the AlphaBus platform is to ensure the competitiveness of European industry in the global market for telecommunications satellites in the 12 to 18 kW power range, thereby complementing the existing European commercial product lines in the low- and medium-power range. AlphaBus will initially be developed to protoflight-model level, but since the establishment of customer confidence in the AlphaBus product requires the qualification of the platform in orbit, a first operational mission is essential to achieve the overall objectives. The availability of the protoflight model also represents a unique opportunity for the in-orbit demonstration of new technologies, systems and services. Based on past experience with Olympus and Artemis, it is also especially important for such a high-capacity spacecraft to define its operational use from the outset to be consistent with the level of investment available for mission implementation.

The AlphaSat mission, based on the AlphaBus protoflight model, is therefore envisaged to consist of two main components, a technology package benefiting from the flight opportunity offered by the maiden flight of AlphaBus, and a core operational payload.

Piggy-back and small-satellite missions
Industry has expressed a need to establish an in-orbit heritage for newly developed equipment. Today, satellite operators and insurers are extremely cautious about accepting equipment on new satellites that does not have a proven track record. This is even true for well-proven designs that have undergone up-dating to replace obsolete parts. The ideal way to establish the

trustworthiness of newly developed or upgraded equipment is via an in-orbit demonstration immediately after completion of its qualification campaign. Such equipment has therefore been flown as piggy-back payloads on ESA or commercial satellites, for example EMS on Italsat, Skyplex on Eutelsat satellites and, as mentioned earlier, AmerHis on Amazonas.

In the context of testing the market with a new or an existing service in an as yet untried geographical area, established operators are searching for a small satellite with a limited capacity and, most importantly, low cost. New service providers are also looking for small, low-cost satellites to gain entry into the market. Several concepts are under evaluation for missions ranging from the in-orbit servicing of geostationary satellites, to the development of a small platform for the commercial market.

ARTES, a Helpful Programmatic Structure

In tackling its ambitious task of supporting satellite telecommunications R&D in European industry, ESA is devoting particular attention to applications that can benefit user communities requiring demonstration and promotion initiatives. Within this framework, financial help is currently being provided through the following ARTES elements:

– ARTES-1: Prospective/market studies and new configurations fully funded by ESA and contributions based on the GNP of Participating States.
– ARTES-3 : Multimedia and mobile systems initiated by ESA and co-funded by industry.
– ARTES-4 : ESA/industry partnership element, proposed and co-funded by industry.
– ARTES-5: Advanced systems and equipment for the future, proposed on an annual basis and fully funded by ESA.
– ARTES-8: Large-platform product line and mission, co-funded.

Several of these lines can ultimately contribute to a single project, depending on its content. Activities deemed to be ‘near-to-market’ are usually be co-funded, whilst those clearly paving the way for future telecommunications initiatives are fully covered by ESA. r

The European Astronaut Centre

– A Look Back at 15 Years of Astronautical Expertise

*Klaus Damian & Michel Tognini**
European Astronaut Centre, Cologne, Germany

The European Astronaut Centre (EAC) in Cologne is unique among the ESA centres for a number of reasons: it is the home base of the European Astronaut Corps, it is located on the premises of a national agency, it has a very specific organisational setup integrating staff from various origins, it enjoys tremendous public visibility and, last but not least, it is the youngest ESA Centre. The Centre has developed impressively since its official founding 15 years ago, with the signing of the Host Agreement with Germany on 10 May 1990.

Early Plans

The first steps towards the setting up of EAC in Cologne were taken in 1988. At that time, the planned European manned space programme was very ambitious. With the goal of achieving autonomous human access to space for Europe, the programme included as major elements the Columbus Laboratory (Attached Pressurised Module, or APM), the reusable Hermes space plane to be launched by Ariane-5, the Man-Tended Free Flyer (MTFF) as a free-flying laboratory, the European Robotic Arm (ERA), and various experimental payload facilities. The original scenario for the astronaut support and training facilities corresponded to the demanding requirements of that programme.

** As Head of the Astronauts Training Division, Klaus Damian, now retired, contributed to EAC's development from the outset. Michel Togini, former ESA astronaut, is now Head of EAC.*

The decentralised training-facilities concept

Early in 1988, an 'Astronaut Training Concept and Associated Facilities' proposal had already been submitted to the ESA Council. Based on the requirements of the Columbus and Hermes programmes, it foresaw a buildup of the ESA astronaut team to 38 astronauts, including 12 Hermes pilots. This was based on the assumption of a permanent European presence onboard the APM, with a crew exchange taking place every three months, two Hermes missions per year for MTFF servicing, and two Shuttle missions per year.

The concept proposed for the astronaut training foresaw a decentralised set-up at various national facilities (see figure): the Hermes pilot training with flight simulators and the Hermes training aircraft was to take place in Brussels (B), the Hermes systems training in Toulouse (F), the training for the Columbus Laboratory, the Hermes/MTFF composite and payload training in Cologne (D), the European Robotic Arm training at ESTEC (NL), and the underwater training for extravehicular activities in Marseilles (F). There was also to be a medical centre in Denmark and crew quarters in Kourou (Fr. Guiana).

For the overall management of astronaut activities, under ESA's responsibility, and as a home base for the ESA astronauts, the planned European Astronaut Centre, called the 'Astronaut Headquarters' at that time, was to be located in Cologne. There were two decisive factors in opting for this location: Germany's major financial contribution to the European manned space programme, and DLR's relevant experience in supporting ESA's first Spacelab mission and carrying out the national Spacelab-D1 mission.

A major step forward was made in September 1989, when the ESA Director General and the Directors for the Columbus and Hermes Programmes met the Board of DLR and representatives of the German Federal Research and Technology Ministry (BMFT) for a site inspection in Cologne. The purpose of this meeting was to choose a site for the 'Astronaut Headquarters'. Basically two options were being discussed: an independent location outside the DLR premises, or a location adjacent to the planned DLR Crew Training Complex (CTC) on the DLR premises. The latter option was ultimately chosen, but with a separate external access as an ESA facility.

This agreement became the basis for the EAC Host Agreement, which granted the smallest ESA centre full international and extraterritorial status, as well as direct privileged access to Cologne Airport, a special requirement for the pilot astronauts.

Realistic Implementation

As we now know, the European manned space programme developed somewhat more modestly than was originally planned. Hermes and the Man-Tended Free Flyer were scrapped, the scale of the Columbus Laboratory docking module was halved, and the overall schedule was extended. On the other hand, the Automated Transfer Vehicle (ATV) came onto the scene as an additional flight element and the fundamental political changes in Russia opened up many new

Artist's impression of the Hermes Pilot Training Facility in Brussels

Top-level site inspection in Cologne

possibilities for cooperation. It took some time, however, for this development to mature and be transformed into formal programmatic changes.

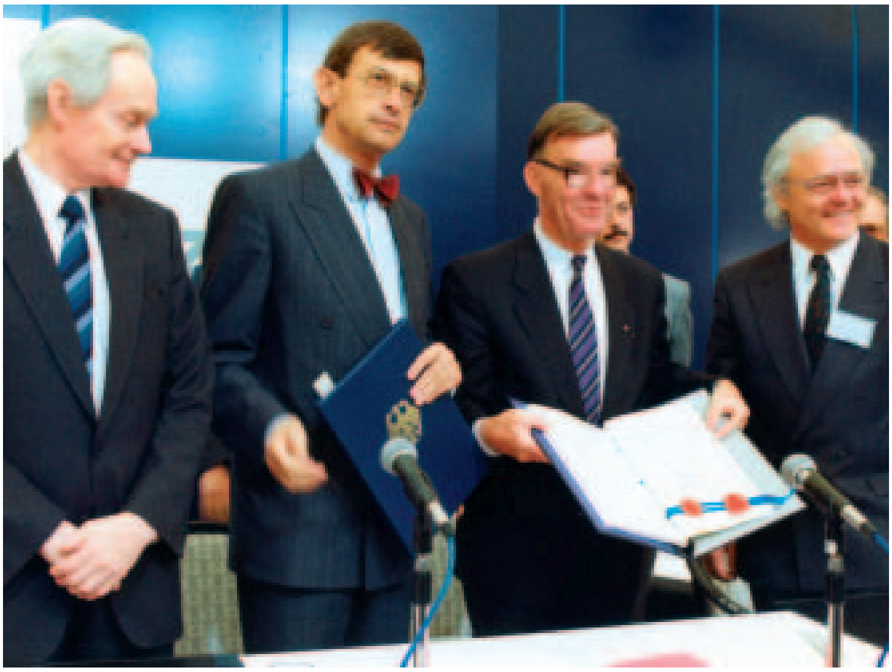
On 1 September 1988, Andres Ripoll, the first Head of EAC, took up duty at ESA Headquarters in Paris. He reported directly to the Director General, but he had to fight for his budget with the Hermes and Columbus Programmes, both of which tried to reduce their contributions below 50%. On 1 October 1989, the first EAC staff member in Cologne, Franco Rossitto, took up duty as Head of the Astronaut Division in temporary offices provided by DLR, followed by the Head of the Astronaut Training Division on 1 November. With a planned long-term complement of about 200 staff, the mid-term recruitment planning aimed at 88 ESA staff and 20 contractors until 1994.

The construction of DLR's CTC building, funded by the German government and the Land Nordrhein-Westfalen on a fifty-fifty basis, was started in 1991. It was ready for use in 1992 and initially accommodated the DLR Training and Crew Operations Departments along with the DLR Astronaut Office. The plans for a separate adjacent EAC building have not been implemented and the EAC staff have been accommodated since 1993 on one floor of the CTC office wing. Initially the EAC and DLR teams worked largely independently on their respective missions, e.g. IML-1 with ESA astronaut Ulf Merbold and MIR 92 with DLR astronaut Klaus-Dietrich Flade. The DLR team also provided support for EAC activities, on the basis of a framework contract.

In parallel, the development and preparation of the first training course at EAC, namely the Basic Training for astronaut candidates, made progress. An overall training concept was worked out and endorsed in 1991 by a Review Board composed of experienced astronauts and training experts from the USA, Russia and Europe under the chairmanship of astronaut Ernst Messerschmid, who later became Head of EAC (1999 – 2004).

Back in 1978, long before the creation of EAC, ESA had recruited three astronauts for the Spacelab-1 mission: Ulf Merbold, Claude Nicollier and Wubbo Ockels. Though assigned to EAC, they remained in their respective environments at DLR, NASA and ESTEC. When the need to recruit more astronauts became obvious, the first astronaut selection process conducted by EAC in 1991/92 was a Europe-wide endeavour, involving national pre-selections with more than 6000 applicants, who were distilled to no more than five candidates per Member State. The final selection of six Astronaut Candidates, endorsed by ESA's Director General, brought the total ESA astronaut team to nine.

Thereafter, it took some time for the decision-makers to come to the conclusion that the maintenanceb of a European and several national astronaut teams in parallel was neither logical nor efficient. This led to the ESA Council's decision in 1998 to integrate the national and European



Signature of the EAC Host Agreement by German Minister Heinz Riesenhuber (left) and ESA Director General Reimar Lüst (right) in Cologne on 10 May 1990

Construction of DLR's CTC building, with its Neutral Buoyancy Facility, in August 1991

astronaut teams. The resulting single European Astronaut Corps grew to 16 members with the following distribution of nationalities: France (4), Germany (4), Italy (3), Belgium (1), Netherlands (1), Sweden (1), Switzerland (1) and Spain (1).

It was then only logical to apply the same integration model to the ESA and DLR support teams working in parallel in the same building. In 1999, therefore, an agreement was reached between ESA and DLR on the integration of DLR experts into the EAC team and the transfer of the former CTC building to ESA for its exclusive use. Under similar agreements, a number of staff from the Italian Space Agency (ASI) and the French Space Agency (CNES) have also been integrated into the EAC team.

The implementation of these organisational changes was, of course, not an easy task, but was successfully accomplished due mainly to the outstanding management skills of the late Erik Slachmuylders while Acting Head of EAC, and his predecessors Heinz Oser and Franco Rossitto.

Today, the Centre has 80 staff drawn from ten different countries, including 13 active astronauts. Of these, 55 work in Cologne, about one third of them being seconded from DLR. A further 20 come from outside firms and organisations: instructors from industry, guest instructors from partner organizations, and other industrial support personnel. The astronauts are periodically assigned, for short- or long-term stays, to training locations such as Houston and Moscow, or to support ESA's programmes at ESTEC or in industry.

Missions Flown

To date, 31 astronauts from ESA and its Member States have taken part in a total of 39 missions. EAC has been actively involved since its establishment in 21 of them: 11 Shuttle missions and 10 Soyuz missions, including 8 to the International Space Station (ISS). The experience accumulated thanks to these missions has proved invaluable in preparing the training and medical support for those European astronauts given ISS assignments. The latest of them, a Soyuz mission known as ENEIDE with Roberto Vittori onboard, was launched on 15 April and successfully completed with a safe landing on 25 April. After the Shuttle's return to flight, the first long-duration mission by an ESA astronaut to the ISS will be that of Thomas Reiter, with Leopold Eyharts as backup.

Training

The work of the Astronaut Training Division has focused on building up the infrastructure and the training facilities for the ISS, preparing the training

The EAC Team

The EAC Training Hall, with the ATV simulator under construction

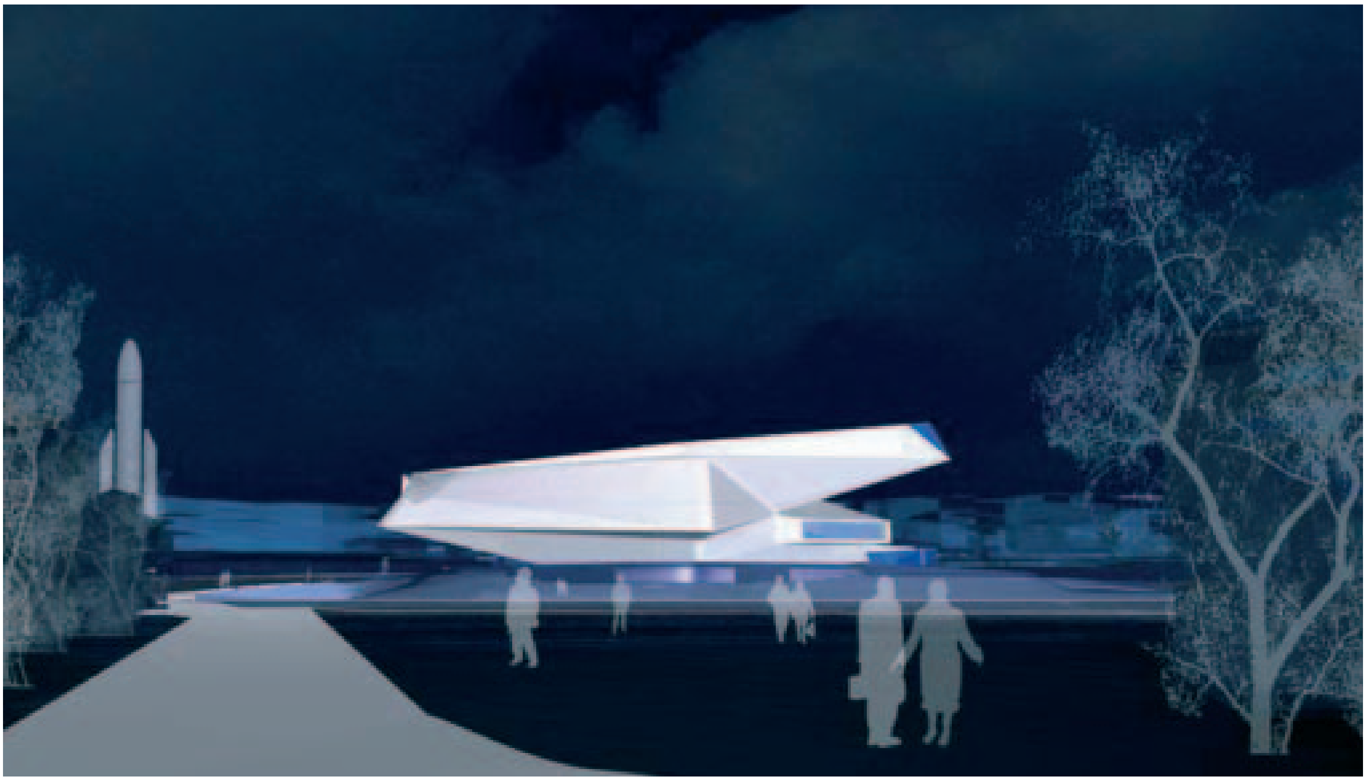
programmes, and qualifying the necessary instructors. Today, the specific training facilities for Columbus, the ATV and the payloads are ready for service and have already been used for a number of training campaigns with international astronaut teams. These facilities notably include a Columbus simulator, a Columbus mock-up, an ATV trainer docked to a mock-up service module, ATV rendezvous and docking simulators, and a simulator for each payload rack. In addition, there are the general training facilities, which include: a huge water-tank for diving exercises in preparation for extra-vehicular activities, class rooms with ultra-modern multimedia equipment, facilities for computer-aided learning and, just as important, a fitness room.

