Technical and Operational Support

The year was marked by the successful launches of the SMART-1 lunar mission, and of the Mars Express mission, and the subsequent critical operations, which culminated in the Mars Express spacecraft's orbit insertion and Beagle lander release over the Christmas holiday period in December. Overall, 2003 was extremely busy, with demand for support from the Agency's programmes 10% higher than in 2002. Of particular significance was the major role played by the Directorate as the driving force in the preparation of the new TRP and GSTP technology programmes, with about 90% of the activities being defined by D/TOS staff. Last but not least, the technical cooperation established over the previous years in the framework of the Network of Centres initiative was continued, and relations with the participating members was reinforced through the elaboration of a number of different cooperative activities.

Mission Operations

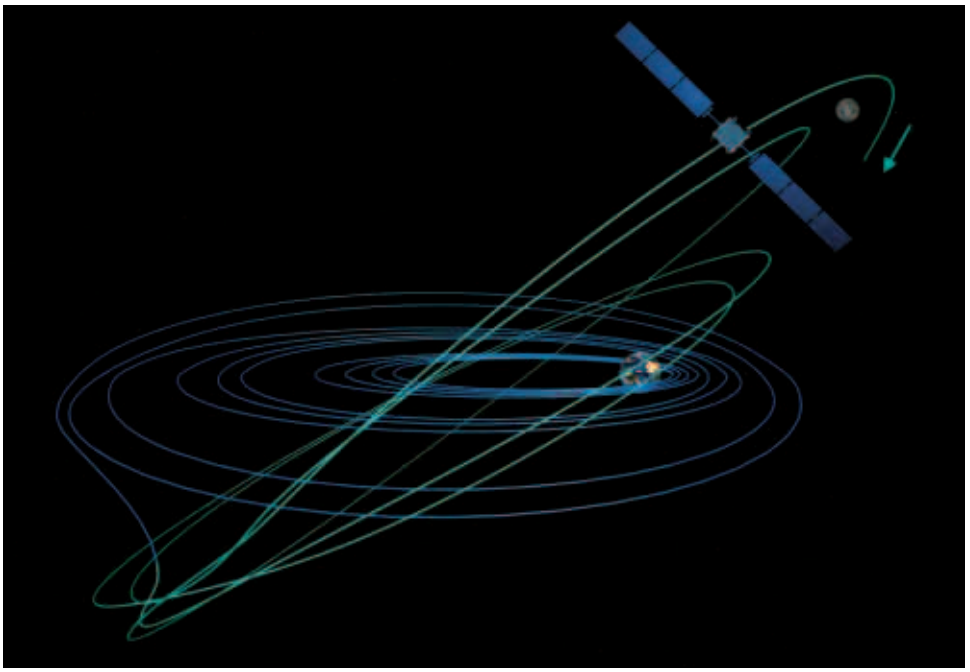
Mars Express

The first ESA mission to Mars was launched from Baikonur on 2 June, with all spacecraft and ground operations being conducted from ESOC. The 7-month cruise to Mars was an intense operations phase, covering trajectory manoeuvres and the checkout of the scientific instruments. In December, Mars Express was precisely targeted at the Red Planet, enabling the Beagle-2 lander to be released on its course to the Martian atmosphere. Mars Express was then retargeted to its capture point where, on Christmas Day, it successfully achieved orbit insertion. Mars Express' on-board instruments have provided spectacular results, including the first direct detection of water ice on the South Pole and the sending back of high-resolution three-dimensional colour images.

SMART-1

The first European lunar mission departed from Kourou on 27 September onboard an Ariane-5. The ESOC Ground Segment and its Ground Station Network performed exceptionally well.

A major achievement in December was the raising of the spacecraft's orbit above the Earth's inner radiation belts. The spacecraft's electric-propulsion ion drive is performing very well, and its efficiency is higher than expected.



