Human Spaceflight, Microgravity and Exploration

At year's end, the International Space Station (ISS) was in good shape with a permanent crew of two, and there were no critical hardware or consumables issues. The European elements delivered so far, namely the Data Management System for the Russian Segment (DMS-R) and the Microgravity Science Glovebox, were also performing well. Preparation of the European-provided Automated Transfer Vehicle (ATV-1), of Node 3 and of the ground segment is on schedule, while the development of other elements such as Columbus, the Cupola and the European Robotic Arm (ERA) has been successfully completed.

A total of six flights were made to the ISS during the year, four of which were logistics flights with unmanned Russian Progress vehicles, and two were Soyuz flights used for crew rotation. The first of the Soyuz flights also hosted the 11-day 'DELTA' Dutch Soyuz mission with ESA astronaut André Kuipers (left), who successfully performed experiments in the fields of life sciences, physical sciences, Earth observation, technology and education.

As the US Space Shuttle is the key transportation element for completing ISS assembly, its grounding following the Columbia accident on 1 February 2003 continued to have a major impact on the European part of the ISS programme during 2004. Currently, the Shuttle's return to flight is planned by NASA for May/June 2005.

Furthermore, 2004 was marked by US President George W. Bush's announcement in January of the New US Space Exploration Vision/Policy, several aspects of which are relevant to the ISS programme:

- confirmation that the completion of ISS assembly by 2010 is the first goal, and that the United States will meet its obligations to International Partners
- the plan to retire the Shuttle when ISS assembly has been completed
- provision of commercial cargo transportation
- cancellation of the development of the Orbital Space Plane, which was foreseen as a crew transport vehicle for the ISS, in

favour of the development of a new Crew Exploration Vehicle, planned to be operational in 2014.

In providing an insight into the new Policy, NASA reiterated that the US is fully committed to: meeting the International Partners' ISS utilisation requirements and US crew-rescue obligations, increasing the ISS crew size beyond three as soon as technically possible, completing the ISS assembly and operating the ISS subsequent to assembly completion, and implementing already agreed cooperative research projects. In view of NASA's decision to cancel the Orbital Space Plane, the International Partners agreed to use a second Russian Soyuz capsule, as soon as technically possible, to increase the size of the permanent crew (a crew of six as of January 2009). Final endorsement of the approved ISS technical configuration, and formal endorsement of the advancement in the assembly sequence of the launch of the European laboratory Columbus such that it immediately follows the launch of Node 2, was later obtained at a meeting of the Heads of Agencies in January 2005.

The delays to ISS elements due to the Shuttle's grounding necessitated some re-planning of European development activities to take into account the delayed launches. The ESA utilisation-related activities for the period 2004-2006 have also been adapted and complemented by a package of Interim Utilisation Activities, which are essential for the user community to bridge the gap until the start of Columbus utilisation. Columbus payload development extension activities were also defined and their contractual implementation is in progress. The Columbus payload racks have been returned to their developers until autumn 2005 for further flight-readiness completion, including further enhancement of technical robustness and implementation of upgrades/modifications to satisfy the latest scientific user requirements. The industrial teams will be maintained until Columbus is launched, and in the meantime studies related to the post-Shuttle-retirement era will be performed.

Biolab, the European Physiology Module, the Fluid Science Laboratory and the European Drawer Rack integrated into Columbus

In preparation for the arrival at the ISS next year of the first ATV, named 'Jules Verne', the ISS Expedition-9 Crew successfully performed two 'space walks' to install some associated equipment on the Russian module 'Zvezda'.

Preparations are well underway for an Italian Soyuz Mission known as 'ENEIDE', to be launched on 15 April 2005 with ESA astronaut Roberto Vittori aboard. A long-duration ISS mission for an ESA astronaut is planned for later in 2005.

Space Infrastructure Development

Testing of Columbus has shown that the audible noise level is well below the requirement threshold, making it the ISS's quietest module. The Integrated System Test (of the Columbus module together with its integrated active payload racks: Biolab, European Physiology Modules, Fluid Science Laboratory and European Drawer Rack) was successfully performed during the year, as were the System Validation Tests 1 (Columbus Control Centre and Columbus engineering model), and 2 (Columbus flight model, payload racks, Control Centre, and User Support and Operations Centres). Testing of the first NASA payload rack installed in Columbus, the Human Resource Facility, was completed in October, and the Columbus Qualification Review 2 was successfully concluded in November.