Whilst this equipment was being built, the necessary personnel for operations and training were being qualified. EAC instructors are certified according to multilaterally agreed standards, and instructors from partner organisations are already being trained at the Centre. The exhaustive Training Readiness Reviews have been successfully completed.

In addition to the experiment training conducted at EAC since 1993 for the Soyuz missions and for some of the European payloads for the Shuttle missions, there have been regular training campaigns since 2002 for the astronauts assigned to ISS duties. Training for the ISS elements is the responsibility of the contributing Partner in each case. This results in decentralised training at the ISS Partners' respective training centres: Houston, Star City/ Moscow, Tsukuba, Montreal and Cologne. Because there will not always be an ESA astronaut onboard the Space Station after docking of the Columbus laboratory, the astronauts of the ISS Partner organisations also have to be trained to tend the ESA elements. To date, astronauts from the USA, Russia and Japan have undergone such training at EAC alongside ESA's own astronauts. This close international cooperation not only allows an all-round exchange of experience, but it also makes for tougher competition on quality, presenting a challenge which even the smaller contributing Partners need to be able to meet.

In the wake of the 'Columbia' Shuttle disaster, the transportation of the Columbus laboratory to the Space Station has been delayed. Once Shuttle operations have resumed and things get back to normal, some 70 ISS astronauts and ESA as well as international flight controllers are expected for training at EAC annually.

The ESA Crew Surgeon and biomedical engineers in the EAC Medical Control Room



Artist's impression of 'Cosmos Cologne'

Operational Medicine

EAC's Medical Support Office is responsible for the medical welfare of the astronauts from their selection and their annual check-ups through to all phases of a mission. It is supported in this task by the DLR institute for flight medicine. The care provided also includes fitness training, nutritional advice and psycho-social care, for relatives too. To support the astronauts during each mission, a Medical Control Room is activated at EAC to monitor all medically relevant data.

Medical Support Office staff, certified as ISS Crew Surgeons and/or ISS Flight Controllers, are already supporting ongoing missions as members of the multilateral medical team.

High Public Interest

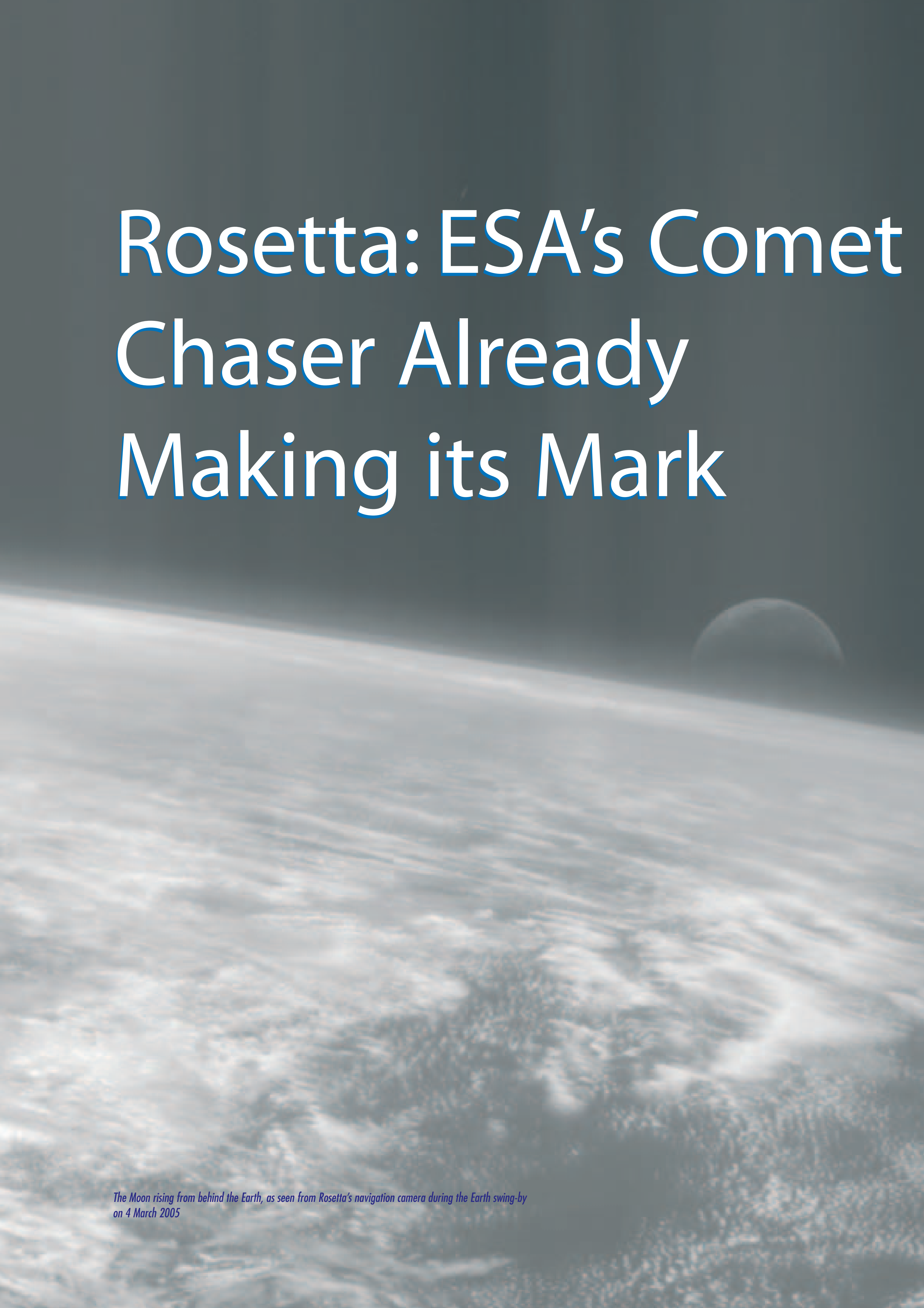
The 'German Space Day' in Cologne, held every two years, is the high-point in terms of numbers of visitors to EAC. People of all ages want to meet the astronauts face to face, marvel at the space technology and be brought up to date regarding the missions taking place. Throughout the year, however, there are an average of forty visitors to EAC every working day. The demand is actually much higher, but the limited availability of personnel and constraints due to non-interference with day-to-day operations limit the numbers that can be received. This has prompted ESA and DLR to jointly consider setting up a dedicated visitor centre, provisionally known as 'Cosmos Cologne', with thought currently being given to how a self-funding, privately-run operation could convey the fascination of space to even more people.

Preparing for the Future

This look back over the last 15 years of EAC is, of course, a good occasion to look into the future also.

EAC is well prepared to support the upcoming long-duration mission to the International Space Station in 2006, and looking forward to the challenging missions related to the European elements of the International Space Station, which include the Columbus launch and activation and the first launch of the ATV 'Jules Verne'. ESA certainly needs a new astronaut-selection process in the near future in order to support the subsequent routine operations. But also looking beyond the next 15 years, EAC will continue to actively participate in the European Space Exploration Programme, which foresees missions to the Moon and Mars by European astronauts by 2030. It is not a dream to imagine ESA astronauts chosen in the next selection process and trained at EAC participating in these missions.

Rosetta: ESA's Comet Chaser Already Making its Mark



The Moon rising from behind the Earth, as seen from Rosetta's navigation camera during the Earth swing-by on 4 March 2005

Paolo Ferri
ESA Directorate of Operations and Infrastructure, ESOC, Darmstadt, Germany

Gerhard Schwehm
ESA Directorate of Scientific Programmes, ESTEC, Noordwijk, the Netherlands

Rosetta, the first planetary cornerstone mission of the ESA Scientific Programme, was launched on 2 March 2004 on its ten-year journey to rendezvous with comet 67P/Churyumov-Gerasimenko. In summer 2014, Rosetta will go into orbit around the comet's nucleus, approaching to within a few kilometres of its surface, will deliver a Lander called 'Philae' onto its surface to make in-situ measurements, and will then accompany the comet on its onward journey for about 1.5 years.

The launch and the first 1.5 years of flight operations have been very smooth, with the spacecraft, its payload and the ground segment performing almost perfectly, with no major anomalies and all parameters well within specification. All planned mission activities have gone according to schedule, and additional 'bonus' scientific and technological operations were even added to the intense operations schedule of the first few months.

Among the mission events to date were the observations of the NASA Deep Impact probe's encounter in July 2005 with comet 9P/Tempel-1, from a 'privileged' position in space just 80 million kilometres away.

The Mission's Launch and Early Orbit Phases

Rosetta's 21-day launch window opened on 26 February 2004, but the first launch attempt had to interrupted 20 minutes before lift-off due to unfavourable wind conditions. It was re-scheduled for the following day, but in the early morning of 27 February a routine inspection of the Ariane-5 launcher on the pad indicated that one or more thermal-insulation tiles had become detached from the cryogenic first stage. This caused cancellation of the second launch attempt and a delay of three days, as the launcher had to be rolled back into the Final Assembly Building for repair. Finally, on the morning of 2 March the launch took place with a perfect injection of the spacecraft into escape orbit, after about 2 hours of ascent and coasting on top of the Ariane-5 launcher.

The early-orbit phase went very smoothly and was completed in less than 72 hours, after which the spacecraft-commissioning activities were started.

Earth seen with Rosetta's Navigation Camera after the swing-by, from a distance of about 250 000 km

Satellite Commissioning

After about a week of subsystem checkout, the commissioning of the payload instruments began. The instruments were activated one at a time, with experts from the instrument teams present at ESOC during daily ground contact with the spacecraft via the New Norcia ground station in Western Australia, usually lasting 10 hours per day. All of the planned payload-checkout and satellite-commissioning activities could be carried out within the foreseen three-month time slot, and were therefore successfully completed by the beginning of June 2004. The correct functioning of all 10 instruments onboard the Rosetta spacecraft and the Philae lander was thoroughly checked during this phase.

Thanks to the smooth execution of the planned operations and the healthy status of the spacecraft, it was possible to include in this phase previously unplanned operations, such as complex spacecraft pointing profiles to allow boresight direction calibration of the remote-sensing instruments on board. On two occasions between the end of April and the beginning of May 2004, some scientific observations of comet C/2002 T7(Linear) were even carried out.

On 25 May, still during the commissioning phase, the spacecraft reached its closest point to the Sun (for this first revolution) of 0.886 Astronomical Units (AU), about 132 million km. The first deep-space manoeuvre of the mission was also carried out during the commissioning phase. The spacecraft's thrusters were fired for more than 3.5 hours, to achieve a total acceleration of about 153 m/s. The precision of this manoeuvre was outstanding, with an error of just 5 mm/s.

After the completion of the commissioning phase, the spacecraft was configured for a quiet cruise phase. Some further subsystem tests were also carried out, mainly to check the spacecraft's thermal behaviour when in the vicinity of the Sun. Other tests analysed the pointing accuracy of the star-trackers in specific parts of the sky.

The most critical post-launch activity took place in July 2004, with the uplinking and activation of the new version of the onboard avionics software. The uplinking activities began on 15 July and, after a week of software patching and verification, the 'reboot' command that would activate the new software was given on 22 July.

From the beginning of June, the number of ground station acquisitions was gradually reduced from one pass per day to two passes per week around mid-July. After the new software had been validated in the second half of July, the spacecraft was configured into 'quiet-cruise' mode and only one ground-station pass per week was used for monitoring purposes.

The second and last payload-commissioning phase was carried out in the period September-October 2004, involving the parallel activation of all onboard instruments and special pointing activities mainly to calibrate the remote-sensing payload.

After two small trajectory correction manoeuvres in November 2004 and February 2005, preparations for the first Earth swing-by began. The spacecraft's closest approach to Earth occurred on 4 March 2005, during the so-called 'swing-by' or 'gravitational-assist' manoeuvre, with Rosetta passing within 1954 km of the Earth's surface. Several payload instruments were activated to perform calibration activities during this phase, taking advantage of the known environment of the Earth and using the Earth-Moon system as targets for the remote-sensing instruments. The Moon also provided a unique opportunity to validate the spacecraft mode that will be used for attitude control during the two asteroid fly-by phases in 2008 and 2010. In this special mode, Rosetta makes use of the Navigation Camera to steer the spacecraft in such a way that the payload platform is kept pointed towards the asteroid – represented in the test by the Moon. The test was very successful, demonstrating exceptional performance in terms of attitude stability, which will be key in providing optimal support to the scientific operations during the real asteroid fly-bys.

After completing the Earth swing-by, Rosetta began its second orbit around the Sun, traveling this time towards planet Mars, which it will reach for a second swing-by manoeuvre in February 2007. At the beginning of this cruise phase, a long in-flight commissioning of the Near-Sun Hibernation Mode took place. This is a special mode that will enable the spacecraft to operate with minimum hardware for periods of up to six months during the long quiet-cruise phases, with ground contact typically taking place just once per month.

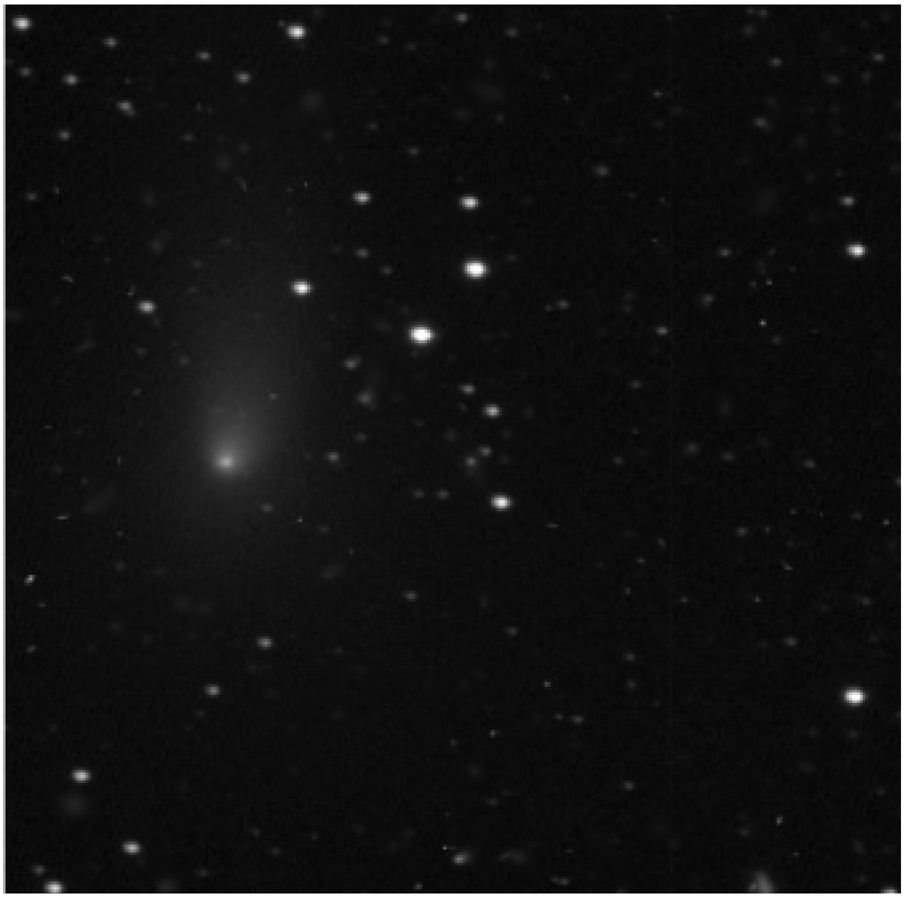


Image of comet Tempel-1 taken by Rosetta's OSIRIS NAC camera in June, prior to the Deep Impact event (copyright 2005 ESA-MPS for OSIRIS Team)

The 'Deep Impact' Observations

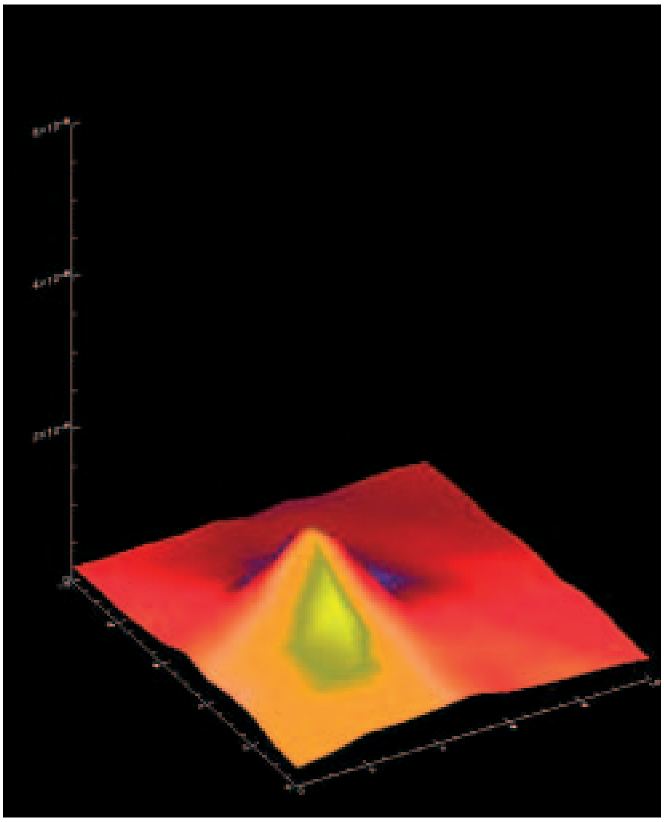
Before entering its Near-Sun Hibernation Mode, in July 2005 Rosetta was commanded to point at comet Tempel-1 during the final phase of NASA's Deep Impact mission, and its four remote-sensing scientific instruments were used to observe the probe's impact with the comet's nucleus on 4 July.