SMART-1 first orbited the Earth in ever-increasing ellipses. When its orbit approaches the Moon, it is altered by the lunar gravitational field. These 'gravitational assists' allow the spacecraft to position itself for going into orbit around the Moon (illustration AOES Medialab)

XMM-Newton

During the year, the XMM-Newton observatory pointed its telescope at more than 1000 X-ray sources, planets and comets, to observe and record the X-rays that they emit. The observatory continued to return excellent scientific data. More than 850 000 telecommands were sent to the spacecraft during 2003.

Integral

Integral began its routine mission phase early in the year, and the operational ground segment was significantly upgraded to support an increase in the spacecraft downlink data rate and hence in the scientific return. There was good cooperation with the XMM-Newton mission, whereby Integral detected several gamma-ray bursts, which XMM-Newton then quickly observed as targets of opportunity.

Cluster-II

All four Cluster spacecraft and their science instruments are in excellent health and continued to deliver a high scientific data return. This was demonstrated particularly during the exceptional solar storms in October. The Cluster constellation was orientated during the summer to focus on various phenomena associated with the interaction between the solar wind and the Earth's magnetic field. A total of 43 manoeuvres were executed to reduce the tetrahedron formation from a 5000 km inter-spacecraft separation to just 200 km.

Ulysses

Ulysses continued to gather data with all of its onboard experiments, which are still functioning flawlessly. The spacecraft continues to return first-class scientific data from its unique vantage point in space. The ESA flight-control team, located at the Jet Propulsion Laboratory (JPL) in Pasadena (USA), are conducting the daily real-time operations.

Huygens

Launched in October 1997, the Huygens probe continued on its long journey to Saturn attached to NASA's Cassini spacecraft, and is due to land on Saturn's moon Titan in January 2005. Two routine in-flight checkouts of the probe during the year confirmed that it continues to be in good health.

ERS-2

The ERS mission completed its 12th year of operation on 17 July. The mission operations were reorganised to cope with the loss of data-recording capability in June. The mission planning system software was updated to include a worldwide network of real-time acquisition stations, with a particular focus on the North Atlantic region.

Envisat

The Envisat mission entered its routine operations phase on 1 January. Commissioning of the communications link via ESA's Artemis spacecraft was successfully completed, and since then a total of 5 to 6 Artemis passes are used daily to downlink background regional mission data. The mission-planning service at ESOC supported several emergency

observations of natural disasters, including the forest fires in Portugal, burning oil fields in Iraq, and the earthquake in Iran.

Missions in Preparation

Ground-segment development and preparations for operations continued for the following missions:

- Rosetta (re-defined mission with a launch in February 2004)
- Venus Express
- SMART-2 / Lisa Pathfinder mission
- Herschel/Planck
- Cryosat
- GOCE
- Aeolus.

The activities for these missions covered the ground-station network, mission-control systems, simulators, flight dynamics, and detailed flight-operations preparation and training.

Third-Party Support

ESOC's flight-operations facilities and expertise continued to be very much in demand by a variety of external customers. Activities completed or in progress in 2003 included the preparation of the MetOp-1 launch and early-orbit phase support for Eumetsat, telemetry, telecommand and ranging services to Eutelsat, GPS orbits and clocks services to Eumetsat and Fugro (N), provision of GPS data to Galileo Industries (B) for GSTB-1, network/ground-station services supporting the USERS (JAXA) re-entry mission, and a number of other study/training/consultancy services.

Ground Systems Engineering

Substantial effort was devoted to supporting the European Technology Harmonisation initiative in the ground-segment software area. The EGOS (ESA Ground Operation System) concept is receiving more and more attention from other centres. It brings together all of the ground-segment data subsystems in a rational way to achieve synergy in terms of solutions and products.

The policy of having all ground data systems Unix/Linux-based is being systematically followed and will put ESA in a vendor-independent position. The migration of the SIMSAT simulator to a Linux platform has been started.

ESOC's operational software includes an open licence policy and support for Member State Industry on product lines such as SCOS-2000, SIMSAT, PSS, TMTCS, etc. DLR, Radarsat and Eutelsat are integrating and validating their new control centres based on SCOS-2000. ASI's Cosmos SkyMed, ESA's Vega Programme and SES Astra are considering baselining it for their control centres. More than 55 SCOS-2000 licences have already been granted within Europe, and one was recently also granted to Johns Hopkins University (USA).

