Human Spaceflight, Research and Applications

ESA astronaut Pedro Duque aboard the ISS in October, in front of the Microgravity Science Glovebox

Highlights

The Space Shuttle accident on 1 February resulted in the tragic loss of 'Columbia' and its crew, and of the seven ESA payloads that were part of the Spacehab mission onboard STS-107.

An independent Columbia Accident Investigation Board was appointed to investigate the cause of the accident and to establish the corrective actions that need to be taken to establish a safe return to flight of the remaining Space Shuttles. Its findings were published in August and, subsequently, the NASA Spaceflight Leadership Council approved a Shuttle Return to Flight within a planning window no earlier than 12 September to 10 October 2004. The return to flight will be a test flight carrying some logistics to the International Space Station (ISS), but no utilisation items. This flight must show that the Shuttle's surface can be inspected independently from the ISS and that tile repair can be performed. The next flight, after a successful test flight, will be the time at which the ISS returns to a crew of three.

The Space Station Control Board evaluated the logistical needs for the ISS for 2003 and 2004 assuming the absence of the Shuttle, and made a number of recommendations. As a result, the Multilateral Control Board decided to convert Soyuz flights 6S (April), 7S (October) and 8S (April 2004) into Crew Rotation Flights, and a two-person crew became the temporary baseline until the Shuttle's return. Consequently, the Soyuz flights of ESA astronauts Pedro Duque and André Kuipers were each postponed by six months.

A Heads of Agencies (HoA) meeting took place in July at which it was agreed to review and update the ISS Programme Action Plan. At the same time, the International Partners declared their solidarity and continuing determination for the programme. On 29 July, during the HoA meeting, the 1000th day of a permanent human presence onboard the ISS was achieved.

An ESA internal assessment of the impact of the delay to the programme determined that the launch of the outfitted Columbus module

could be delayed by some two years. This, in turn, has a direct impact on utilisation planning, which has to be adjusted to provide additional interim flight opportunities in order to mitigate the negative impacts on the scientific community due to the later in-orbit availability of ESA's four multi-user facilities, namely Biolab, the European Physiology Module, the Fluid Science Laboratory and the European Drawer Rack with the Protein Crystallisation Facility, for ISS utilisation. Re-planning is currently going on within the programme.

A total of five flights were made to the ISS during the year, three of which were logistics flights with unmanned Russian Progress vehicles, and two were Soyuz flights used for crew rotation.

The second of the two Soyuz flights, launched from Baikonur on 18 October, also hosted the delayed Spanish Soyuz mission 'Cervantes' with ESA astronaut Pedro Duque. During his eight-day stay aboard the Station he performed an experimental programme that included a large variety of scientific investigations, as well as educational and other activities. A total of 24 investigations/activities were performed, with more than 85 kg of payload uploaded and 15 kg downloaded. More than 50 hours of crew time was contributed to the 'Cervantes' mission.

Space Infrastructure Development

More than 90% of the ISS Development Programme and Microgravity Facilities for Columbus (MFC) activities have been committed and are nearing completion. In general, all of the elements being produced are proceeding well.

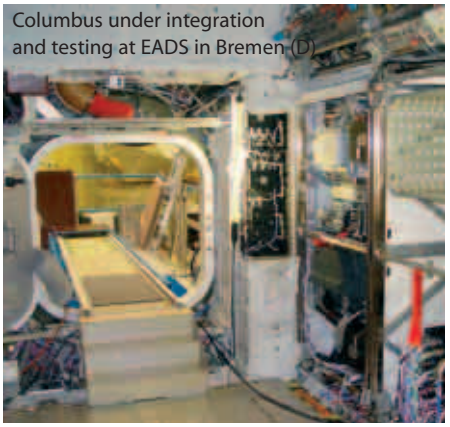
The qualification test campaign on the Columbus flight model was completed to the point of being ready for payload integration, and the Columbus Qualification Review Part 1 and Safety Review 3 were held successfully. Microgravity and audible-noise testing was also successfully completed. Testing, using the Rack Level Test Facility (RLTF), of the Columbus payload facilities Biolab, the European Physiology Module and the Fluid Science Laboratory, was successfully concluded, and testing of the European Drawer Rack has been prepared. Preparations are underway for the installation of the racks inside the Columbus module prior to integrated system testing including the ground segment.