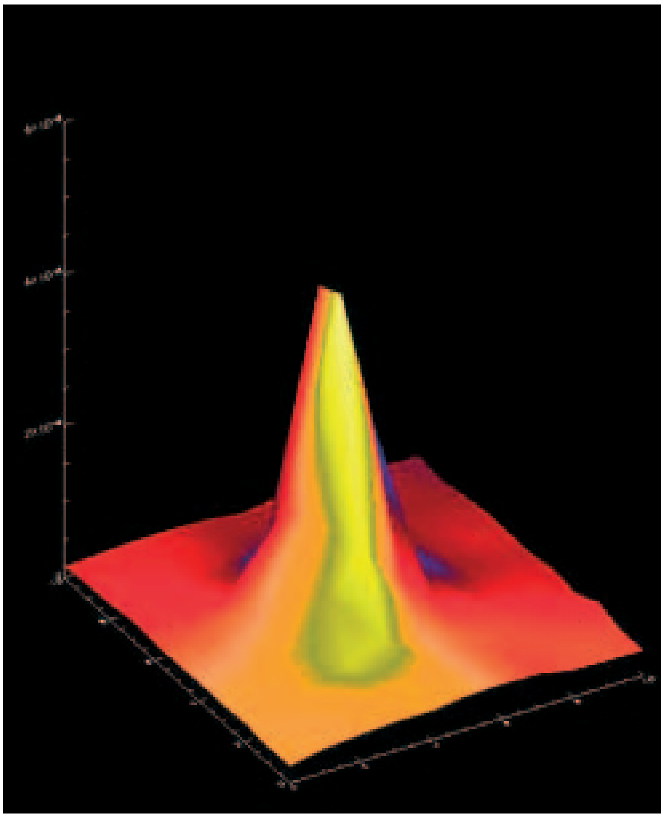
At NASA's request, Rosetta's entry into quiet-cruise mode had been postponed by a few months to allow the spacecraft to pointed to observe the collision. Rosetta happened to be in a good observing position, about 80 million kilometres from the comet, with an ideal angle of 90 degrees between the Sun and comet directions, which provided optimum observing conditions. Rosetta was first pointed towards comet Tempel-1 on 29 June and kept tracking it until 14 July. Its four remote-sensing instruments - Miro, Alice, Virtis and Osiris - were operated in parallel using a complex pointing profile to gather the best scientific data with all four instruments.

The NASA impactor hit the nucleus of Tempel-1 as planned at 05:52 UTC on 4 July. The impactor itself and the Deep Impact spacecraft delivered impressive pictures of the impact on the comet's surface. At the same time, observatories around the world pointed their instruments at the comet to register the electromagnetic radiation generated at infrared, visible and ultraviolet wavelengths. Thanks to the absence of an atmosphere between its instruments and the comet, Rosetta could monitor the event continuously as, unlike the ground-based telescopes, it did not have to cope with the Earth's rotation.

The scale of the impact was such that the event was clearly recorded by Rosetta's instruments. Observations continued for about 10 days after the impact, providing a wealth of data on its evolution and effects. Over the 18 days of its observations, Rosetta delivered an average of 60 Mbytes of data per day. The scientific processing and evaluation of these data is still in progress, but it has already provided indications of the high quality of the data and of the possible results.

The Deep Impact observations have demonstrated that the Rosetta spacecraft is not only extremely reliable, but also versatile and flexible. The planning of this complex activity took only a few weeks from the formal decision to go ahead, to





Brightness of comet Tempel-1 in OSIRIS camera images before and after being struck by the Deep Impact probe (copyright 2004 ESA-MPS for the OSIRIS Team)

the actual execution of the operation. The scientific instruments worked flawlessly and the pointing performance of the spacecraft was accurate beyond all specifications. In addition to constituting a unique and precious scientific opportunity, the Deep Impact observations are also an example of how efficient and cost-effective inter-agency cooperation between ESA and NASA can be.

The Long Journey Continues

Following the Deep Impact scientific operations, Rosetta has finally been put into Passive-Cruise mode, in which it will remain for most of the rest of its journey to Mars. After the Mars fly-by, there will be two more Earth fly-bys, two fly-bys of asteroids Steins (2008) and Lutetia (2010), a long deep-space cruise phase in which the spacecraft will be spun-up and almost completely deactivated, and finally the rendezvous with comet Churyumov-Gerasimenko in 2014, with the soft landing by Philae on the nucleus's surface planned for the last quarter of the year. The end of the mission is currently foreseen for December 2015, a few months after the comet's perihelion passage.

Conclusion

The Rosetta mission has begun in the best possible way: a perfect orbital injection and excellent performance from both the spacecraft platform and the instrument payload. This is a very good but also necessary beginning for such a long-duration mission, during which hardware-obsolescence problems can sometimes occur.

The level of ground activity has been higher than expected, due to the intense use of the spacecraft for in-flight testing, the additional unforeseen scientific observations, and instrument characterisation efforts. Intense use of the spacecraft engineering model at ESOC has contributed greatly to the success of mission operations so far, but at the expense of a high workload for the flight-control personnel. This has, however, been rewarded in the end by the smooth operation and excellent performance of the spacecraft.

During Rosetta's first 18 months in space, therefore, both the Mission Operations Team and the Science Operations Team have certainly demonstrated that they are more than able to operate both the spacecraft and the payload in the most efficient way possible and thereby optimise the scientific harvest from this exciting mission.

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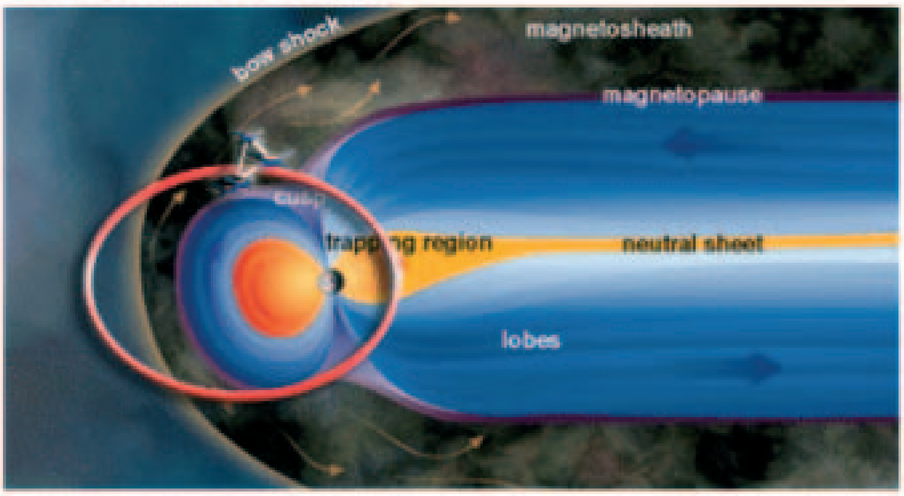

First direct measurements of the ring current

A publication in the Annales Geophysicae reports on the first ever measurement of the current density in the ring current region using data from the Cluster spacecraft.

MORE

VENUS EXPRESS JOURNAL

- Flight Acceptance Review Completed

JOURNAL ARCHIVE

UPCOMING EVENTS

07-Aug-2005 **IAU Symposium No. 229 - Asteroids, Comets, Meteors** (6 day event) MORE

09-Aug-2005 **Neutron Stars at the Crossroads of Fundamental Physics** (5 day event) MORE

15-Aug-2005 **IAU Symposium No. 230: Populations of High Energy Sources in Galaxies** (5 day event) MORE

MONTHLY CALENDAR

SATELLITES IN ORBIT

- Rosetta Status Report
- SMART-1 Status Report
- Mars Express Status Report
- Double Star Status Report
- INTEGRAL Status Report
- Cluster Status Report
- XMM-Newton Status Report
- Cassini-Huygens Status Report
- SOHO Status Report
- Hubble Status Report
- Ulysses Status Report
- ISO Status Report

STATUS REPORTS ARCHIVE

LATEST PUBLICATIONS

- Flares observed with XMM-Newton and the VLA
- INTEGRAL spectroscopy of the accreting millisecond pulsar XTE J1807-294 in outburst
- Tentative detection of warm intervening gas towards PKS 0548-322 with XMM-Newton
- The Magnetic Structure of Filament Barbs
- Transition Region Downflows in the Impulsive Phase of Solar Flares
- Discovery of an aurora on Mars
- Possible Cryovolcano on Titan
- Simulations of the formation, evolution and clustering of galaxies and quasars
- A fresh start for Europe's space agency
- Mars Exploration: Going Underground

PUBLICATIONS ARCHIVE

Information Services to the Scientific Community on the Web

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ESTEC, Noordwijk, The Netherlands

***F**or the past several years, the ESA Science Directorate has run a number of websites serving the wider scientific community. Much of the information, from the moment a scientific mission is conceived to the moment it ceases operations, needs to be processed and made available to a wide range of audiences. These audiences range from Member State delegates, at decision-making level, to the scientists working on various aspects of the mission, to the engineers who actually build the spacecraft, to operations and to the curious public, both informed and uninformed, all of whom are interested in following developments at ESA.*

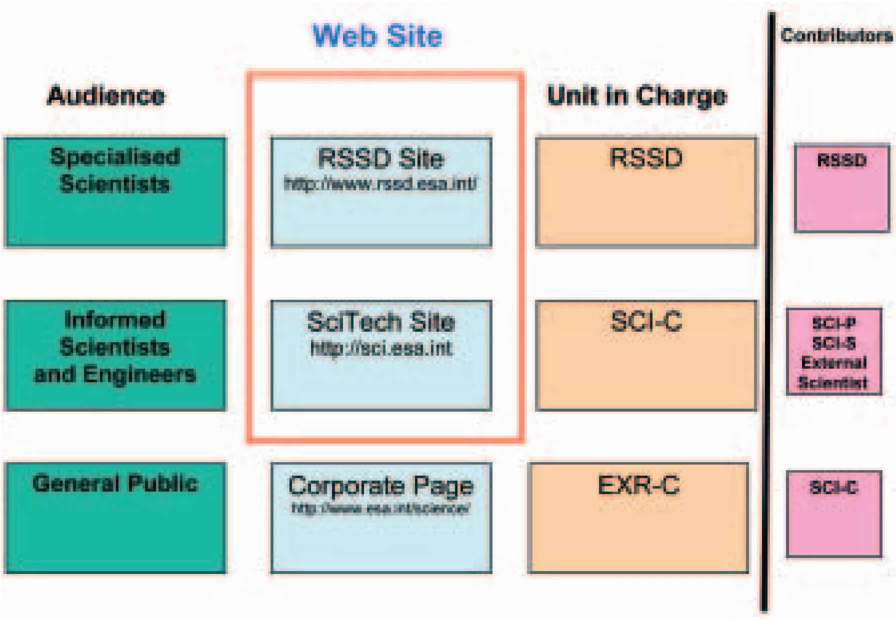
This article sheds some light on what lies behind the scenes and attempts to explain the individual steps taken to ensure that the information put into the public domain is both correct and up-to-date.

The Science Web

There are basically three tiers to the Science Web services: the Research Website, which caters for the needs and requirements of every scientific project run by ESA; the Science and Technology Website, which provides in-depth information about each spacecraft and status reports on the operational satellites; and the area devoted to the general public, which is integrated into the ESA Portal. This the first two websites, which are a part of the services that the Science Programme provides directly to the scientific community.

The Research Science Portal

The teams who provide the payloads for the ESA science missions interface with their Project Scientists in the Research and Scientific Support Department (RSSD). Since these days most of the payload teams, and the user communities, are very



The three web services offered by the ESA Science Directorate are targeted at three different audiences. The specialised communities involved in a particular mission would access the RSSD site. The informed scientists and engineers interested in following developments in all areas of science would access the Sci-Tech website. The general public interested in event-driven news, such as a launch or a major mission milestone, would access the ESA Corporate Webpage

large, RSSD provides facilities to help coordinate these activities within the RSSD Science Portal.

The Research Science Portal is not a 'typical' website in that it is not 'outward-facing', nor is it a purely local intranet. It is a hybrid, a 'wide-area intranet' or 'e-community', i.e. an HTTP-based framework to facilitate communication within and between the various science teams and mission groups inside ESA and in the wider community. Based on web technology, and making use of the www paradigm, the portal also provides a structured environment for communication, data dissemination, and application delivery. In addition to the centrally located RSSD Portal, the operational and post-operational data archives located at ESAC in Villafranca (E) also fall within the remit of RSSD Web Services and, in line with the policy of centralising the resources, the RSSD Portal provides an interface to these sites.

In addition to supporting the mission communities, the RSSD Portal serves as the interface to the many administrative functions associated with the Science Directorate, providing access to the research Publications Management System, the Electronic Preprint Delivery Service, the RSSD Document Management System, LDAP Directory Services and Mailing List generators, the Journal Library Catalogue, Technical Mail Services and infrastructure/software support to RSSD staff and contractors. Capturing the complete record of a project's scientific publications throughout all of its phases has never before been attempted and offers a challenge for the service – this task normally being restricted to the exploitation phase once in orbit.

The Science and Technology Portal

SciTech took over from the original Science Website, which was originally conceived purely as a communication tool, in June 2003. The main objective is to combine a wide range of information gathered from all parts of the Directorate and to present this via one consistent portal. The site attempts to generate a consistent web structure and hierarchy for each mission. The site navigation is built up from technical descriptions of the spacecraft and instruments, 3D models, orbital simulations, science and services such as technical publications, an event calendar and conferences. In addition, news, images and the latest status reports from operational satellites are provided.

The SciTech website can be considered as a general scientific journal, one that can be read by the educated public, scientists and engineers wishing to be kept up-to-date on all of the scientific missions ESA is flying. Technological aspects of instruments and experiments are regularly updated and combine all engineering and scientific issues at a single reference point on the web.

Phases of a Science Programme

There are several phases through which a scientific mission passes, before it is built and flown, and the SciTech site structure is

built around these phases. The most relevant ones, from the web-services point of view, are:

Assessment Phase
The Science Mission Team, composed of scientific and technical staff from the Directorate, set down their ideas and concepts during this phase. A model payload is drawn up. The feasibility of the mission is first investigated, culminating in the submission of a Study Report to the ESA Science Programme Committee (SPC).

These Study Reports are made available through the SciTech website to the broader community and the first designs for each spacecraft are published. As we progress into the definition phase, the number of articles and reports increases. Some of these directly involve academic institutions and industry, which provide input via their respective ESA interfaces.

Definition Phase
After assessment has been successfully completed and approved, a set of study projects are initiated to establish the cost and schedule of the mission in greater detail. During this 'Definition Phase', the spacecraft really begins to take shape and detailed descriptions of all its parts and payloads are assembled. The SPC is kept up to date regarding the status of each study, and finally estimates of the total cost and schedule are presented to it. Now we are ready to actually start building the spacecraft.

Implementation
At this point, a project team and a science team are put together. A Project Manager and Project Scientist are nominated to follow up each and every technical aspect of the mission during its implementation and construction. This phase ends at the moment ESA receives the spacecraft from the industrial consortium and accepts it as being ready for launch.

The project teams are now ready to build the spacecraft, and all of its specifications have been laid down. This enables the SciTech website to provide instrument-description pages, as well as detailing the final scientific objectives. Reports come in on a regular basis, as each milestone is reached during the building phase. These can range, for instance, from the delivery of the Herschel mirror, which is ready to be integrated, all the way to the systems tests carried out on Venus Express. This is usually also one of the longest and busiest periods for the project's technical and scientific teams.

During the pre-operational phases of a mission, the RSSD Portal serves as a focal point for the mission's numerous team members, who may be spread geographically throughout the world (e.g. Gaia and Planck both have several hundred contributors spread across four continents). In addition to the communication aspect, the RSSD Portal also provides a unified interface to the many applications that are being implemented for use during both the developmental and operational phases of the missions (e.g. Planck-IDIS, Gaia Parameter Database, document sharing, calendars, etc). These generic tools help the Project Scientist to better coordinate the payload providers' activities and obviate the need for each payload team to maintain redundant information sets.

Launch
The launch phase begins with the placing of the spacecraft into orbit and culminates at the end of the commissioning period. It is the period during which acceptance tests are carried out on all instruments and all operational units, and all necessary checks prior to the spacecraft beginning its operations are made.