The flight model of the first Automated Transfer Vehicle (ATV-1) being prepared for environmental testing in the ESTEC Test Facilities

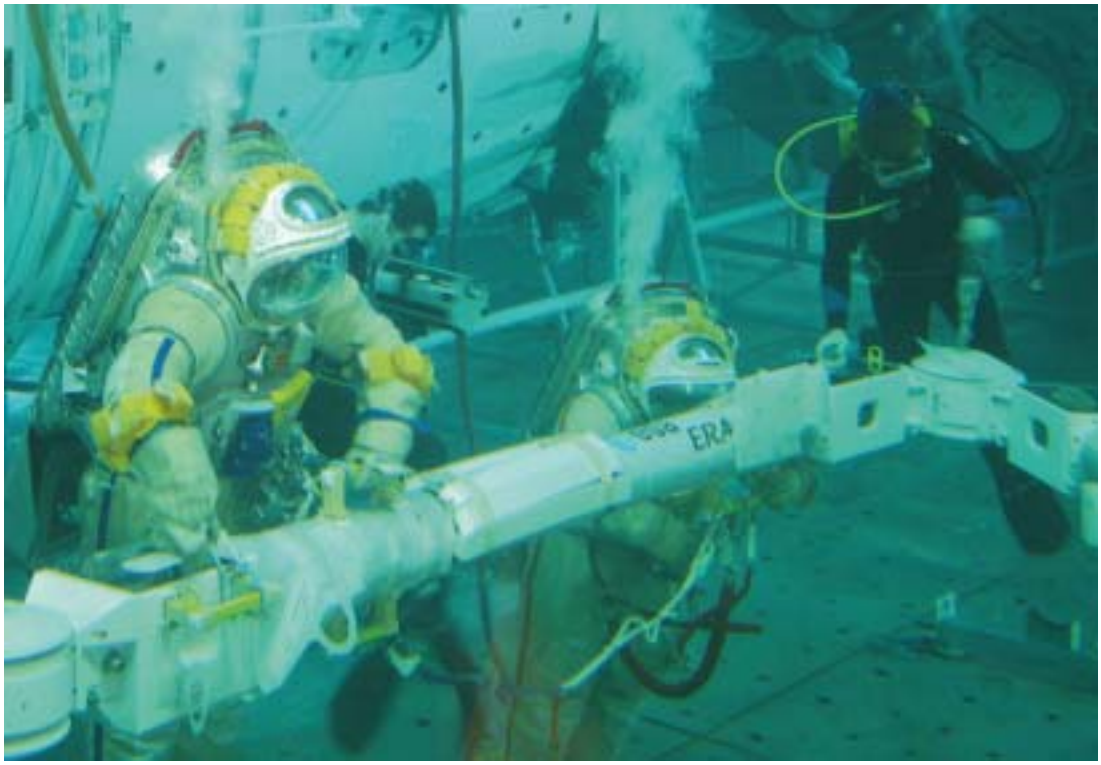
The flight model of the Cupola, which was delivered to NASA/KSC

The ATV-1 Spacecraft Structure Qualification Review and System Validation Tests involving the ATV flight and ground segments and using the Data Relay Satellite System, were also successfully performed. In mid-July, the flight model was delivered to ESTEC in Noordwijk (NL) for extensive environmental testing prior to shipment to Europe's Spaceport in French Guiana for launch. The first mating of the flight model and the first part of the environmental test campaign were successfully completed, and functional testing continues. Development of the very complex Flight Application Software and the adaptation of Ariane-5 necessary to launch the ATV are ongoing.

During the year the management of the Nodes programme, which had previously been delegated to ASI (I), was transferred to ESA by mutual agreement. An updated technical baseline, an updated schedule (for delivery in late 2006), and a joint ESA/NASA management approach for the future implementation of the remainder of the Nodes 2/3 project was established with NASA and industry. In the meantime, the external structure of Node 3 has been completed and the post-proof Non-Destructive Inspection successfully performed. The overall integrated leak test on Node 2 was successfully performed in the vacuum chamber at NASA's Kennedy Space Center (KSC).

Development of the Cupola was completed in September, and the flight unit was delivered to KSC, where the post-shipment incoming inspection was successfully performed.

