Human Spaceflight, Microgravity and Exploration

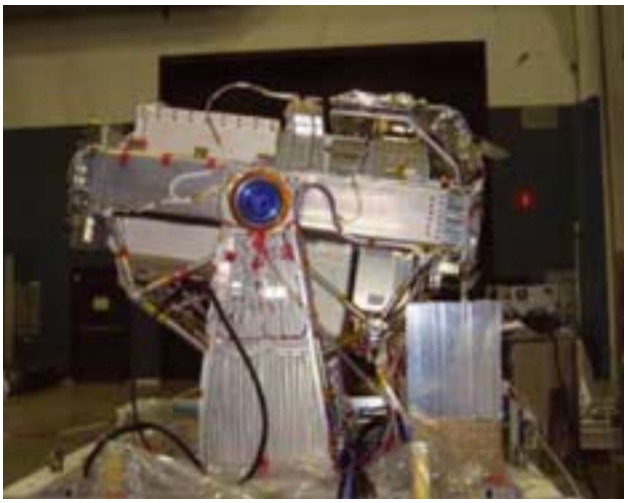
ISS/STS

At a meeting of the International Space Station Partners Heads of Agency (HoA) in January, a revised Assembly Sequence and overall ISS configuration was agreed by all parties, based on a Shuttle-flight programme of 28 missions before end-2010. Subsequently, during the summer, following internal studies ordered by the new Administrator Dr. M. Griffin, NASA announced that there would be 18 flights to the Station, and a revised plan for these flights had to be established. In cooperation with all of the International Partners, ESA has worked to optimise the assembly sequence and its associated schedule, aiming to advance the launch of the Columbus module in the process, with a view to achieving agreement at a further HoA in spring 2006.

Meanwhile, the ISS continued to remain in good technical shape throughout 2005, celebrating the fifth year of permanent human presence on the Station. The European elements already in orbit, namely the Data Management System for the Russian Segment and the Microgravity Science Glovebox, have performed flawlessly. Four logistic flights and two crew-rotation flights were made to the Station, one carrying ESA astronaut Roberto Vittori on his second mission 'Eneide', as well as the first Shuttle flight for two and a half years.

This Shuttle Return-to-Flight mission (LF-1) took place successfully in July, but some foam loss from the external tank and the consequences of hurricane Katrina led to the postponement of its next launch (flight ULF1.1) to no earlier than May 2006. ESA astronaut Thomas Reiter will fly on ULF1.1 to become the first European long-duration ISS crew member, and during this 'Astrolab' mission he will perform the normal ISS crew system activities as well as a programme of European scientific and educational activities.

ESA astronaut Roberto Vittori (right) during the Eneide mission to the ISS in April



The SOLAR flight model

EuTEF during interface testing at EADS in Bremen (D)

Columbus

During the year the Columbus system successfully completed an extensive system test campaign involving the module, its payload complement and the ground segment. A final end-to-end system validation test involving the User Support and Operations Centres (USOCs) will be performed prior to the Final Acceptance Review and shipment to Kennedy Space Centre in May 2006. The module itself has achieved its Certificate of Qualification from ESA.

The payload-rack facilities – Biolab, Fluid-Science Laboratory, European Physiology Module, and European Drawer Rack – completed their qualification and were installed in the module to support the successful testing of the flight configuration. They will be delivered to the launch site in their launch configuration inside the module. The external payloads SOLAR and EuTEF were also successfully tested with the module. They have since been returned to the developers for final closeout activities prior to their separate shipment to the launch site, also by mid-2006.

The Columbus Control Centre (Col-CC) completed much of its qualification, and the Qualification and Final Acceptance Reviews will be concluded by mid-2006. With the completion of the Col-CC infrastructure development, the flight control team for the upcoming ISS missions – the long-duration 'Astrolab' mission and the Columbus launch – can take over. A dedicated Mission Operations Service has been set-up with EADS-ST and DLR. An ESA Flight Operations Team located at the Col-CC has been formed with an ESA Operations Manager on-site to interact with the Service's Flight Director Office. The USOCs are also in an advanced stage of completion and, together with the Col-CC, will support the final end-to-end testing of the Columbus system early in 2006.