The SciTech Website has now covered a number of launch campaigns and time-critical mission events, such as the recent descent and landing of the Huygens probe. The concept of a regular mission status report was first fully applied for the SMART-1 mission, with the full support of both the project and scientific teams. In the first months, status reports were received and published on a weekly basis. At the time of writing, 39 reports have been produced since launch, providing a comprehensive archive on the evolution of the mission from launch, through the coast phase, lunar capture and now into lunar science operations. Over time, the frequency of reporting has been reduced from weekly to monthly, to reflect the changing operational status of the spacecraft.

Input for the reports can come from a variety of sources: the Project Scientist, the Project Manager, or ESOC. The editorial team combines these various inputs to produce an acceptable online report, ensuring consistent style and content.

The same approach is being applied for the Rosetta mission, launched on 2 March 2004 and now ready to be handed over from the project team to the science team. At the time of writing, there are 43 status reports on line.

Operations

As a mission evolves, there is a change in the reporting of results on SciTech. Since all of the data sources have some proprietary period, the reporting of results can depend on information being released through Principal Investigators (PIs). Over time, however, more and more data enters the public domain and the number of results appearing in external publications with various degrees of specialisation, such as Nature or New Scientist, also increases. The website serves as a link to those results appearing in a wide variety of publications.

Science payloads fall into two basic categories – the facility type, used mostly for observatory missions, which are common in the astrophysics domain, and the PI-experiment type, which are dominant in solar-heliospheric and planetary missions. At present, most astrophysics missions are operated by the Science Operations Centre located at ESAC (E). Wherever possible, the community support also becomes the responsibility of the ESAC teams, inheriting the knowledge built up prior to launch and available in the RSSD Science Portal. ESAC is also responsible for user support during operations and the development of the final data archives.

The solar-heliospheric and planetary communities have traditionally been more independent, but the increased complexity of payloads and today's geographical spread have necessitated, in the case of programmes such as Rosetta, BepiColombo and Huygens, a similar support approach by RSSD. Furthermore, the ongoing development of the Cluster Active Archive and the SOHO Archive is bringing the solar-system missions more in line with the paradigm traditional in the astrophysics community. In the future, interplanetary missions are also foreseen to be operated from ESAC.

The need for strong information security in the pre-operational period is a key design parameter, and the portal was designed to support the requirement for tight, mission-based (even team-based), multi-level, information security. It therefore provides a configurable, flexible, authentication system incorporating single-password access to all registered applications.

Post Operations

The RSSD Web presence continues into the operational and post-operational phases, hosting the data archives and data-delivery systems for all operational science missions. These systems provide web-based access for the wider scientific community to both the raw and interpreted mission data. Most of these systems are (or will soon be) physically located at ESAC, but for the purposes of consolidation, the RSSD portal hosts interfaces to each of these archives. The Planetary Archive (which combines the data from all planetary missions, and currently covers Rosetta and Mars Express) is tightly linked to the RSSD Portal, which hosts a copy of the Planetary Science Archive access application and support pages. The Portal also provides direct links to the XMM-Newton, Integral and ISO data archives.

Other Services

In addition, SciTech is a vital point of information for other aspects of the Directorate. The Cosmic Vision plan is updated regularly, giving a glimpse behind the scenes on the evolution of the programme and the foreseen schedule of launches. The Director's Desk offers a view into issues concerning the advisory body of the programme. Services specifically set up for the various Working Groups, the Space Science Advisory Committee (SSAC) and the Science Programme Committee (SPC) can be found there, together with a full list of the members of each committee.

The Agency's PRODEX Programme provides funding for the industrial development of scientific instruments or experiments proposed by institutes or universities in the Participating States and selected by ESA for one of its programmes in the various fields of space research. Each contributing country is represented in the PRODEX section of the website, with details about the annual funding and the research activities being undertaken. This service allows the whole PRODEX community to view the areas of current research and identify potential areas for future collaboration.

The Payloads and Advanced Concepts web section reports on ongoing technological feasibility studies. These crucial studies define the future missions and pave the way towards a better understanding of where the technological limitations are, prior to carrying out a mission. The Advanced Concepts group can be considered visionary in that it defines the framework for building a mission. In addition, the group is tasked to develop instrument technologies and run the laboratories for the Directorate.

Another recent addition has been the Science Educational Support web section. This particular service is targeted at teachers and educators wishing to make use of material that is otherwise hard to find on other sites. It is an integral part of the website in that much of the information found there is gathered from other sources that have been specifically targeting the scientific community. We do not distinguish between a schoolteacher and scientific or engineering staff, since all of these professions possess a common understanding of the underlying science in the domains of astrophysics, solar-system sciences and fundamental physics.

The Science Educational Support web pages offer, for instance, exemplar material that fits most European curricula. This material can be used for lectures, lessons, hands-on activities, role-playing, homework content, examinations, etc. In addition, there is also supporting and illustrative material for teacher tools used in the classroom. Material already available on the SciTech site has simply been repackaged to make it more accessible and comprehensible to teachers, whilst partnerships have been established with other stakeholders who redistribute the content through various other channels. The advantage of this approach is that it ensures that students at all levels come into contact with ESA's science missions and their results, and gain a better understanding of how space technology works.

Finally……..

The vast amount of information that we are currently accumulating will lead to a better understanding of space science and its benefits at all professional levels. The exchange of information among professionals and keeping abreast of ongoing activities yields an increase in the quality of work on the task at hand. Our approach and conviction is to continue to be a major reference point on the Internet for all aspects of ESA's Science Directorate missions and to continue to serve the professional world at all levels.

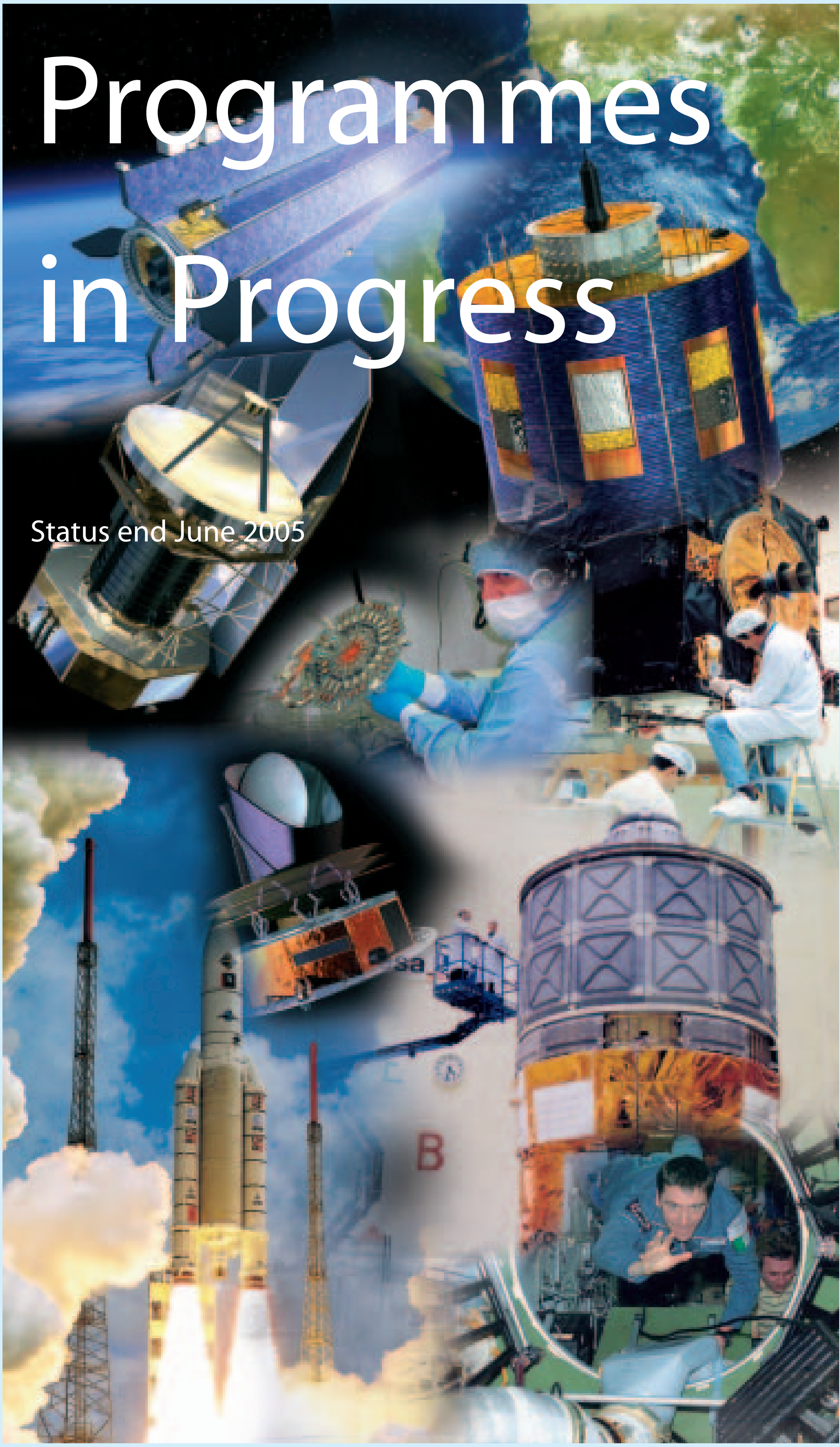
Acknowledgements

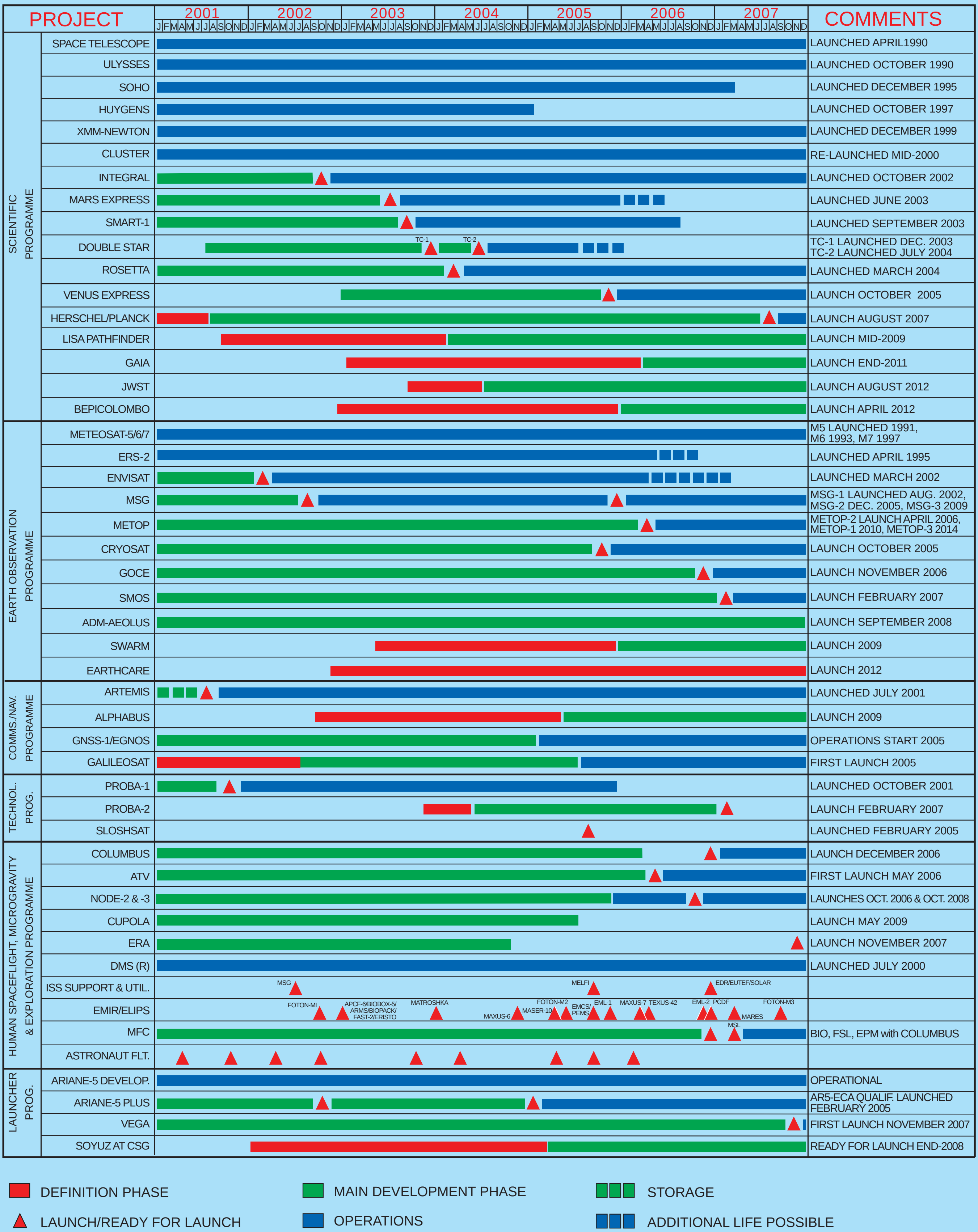
We would like to thank the Staff of the Science Directorate for their dedication and commitment to keeping the content of the Directorate's web pages up-to-date, and their continued motivation and active support in recognising this tool as a crucial means of informing and educating the public.

The SciTech Website can be found at: http://sci.esa.int/
The RSSD Website can be found at: http://www.rssd.esa.int/
The General Public Science Webpage can be found at: http://www.esa.int/science

Programmes in Progress

Status end June 2005




PROJECT
2001
2002
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2006
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COMMENTS
SCIENTIFIC PROGRAMME
SPACE TELESCOPE
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ULYSSES
LAUNCHED OCTOBER 1990
SOHO
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HUYGENS
LAUNCHED OCTOBER 1997
XMM-NEWTON
LAUNCHED DECEMBER 1999
CLUSTER
RE-LAUNCHED MID-2000
INTEGRAL
LAUNCHED OCTOBER 2002
MARS EXPRESS
LAUNCHED JUNE 2003
SMART-1
LAUNCHED SEPTEMBER 2003
DOUBLE STAR
TC-1
TC-2
TC-1 LAUNCHED DEC. 2003
TC-2 LAUNCHED JULY 2004
ROSETTA
LAUNCHED MARCH 2004
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LAUNCH OCTOBER 2005
HERSCHEL/PLANCK
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LISA PATHFINDER
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M6 1993, M7 1997
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MSG-2 DEC. 2005, MSG-3 2009
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METOP-1 2010, METOP-3 2014
CRYOSAT
LAUNCH OCTOBER 2005
GOCE
LAUNCH NOVEMBER 2006
SMOS
LAUNCH FEBRUARY 2007
ADM-AEOLUS
LAUNCH SEPTEMBER 2008
SWARM
LAUNCH 2009
EARTHCARE
LAUNCH 2012
COMMS./NAV. PROGRAMME
ARTEMIS
LAUNCHED JULY 2001
ALPHABUS
LAUNCH 2009
GNSS-1/EGNOS
OPERATIONS START 2005
GALILEOSAT
FIRST LAUNCH 2005
TECHNOL. PROG.
PROBA-1
LAUNCHED OCTOBER 2001
PROBA-2
LAUNCH FEBRUARY 2007
SLOSHSAT
LAUNCHED FEBRUARY 2005
HUMAN SPACEFLIGHT, MICROGRAVITY & EXPLORATION PROGRAMME
COLUMBUS
LAUNCH DECEMBER 2006
ATV
FIRST LAUNCH MAY 2006
NODE-2 & -3
LAUNCHES OCT. 2006 & OCT. 2008
CUPOLA
LAUNCH MAY 2009
ERA
LAUNCH NOVEMBER 2007
DMS (R)
LAUNCHED JULY 2000
ISS SUPPORT & UTIL.
MSG
MELFI
EDR/EUTEF/SOLAR
EMIR/ELIPS
FOTON-M1
APCF-6/BIOBOX-5/
ARMS/BIOPACK/
FAST-2/ERISTO
MATROSHKA
MAXUS-6
FOTON-M2
MASER-10
EMCS/
PEMS
EML-1
MAXUS-7
TEXUS-42
EML-2
PCDF
MARES
FOTON-M3
MFC
MSL
BIO, FSL, EPM with COLUMBUS
ASTRONAUT FLT.
LAUNCHER PROG.
ARIANE-5 DEVELOP.
OPERATIONAL
ARIANE-5 PLUS
AR5-ECA QUALIF. LAUNCHED
FEBRUARY 2005
VEGA
FIRST LAUNCH NOVEMBER 2007
SOYUZ AT CSG
READY FOR LAUNCH END-2008
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
STORAGE
LAUNCH/READY FOR LAUNCH
OPERATIONS
ADDITIONAL LIFE POSSIBLE

ISO

Version 8 of the ISO Data Archive was released in May. This major new version incorporates functionalities that have been developed for other science archives at ESAC, via the use of a Common User Interface, and will simplify its maintenance after the end of the ISO project in 2006. Version 9, in beta testing for release in July, will deploy for each observation the best products set obtained from the legacy automatic pipeline software or from advanced interactive processing. Six new ISOPHOT catalogues have been prepared for ingestion as Highly Processed Data Products in this new version.