The future SCOS-2000 multi-mission version (available by beginning 2005) will provide the advanced functions needed to operate fleets or constellations of satellites. It is the baseline for the Galileo Mission Control System.

The development of the new generation of telemetry and telecommand baseband systems (TMTCS) was started. It will constitute a new cornerstone in the ground-segment infrastructure. CNES and DLR have contributed to its specification and will jointly follow-up the development phase with the intention of possibly deploying the same system on their side.

This systematic approach towards a coherent ground-data-system infrastructure results in substantial cost savings, and has also increased industrial competitiveness in this area.

Those infrastructure elements that were customised for the Mars-Express and SMART-1 missions have been performing flawlessly, demonstrating once more the validity of the product policy being followed.

Flight Dynamics

2003 was the year of the interplanetary missions for ESA. In terms of ground operations, flight dynamics is the discipline most affected by the specific characteristics of interplanetary

flights. Both the orbit determination and orbit/attitude manoeuvring are drastically different from what is needed for Earth orbiters.

The year started with the challenge of a completely revised Rosetta mission after the decision was taken to postpone the launch. Having completed all of the activities needed to be ready for launch and the critical initial operations, the combined Rosetta/Mars Express/ SMART-1 operations team was faced with managing conflicting tasks. After the launch of Mars Express in June much more effort than planned had to be invested to sort out initial problems with the spacecraft. This in turn had to be managed in parallel with the preparations for the further and further delayed launch of SMART-1. After it was eventually launched in September, the team succeeded in supporting the resolution of the initial difficulties connected with the operation of the electrical propulsion system, again in parallel with preparations for the planetary orbit insertion of Mars Express.

At the end of the year, the flight dynamics team could therefore look back on a record of extraordinary achievements and successes. It is ready again for the delayed launch of Rosetta, planned in early 2004; SMART-1 is on its way to the Moon with an electric-propulsion manoeuvre strategy that has never been implemented before; and Beagle 2 has been precisely targeted and ejected from Mars Express. The culmination was the highly critical insertion of Mars Express itself into Mars orbit, the achievement of which put ESA alongside the few big World players in the interplanetary-flight arena.

A survey of the geocentric location antennas in the ESA tracking network, made by taking advantage of global GPS infrastructure, provided essential data for the first ESA interplanetary missions. Significant volumes of GPS ground data were provided to Eumetsat for MetOp, and to the Galileo System Test Bed.

Electrical Engineering

In the Electrical Engineering domain, many activities have been conducted in the context of fast-advancing technologies and applications. Just a few of them are highlighted below.

Communications

ESA has actively supported the definition of the new DVB-S2 global standard for satellite digital communications. It will succeed DVB-S, which currently has hundreds of millions of users worldwide, for direct-to-home digital satellite broadcasting.

Performance improvements in the order of 30% (broadcast systems) and 100-200% (point-to-point systems) have been achieved with digital communications techniques. These improvements are expected to make satellite-based solutions substantially more appealing for mitigating the digital divide in sparsely populated or underdeveloped areas.

Space Weather, Environment and Effects

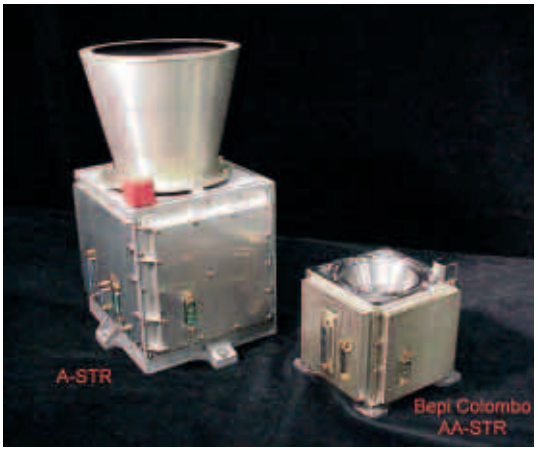
ESA has continued to co-sponsor the development of the Geant4 physics toolkit in collaboration with CERN and other institutes around the World. While aiming at space-related applications, such as manned or science missions, many of the developments have been adopted by the medical and nuclear-physics communities

The Hubble space telescope solar arrays were returned to Earth, where impact features and other damage caused by meteoroids and space debris were recorded and analysed. A pilot project to develop a network of European space-weather services was started in 2003, based on existing assets, in close cooperation with users.