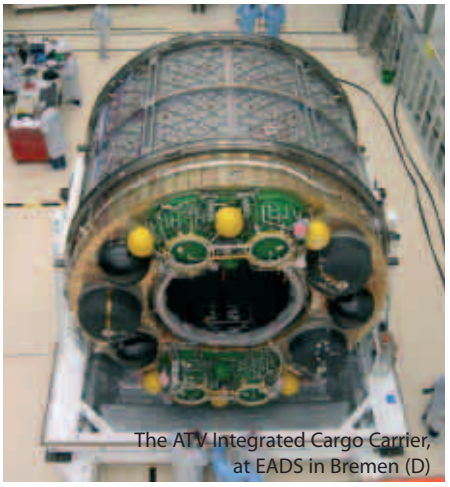
Flight-model manufacturing and integration of the first Automated Transfer Vehicle (ATV), christened 'Jules Verne', progressed well, with all main assemblies being at the integration site. However, there are delays in the completion of the flight software development and verification, leading to a slippage in the readiness-for-flight date to October 2005.

Following its delivery to the Kennedy Space Center, Node 2 ownership was transferred to NASA on 18 June. Subsequently, Multiple Element Integrated Testing with Node 2 and the Japanese Experiment Module (JEM) was successfully completed. Delivery of Node 3 is now planned to take place early in 2006.

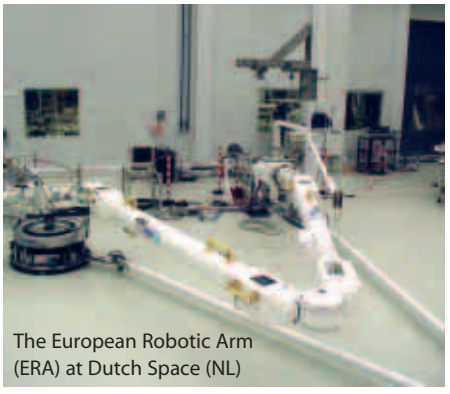
Testing of the flight model of the European Robotic Arm (ERA) was completed and the Qualification Review/Acceptance Review was declared successful. Acceptance of the flight spares and Mission Preparation and Training Equipment was also accomplished. Man-in-the-loop tests and operations verification remain late in the programme and a launch scenario has still to be determined.

Development of the Cupola was nearing completion by year's end, with delivery to NASA expected by Summer 2004.


Columbus under integration and testing at EADS in Bremen (D)


The ATV Integrated Cargo Carrier, at EADS in Bremen (D)


Node 2 in the Space Station Processing Center at KSC (USA)

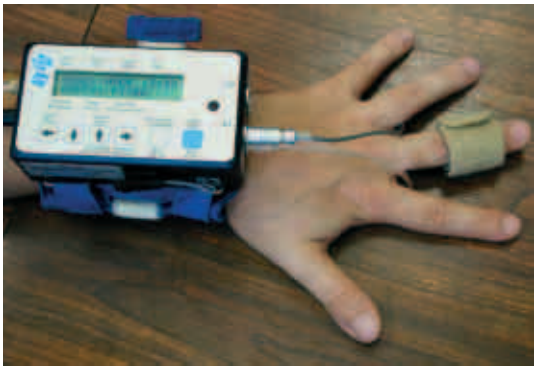

The European Robotic Arm (ERA) at Dutch Space (NL)

Operations and Related Ground Segments

On 18 October a Russian Soyuz vehicle was launched from the Baikonur Cosmodrome in Kazakhstan carrying the ISS Expedition 8 two-man crew onboard as well as the Spanish ESA astronaut Pedro Duque, who was participating in the 'Cervantes' mission. This mission was originally planned for April 2003, but in the aftermath of the 'Columbia' accident ESA relinquished that flight opportunity to allow a crew-exchange flight instead.

The mission proceeded flawlessly with the completion of the experiment programme, the changeover of ISS Expedition crews, and the exchange of the Space Station's Soyuz TMA lifeboat.

During his 8-day stay on the ISS, Pedro Duque carried out an extensive programme of scientific, technological, and educational experiments as part of the 'Cervantes' mission, the majority of which were sponsored by the Spanish Ministry of Science and Technology. The experiment programme was a great success with results being obtained for all 22 experiments, which included two physical science experiments utilising the ISS's European-built Microgravity Science Glovebox, four biological experiments, four human-physiology experiments, and a number of educational experiments and technology demonstrations.



An experiment flown on the ISS 'Cervantes' mission to investigate adaptation to weightlessness and re-adaptation to gravity by the human cardiovascular system

During the 'Cervantes' mission, Pedro Duque had numerous contacts with the media from Spain and Germany. He talked via an amateur radio link with primary-school children, winners of the 'Habla ISS' competition, who had the chance to ask him questions, and also spoke live with the President of Spain, José María Aznar.