ISO continues to have a significant presence in the refereed literature, with 1256 papers published to date, embracing all areas of astronomy. Recent highlights include the identification of calcite in the LWS spectra of protostars. In 2002, calcite had been reported close to dying stars from analysis of ISO-SWS spectra. Carbonates had been used as tracers for planets with liquid water, but the latest observational evidence points to another mechanism for their formation.

Ulysses

Ulysses continues to provide new and important insights into the Sun's behaviour. A good example is the recent analysis of the energetics of so-called 'giant solar flares' using data from the solar X-ray and gamma-ray burst detector onboard the spacecraft. In the course of each 11-year solar-activity cycle, the Sun produces one or two solar flares that are so energetic that they saturate many of the Earth-orbiting monitors, making it difficult to calculate their total energy output. Being farther away from the Sun than the Earth, the X-ray detector onboard Ulysses does not suffer from this problem. A case in point is the flare that occurred on 4 November 2003, during the 'Halloween' series of solar events. The data from the Ulysses instrument, which was able to measure the flare output without saturation, indicate that the total energy produced in this flare exceeded the energy available in the local magnetic field (generally assumed to be the source of the flaring activity). The implication is that resources from a large part of the solar atmosphere outside the active region itself are needed to power such giant flares. These results appeared in a recent issue of Astronomy & Astrophysics.

SOHO

While SOHO continues to experience 'keyhole periods' every three months, a new onboard patch for intermittent recording of only selected packets has allowed continuous data to be secured for all three helioseismology instruments (MDI, GOLF, and VIRGO) during the two recent keyholes, and LASCO and CELIAS telemetry for a large fraction of the time.

On 17 June a nominal station-keeping, momentum-management and roll manoeuvre was performed. It required just 0.034 kg of hydrazine, and 118 kg still remains available. The solar-array degradation after 114 months of flight is 17.04%, corresponding to 1.79% per year.

With the discovery of the 900th SOHO comet, the SOHO team launched a contest to predict the date and time of perihelion passage of SOHO's 1000th comet. Nearly 10 000 people participated in the contest, which was closed on 13 May after the discovery of SOHO comet 960. As of 30 June, the count is at 989, which means that nearly 50% of all comets discovered since Halley first computed a cometary orbit have been discovered by SOHO.

Using SUMER and MDI data, a Chinese-German team of scientists has located the source region of the fast solar wind between 5000 and 20 000 km above the solar surface in magnetic funnels. According to their new model, the solar-wind plasma is supplied by closed magnetic loops that are swept by convection to funnel regions, where they undergo reconnection with existing open field lines. Plasma previously confined within closed loops is thereby released and accelerated to form the solar wind. The results appeared in the 22 April issue of Science magazine.

Cassini/Huygens

The first phase of the engineering analysis of the Probe system's performance is nearing completion. It appears that its performance was excellent. The entry-detection and parachute-deployment sequence was nominal. It has been verified that all back-up systems for Probe wake-up and entry detection (G-switches) functioned correctly, but were not exercised as the nominal sequence, based on entry accelerometer measurements, was executed flawlessly. The performance of the three parachutes has been assessed in detail. The drag on both the pilot and the main chutes appears to have been slightly lower than anticipated. The descent time under the third parachute was somewhat longer than predicted, but still within the expected envelope.

Analysis of the Earth-based Huygens radio observations is progressing well. The received signal was still strong when the most westerly telescope in the network lost contact with the Probe, indicating that Huygens was still transmitting nominally more than 3 hours after landing. Analysis of the engineering telemetry indicates that the Probe may have transmitted for another 10-20 minutes before the batteries were depleted.

The European-led VLBI experiment, which involved 17 telescopes (including GBT and Parkes), recorded an excellent and unique data set. It has proved to be much richer than ever anticipated and contains information about the Probe's dynamics during its parachute descent. The atmospheric profile (density, temperature) was reconstructed from entry accelerometry measurements below 1500 km. Above 1000 km, the atmosphere density was higher than expected. Huygens landed in what could be a river or a lake bed covered with a thick layer of organic matter. Water-ice pebbles of all sizes up to 10-15 cm are clearly visible in the camera images obtained from the surface. Titan appears to have atmospheric, geological and geophysical processes equivalent to those acting on Earth, but with different ingredients. Titan's surface near the landing site has been shaped by methane flows, which carved drainage channels and rivers. No direct evidence of the presence of liquid has been found by Huygens, but the evaporation of methane from the surface after the landing indicates that the surface was wet.

All six Huygens experiment teams have completed a preliminary analysis of their data sets. A coordinated set of publications was submitted to the scientific journal Nature in May and are expected to appear in print this autumn.

XMM-Newton

XMM-Newton operations continue to run smoothly, with the spacecraft having made its 1000th revolution around the Earth on 25 May. On 14 June, the ground-segment (MOC and SOC) switchover from the SCOS-1b to the SCOS-2000 control system was made, and the transition went very smoothly. All XMM-Newton mission operations are now being executed with the new Mission Control System, with the SCOS-1b system still being run in the background for a few months for safety reasons.

Processing problems at the Survey Science Centre (SSC), responsible for pipeline processing of all XMM-Newton data, have led to delays in data delivery to observers. As a temporary solution, these observers were informed about alternative ways of accessing and processing their proprietary data. Data processing at the SSC has since resumed and all delays have been recovered.

The completion status of the observing programme is as follows:
AO-3 programme: 98.8 %
AO-4 programme: 21.9%.

Currently, over 4113 observation sequences have been executed and the data for 3877 of these have been shipped. XMM-Newton was heavily involved in the observations covering the NASA 'Deep Impact' with comet Tempel 1.

An XMM-Newton Users' Group meeting was held at the European Space Astronomy Centre (ESAC) on 19-20 May. They were happy with the overall project status, with the progress in calibration, especially at the low-energy range of the EPIC cameras, and with the progress of the slew survey.

The XMM-Newton Science Archive (XSA) has some 1460 registered users. The monthly usage can be characterised by the numbers for May, when more than 3500 separate data sets were downloaded by 92 external users, exceeding normal usage by a factor of five. A total of 844 papers based completely or partly on XMM-Newton observations had been published in the refereed literature by 13 June.

The next call for observing proposals, AO-5, will be released on 5 September.

ESAC is leading the organisation of an astrophysical conference entitled 'The X-ray Universe 2005' to be held from 26 to 30 September in the Euroforum, El Escorial, Madrid. By the time of the registration deadline, no fewer than 294 scientists had registered and 340 abstracts for oral presentations/posters had been submitted.

Cluster

The Cluster Active Archive is progressing well, with the Implementation Review taking place at the end of June. The Review Board acknowledged the good progress but identified a few instruments that would be late in delivering data – the goal is to open the archive in the autumn.

Two papers based on Cluster multipoint observations, published on 28 April in Geophysical Research Letters, address the fundamental question of how the solar wind enters the Earth's magnetotail when the interplanetary magnetic field is oriented strongly northwards. With this orientation, the Earth's magnetic field should act as a barrier against solar-wind material. Different solar-wind transfer processes have been identified in the past, but which is the dominant one? Quantitative comparison of global simulations of the Earth's magnetospheric dynamics with Cluster data, recorded during the Halloween 2003 solar storms period, shows that magnetic reconnection in the cusp regions can be the dominant process.

Double Star

The two spacecraft and their instruments are operating well. The ESA Science Programme Committee (SPC) approved an extension of the Double Star mission until the end of 2006, with the main objectives for the extension being to: (i) perform the first simultaneous measurements at small, medium and large scales in the magnetotail (respectively, at 1000, 10 000 and 60 000 km) with Double Star and Cluster, (ii) acquire sequences of 'stereo' ring-current ENA images with Double Star TC-2 and the NASA IMAGE spacecraft, and (iii) measure the size of large-scale structures at the magnetopause/cusp.

The European Payload Operation System (EPOS) coordinates the operations for the seven European instruments on TC-1 and TC-2 and is running smoothly. ESOC acquires data for on average about 3.3 hours per day with the Vilspa-2 antenna and then sends that data to China using a dedicated communication line.

Two recent observations with Double Star and Cluster suggest that the process of magnetic reconnection, responsible for the transfer of solar energy to the magnetosphere, is taking place in front of the magnetosphere around the equatorial plane (also called the sub-solar point). Firstly, Double Star and Cluster simultaneously observed plasma jets at the sub-solar point and near the cusp, suggesting that reconnection is initiated near the sub-solar point and then propagates to the cusp. Secondly, electromagnetic waves were observed with an intensity 10 times higher at the sub-solar magnetopause than near the cusp. This could explain why reconnection takes place preferentially at the sub-solar point, since these waves seem to be associated with the reconnection process. These results are very important for the preparation of future missions that will focus on gaining a better understanding of the reconnection process.

Integral

The ground-based HESS observatory has discovered a new population of very-high-energy gamma-ray sources located along the Galactic Plane. These sources emit gamma-rays with energies around a million times higher than even those that Integral observes. Such extreme-energy gamma-rays are of great interest because they provide insights into the mysterious sites where galactic cosmic-rays are thought to be accelerated. Eight new high-energy sources have been detected by HESS and most of them seem to be associated with supernova remnants, pulsar-wind-powered nebulae, or known gamma-ray sources. However, two of the new sources have no known radio or X-ray counterparts, suggesting the exciting possibility of a new class of 'dark particle' accelerators.

However, recent Integral observations have revealed a new soft gamma-ray source, IGR J18135-1751, which is spatially coincident with one of the two unidentified HESS sources. Furthermore, the Integral astronomers found that the X-ray satellite ASCA may have observed the same source at lower energies whilst scanning along the Galactic Plane. These results imply that HESS J1813-178 is probably either a pulsar wind nebula embedded in its supernova remnant, or a pulsar in a high-mass binary system. Either model excludes the exciting hypothesis that HESS J1813-178 belongs to a new class of very-high-energy objects, or that it is a cosmic 'dark particle' accelerator.

Mars Express

The second quarter of 2005 has been marked by activities relating to the deployment of the MARSIS radar antenna and recovery from some anomalies encountered therewith. Soon after the deployment of the first boom of the MARSIS antenna it was realised that the boom was not entirely straight. Proper thermal conditioning of the suspect hinge quickly released the boom into its straight and locked position. Following these events, analyses were started to evaluate what had happened and to develop deployment scenarios for the second boom that would include intrinsic heating phases, thereby avoiding this problem.

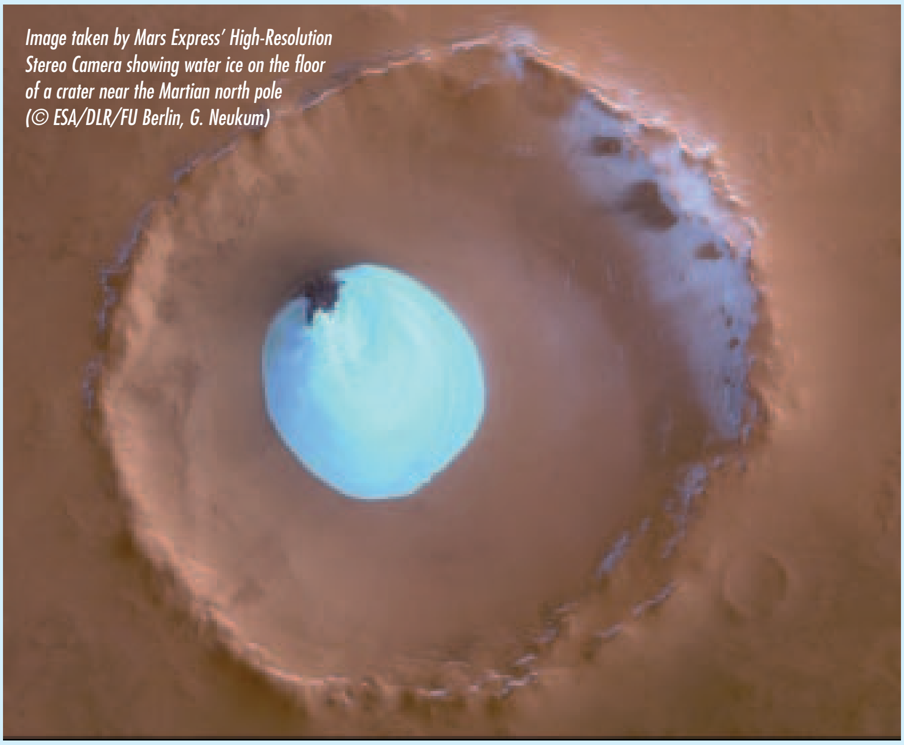


Image taken by Mars Express' High-Resolution Stereo Camera showing water ice on the floor of a crater near the Martian north pole (© ESA/DLR/FU Berlin, G. Neukum)

Using such a scenario, the second boom was successfully deployed on 14 June. Soon afterwards, the third, much smaller, monopole boom was released and MARSIS commissioning activities were started.

Some science operations necessary to maintain coverage of seasonal effects were executed between the first and second boom deployments. A new version of the Solid State Mass Memory (SSMM) software (fixing multiple known SSMM anomalies) was also successfully uploaded during this same period.

Science operations resumed in earnest in early July when illumination conditions still favoured the nightside observations, but rapidly also allowed dayside observations. Exciting papers on Mars Express results, for example on the discovery of an aurora at Mars, appear regularly in the refereed literature.

Rosetta

The Rosetta spacecraft is on its quiet cruise to Mars, which it will reach in February 2006. The Near-Sun Hibernation Mode (NHSM) was tested in flight during April and May and eventually commissioned. In June, preparations for the campaign of scientific observations of the NASA Deep Impact spacecraft's encounter with comet Tempel 1 were carried out at the Rosetta Science Operations Centre (RSOC), in close cooperation with the OSIRIS, MIRO, VIRTIS and ALICE instrument teams, and the ESOC Flight Dynamics Team for the Navigation Camera.

In preparation for this campaign, several series of payload tests were performed, including the uploading of software patches. Most notably, the software to operate the OSIRIS front doors was successfully modified and tested.

The Deep Impact observation campaign started on 28 June and lasted until 14 July, and the initial data received from Rosetta looked scientifically very promising.

SMART-1

SMART-1 has been in its operational science orbit since March and is producing a great deal of data. However, the detailed analysis of these data has not yet started, since the calibration activities for SIR, the infrared spectrometer, and DCIX, the X-ray spectrometer, have yet to be completed. Due to onboard software upgrades, operability of the spacecraft has improved considerably, benefiting payload operations planning also.

The orbit scenario for the SMART-1 extended mission was prepared by the Flight Dynamics Team and has been approved by the Project and the SMART-1 Science Working Team. It is optimised to provide very good conditions for science data taking throughout the approved mission-extension period. All contract actions required to have the necessary support in place for the mission extension have been started.

A Lunar Workshop and a SMART-1 Science Working Team meeting organised by the SIR instrument team took place from 6 to 9 June at the Physics Centre in Bad Honnef, Germany.

Venus Express

During the last quarter, the spacecraft has been completed in flight configuration and its final environmental and overall system testing has taken place. The spacecraft has also successfully passed the final command and data-compatibility tests with the ESOC Mission Operations Centre.

During this same period, the instruments' performances were reviewed in detail and in some cases modifications were ordered. In the case of two instruments, namely the Venus Monitoring Camera (VMC) and the SPICAV/SOIR, entirely new units have been installed based on their superior scientific performances and their demonstrated ability to cope with the flight environmental regime.

A major milestone was achieved by the industrial and ESA teams when they successfully completed the system review as part of the Flight Acceptance Review, heralding the beginning of the launch campaign. The Soyuz launch of Venus Express has been confirmed for 26 October from the Baikonur Cosmodrome in Kazakhstan.

Herschel/Planck

Spacecraft development is progressing well, with several major milestones having been achieved on both Herschel and Planck. The protoflight model of the Herschel cryostat has been closed, with all its internal elements and components in place, and is presently being prepared for its first 'cool down' at Astrium in Friedrichshafen (D). The structural/thermal model of the Herschel Service Module has successfully completed its environmental test campaign, including the major thermal and environmental testing at ESTEC (NL). The flight models of the Herschel and Planck Service Modules are undergoing integration at Alenia (I). Assembly of the Planck Payload Module qualification model was completed by Alcatel and the spacecraft has been transported to the CSL facilities in Liege (B), where it will soon undergo cryogenic testing.

The polishing of the protoflight model of the primary mirror for the 3.5 metre Herschel telescope was successfully completed and the mirror coated in Calar Alto, Spain. All telescope flight hardware is now available and integration of the telescope has started, in line with its planned completion by the end of 2006. The Planck reflector cryo-optical tests have been completed for the secondary mirror, down to the operational temperature of 50 K, showing good-quality results.