Software Systems

For ESA's Rosetta mission to be a success, the onboard software must be able to control the many complex navigation and landing manoeuvres perfectly, with no room for error. Independent software validation was therefore mandatory, and extensive testing was carried out throughout the year.

Software technology is also applied in the functional testing of satellites, as part of the Electrical Ground-support Equipment (EGSE). A



The star tracker developed for the BepiColombo mission, compared with the current A-STR technology

'virtual representation' of Rosetta has therefore been developed to support planning and instrument operations. This end-to-end simulation will be used during the final approach to the comet, the shape and gravitational-field details of which are not completely known today.

On-board Control Systems

The main focus during the year was on designing advanced control systems for missions such as LISA and Darwin. The second priority was the continuing development of a range of compact and highly performant attitude sensors. Significant progress was made with technologies for low-cost magnetometers, multi-head and compact star sensors, and fibre-optic gyroscopes.

On-board Data Systems

Good progress was made in improving both the compactness and performances of onboard computers. Onboard networks based on SpaceWire high-speed links are now standardised (ECSS-E50-12A), and a large family of devices already exist or are under development.

Development of the 'LEON2' next-generation 32-bit microprocessor progressed significantly, with a fully functional version produced with commercial technology (UMC). Prototypes of a radiation-tolerant version will be available in 2004.

To keep ASIC manufacturing costs at an affordable level, a special setup has been put in place with a major space supplier that allows several ASIC designs to be regrouped on the same wafer.

Proba Satellite Development

The Proba-1 mission (launched in October 2001) has been extended until at least end-2004, following an appraisal of the health of the spacecraft. All instruments will continue to be operated and acquire scientific data. The CHRIS/Proba Earth-observation mission is being revisited to possibly involve new scientists. Use of Proba in the framework of the International Charter on Space and Major Disasters is also currently being analysed.

The Proba-2 mission, initiated in 2003, will also be dedicated to the in-orbit demonstration of the latest spacecraft technology. It will also carry a set of advanced scientific instruments, this time dedicated to monitoring the Sun and plasmas. Launch is planned for 2006.

Power and Energy Conversion

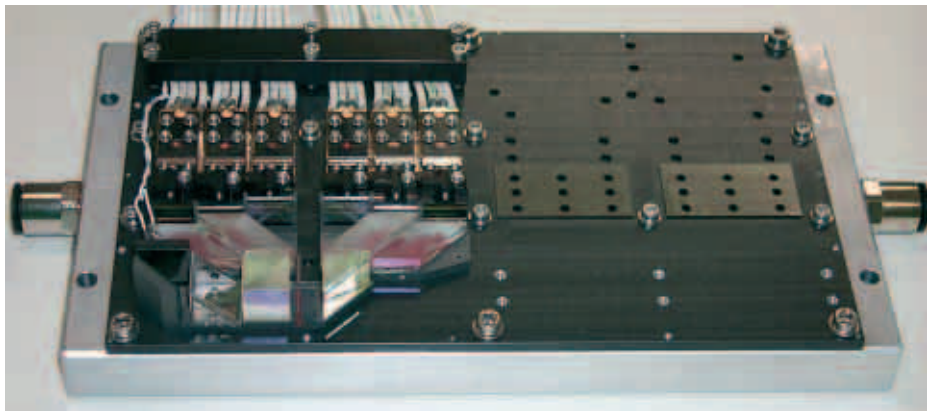
2003 saw the continuation of the development of high-performance European solar generators, with an efficiency of 28% already demonstrated. Power conditioning was also brought within the ongoing technology harmonisation process, together with all related power and energy conversion disciplines.