The command module of the Soyuz TMA-2 spacecraft landed near the town of Arkalyk in Kazakhstan on 28 October, marking the completion of the successful 10 day 'Cervantes' mission. It was the fourth Soyuz mission to the ISS with an ESA astronaut onboard.

Real-time operations during Pedro Duque's mission were coordinated from the Erasmus Payload Operation Centre, located at ESTEC in Noordwijk (NL), with experiment support being provided by both the Spanish and Belgian User Support and Operations Centres (USOCs). The ground-segment interconnection was provided and controlled by a team at ESOC in Darmstadt (D).

The Data Management System (DMS-R) onboard the Russian Service Module and the Microgravity Science Glovebox in the US laboratory 'Destiny' both continue to perform well.

Following the ATV Control Centre (ATV-CC) proposal evaluation and negotiation, the technical and financial baseline was agreed, culminating in the signature of the ATV-CC Design and Development and Operations Preparation contract on 17 April. The System Integration Readiness Review Board was successfully completed on 13 August and, by November, the Critical Design Review (CDR) also. The ATV-CC Operations Implementation Review was kicked-off in early July and completed by the end of September. The first System Verification Test was conducted on 18-20 November.

The Phase-C/D proposal negotiations for the Columbus Control Centre (COL-CC) were successfully completed and signature of the development contract took place on 31 March. The Preliminary Design Review closeout meeting was held on 18 July, and a number of open issues were carried forward to the COL-CC System Design Review 1, which was held on 9 September.

The ATV Control Centre in Toulouse (F)

The Columbus Control Centre in Oberpfaffenhofen (D)

The COL-CC communications nodes for Houston and Huntsville have been successfully installed and tested, and successful command and telemetry tests have been executed between the Mission Control Centre Houston (MCC-H) and the COL-CC. The installation of the Wide Area Network for MCC-H and ATV-CC has also been completed.

The verification and validation review for the ATV Trainers and Simulators was successfully completed.

Utilisation Planning, Payload Developments and Preparatory Missions

ESA and NASA signed the Transfer of Ownership of the Microgravity Science Glovebox (MSG) to NASA on 15 July and 14 August, respectively.

The -80°C Freezer (MELFI) Flight Unit was installed in the Multi-Purpose Logistics Module (MPLM) ready for launch. However, with the 'Columbia' accident's effect on flight opportunities, the MELFI Flight Unit was de-integrated from the MPLM in July and stored in the Space Station Processing Facility at the Kennedy Space Center.

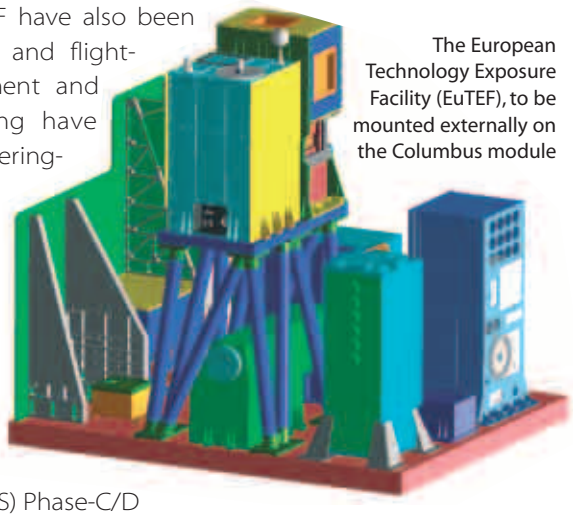
The Cryosystem Phase-B continues; the System Requirements Review was completed on 13 June, and the System Preliminary Design Review commenced in November.

The Crew Refrigerator/Freezer (RFR) is approaching qualification level, and its use as a Refrigerator/Freezer for biological samples is under discussion with NASA.

Final testing for the Hexapod pointing platform is in progress, and negotiations on whether it is to be delivered to NASA or stored in Europe are ongoing.

The Phase 2 Flight Safety Review for the external payload SOLAR was completed in September, and the Critical Design Review (CDR) in November.

Relocation of the space radiation exposure facility EXPOSE from the EXPORT assembly (with Coarse Pointing Device) to the EuTEF assembly (without CPD) has been implemented. Investigators have agreed to the new external location on EuTEF that provides for reduced Sun-pointing of the EXPOSE experiment specimens. The EXPOSE qualification tests have been completed and the flight model (with dummy trays) is ready for delivery. The CDR and safety reviews for EuTEF have also been successfully performed, and flight-model parts procurement and hardware manufacturing have started. Electrical engineering-model testing with the remaining experiments continued; all Batch-1 experiments have been successfully tested and are in the Acceptance Review process.