A new mission scenario for the European Robotic Arm (ERA) has been established, whereby it will be launched in late-2007 by a Russian Proton rocket together with the Russian Multipurpose Laboratory Module, which will act as its 'home base'. The ERA development activities were completed and its ownership transferred to ESA in November; some design adaptations and re-qualifications will be needed, as well as modifications to the



An underwater test on the ERA Weightless Environmental Test Model, in progress at the Gagarin Cosmonaut Training Centre near Moscow

operations planning and training scenarios, to fit with the new plan.

Operations, and Related Ground Segments

The highly successful DELTA mission was launched, with ESA astronaut André Kuipers serving as flight engineer, on 19 April from the Baikonur Cosmodrome in Kazakhstan. It concluded with a successful landing on 30 April near the town of Arkalyk, also in Kazakhstan. The 11-day mission, which included nine days on the ISS, achieved all of the major objectives set for it: the intense experiment programme was successfully carried out, the ISS Expedition-8 crew was exchanged, and the Soyuz spacecraft, which had served for six months as the crew lifeboat, was replaced.

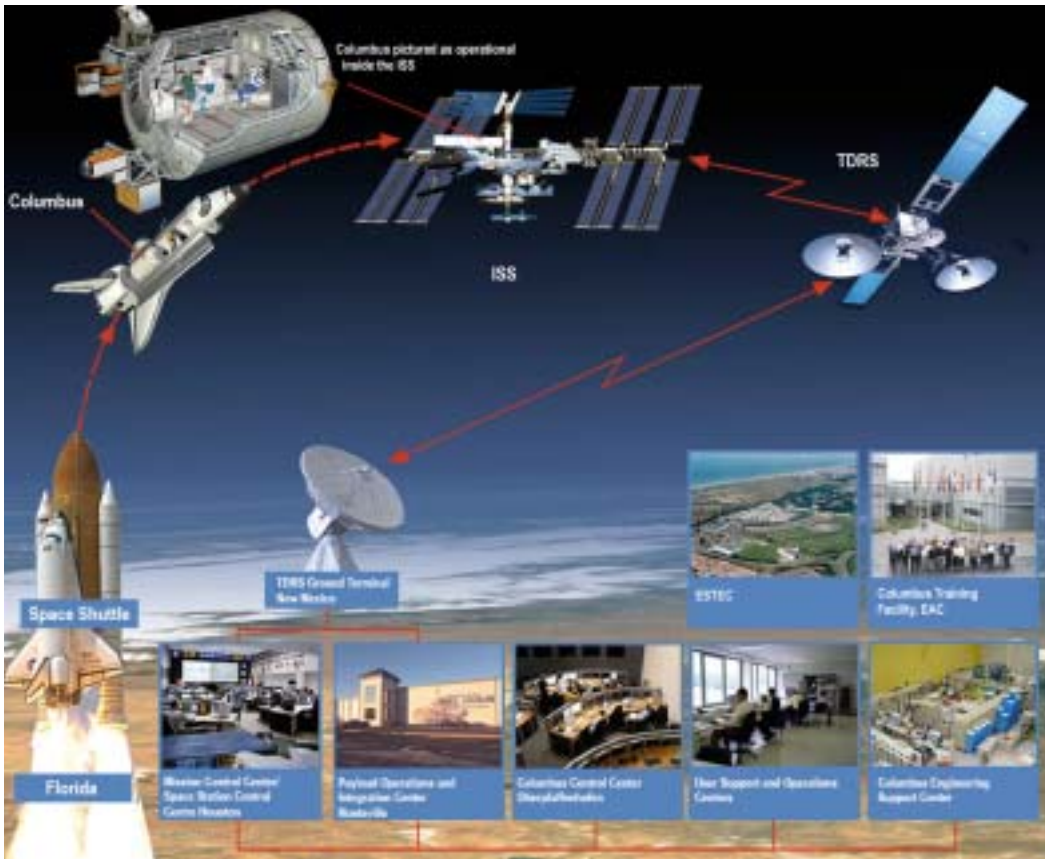
During the DELTA mission, Kuipers carried out one of the most extensive experiment programmes ever undertaken by a European astronaut onboard the ISS, conducting a total of 21 experiments in the fields of human physiology, biology, microbiology, physical science, Earth observation, education and technology. There were also numerous contacts with the media in The Netherlands and other countries during his stay onboard.

Real-time operations during the Dutch Soyuz mission were coordinated from the DELTA Payload Operations Centre at ESTEC in Noordwijk (NL), which acted as an interface between Kuipers, the Dutch Investigator Support Room and the Control Centres in Moscow, Houston and Huntsville. The European Astronaut Centre (EAC) near Cologne (D) was responsible for the ESA astronaut's medical support and crew safety.