Intensive support was provided during the year for power-critical missions such as SMART-1 and Mars Express, as well as missions such as Venus Express, Cryosat, GOCE, Aeolus and Herschel/Planck which are now in preparation.

Electromagnetics and Antennas

A conformal phased-array antenna demonstrator has been built with ESA Technology Research Programme funding by Alcatel Space (F). It is the design baseline for the science telemetry link antenna for the Gaia spacecraft, to be launched in 2012. Its electronic beam-steering capability avoids perturbations in the spacecraft's attitude, which is crucial for the correct acquisition of scientific data. Moreover, the semi-active excitation of the antenna sub-arrays, an ESA-patented concept, makes it possible to drive the active components at a constant, optimum output

level, while also providing for graceful antenna performance degradation should any of the amplifiers fail.



Breadboard of a high-power laser amplifier pump unit, powered by two sets of six laser-diode arrays. Micro-optics and prisms rotate to re-arrange the individual laser beams to optimally fill the output fibre

Mechanical Engineering

Mechatronics and Optics

Major R&D effort was directed in 2003 to the preparation of advanced optical payload technologies for science, Earth-observation and communications missions. A large-format CCD focal-plane-assembly technology demonstrator was developed as one of the most critical elements for the Gaia Cornerstone mission. A first front-illuminated prototype of a large-format CCD with front-end electronics and appropriate focal-plane accommodation was produced for Gaia's ASTRO instrument. Ultimately, 180 back-illuminated CCDs will populate the main ASTRO instrument, where minimum gaps, the highest thermal stability and exemplary noise performance (minimal cross-talk) must be achieved. The Gaia mission preparation was further supported with the development of both a large (1.4 m x 0.5 m) SiC mirror demonstrator and a large deployable solar array and sunshield assembly.

Intensive optical-engineering and technology-development effort was also devoted to other scientific missions such as Herschel-Planck, the James Webb Space Telescope, LISA and Darwin, with emphasis on technological issues related to infrared telescope testing, high-stability optical benches, infrared optical interferometry and metrology. As part of these endeavours, Nd:YAG solid-state laser technology was further advanced for potential application on LISA and Darwin.

In the optical communications domain, particular emphasis was placed on the potential use of this technology for deep-space links, orbiter-lander data relay, and links between satellites and the ground. Advanced quantum-communications concepts were also investigated in the light of their promise for global secure-key distribution for data encryption.

Numerous activities were also undertaken in the areas of mechanisms, robotics, microgravity-science instrumentation, and optical diagnostics in support of the Human Spaceflight Directorate. Expertise in space mechanisms and robotics was provided to ATV, ERA and MFC, and work continued in the Automation and Robotics Laboratory on 'Eurobot', a space robot capable of performing the typical inspection, servicing and maintenance tasks at the International Space Station (ISS).

In terms of life-science instrumentation technology, two developments were completed and are expected to find immediate application in projects. The miniature fluorescence microscope will be used for ISS experiments in Biolab, and the ultrasonic beam scanner in the European Physiology Modules (EPM). The latter is able to monitor the dynamics of bone demineralisation during the exposure of humans to zero gravity.

The miniature fluorescence microscope

The ExoMars rover demonstrator

In support of ESA's endeavours in planetary science and exploration, much effort was spent on the study and development of highly miniaturised devices, including micro-rovers, planetary aerobots, microprobes, moles, drilling devices and micro-sensors for the in-situ measurement of chemical and physical parameters. Much of this work was directed to the preparation of the BepiColombo surface element and the Aurora exploration programme, the first mission of which will rely on robotic elements such as the ExoMars rover.