The Columbus Control Centre at Oberpfaffenhofen in Germany

Artist's impression of ATV cargo transfer

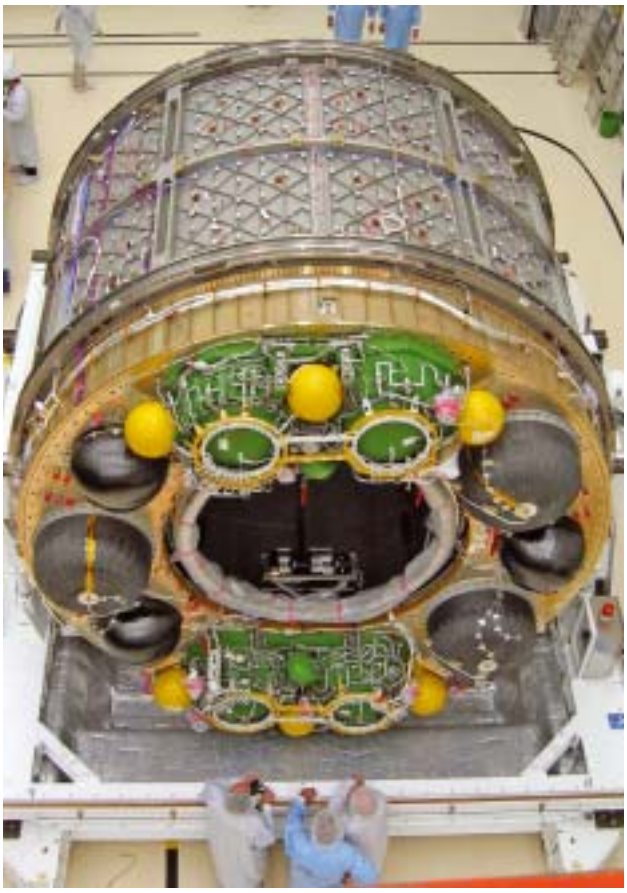
With respect to crew training for the Columbus system, the 'user- and operator-level' training development was completed and the respective training dry-runs were performed. The 'specialist-level' training is also well advanced. The training team is ready to train the ISS Assembly flight 1E Shuttle crew and the subsequent Station crews for Columbus.

The Columbus Trainer at EAC was successfully connected to the Control Centre's mission control system and has participated in integrated tests. The corresponding trainer at NASA/JSC (Houston) also successfully supported integrated tests.

ATV

Major advances were made during the year in freezing the Automated Transfer Vehicle's overall mission scenario, which had led to many design changes in the past. The flight applications software, which was previously a major problem area, is now stable.

The first ATV spacecraft, 'Jules Verne', successfully passed its integrated system EMC tests, various crew interface tests and the first end-to-end system interface tests. However, the test campaign was seriously impacted by various hardware problems, in particular the failure of latch-valve



The ATV propulsion module in the test facilities at ESTEC in The Netherlands

Participants in the ATV Increment training at EAC in Cologne-Porz (D) in August

rods (all 44 of which have had to be replaced), noise in the potentiometer of the solar-array drive (which necessitated adding a back-up position-reading mechanism), and failures of the ISS camera target (since redesigned). The system functional qualification test programme on the engineering model progressed, but proved far more difficult than originally planned. All of these problems led to significant slippages in the qualification and acceptance programme, but by the end of the year the situation had stabilised and the project was back on track.

Production of additional ATVs was deliberately slowed and adapted to the progress of the ISS assembly and 'Jules Verne' development. The number of additional ATVs to be procured was also reduced from 6 to 4 in order to accommodate the current ISS scenario.

The ATV Control Centre successfully performed the planned system validation test, and the monitoring and control system is ready to undergo formal acceptance. The remaining open areas from the Flight Operations Readiness Review were finalised and development of the multi-segment operations products is proceeding. The full Flight Control Team is in place and the development of the engineering support tools has started. Official inauguration of the ATV Control Centre is planned for mid-2006.

The Cargo Operations Team finalised the second analytical integration cycle and established a reference cargo manifest. All the ATV-related equipment required on the ISS Service Module ('Zvezda') was transported to, and installed on, the ISS, including the proximity communication system, the new camera, a new Russian GPS and a new crew display.

From the crew perspective, the material for the first part of ATV training was finalised by the training team and successfully used to train all ISS Increment-13 prime and backup crew members for one week at the European Astronaut Centre (EAC). All Service Module crew hardware and software interfaces have been defined and the final testing is now taking place. The crew-monitoring concept was agreed by all International Partners and most of the new procedures were developed and are now under review.

The testing of the adaptations to Ariane-5 for ATV was completed on the Vehicle Equipment Bay and the upper-stage engines. The qualification review for the adaptations will be held in mid-2006.

A credible schedule is now in place for all elements of the 'Jules Verne' mission to the ISS, leading to its readiness for launch in spring 2007.

Other Flight Elements

Node 2 integration at Kennedy Space Centre (KSC) is complete and interface tests with the JAXA JEM module

Node 2 at Kennedy Space Centre in Florida (USA)

Node 3 at Alenia in Turin, Italy

have been successfully completed. Node 2 is currently being closed-out ready for launch on ISS Assembly flight 10A. The integration activities on Node 3 in Turin (I) were completed during the year and the testing and verification programme started on schedule to support a delivery to NASA in December 2006/early-2007.

The planned Cupola activities at KSC were completed and it is currently in storage, awaiting a launch flight allocation.