The Automated Transfer Vehicle Control Centre in Toulouse (F) during a System Validation Test

The human upper-body radiation phantom 'Matroshka', mounted on the Russian Service Module during an EVA at the end of February, is performing as expected with on-orbit science operations proceeding satisfactorily.

System Validation Tests, including end-to-end tests with the NASA Tracking and Data Relay Satellite System, and involving the ATV Control Centre (ATV-CC) in Toulouse (F), were successfully performed. The ATV-CC infra-structure is currently nearing completion and the operations products are in preparation. The ATV Flight Operations Readiness Review was successfully held in September. The first



The Columbus mission scenario

Experimenters at work during the 37th Parabolic Flight Campaign in June

interface tests between the ATV-CC and the Houston Mission Control Centre, and between the ATV-CC and the Russian Service Module Simulator, have been conducted successfully.

The Columbus Control Centre (COL-CC) was inaugurated on 19 October, signifying its readiness to support mission preparation. During the year, significant progress was made in preparing the COL-CC to support the Interim Utilisation Activities, the 'Jules Verne' ATV mission, and the Italian Soyuz mission. The COL-CC will in fact control and command the European science experiments during the ENEIDE mission.

Work on preparing the User Support and Operations Centres is progressing well, with all USOCs being outfitted with ESA-furnished communications, data-processing, archiving, voice and video equipment.

Signature of the Initial Exploitation Contract, involving a total of around one billion Euros and covering the production of six ATVs, logistics and sustaining engineering, ATV crew training and operations-preparation activities, took place on 13 July.

Utilisation Planning, Payload Development and Preparatory Missions

Additional experiment drops have been performed within the Interim Utilisation activities. December saw the inauguration of a new catapult system at the ZARM Drop Tower in Germany, which allows vertical rise-and-fall trajectories to be performed, thereby almost doubling the free-fall time.

During the 36th, 37th and 38th ESA Parabolic Flight Campaigns, which took place in March, June and October, respectively, a total of 36 experiments were performed. 30 experiments were also conducted during the 7th ESA Student Parabolic-Flight Campaign in July.

Development was completed of the 400 kg payload complement (15 facilities and 38 experiments in the fields of physics, biology, technology and education) for the unmanned Foton-M2 capsule flight scheduled for 30 May 2005. The 315 kg ESA scientific-payload complement for Foton-M3 (14 facilities and 35 experiments), scheduled for launch at the end of 2006, was approved in early November and the necessary development work has already started.

The Maxus-6 sounding-rocket launch from Esrange (S) on 22 November

The Maxus-6 sounding-rocket mission was successfully launched on 22 November from Esrange in Sweden. Carrying eight scientific experiments in biology, fluid physics and materials science, the rocket reached an altitude of 706 km before falling back to Earth, providing 12.5 minutes of microgravity for its scientific payload.

The Pulmonary Function System and the Percutaneous Electrical Muscle Stimulator, to be integrated into NASA's Human Resource Facility-2, have been delivered to NASA and are ready for launch in 2005 on LF-1.

Following a successful Flight Acceptance Review, the flight model of the European Modular Cultivation System (EMCS) was shipped to KSC, where final testing will be completed by March 2005, prior to its launch in an EXPRESS rack on the ULF-1.1 mission to the ISS.

The Portable GloveBox's development (for biology-experiment handling in orbit) is progressing towards its launch with ATV-1, and training- and flight-model deliveries are on schedule.

Testing of the -80°C Freezer MELFI Flight Unit 1 and 2 at KSC was successfully concluded. MELFI FU-1 will also be launched on ULF-1.1.

The European Transport Carrier Final Acceptance Review 1 was completed in December.

All Columbus rack payloads (Biolab, EPM, FSL, EDR) have successfully passed their interface verification tests and have been returned to the developers for verification closeout, further science-driven upgrades, and robustness testing. Biolab, EPM, and FSL have also passed their Flight Acceptance Reviews.

The preliminary acceptance of the engineering model of the Protein Crystallisation Diagnostics Facility took place in December, and the Acceptance Review for the flight model began in November.

Post-shipment activities for the engineering models of the Materials Science Laboratory (MSL) and the Low Gradient Furnace were completed at NASA's Marshall Spaceflight Center.