The qualification models of the scientific instruments are presently integrated into their respective Herschel or Planck Payload Modules and undergoing system-level testing. The focus is now on the instrument flight-model activities, where integration and testing has also started.

LISA Pathfinder

The Implementation Phase activities are progressing according to the agreed schedule. A slowdown in the spacecraft activities has been agreed with the industrial prime contractor (Astrium) in order to keep the spacecraft's development in phase with the delayed LISA Technology Package (LTP) consortium's start-up. The new planning is designed to minimise both the slippage in the launch (now expected not earlier than mid-2009) and the additional cost to the project, whilst also ensuring a more synchronised development with the LTP.

The prime contractor's main activity of late has been preparation of the System Preliminary Design Review, to be held in August and September. Another important activity that has continued but with a minor slowdown is the preparation and issuing of the various Invitations to Tender (ITTs) for the spacecraft subsystems and equipment. Most of the subcontractors will be selected within this calendar year.

The LTP Multilateral Agreement, formalising the national contributions, has finally been signed off. Nearly all of the industrial contracts pertaining to the Agreement have now been finalised. The remaining contract let by ASI for the inertial sensor is also now being finalised.

Gaia

The definition studies performed by the two independent Alenia/Alcatel and Astrium teams reached the last milestone with the final presentations. Both consortia presented the status of their spacecraft design approaches and any open/critical areas to the ESA Project Team and members of the Gaia Science Team.

Preparatory activities for the Gaia implementation phase were successfully concluded with the issuing of the ITT for the two identified potential prime contractors on 1 July. At the contractors' sites, the main activity for the time being is dealing with the preparation and issuing of the proposal.

Several technology activities have been completed as part of the Gaia technological plan. The contract for the procurement of the Gaia focal-plane CCDs has been signed off. The early start with this procurement will allow the overall Gaia schedule to be preserved.

James Webb Space Telescope

The road map defined by NASA for re-establishing an affordable JWST project is progressing as planned. The independent Science Assessment Team has concluded its work with a set of recommendations that have largely been endorsed by the JWST Science Working Group. Those recommendations include relaxed specifications for the telescope at 1 micron wavelengths, the deletion of tuneable filters, relaxed contamination specifications allowing simpler end-to-end optical testing, and focussing on scientific objectives from 1.7 to 28 microns rather than the original 0.6 to 28 microns. None of the recommendations involve a change in the overall design concept or the main features of the mission.

The independent cost teams completed their work at the end of July and the overall re-planning exercise is expected to be concluded by mid-September.

NIRSpec
The Preliminary Design Review (PDR) for the NASA-supplied micro-shutter mechanism has been successfully concluded, but the manufacturing technology remains problematic.

At instrument level, the Configuration Freeze Review has also been successfully concluded: it represented a major effort to get agreement on the external interfaces to JWST and the internal interfaces between NIRSpec and the NASA-supplied subsystems.

The subsystem procurement activities are progressing as planned, with kick-offs for the major sub-assemblies planned for end-September/October.

MIRI
The MIRI Cryo-cooler Confirmation Review has been successfully concluded. Due to an overall mass problem on JWST, it was decided in March to change from a solid-based hydrogen cryostat to active cryo-coolers. This change has only a minor impact on the MIRI instrument, but has major implications for the remaining system design.

Final preparations for the thermal testing of the MIRI instrument structural/thermal model are ongoing. Several manufacturing-readiness reviews have been held to initiate the component manufacturing for the MIRI verification model.

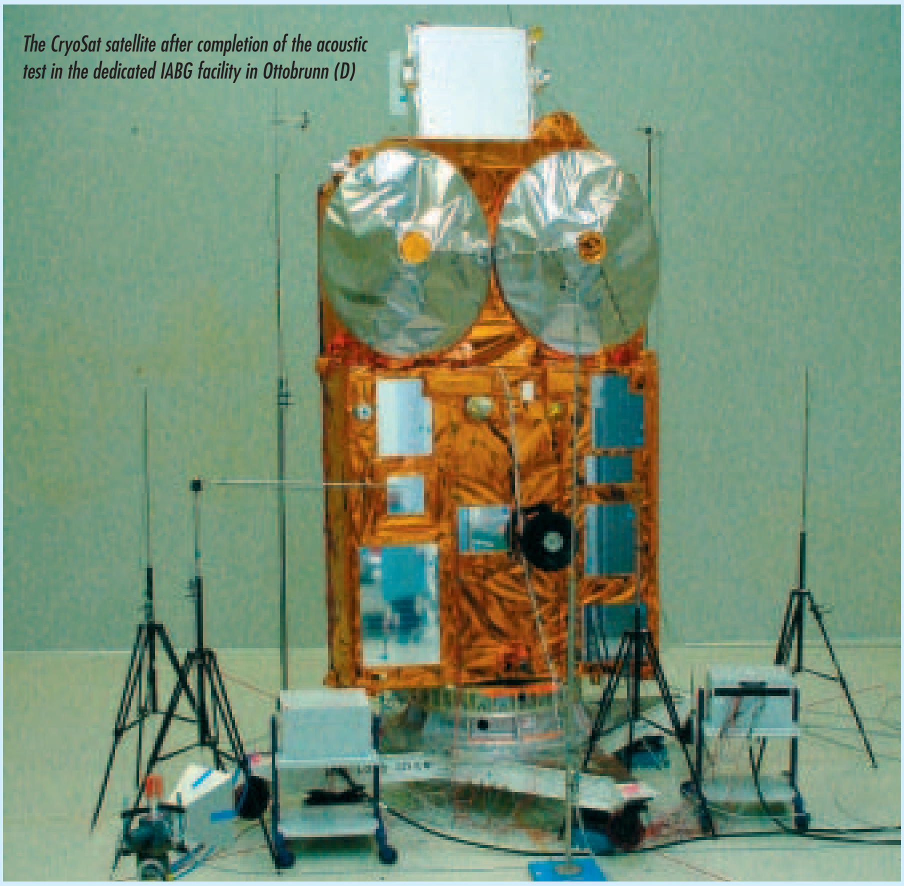
CryoSat

Good progress has been made in the past months with the satellite's development, particularly the testing programme conducted at IABG by the prime contractor, EADS Astrium GmbH (D). After repairing a leaking valve in the Reaction Control System and the replacement of a critical electronic component in the SIRAL radar altimeter, the spacecraft has undergone the two major remaining tests – a thermal-vacuum/thermal-balance test and an acoustic test – both of which were successfully completed in a timely manner. This concluded the satellite's environmental test campaign on a positive note.

On the launcher side, the last details concerning the preparation of the launch campaign in Russia have been agreed with Eurockot and Khrunichev.

The CryoSat Ground Segment activities are also progressing. On the Flight Operations Segment side, ESOC has initiated the simulation campaign for the launch and early operations phase (LEOP). On the Payload Data Segment side, the Reference Planning Facility and the Monitoring Facility are now both operational. An overall validation of the ground segment has also been performed.

Significant effort has been devoted to the



The CryoSat satellite after completion of the acoustic test in the dedicated IABG facility in Ottobrunn (D) preparation of the two mandatory reviews prior to launch: the Flight Acceptance Review (FAR) and the Ground-Segment Readiness Review (GSRR). The major activities remaining are the finalisation of the onboard software and the demonstration, by a last Satellite Validation Test (SVT), of the satellite's operability by ESOC.

The launch, which will take place from the Plesetsk cosmodrome on a Rockot vehicle, has now been re-scheduled for 7 October.

GOCE

Following a bottom-up approach, the sequence of Critical Design Reviews (CDRs) that had taken place so far at equipment, platform and gradiometer levels culminated in the GOCE system-level CDR, which was held from May to July.

The Gradiometer engineering model has successfully completed functional testing and has been delivered to the prime contractor. Progress has been made in the investigation and resolution of the stiffness anomaly detected on three Accelerometer Sensor Head (ASH) flight models integrated at ONERA (B). A new ASH, integrated under special cleanliness conditions, has been successfully tested, showing no stiffness anomaly. This result indicates that the stiffness anomaly occurs when particles are present in an ASH core, due either to contamination during integration and/or to the hitting of the proof mass against the corner stops during vibration testing. The successful test with the special cleanliness precautions seems to indicate that the first of these possibilities can be eliminated. What remains to be proved is that vibration testing does not generate particles large enough to affect the ASH's performance.

Also in the payload domain, the Satellite-to-Satellite Tracking Instrument (SSTI) engineering qualification model test campaign has been completed.

On the platform side, the functional testing of the engineering-model Test Bench is continuing. The endurance testing of the solar array's triple-junction, gallium-arsenide shunt diodes has been successfully completed, demonstrating that the baseline solar cells are compliant with the GOCE requirements. This positive result has allowed the release of the manufacturing of the flight photovoltaic assembly. Moreover, the flight-model wing panel that had shown some delamination after thermal-vacuum testing has been repaired and has subsequently passed the mechanical and thermal-vacuum tests needed to verify the quality of the repair. The investigations performed in order to identify the cause of the performance instabilities discovered during the qualification testing of the Ion Thruster Assembly qualification model have led to the conclusion that the problem originated in the ground-support equipment used during the test, rather than in the thruster itself. Finally, following an Agency-wide alert issued on Actel Field Programmable Gate Arrays (FPGAs), risk-mitigation actions have been pursued on a case-by-case basis for the GOCE units affected.

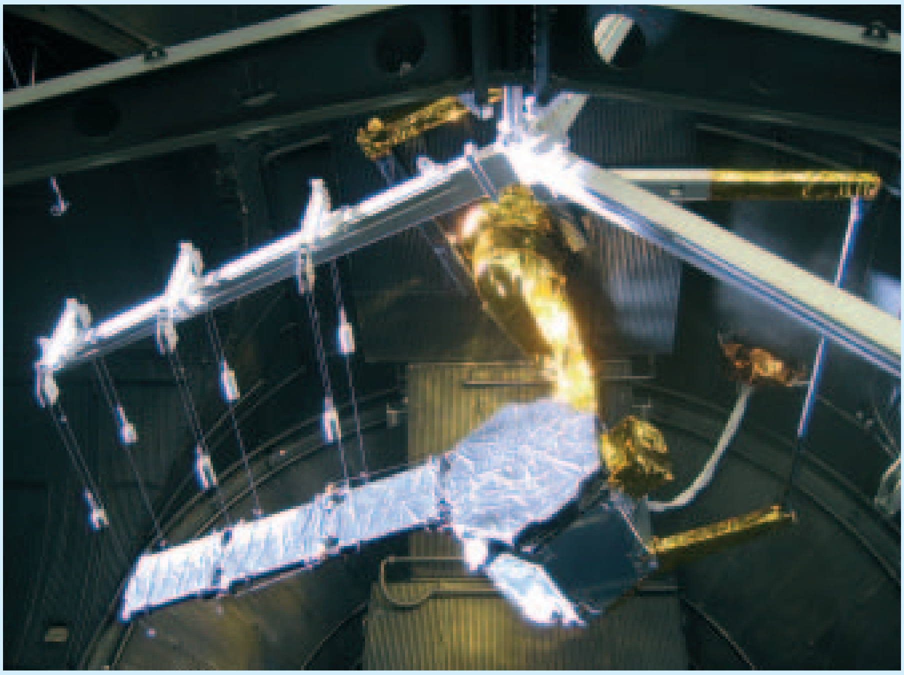
On the Ground Segment side, all development activities are progressing at a nominal pace. Preparations for the first System Validation Test (i.e. SVT-0), planned for mid-July, have been completed at ESOC. The System Requirements Review (SRR) for the Reference Planning Facility has been closed and the Calibration and Monitoring Facility algorithm workshop has been successfully concluded. Activities have also continued nominally at the European GOCE Gravity Consortium responsible for the development of the High-Level Processing Facility (i.e. the Level-1 to Level-2 data processor).

SMOS

The payload development programme is progressing well. The 'reduced engineering model' has basically completed its test programme, and some suspected minor internal interferences are now being investigated.

The structural/thermal model mechanical-qualification programme has been successfully completed, as well as the thermal-balance test in ESTEC's Large Space Simulator. Test reports and evaluations are now being compiled for the payload Critical Design Review (CDR) scheduled for late-autumn.

In parallel, the series production of flight units that are needed in large numbers, namely the antennas, bandpass filters and receivers, has started.



SMOS in the Large Space Simulator (LSS) at ESTEC in Noordwijk (NL)

Structural model of Aeolus mounted on the multi-shaker in the ESTEC Test Centre in Noordwijk (NL)

The satellite Preliminary Design Review (PDR) has been successfully completed, enabling the formal go-ahead to be given for the recurrent Proteus platform assembly programme.

A Request for Quotation for the data-processing ground segment was issued to a consortium led by INDRA (E) and their proposal received. The evaluation has since been completed and the negotiation process with industry has started.

ADM-Aeolus

A full-size optical and thermal model of the instrument has completed optical and thermal tests at CSL in Liege. These tests proved that the highly complex heat-pipe configuration works correctly, and that the telescope focus is stable under thermal-vacuum conditions. This instrument was then mounted on the structural model of the platform at ESTEC. The resulting structural/thermal model satellite has successfully completed acoustic, sine and shock testing. The shock test was conducted with a Rockot-launcher clamp band, and supported by a number of Russian test engineers.

There has been good progress with the laser. The master oscillator and first, double-pass pump chamber are working together in the engineering qualification-model configuration, which is flight-representative. The second pump chamber will be added shortly, completing the infrared portion of the laser. Sufficient pump diodes have now been delivered for flight, and the best specimens have been selected. Lifetime testing in burst mode will be started in October.

Testing for the susceptibility of components to laser-induced damage continues. Most results are very encouraging. In particular none of the contamination tests conducted under realistic conditions has shown performance degradation. A few components do, however, present problems and solutions are being actively sought in these cases.

Preparations for the Critical Design Review (CDR) are well under way and it will be completed by the end of September.

Launch remains scheduled for September 2008.

MetOp

The first MetOp satellite scheduled for launch in the second quarter of 2006, MetOp-2 (to be nominated MetOp-A after launch), successfully passed its Flight Acceptance Review in July, following the conclusion of its integration campaign. The Review was jointly chaired by ESA and Eumetsat. The satellite now enters a dormant phase (except for some open-work items) until its call-up for launch, expected at the end of 2005. Meanwhile, detailed preparations for the launch campaign at the Baikonur Space Centre and the subsequent in-orbit verification phase continue.

Eumetsat continues to prepare the ground segment, which has made considerable progress with the delivery of the launch version of the Core Ground Segment and the success of the last design review with the

The MSG-2 spacecraft container in the nose of the Antonov-124 cargo plane after arriving at Rochambeau Cayenne Airport in French Guiana

Launch and Early Orbit Service Provider (ESOC). Nonetheless, the completion of the relevant activities, including overall system-level testing, de-bugging and verification with the satellite, remains on a critical path in terms of meeting the overall launch schedule.

A further aspect in work are the remaining qualification activities for the Soyuz launch vehicle. Whereas the basic Soyuz launch vehicle is extremely well qualified (1500 plus launches), the design modifications relevant to the ST version (digital avionics, fairing and support structure, ground-support equipment) are still in the process of qualification.

Finally, the remaining activities on the MetOp-3 Payload Module were completed, and this has now joined the MetOp-1 Module in storage. Work on the MetOp-3 Service Module is continuing through September/October for the thermal-vacuum test campaign, after which the module will be put into storage.

Meteosat Second Generation (MSG)

MSG-1
Meteosat-8 (formerly MSG-1) operations have been nominal during the reporting period and instrument performance remains excellent.

MSG-2
The satellite was taken out of short-term storage and preparations for transport restarted. A first Launch and Early Orbit Phase (LEOP) simulation session took place at the beginning of June. The satellite was then transported to Kourou by an Antonov-124 aircraft on 21 June.

The launch campaign was started, but had to be stopped before battery integration, when it became clear that an August launch could no longer be supported by Arianespace. The spacecraft is now in storage configuration in the clean room at CSG awaiting the restarting of the campaign. Due to problems with the Ariane-5 GS vehicle, Arianespace does not expect the MSG-2 launch to take place before mid-December.

MSG-3
MSG-3 remains in short-term storage in the Alcatel clean room. After re-integration of missing units, some additional EMC investigations will still have to be performed. The MSG-3 spacecraft will be kept available as a source of spares for MSG-2 during its launch campaign. Thereafter it will be put into long-term storage, awaiting its own launch, which is currently foreseen for 2009.

MSG-4
The MSG-4 assembly, integration and test activities are proceeding according to plan. The platform bus mechanical-integration activities have been completed and a Test-Readiness Review for the electrical integration of units already mounted on the bus has been held.

Activities were discontinued to allow for the MSG-2 transport activities, with the spacecraft remaining in the Alcatel clean room. Electrical integration and testing will begin in mid-August.

The SEVIRI instrument's final alignment was completed and was followed by the mechanical/vibration tests. The thermal-vacuum test is planned for the beginning of October in the Focal V facility at CSL (B).

All MCP units have been delivered, except for the S-band TTC transponder.