Activities required to prepare the European Robotic Arm (ERA) for launch on the Russian Multipurpose Laboratory Module (MLM) started, and the related modifications to the operations planning and training scenarios were performed. The Mission Preparation and Test Environment (MPTE) was prepared for shipment to Russia after the Russian Instructors had completed their training at ESTEC.

Utilisation

A steadily expanding European life and physical sciences user community now numbering some 2000 resulted in the solicitation, within the framework of ILSRA-2004 and AO-2004, of many new, highly ranked, fundamental and applied research proposals, which were subsequently peer-reviewed and approved by the Programme Board. Some 200 projects are targeting the ISS as a research platform, while a similar number use other mission platforms or are ground-based (e.g. bed-rest studies or artificial gravity).

The international WISE bed-rest study was extremely successful. The results will be of major importance for crew health during future long-duration space flights.

The Zarm drop tower in Bremen, Germany

Various European Commission projects such as those in human physiology (Telemedicine; Advanced Detection of Bone Quality) were successfully performed. Joint activities with the EC were also initiated in education and the resulting products were widely distributed within the ESA Member States.

The Maser-10 launch from Esrange (S) in May

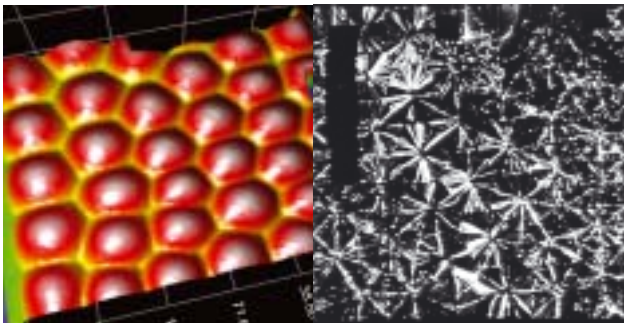
The Zarm Institute's drop-tower infrastructure in Bremen (D) supported various preparatory research experiments in fundamental physics and combustion. In the future, the catapult function will facilitate a doubling of the time available in microgravity.

The Airbus A300 aircraft was used for three ESA flight campaigns, with further experiments being flown on national CNES and DLR campaigns.

The Maser-10 sounding-rocket mission, comprised of five modules containing experiments in biology and fluid physics, was launched in May from Esrange in Sweden.

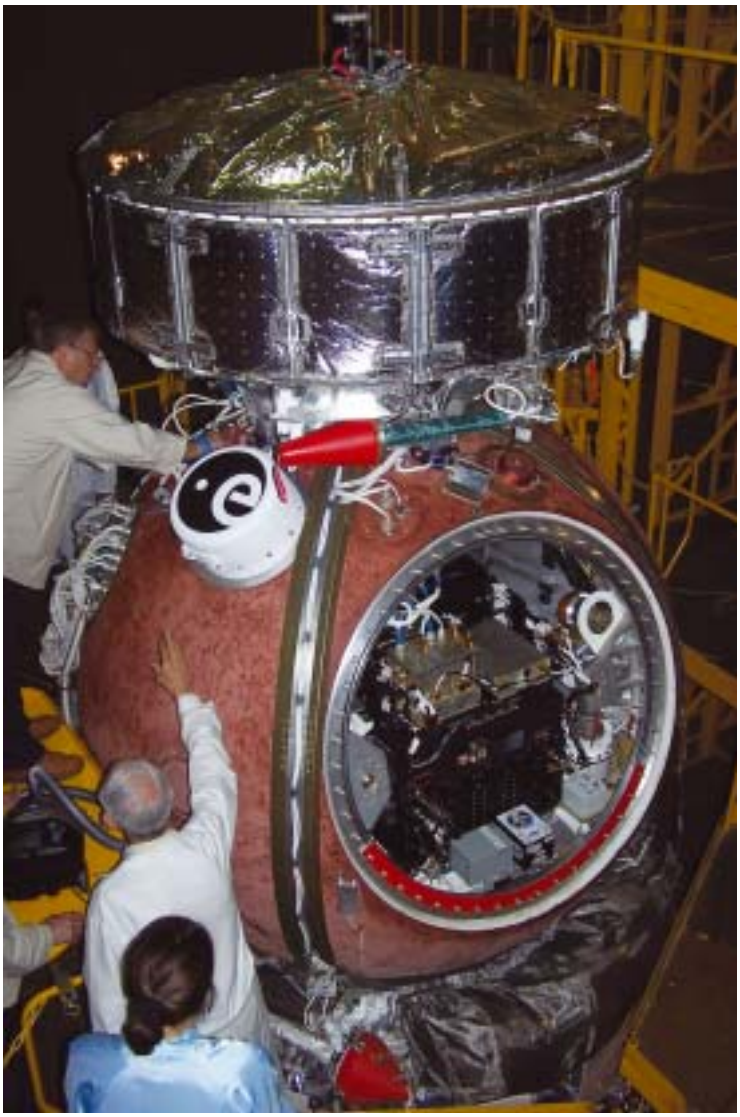
The maiden flight of the Electromagnetic Levitation Module on a Texus sounding rocket facilitated the delivery of the first space-experiment results for the ESA/EC IMPRESS project.