The first three experiments for EuTEF (an external payload providing accommodation for

Interface testing of the first three experiments to be integrated on the EuTEF flight model

up to nine technology experiments) were integrated on the flight model, and interface testing with Columbus was successfully completed in November.

The acceptance of the three SOLAR (Solar Monitoring Observatory Facility) flight-model instruments is in progress, and interface testing of the SOLAR engineering model with Columbus was successfully completed in December.

The Payload Preliminary Design Review for the Atomic Clock Ensemble in Space (ACES) was successfully closed out and the payload development continued. The Status Evaluation for the Space Hydrogen Maser (SHM) is in progress, and agreement has been reached on the development of the other instrument, PHARAO (laser-controlled atomic clock), up to completion of the engineering model in December 2006.

The Muscle Atrophy Research and Exercise System (MARES) completed its Critical Design Review and the full functionality of its interface with the Percutaneous Electrical Muscle Stimulator was verified.

The first 60-day campaign of Long-Term Bed-Rest Studies on females, being conducted in cooperation with NASA and CNES, is scheduled to start on 22 February 2005.

Dutch and Belgian children who won the 'Zeg Het ISS' competition putting their questions during the live ARISS link with André Kuipers on the ISS

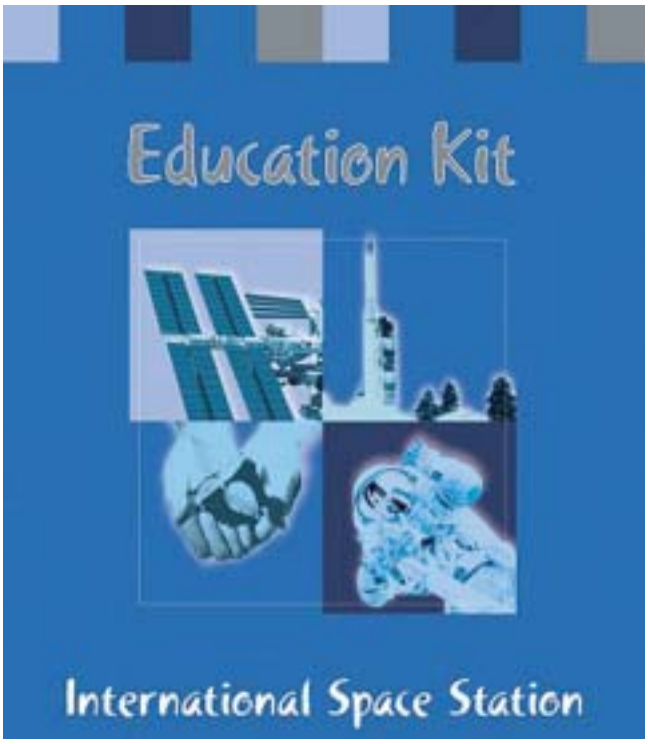
32 Microgravity Application Promotion (MAP) projects are continuing into Phase-2.

In response to the International Life Science Research Announcement (ILSRA2004), around 70 proposals were received, of which 15 have been selected for definition studies; ESA's AO 2004 elicited some 150 proposals, 120 of which have been selected for definition studies..

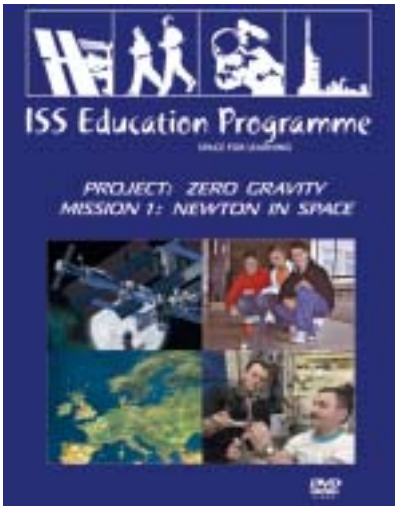
2004 also marked the start of important utilisation projects involving the European Commission (EC). ESA, the World Health Organization, the International Telecommunication Union, and the EC Directorate of Information Society Technologies Programme signed a contract for the TM Alliance Telemedicine project, which officially started on 1 August. The second phase of the project, TeleMedicine Alliance-Bridge, has also been approved by the EC and is proceeding smoothly towards the next phase. 1 November marked the official start of the 41 MEuro IMPRESS Integrated Project, which will investigate the materials processing, structure and properties of new higher-performance inter-metallic alloys for industrial applications.