Human Spaceflight, Research and Applications

Highlights
The 10-day ENEIDE Italian Soyuz mission was successfully conducted between 15 and 25 April, with ESA astronaut Roberto Vittori taking

an active role in piloting and docking the spacecraft on both the outward and return journies. All of the mission's main objectives were successfully accomplished.

The Foton-M2 mission was launched on 31 May and the capsule returned to Earth on 16 June.

With regard to the International Space Station (ISS) Assembly Sequence, different scenarios are under investigation by NASA with different numbers of Shuttle flights. The resulting options are to be submitted to the White House. A Heads of Agencies meeting is tentatively scheduled for mid-September.

The Russian Progress cargo spacecraft (18P) docked with the ISS on 18 June.

Space infrastructure development
All Columbus module repair activities have been completed and the module powered up to perform a protoflight-model system acceptance test before the payloads are integrated. Validation of operations products on the Electrical Test Model is progressing. The System Validation Tests SVT2b (between the Columbus Control Centre and Columbus with external payloads) and SVT4.1 (end-to-end space/ground validation) are being prepared.

The initial part of the system Qualification Review (QR1) for the ATV system was completed with the Board being held successfully on 28 June. Whilst no new problems were uncovered, there is clearly much work still to be done, especially with respect to system functional qualification. The project team is re-evaluating the logic process for completion of the qualification campaign. System Validation Test 2A was performed on the Functional Simulation Facility (FSF) and BIVP 11A delta (software end-to-end ISS manoeuvre test in Moscow) was completed successfully.

The ESA/Alenia and NASA/ESA Node contracts have been signed. Harnesses and piping have been integrated in the Node 3 stand-offs (on which the racks are mounted) and Node 3 cone integration has started.

The final Cupola hardware items were shipped to Kennedy Space Center, the Acceptance Review was successfully closed, and ownership was transferred to NASA on 7 July.

The Industrial Proposal for the launch of the European Robotic Arm (ERA) onboard the Russian Multipurpose Laboratory Module (MLM) has been received and discussions are ongoing regarding price and content.

Operations and related ground segments
The ATV Control Centre (ATV-CC) Interface Test (IT6) was successfully performed and the ATV Ground Control Simulator emulation platform Qualification Review was successfully completed. The ATV System Validation Test 2A was successfully conducted between the ATV-CC and the ATV Functional Simulation Facility (FSF) in Les Mureaux, France. In June, interface tests between the ATV-CC and the Columbus Control Centre (COL-CC), Redu/Artemis and the Mission Control Centre-Moscow (MCC-M) were successfully performed and the Flight Application Software command checker was successfully integrated into the Monitoring and Control System.

Part 1 of the Columbus Control Centre Qualification Review was kicked off on 13 June. Interface testing of the COL-CC to the ATV-CC, NASA JSC and MSFC is ongoing, and has been completed with MCC-Moscow. The COL-CC Voice System Site Acceptance Review was successfully performed in June.

Utilisation planning, payload developments and preparatory missions
The European Union has selected the ESA proposal for using the ISS as a research infrastructure ('SURE') project.

The first part of the Women's International Space Simulation for Exploration (WISE) Bed Rest Study has concluded at the MEDES facility in Toulouse (F).

Definition studies are ongoing for human-physiology project proposals that were received following the 2004 Announcement of Opportunity (AO2004) and the International Life Sciences Research Announcement (ILSRA). Evaluation of the Microgravity Application Promotion (MAP) proposals was performed and the evaluation panel recommended 14 out of the 25 MAP proposals received.

The European Modular Cultivation System (EMCS) facility flight model has been integrated into an Express transport rack for launch with Shuttle flight ULF1.1, while the MELFI Flight Unit 1 (FU-1) has been integrated into the MPLM for launch on the same flight.

The European Drawer Rack (EDR) flight model's acceptance is in progress.

The Protein Crystallisation Diagnostics Facility (PCDF) flight model Preliminary Flight Acceptance Review (PFAR) has been split into two parts: the PFAR for the flight-model Electronic Unit has taken place, and the Unit is now available for integration into the EDR flight model; the PFAR for the Process Unit flight model and Experiment Boxes will be performed in early-July.

The Pulmonary Function System (PFS) is scheduled to be launched to the ISS on Shuttle flight LF1 in July, in NASA's Human Research Facility (HRF-2 rack). The PFS Phase-B is progressing according to plan.

Integration of two Columbus external payloads – EuTEF and SOLAR – is progressing and the System Validation Test-2, involving the Columbus module, is in preparation.

The Atomic Clock Ensemble in Space (ACES) Mission Preliminary Design Review (M-PDR), which will confirm the feasibility of the overall mission, is now planned for mid-2006; the Mission System Requirements Review (M-SRR) was kicked-off in mid-June and is approaching finalisation. Consolidation of the Swiss Hydrogen Maser (SHM) experiment is progressing.

Delivery of the Portable Glovebox flight model is planned for late-August and launch is scheduled with ATV-1 as an ESA upload.

The CryoSystem is on hold pending a review by NASA of their need for it on the ISS.

The documentation for the Crew Refrigerator has been finalised and the qualification model will be shipped to Johnson Space Center in July.

On 2 May, the Maser-10 sounding rocket was successfully launched from Kiruna in Sweden carrying five scientific experiments. During the free-flight phase, all experiment facilities worked correctly and transmitted their data in real-time to the ground. During re-entry, however, the main parachute system in the recovery module failed to release, resulting in a hard landing and serious damage to the experiment hardware. However, all experiment results, with just one exception, could be recovered. A Failure Inquiry Board has been established.

The implementation of upgrades and robustness testing on the Columbus payload-rack facilities (Biolab, European Physiology Modules, Fluid Science Laboratory) is progressing towards final delivery of the flight models for final integrated system testing in September.

The Foton-M2 mission was launched on 31 May and the capsule landed safely on 16 June. The majority of experiments performed well, although the Russian Polizon furnace suffered a failure and the technology payload Favorite did not perform according to plan.

The 40th ESA Parabolic Flight Campaign took place between 20 June and 1 July. One of the 13 originally foreseen experiments had to be disembarked due to a technical failure during preparation; the remaining 12 experiments performed well during all three flights.

ISS education

Education experiments were successfully performed during both the ENEIDE and Foton-M2 missions. Good candidates for the Long Duration Mission and ATV-1 are now being identified.

The tri-lateral (ESA/NASA/Dutch Ministry of Education) Delta Researchers School Programme was kicked-off at ESTEC (NL) on 13 June.

On 21 June, the ELIPS/Education Programme was presented to representatives of the Greek Ministries of Education and Development. This was followed on 22 June by the filming of 'Matter in Space' ground experiments in a Greek school for a DVD. This DVD will be the third in a series for secondary schools, with onboard experiments filmed during the ENEIDE mission.

Commercial activities

ESA, represented through its commercial-agent network for Biotechnology, Health and Food and Nutrition, was present at the BIO 2005 trade show in Philadelphia, USA, which took place on 19-22 June. The commercial agent is also preparing two commercial proposals for the Long-Duration Mission with ESA astronaut Thomas Reiter.

Astronaut activities

The 10-day ENEIDE Italian Soyuz mission was successfully conducted between 15 and 25 April. ESA astronaut Roberto Vittori took an active role in piloting and docking the spacecraft during both the ascent phase and the return journey. All of the mission's main objectives were accomplished.

Thomas Reiter and his backup for the Long-Duration Mission, Leopold Eyharts, have received training at both Johnson Space Center and the Gagarin Cosmonaut Training Centre (GCTC). Frank de Winne and André Kuipers have been training in the USA, and training for Christer Fuglesang for STS-116 is intensifying.

The Soyuz-TMA fit-check for Paolo Nespoli was successfully completed, thus concluding the qualification of all ESA astronauts for flying onboard the Soyuz-TMA, which is a prerequisite for assignment as an ISS crew member.

An Instructor Training Course with Columbus Control Centre, Italian Army, Facility Responsible Centre (FRC) and European Astronaut Centre (EAC) participants took place between 6 and 24 June, and an Instructor Proficiency Training session for Columbus, Payload and ATV instructors and training engineers was organised on 14 and 15 June

Vega

During the mid-April to July period, several important milestones for the launcher occurred, including:

- sub-assembly key points reached
- Inter-stage 1/2 Critical Design Review (CDR) completed
- AVUM structure CDR completed
- readiness review of system loop analysis carried out.

The Recovery Plan for the Zefiro inert motor cases has further progressed, after a minor defect had been detected during the hydro-proof testing of P9 DM0. Additional investigations and corrective actions have been carried out and will allow the casting of the propellant of the first motor before the end of July. The manufacture of P9 DM1 is in progress, while that of P23 DM0 is complete.

At system level, comprehensive loop-analysis-related activities have started in view of the CDR. A first intermediate milestone to check the consolidation of the definition and closure of major actions is planned for 27 July. The trade-off regarding implementation of the additional roll-control device using hydrazine thrusters has nearly been completed, pending consolidated data from suppliers.

The Assemblies/Stages documentation key-point activities have been successfully concluded, and the Intermediate Safety Review was successfully completed at CSG during the first week of July.

Regarding the P80 programme, the lessons learned during the manufacture and testing of the reduced-length technological-model motor and of a test skirt have been assessed and factored into the manufacturing of the first full-scale motor, which is due to start in late July. The thrust-vector-control activities are proceeding, with assembly of the first actuator and the software Preliminary Design Review (PDR) completed. The PDR for the TVC batteries is also nearing completion. The investigations into some difficulties encountered during the manufacture of certain elements of the P80 nozzle (flexible joint and

The Vega fairing (courtesy of Contraves Space)

Also on 19 July, the System Architect contract was signed at Headquarters by ESA's Director General and the President of CNES. The objective is to have a first launch of a Soyuz 2.1a from French Guiana before the end of 2008. The contract between CNES and Arianespace for the so-called 'Russian deliveries' was also signed on the same day.

exit cone) have led to the implementation of significant improvements in the processes, with good results.

The negotiation of the updated proposal from the Ground Segment prime contractor Vitrociset (I) has been concluded and the company's contract with ESA was signed on 21 July in Rome. The industrial work related to the preliminary preparation phase for the ground facilities in Kourou is nearly complete, and the detailed design activities for the mechanical and civil engineering work are proceeding normally.

The industrial PDR for the Control Bench has been carried out, but was not considered conclusive due to a lack of definition of some elements and justification of the overall architecture with respect to requirements/performances. A set of recovery actions has been put in place with the prime contractor and many of them have already been completed. The complementary review should be held by end-September/October.

The VERTA (Vega Research and Technology Accompaniment) programme proposal and the relevant declaration and implementing rules were presented and discussed at the June meeting of the Ariane Programme Board and in meetings with potential participating Member States. This programme, covering the five years after the Vega qualification flight in 2007, is aimed at demonstrating the capabilities and flexibility of the Vega launch system through a series of technological and quality-monitoring activities, and five specific flights covering the wide range of missions that will be possible using Vega.

Soyuz at CSG

The 'Soyuz at CSG' Programme was formally given the go-ahead for work to start during the ESA Council meeting last December. The necessary funding has since been put in place by ESA and by Arianespace, which has accepted to contribute of the order of one-third of the overall programme costs, via a loan from the European Investment Bank guaranteed by the French Government.

A Preliminary Authorisation to Proceed was issued to CNES – including some subcontractors such as Arianespace (Russian deliveries) and Ribal (earth works) – to start activities on two fronts: the main earthworks for the Soyuz Launch Site (SLS) and additional studies in relation to the complementary Preliminary Design Review (PDR), which took place at the end of June. The Review Board, meeting at ESA Headquarters on 19 July, gave its formal approval to move on to the next phase.

Soyuz

In Brief

Luxembourg becomes ESA's 17th Member State

Luxembourg has become ESA's 17th Member State with effect from 30 June 2005 after ratifying the ESA Convention. Cooperation between ESA and Luxembourg began with an agreement in September 2000, enabling Luxembourg to participate in ESA's ARTES telecommunications programme.

The agreement between ESA and Luxembourg was signed by Erna Hennicot-Schoepges, Luxembourg's Minister for Culture, Higher Education and Research and Jean-Jacques Dordain, ESA's Director General, on 6 May 2004.

Mars Express radar collects first surface data

MARSIS, the sounding radar on board ESA's Mars Express spacecraft, is collecting the first data about the surface and the ionosphere of Mars. The radar started its science operations on 4 July 2005. Due to the late deployment of MARSIS, the commissioning, originally planned to last four weeks, was split into two phases, one of which has just ended and the second one to be started by December this year.

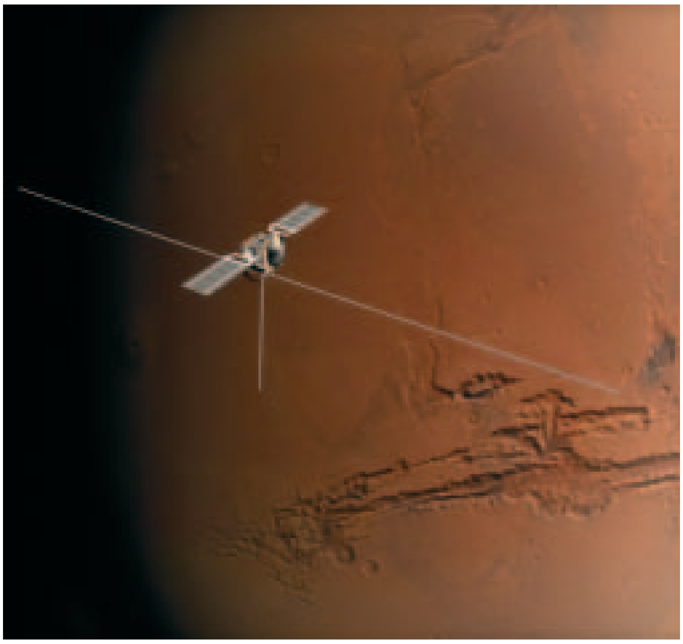
This has given the instrument the chance to start scientific observations earlier than initially foreseen, while still in the Martian night. This is especially favourable for subsurface sounding, because the ionosphere is more 'energised' during the daytime and disturbs the radio signals used for subsurface observations.

From the beginning of the commissioning, the two 20-metre long antenna booms have been sending radio signals towards the Martian surface and receiving echoes back. "The commissioning phase confirmed that the radar is working very well, and that it can be operated at full power without interfering with any of the spacecraft systems," says Roberto Seu, Instrument Manager for MARSIS, from the University of Rome 'La Sapienza', Italy.

MARSIS is a very complex instrument, capable of operating in different frequency bands. Lower frequencies are best suited to probe the subsurface, highest frequencies are used to probe shallow subsurface depths, while all frequencies are suited to study the surface and the upper atmospheric layer of Mars.

The MARSIS radar is designed to operate around the orbit 'pericentre', when the spacecraft is closer to the planet's surface. During each orbit, the radar has been switched on for 36 minutes around this point, dedicating the central 26 minutes to subsurface observations and the first and last five minutes of the slot to active ionosphere sounding.

The first ionospheric measurements performed by MARSIS have revealed some interesting preliminary findings. The radar responds directly to the number of charged particles composing the ionosphere. This has shown to be higher than expected at times.



Artist's impression of the complete deployment of the Mars Express MARSIS experiment, showing the two 20-metre booms and the 7-metre boom.

"We are now analysing the data to find out if such measurements may result from sudden increases of solar activity, or if we have to make new hypotheses. Only further analysis of the data can tell us," said Jeffrey Plaut, Co-Principal Investigator, from NASA Jet Propulsion Laboratory, Pasadena, USA.

MARSIS will continue send signals to hit the surface and penetrate the subsurface until the middle of August, when the nighttime portion of the observations will have almost ended. After that, observation priority will be given to other Mars Express instruments that are best suited to working during daytime, such as the HRSC camera and the OMEGA mapping spectrometer.

However, MARSIS will continue surface and ionospheric investigations during daytime, with the ionospheric sounding being reserved for more than 20% percent of all Mars Express orbits, under all possible Sun illumination conditions.

In December 2005, the Mars Express orbit's pericentre will enter the nighttime again. By then, the pericentre will have moved closer to the south pole, allowing MARSIS to restart optimal probing of the subsurface, this time in the southern hemisphere.

Venus Express launch campaign starts

ESA's Venus Express spacecraft has completed its last phase of testing in Europe and has been shipped to its launch site at the Baikonur Cosmodrome in Kazakhstan. It will be launched in the autumn. One and a half years after its sister spacecraft Mars Express arrived at Mars, Europe's newest planetary probe is ready to depart on the first leg of its journey to Earth's own sister planet, the mysterious Venus.

"The spacecraft really deserves its name, as never before has an ESA scientific mission been developed that rapidly!" said Don McCoy, ESA Project Manager for Venus Express. The mission has in fact taken only four years from concept to launch.

Work on Venus Express began in earnest eight months before Mars Express was launched. This meant that continuity was maintained in the programmes and the industrial consortium was kept almost unchanged. Thirty-four months later, the spacecraft has passed its Flight Acceptance Review, and is ready for shipping.