Interfacial turbulence in evaporating liquids (from the ITEL experiment on Maser-10)



Marangoni convection in microgravity (from the BAMBI experiment on Foton-M2)

The Electromagnetic Levitation Module, flown for the first time on the Texus-42 sounding-rocket flight



Foton-M2 during integration in Baikonur

The Foton-M2 free-flyer mission was launched for the first time from the Baikonur cosmodrome and accumulated about 380 hours of orbital flight with a 385 kg ESA payload comprising 39 internal and space-exposure experiments. A total of eight agencies and 19 industrial entities were involved.

In April, the Italian-sponsored 'Eneide' mission to the ISS with ESA astronaut Roberto Vittori included a wide range of life/physical sciences, technology and education experiments. During this and previous ISS expeditions, a continuous series of European experiments has been

The European Modular Cultivation System (EMCS)

performed by Russian cosmonauts and US astronauts. Preparation of a substantial experiment package for the long-duration flight of ESA astronaut Thomas Reiter is progressing.

ESA's Pulmonary Function System (PFS), launched with Shuttle flight LF-1, was successfully commissioned in the US 'Destiny' laboratory as part of the Human Research Facility (HRF), which will be transferred to Columbus once in orbit. In preparation for the next Shuttle mission, ULF-1.1, the -80ºC freezer rack (MELFI) and the European Modular Cultivation System (EMCS) were integrated into the Multi-Purpose Logistics Module (MPLM). These ESA payloads will substantially enhance the ISS's research capabilities and support further European research onboard.

Development of ESA's ISS internal-rack and external payloads was successfully completed. Following their launch with Columbus and subsequent commissioning, the full European utilisation of the ISS will commence.

The European life and physical sciences community produces more than 40% of the worldwide publications in their domain each year, with an even higher citation ratio.

Exploration

The year opened with a significant increase in contributions to the Aurora Preparatory Programme. Many new activities were initiated, the most significant of which was the awarding of the ExoMars Phase-B1 contract. At the end of the year, the European Space Exploration Programme - Aurora - was approved at the Ministerial Council in Berlin. This represents a decision of paramount importance for European space policy. The approval includes the full development and operation of ExoMars, and also creates the framework for the preparation of Europe's long-term engagement in space exploration.

With the help of the Exploration Programme Advisory Committee (EPAC), the Programme was organised into a Core element and an element devoted to Robotic Missions, of which ExoMars is the first. Aurora remains a programme with a long-term vision for the robotic and human exploration of the Moon and Mars.

Throughout the year, special attention was paid to refining the ExoMars mission configuration and its model payload, and a large scientific workshop, jointly organised by ESA and BNSC, was held in Birmingham (UK) in April. There, the scientific community favoured an approach to ExoMars that safeguarded the scientific value of the mission while calling for enhanced international cooperation. The European scientific community also reaffirmed its strong interest in a Mars Sample Return mission before the end of the next decade. Subsequently, in August, an ExoMars/Pasteur scientific workshop was held at ESTEC.

The ExoMars definition phase benefited greatly from the technology activities that had been started in the first phase of the Preparatory Programme and drew to a close during the year. The results could be injected into the mission's Phase-B1, in particular the first round of tests that were conducted for the vented airbags concept, yielding very positive results.

Further studies of lunar missions were conducted in the ESTEC Concurrent Design Facility, and further development activities on key capabilities for future exploration endeavours, such as the docking mechanism and the regenerative air-revitalisation system ARES, were carried out. In addition, a variety of research activities in human physiology (Concordia) and life support (Melissa) were pursued.

Activities related to the transportation aspects of exploration, such as planetary and Earth re-entry systems,

A concept for the ExoMars Rover

science and sample-return systems, and human transportation systems were studied. Of particular note was the initiation of discussions with the Russian Federal Space Agency Roskosmos on human transportation and the Clipper programme.

The definition of a long-term strategy for space exploration was addressed in meetings and workshops with a large community of stakeholders, including several from outside the space sector, to analyse the international context and the potential European role. Also in the context of international cooperation, the First Workshop on International Cooperation for Sustainable Space Exploration, which was organised jointly with ASI in Italy, took place in May, with participants from the USA, Canada, Japan and several European countries.

Activities with academia included two major events organised at ESTEC, and a call for innovative ideas and concepts for lunar exploration, which was issued in connection with an architecture study awarded to industry.