The new low-shock payload-separation system

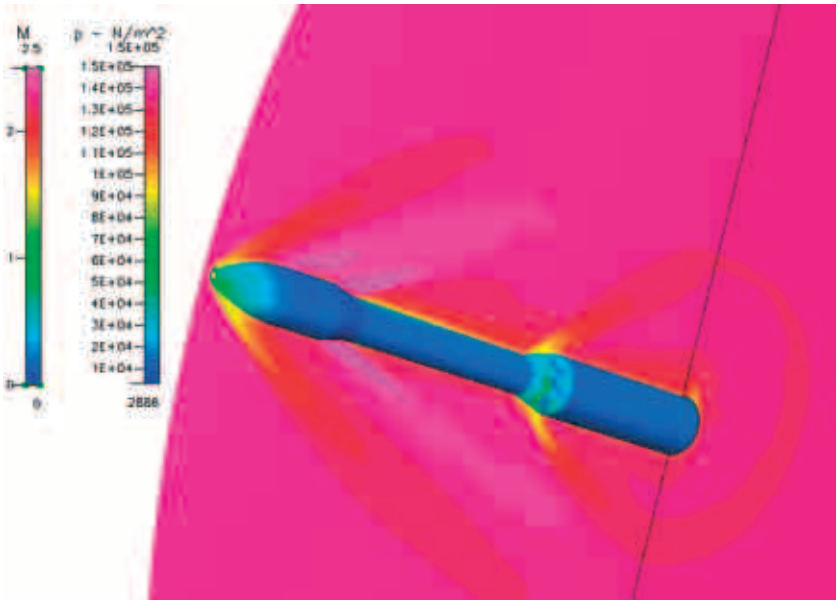
In the area of space mechanisms, considerable attention was paid to technologies serving the competitiveness of European space industry, focusing on the development of such strategic items as motors, momentum wheels, solar-array drive mechanisms and deployable booms. An example of this effort is a new low-shock payload-separation system that was successfully qualified and flight-proven, and has now been selected for use by three major US launch-vehicle operators (Atlas-V, Delta-IV and Sea Launch). This new family of separation systems is on its way to becoming the new industry standard, with 16 orders already received.

Thermal and Environmental Control

New activities have been initiated in support to ongoing and future launcher and re-entry vehicle programmes to develop insulation for hot structures and cryogenic tanks, smart thermal pyrotechnic systems, and onboard oxygen-separation systems. The harmonisation goals identified in the area of cryogenic, pulse-tube and Stirling coolers are being implemented. Two European miniature pulse-

tube designs have been manufactured and promising test results obtained.

In the environmental-control and life-support area, there were major events in terms of preparation for long-duration manned space missions. A water-treatment unit based on Melissa technology was developed for use at the Concordia base in Antarctica, which will provide valuable information for space missions. Two experiments were successfully performed aboard the ISS during the 'Cervantes' mission. One experiment assessed the effects of space conditions on genetic and metabolic processes, and the other investigated bio-contamination of the microbial population of the ISS's atmosphere and surfaces.



Numerical simulation of the aerodynamic forces on the Vega launcher

Structures and Pyrotechnics

Important technology advances were made in a number of structural domains. For inflatable structures, the development of relevant building blocks, material curing methods, as well as advances in numerical analysis tools, have paved the way for the development of a flight demonstrator foreseen for 2004-2005. Inflatable structures are candidates for use in solar arrays, shields, antennas and other large spacecraft appendages.

A Large Deployable Antenna is being developed under an ESA contract with Alenia Spazio (I) as Prime Contractor. The current design is based on a 12 m-diameter reflector antenna, with capabilities to grow to 25 m, making it the biggest antenna of its kind ever developed in Europe and posing several technical challenges, including complex structural verification. The test verification phase begins in 2004.

New versions of the Agency-supported thermal-analysis tools ESARAD (v5.4) and ESATAN/FHTS (v.8.9) were released to industry, providing new features requested by users and by ESA missions (notably BepiColombo). A cluster of 30 Linux PCs was successfully deployed, enabling very large thermal-analysis parameter studies to be conducted rapidly and at very low cost.

The harmonisation of thermal and space environment analysis software and interfaces, which was endorsed by Delegations and Industry, has been initiated. This will lead, in 2004, to an elaborated recommendation to ESA's Industrial Policy Committee (IPC) for a new generation of thermal and space environment analysis tools.