Built by Alenia Spazio of Turin, Italy, the spacecraft was delivered to EADS in Toulouse for final pre-launch testing with its seven scientific instruments, mainly inherited from the Mars Express and Rosetta missions, already integrated. These instruments will provide new clues about the planet's peculiar features that are still unexplained even though more than 20 Russian and US probes have visited Venus since 1962.

The mission will provide the most comprehensive study ever of the Venusian atmosphere. It will dig into mysteries such as the unexplained fast atmospheric rotation in four days around the planet and the polar vortices, and study the global thermal balance and the role of the strongest 'greenhouse effect' found in the Solar System, as well as the structure and dynamics of the clouds and the mysterious ultraviolet markings detected above the cloud cover.

The spacecraft closely resembles Mars Express, but has been redesigned with several major modifications to allow it to face a very different environment around Venus. Venus Express has improved thermal control systems, to sustain a spacecraft heating that at Venus is four times greater than at Mars. As the spacecraft will be much closer to the Sun than Mars Express, the solar arrays have been redesigned to be smaller than those of its sister spacecraft. Also, their new gallium-arsenide-based technology is more tolerant to high temperatures.

Unlike Mars Express, instead of one high-gain antenna, Venus Express has two antennas pointing in opposite directions. In fact, as seen from Venus, Earth is an outer planet and it can be in any direction relative to the Sun. Two antennas will allow the spacecraft to communicate with Earth in any configuration, always having the side hosting delicate instruments away from the Sun.

New Chairman of ESA Council

Sigmar Wittig is the new Chair of the ESA Council.

Sigmar Wittig, currently Chairman of the Executive Board of the German Aerospace Centre (DLR), is the new Chair of the ESA Council for the next two years.

Professor Wittig was unanimously elected at the 179th Council meeting, held at the European Space Operations Centre (ESOC) in Darmstadt, Germany on 21-22 June. He takes over from Per Tegnér of Sweden.

Born on 25 February 1940 in Nimptsch, Sigmar Wittig studied mechanical engineering and was awarded a PhD from the University of Aachen. After nine years in the United States (1967 – 1976), he worked for many years as professor and head of the institute for thermal turbomachinery at the University of Karlsruhe, eventually becoming University President in 1994.

In March 2002, he was appointed Chairman of the Executive Board of DLR and has been Head of the German Delegation to ESA since then.

New Director of External Relations takes up duty

René Oosterlinck, who was appointed Director of External Relations by the ESA Council in December 2004, took up duty on 1 June.

Of Belgian nationality, married and with four children, René Oosterlinck (61) was awarded an engineering degree from the Higher State Technical Institute for Nuclear Industries of Brussels, Belgium in 1966. In 1969 he obtained a degree in civil engineering from the University of Leuven, Belgium, and in 1977 he obtained a degree in law from the University of Leiden in the Netherlands.

Besides Dutch, his mother tongue, he speaks French, English and German fluently and has good knowledge of Spanish and Italian. Chinese and Japanese complete his interest in foreign languages.

René Oosterlinck started his career in 1969 as a teacher of physics and mathematics in Zaire (now Congo). Two years later he became a patent examiner at the International Patent Office in The Hague. In 1979 he joined ESA, where he held the post of Head of the Intellectual Property, Transfer of Technology and Information Policy Office until 1984, when he became Head of the Personnel and Site Services Department.

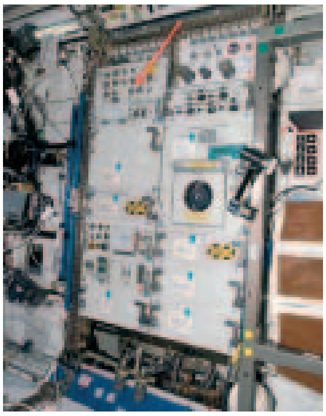
After a period heading the Legal Affairs Department (1998-1999), he became Head of the Navigation Department, where he was in charge of the Galileo and EGNOS programmes. Since 2004 he has been lecturing in Space Law at the University of Ghent in Belgium.

Mr Oosterlinck will now be in charge of a Directorate that comprises three Departments: International Relations, Corporate Communications and Education:

“The Directorate of External Relations is ESA’s window on the outside world” says Mr Oosterlinck. “It is through International Relations that we interface with other organisations and agencies such as NASA in the USA and Roskosmos in Russia, but also with Japan, India and China and non-Member States in Europe that show interest in sharing in our activities. Through Corporate Communications we address decision-makers, the media and the general public, while the Education Department, formally established at the Agency only a few years ago, reaches out to youngsters and their teachers”.

“Presenting the multifaceted reality of ESA to the external world and fostering true international cooperation is a real challenge, which I feel ready to take up because I truly believe that Europe in space is a reality we can be proud of and, with the help of my colleagues in the Directorate, I will do my utmost to make our activities more visible and to explore new avenues to improve the good relations we already have with our international partners”.

Research facility installed in Destiny Lab



Housed within the Human Research Facility #2, the Pulmonary Function System installed in the ISS's Destiny laboratory

A new research facility, which includes the European-built Pulmonary Function System (PFS), has been installed in the US Destiny Laboratory on the International Space Station (ISS) during the recent Shuttle mission to the ISS. The device will be used for breathing analysis and provide near-instant data on the crew's state of health.

The Pulmonary Function System was delivered to the ISS on the Multi-Purpose Logistics Module (MPLM) carried within Discovery's cargo bay. Originally planned for launch in the European Columbus Laboratory, NASA offered ESA an earlier flight opportunity to launch the PFS.

Developed by the Danish company INNOVISION SA, the Pulmonary Function System can measure six different gases simultaneously, with several measurements being made in a single breath. The data will provide a wealth of information about the astronauts' lung function, blood flow and entire cardiovascular system.

Check-out and commissioning of the Pulmonary Function System, which will be performed by ISS crew members, is scheduled for this autumn. A team of specialists based at Damec Research Aps, the Danish User Support Operations Centre (USOC), will provide support on the ground.

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European experiments back on Earth with successful conclusion of Foton-M2 mission

The re-entry module of the Foton-M2 spacecraft made a successful landing on 16 June in an uninhabited area in Kazakhstan. The unmanned Foton-M spacecraft, which was launched on 31 May from the Baikonur Cosmodrome in Kazakhstan, carried a European payload of 39 experiments in fluid physics, biology, crystal growth, meteoritics, radiation dosimetry and exobiology.

ESA representatives were on hand at the landing site to undertake initial procedures related to European experiments. This included immediate retrieval of the Biopan, Stone and Autonomous Experiments. The same team removed the FluidPac experiment facility's digital tape recorder and configured FluidPac for safe transport to the TsSKB-Progress factory in Samara. The Foton capsule was then transported to Samara where the FluidPac facility and the Telescience Support Unit were removed and shipped to ESA/ESTEC in Noordwijk, the Netherlands.

"I am extremely pleased that the majority of experiments have performed well." said ESA's Project Manager for Foton missions, Antonio Verga. Fluid physics experiments were conducted in the FluidPac and SCCO experiment facilities. The data return from these is nearly complete and most of the scientific objectives were achieved. The BAMBI experiment produced some excellent images, a substantial role in which was played by the on-line processing capability of the TeleSupport Unit.

The Agat furnace also performed flawlessly. The processed samples should provide the material science community with good specimens to analyse. Unfortunately, the Russian Polizon furnace suffered a failure for as yet unknown reasons, which prevented the processing of the semiconductor alloys stored in its drum at the required high temperatures.

The very successful MiniTherm technology experiment was performed during the mission, which deals with the performance of a new design of heat pipes. This experiment was controlled from Esrange in Sweden during its 5 day-long execution.

The European Space Agency has participated in this type of scientific mission for 18 years and with a total of 385 kg of European experiments and equipment, this mission constituted the largest European payload that has been put into orbit.

"The Foton-M2 mission has been a resounding success and I look forward to seeing the positive impact the results of the experiments will have in the future," said Daniel Sacotte, ESA's Director of Human Spaceflight, Microgravity and Exploration. "I also look forward to building on this success with the Foton-M3 mission, which is planned to be launched in 2007."

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Further steps towards a European Space Policy

The second meeting of the Space Council – a concomitant meeting of the ESA Council at Ministerial Level and the European Union Competitiveness Council (Internal Market/Industry/Research) – was held at the Kiem Conference Centre in Luxembourg on 7 June. It was chaired jointly by Mrs Edelgard Bulmahn, German Minister for Education and Research and current Chair of the ESA Council at Ministerial Level, and Mr François Biltgen, Minister for Labour and Employment, Minister for Culture, Higher Education and Research in Luxembourg, and current Chair of the EU Competitiveness Council. The meeting was also attended by Mr Günter Verheugen, European Commission Vice-President, in charge of enterprise, industry, competitiveness and space matters, and by Mr Jean-Jacques Dordain, ESA's Director General.

In consultation with private and public stakeholders, the Space Council is working on the definition of a coherent European Space Policy and associated programmes, covering the activities of the EU, ESA and their Member States. The objective is to endorse, at the third Space Council meeting planned for November this year, a European Space Policy and European space programme for the period up to 2013.

The Space Council was established to coordinate and facilitate cooperative activities between the European Community and ESA through their Framework Agreement, which entered into force in May 2004. At this second meeting, the Council confirmed that the European Space Policy should cover mainly the following:

– a European space strategy
– a European space programme matching the strategy and reflecting associated costs and funding sources
– a commitment by the main contributors as to their roles and responsibilities
– the key principles of implementation.

The aim of the strategy is to develop increasingly advanced space systems according to user needs. All of the benefits derived from associated services will be shared by all. The EU will have to identify user needs and build a political will around them. ESA and its Member and Cooperating States will develop future space technologies and systems and pursue excellence in space-based scientific research.

Priorities within the European space programme see the EU focusing on space-based applications to contribute to the achievement of its policies, particularly the Galileo and Global Monitoring for Environment and Security (GMES) programmes. ESA will focus on space exploration and on the basic tools on which the exploitation and exploration of space depend. Securing guaranteed access to space through a complete, competitive family of launchers, pursuing excellence in space science, and exploiting its knowhow in the exploration of the planetary system and in developing technologies to maintain a competitive space sector will be among ESA's main tasks.

The investments needed for addressing these priorities for the EU, ESA and Member States will be identified in the coming months and pass through each organisation's normal budgetary and programmatic approval procedures. By coordinating efforts, the players will ensure that new investments bring additional benefits. Financing sources for space-related activities for the EU are the Seventh Framework Programme of research, technology and development, the trans-European network programme, and the competitiveness and innovation programme. ESA draws on Member States' contributions to its mandatory and optional programmes.

EU space-related programmes will be managed in line with an efficiency criterion, in accordance with the Framework Agreement, and will benefit from ESA's technical and management experience, in cooperation with the relevant agencies and entities in Europe. ESA programmes will be managed in line with its Convention. Decisions on future programmes taken at ESA's Ministerial Council meeting in December this year, and discussions on future EU financial prospects, will make it possible to determine whether the programme is consistent with the ambitions of the European Space Policy.

German Minister Edelgard Bulmahn said after the meeting: "Today we are sending an important signal: ESA and the EU are moving ahead on their way to putting space at the service of the European citizen and EU policies. Building on the long-standing experience of ESA, the European Space Programme will enable Europe to face the political, economic and scientific challenges of tomorrow."

ESA Director General Jean-Jacques Dordain added: "ESA has just turned 30. Thanks to the continuous support of its Member States, it has grown to make the European space sector one of the foremost competitors in the World, and at the same time has become a respected partner. Now the European Space Policy is being integrated within the wider ambitions of Europe and space is set to become a much larger and more integrated undertaking in our future. ESA is prepared to adapt in order to take on an even greater role for Europe."

ESA joins the Open Geospatial Consortium (OGC)

ESA has joined the Open Geospatial Consortium (OGC) as a Technical Committee Member. The OGC (http://www.opengeospatial.org) is an international industry consortium of more than 280 companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications. OpenGIS® Specifications support interoperable solutions that 'geo-enable' the web, wireless and location-based services, and mainstream IT. The specifications empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

In parallel, OGC's European subsidiary OGC Europe was awarded a three-year-framework contract for the 'ESA Harmony' project. The project's objectives are to support ESA with its membership of the OGC and to assist it in tailoring the Agency's Earth-observation products and services to match the expectations of the geospatial community, and in introducing requirements into the OGC standardisation processes. In addition, OGC Europe is assisting ESA in identifying the appropriate programmes, committees and working groups within the OGC in which the Agency should become an active participant and contributor.

As an initial contribution, ESA has defined and documented a 'Minimal Profile for Earth Observation (EO) Products using WSDL and SOAP' for the OGC Catalogue Specification. It is currently under consideration by the OGC members for release as a 'discussion paper'. As part of the OGC standards-development process, there will be a public review period for the geospatial information industry as well as the general public. The longer term intention is to have this document approved as an adopted profile of the OGC Catalogue Specification. This will be an important achievement directly related to the objectives of ESA's 'Heterogeneous Missions Accessibility–Interoperability (HMA-I)' project, which is scheduled to start in September.

The 36th COSPAR Scientific Assembly

The next Scientific Assembly of the Committee on Space Research will take place on 16 - 23 July 2006 in Beijing, China. The Chair of the Scientific Programme will be Prof. Ronglan Xu of the Centre for Space Science and Applied Research (CSSAR) in Beijing.

The Assembly will be comprised of approximately 80 meetings covering the various fields of the COSPAR Scientific Commissions (SC) and Panels:

- SC A: The Earth's Surface, Meteorology and Climate
- SC B: The Earth-Moon System, Planets, and Small Bodies of the Solar System
- SC C: The Upper Atmospheres of the Earth and Planets Including Reference Atmospheres
- SC D: Space Plasmas in the Solar System, Including Planetary Magnetospheres
- SC E: Research in Astrophysics from Space
- SC F: Life Sciences as Related to Space
- SC G: Materials Sciences in Space
- SC H: Fundamental Physics in Space
- Panel on Satellite Dynamics (PSD)
- Panel on Scientific Ballooning (PSB)
- Panel on Potentially Environmentally Detrimental Activities in Space (PEDAS)
- Panel on Radiation Belt Environment Modelling (PRBEM)
- Panel on Space Weather (PSW)
- Panel on Planetary Protection (PPP)
- Panel on Capacity Building (PCB)
- The Public Understanding of Space Science
- Space Science Education and Outreach.

The deadline for the submission of Abstracts will be 17 February 2006, and the Papers eventually selected for presentation will be refereed for publication in Advances in Space Research.

Further information can be obtained by visiting:

http://www.copernicus.org/COSPAR/COSPAR.html
or by contacting the:

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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 Newletters

ECSL NEWS NO. 30, MAY 2005
NEWSLETTER OF THE EUROPEAN CENTRE FOR SPACE LAW
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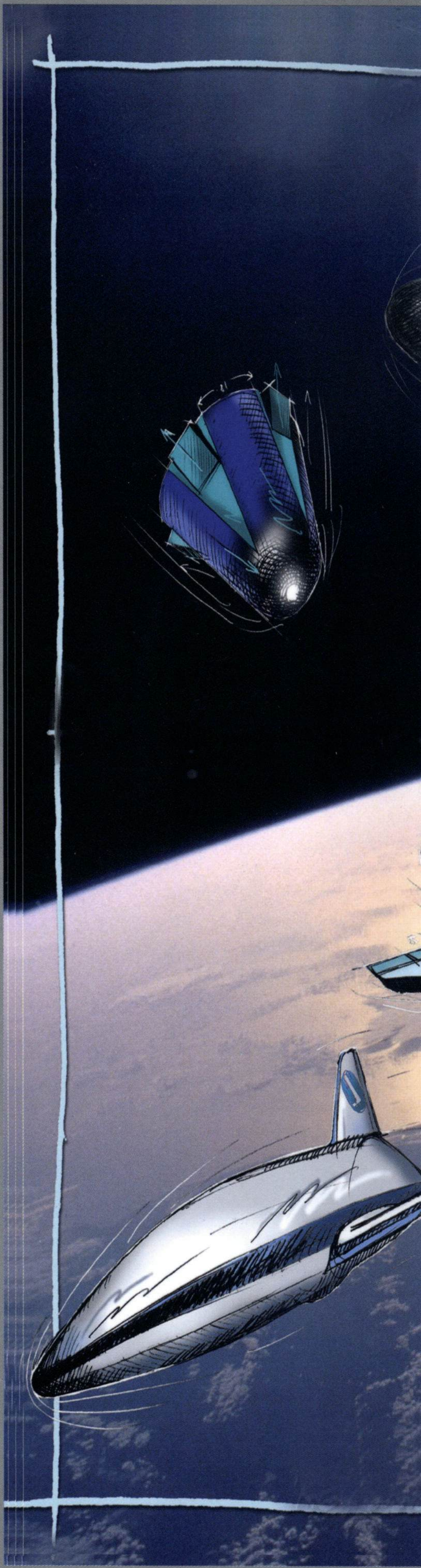

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