ISS Education

An education programme including experiments and activities for the full formal school cycle was implemented during the Dutch Soyuz mission. The Dutch and Belgian children who won the 'Zeg Het ISS' competition (project for primary schools) were rewarded with the opportunity to put questions to André Kuipers during an Amateur Radio on the ISS (ARISS) live link. Two such links were set up during the mission. Two university biology experiments were performed, as well as the 'Seeds in Space' experiment, in which 70 000 Dutch pupils took part. An educational demonstration of human physiology, made by filming four basic physiology experiments onboard the ISS, is currently being used, together with experiments shot on the ground at schools in Denmark, France, The Netherlands and Belgium, to prepare a DVD titled 'The Human Body in Space', to be released in 2005.



The secondary-level ISS Education Kit, now available in 11 languages



The educational DVD 'Newton in Space' distributed in September

In September, the EC project 'Life in Space 2004', undertaken in the framework of the ERASMUS/SOCRATES Programme, concluded with a two-week Workshop in Banyuls-sur-Mer (F). The 35 life-sciences students who took part, from five European universities, were introduced to the latest European research in space biology.

In 2004, eight new funding members joined the ISS Education Fund, which continues to support the development of new educational products. Meanwhile, the existing education material, such as the DVD 'Newton in Space' and the secondary-level ISS Education Kit, which is now available in 11 languages, are in great demand.

The didactic content of the new ISS Education Kit for primary schools was assessed by a group of teachers from five ESA Member States at a Workshop in Glasgow (UK). In another Workshop at ESTEC, teachers validated the 'Space Team' web site.

Starting in 2005 for a period of three years, 15 Dutch primary schools will be able to qualify for the title of DELTA Researcher School by developing a lesson plan using human spaceflight to attract pupils aged 10-12 into science and technology. The initiative forms part of the five-year Dutch Space Action Plan, and is a cooperative venture between ESA, NASA and the Dutch Ministry of Education, Culture and Science, as a follow-up to their collaboration in the DELTA Soyuz mission education programme.

The third edition of the SUCCESS contest for university-student experiments to be performed onboard the ISS was launched on 1 December.

Commercial Activities

The MEDIET (Mediterranean Diet) experiment, sponsored by the COOP supermarket chain and conducted onboard the ISS during the Dutch Soyuz mission, attracted extensive media coverage.

The European Health Care Network, aimed at exploiting ESA's expertise, technology, access to research facilities and high-tech image commercially in the healthcare and well-being sectors, was launched in May. Products integrating ESA technologies and know-how, and developed with the support of the Network, will be branded using the new ESA Space Solutions trademark.

Contracts for commercial 'ESA Space Training' and for appointing a Commercial Agent to market the use of the European facilities and resources onboard the ISS, were signed in September. Meanwhile, the ISS Business Club continues to acquire new members.

Exploration

As part of an Agency internal reorganisation, from 1 November activities related to Exploration have been integrated into the newly created Directorate of Human Spaceflight, Microgravity and Exploration.

In line with the goals expressed by ESA's Director General, and renewed interest in exploration worldwide, the Agency has introduced Space Exploration as an inspirational element of the European Space Programme, continuing the activities carried out since 2001 within the Aurora Programme. In late 2004, the Participating States approved a significant increase in the financial envelope for Aurora, with emphasis being placed on conducting a Phase-B1 study of the ExoMars mission, and associated instrument and technology studies, and the development of a European long-term scenario for space exploration. Sweden has joined this optional programme, and the EC has Observer status in accordance with the Framework Agreement.

Following President Bush's announcement of the New US Space Exploration Vision/Policy in January, ESA staff had a number of meetings with their NASA counterparts to understand fully the content of the US programme, to analyse its potential interest to Europe, and to evaluate possible cooperation scenarios.

Whilst Mars remains the long-term goal for the ESA human-exploration activities, lunar-exploration scenarios are also being evaluated as an important intermediate step, and their integration into the overall European roadmap for exploration is in progress. To that end, the industrial mission-study initiatives in the framework of the Aurora Programme – Phase-A of ExoMars, Entry Vehicle Demonstrator feasibility, and Mars Sample-Return mission definition – were completed in 2004, and will be followed up in greater detail in 2005.

A study on Human Lunar Exploration was also performed in the ESA Concurrent Design Facility, which examined mission architectures and common elements for different lunar-exploration objectives, such as Mars technology demonstration and lunar exploration.