In 2003, ESTEC hosted the 2nd Space System Design Verification & AIT Workshop, the 17th European Workshop on Thermal and ECLS, the International Two-Phase Thermal Control Technology Workshop, and the FENET Workshop on the dissemination of engineering analysis technology. FENET is a European Union thematic network involving more than 100 partners from many industry sectors, in which ESA is leading the aerospace sector together with Airbus.

Propulsion and Aerothermodynamics

In the chemical-propulsion domain, significant support was provided to several ESA projects, including Vega, ATV and Herschel/Plank. The Propulsion Engineering Section also supported the SMART-1 and Mars Express launch campaigns. The development and qualification of ITAR-free components and advanced materials for propulsion continued, including a high-performance 500 N apogee motor for spacecraft, using a combustion chamber made of high-temperature-resistant ceramic material, and a new 200 N-class engine with a SiCrFe-coated niobium combustion chamber. The replacement of highly toxic propellants with

non-toxic (green) propellants of equal or higher performance is being studied.

In the electric-propulsion domain, there were two major events: the rescue of the Artemis satellite thanks to its ion engines, which allowed the spacecraft to be placed in its correct orbit at the end of February, and the launch of SMART-1 to the Moon in September with SNECMA's PPS-1350 Hall-effect thruster as its primary propulsion system. SMART-1 flight data are currently being analysed by a number of European groups coordinated by ESA with a view to using electric propulsion on the new European geostationary satellites, including Alphabus. Electric-propulsion systems are also being developed for several ESA missions, including GOCE, SMART-2, BepiColombo, LISA, Darwin and Gaia. The electric-propulsion system for CNES's Microscope mission is also being provided by ESA.

A major step forward in aerothermodynamics was the initiation of Phase-B of EXPERT, which will provide critical hypersonic flight data for aerothermodynamic tool validation.

Launcher-related activities included the study of Ariane-5 nozzle jet flow interactions, covering numerical and experimental unsteady (buffeting) flow nozzle coupling analysis, and Vega wind-tunnel, acoustics, stage separation, and stage propulsion jet interaction issues.

Product Assurance

Software Product Assurance

The generic SPICE methodology for software process assessment and improvement was complemented through ESA studies to meet the specific needs of space projects, resulting in the so-called SPICE for Space (S4S) assessment framework. During 2003, mixed teams of ESA and external assessors performed a number of voluntary S4S assessments of space system integrators and space software suppliers. The assessment requested by CNES gave it the additional benefit of training for its own internal assessors.

Prompted by the extensive and positive feedback on the added value provided by the S4S approach, a study was performed to evaluate the commercial viability and sustainability of the S4S related services, in particular the certification of the process capability level of software suppliers. The study showed that the space system integrators and software suppliers would be very motivated to certify their software processing capabilities. Although the space market itself seems to be relatively small, it would become attractive if combined with other sectors.

EEE Components

The Component Engineering Division has successfully identified the European space community's technology needs and continued to launch device development and evaluation tasks intended for inclusion in the next generation of European equipment and missions. Working closely with the national agencies, industry and academia to ensure that the right components are developed and that their usage and applications are well specified, the Division continued to promote new technologies such as the radiation-hardened sub-micron and deep-sub-micron silicon technologies, wide-band-gap semi-

conductors, MEMS and nano-technologies, as well as 3 D packaging concepts. In addition, its extensive component-engineering experience and knowledge is being applied to component quality assurance, and a programme of development and improvement of test methodologies and standards is being actively pursued.

The data generated is shared through ESCIES (https://escies.org), the space-component community's on-line information system. It continues to gain in stature and usage, with interest also being shown by organisations beyond the ESA Member States.

Some of the many visitors to the Concurrent Design Facility (CDF) during the year

Materials and Processes

The Division devoted the majority of its resources in 2003 to supporting ESA projects, in particular by evaluating new materials and processes for future missions. Especially the new ESA scientific missions to the inner part of the Solar System, such as BepiColombo, Venus Express and the Solar Orbiter, pose a great challenge for materials and processes due to the extreme temperatures and harsh solar radiation that prevail.

In addition, materials and processes standards were published, via the ECSS, to enhance the quality of space hardware. The Division also organised the highly successful 9th International Symposium on Materials in a Space Environment in June at ESTEC, where a record number of papers were presented.

European Cooperation for Space Standardization (ECSS)

The ECSS's mission is to achieve harmonisation of space requirements in the management, product assurance, and engineering field, with the aim of achieving a single set of space standards in Europe. From the outset, the ECSS concentrated on the creation of standards with the unique characteristic of being a logical and coherent system, well-suited to the needs of the European space projects, in the following areas:

- Product Assurance and Safety (ECSS-Q series)
- Engineering (ECSS-E series)
- Management (ECSS-M series).

Altogether work has progressed on 120 standards (not including revisions and document requirements definitions), which have either been published, are presently under review, or in the drafting stage.

In addition, 40 ECSS standards were approved as European Norms (ENs) and three as international ISO Standards.

There has been a sharp increase in the use of the ECSS standards in ESA programmes and projects, including the Galileo Programme. To reinforce this positive trend, the ESA Standardization Steering Board (ESSB) organised two Workshops for ESA's programme managers in 2003 on the application of the ECSS standards to ESA activities.

Concurrent Engineering

Concurrent Engineering methods and tools were applied for a wide range of applications in support of several Directorates and Programmes, including robotic and human exploration missions, launchers and payload instrument design. Several new applications required the development of more complex models and the inclusion of new disciplines, parameters and data.

The Concurrent Design Facility (CDF) continued to provide effective multidisciplinary support to many ESA Programmes, including Aurora, Science, Microgravity, General Studies

and Launchers. The following potential future missions were studied and designed at conceptual level during the year:

- Mars Sample Return: all phases and elements
- Crew Transportation and Rescue Vehicle: modelling and trades
- Mars Network Science: probe network on Mars
- AeroCapture Demonstrator: Earth and Mars orbits
- Socrates Reusable Launcher Demonstrator
- Human Missions to Mars
- Human Spaceflight Vision: permanent lunar base.

Mixed teams of specialists from ESA, national Agencies and European Industry were created to perform some of the above studies. This contributed to the sharing of experience and knowhow in concurrent-engineering principles with other European partners, as well as supporting them in the development of their own concurrent design centres and the application of related methodologies and tools.

The CDF also played an active role in the areas of Education and Technology Transfer, hosting several studies and reviews, presentations, and workshops. It was also visited by scores of people from the space and other engineering disciplines, academia, and industrial companies.

Last but not least, the generation of standards for exchanging data produced during the preliminary phases of a project's life-cycle was initiated. The next step will be to propose the creation of a 'network of excellence' in concurrent engineering in the European space field.

Network of Centres Initiative

ESA continued to coordinate the various pilot networks of the Network of Centres initiative, reinforcing relations with the participating members through the elaboration of a number of different cooperative activities at both the management and technical level.

The Project Reviews pilot successfully completed the Qualification Phase by passing an independent review, and the subsequent Operational Phase is allowing participating members mutual access to a large pool of experts as and when required, on a non-exchange-of-funds basis.

After completing its Qualification Phase, the Flight Operations pilot was deemed not ready to enter the operational phase. The subsequent consultations between ESA and the participating Member States resulted in a clear understanding of the open policy issues and culminated in the definition of a step-wise approach to the creation of a future operational network.

Technical cooperation in the flight-operations domain was also intensified between participating technical centres - particularly ESOC, GSOC and CNES - while initiatives for the exchange of experts in satellite design and related technologies between ESTEC and CNES have also been started. In particular, new networking possibilities in the field of technical competencies and laboratories are being considered and proposals elaborated.

The Network of Centres Pilot on Space Debris continued to implement the agreed work programme with its partners, as well as providing a rapid response to satellite-debris and related re-entry questions.

In addition, an ESA Task Force was set up to analyse the further evolution of the Network of Centres Initiative in general, addressing not only the relations with future programmes, but also clarifying the commitments and obligations of participating agencies and their technical centres and addressing those technical domains where networks could be considered valuable in the future.