The European Technology Exposure Facility (EuTEF), to be mounted externally on the Columbus module

The Atomic Clock Ensemble in Space (ACES) Phase-C/D contract was signed on 11 July and, within the Preliminary Design Review, the first Board meeting was held end-September.

The European Drawer Rack (EDR)

The Global Transmission System (GTS), which is mounted externally on the Russian segment of the ISS, is operating nominally.

The CDR for the radiation phantom 'Matroshka' has been successfully completed and parts procurement and hardware manufacturing are ongoing. Thermal and structural testing of the Matroshka flight model has been completed, and its launch is planned with the Progress 13P flight in January 2004.

The Columbus External Payload Adaptor (CEPA), developed by NASA for delivery to ESA and required to mount the external payloads, has been completed. The CEPA Technical Assistance Agreement has been consolidated and delivery to Europe for integration of EuTEF and SOLAR is progressing.

The Integrated Phase 3 Safety Review for the European Drawer Rack (EDR) was held successfully on 30 July, and the flight model will be delivered for RLTF testing in January 2004.

The CDR for the European Transport Carrier (ETC) was completed on 8 August, and the Safety Review III was successfully held in December.

The environmental test campaign for the European Modular Cultivation System (EMCS) flight model has been completed and launch on flight ULF-1.1 is anticipated.

The Muscle Atrophy Research and Exercise System (MARES) technical developments are on track.

One of the ESA Parabolic Flight Days

The Maxus-5 sounding rocket on the launch pad in Kiruna (S)

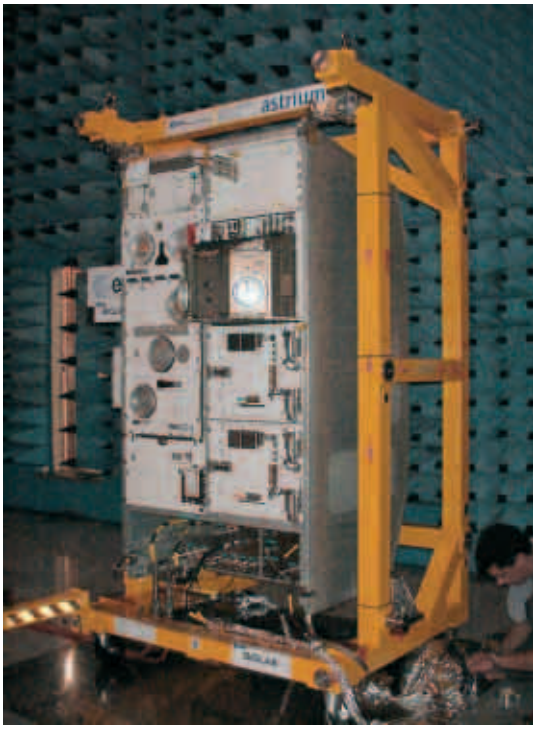
In March, the IMPRESS proposal (multi-disciplinary, product-oriented research in the field of materials science) and the Healthy proposal (bone-physiology project) were submitted to the European Commission (EC). The IMPRESS proposal received a positive formal response from the EC in late-September.

Of the 43 Microgravity Applications Promotion (MAP) projects that were initiated in the first phase, 14 are to submit a continuation proposal and four are to re-submit their continuation proposal. Twenty projects have been recommended for further support by ESA. The MAP projects have involved 93 laboratories spread across Europe.

During the 34th and 35th Parabolic Flight Campaigns, which took place in April and October, a total of 24 experiments were completed successfully.

A procurement order with Rosaviakosmos for two unmanned Foton capsule flights was signed on 21 October and will cover the Foton-M2 and -M3 missions, which will have 660 kg of ESA-supplied scientific payloads onboard. The two launches, scheduled for May 2005 and Autumn 2006, will provide re-flight opportunities for almost the entire experiment programme originally assigned to Foton-M1 which was lost when that launch failed in October 2002. They will also cover a substantial part of ESA's scientific objectives for the ill-fated 'Columbia' mission.

The Maxus-5 sounding-rocket mission was successfully launched on 1 April from Esrange, near Kiruna in northern Sweden. The 11.5 tonne rocket carried a 488 kg payload of five scientific experiments designed to investigate phenomena in biology, fluid physics, material science and fundamental physics. From booster burnout until atmospheric re-entry 740 seconds later, the payload was exposed to excellent microgravity conditions.



Biolab during its electromagnetic testing

Development and qualification of the three major Columbus multi-user facilities - Biolab, the European Physiology Module, and the Fluid Science Laboratory - were just being completed at year's end, and their installation into Columbus for integrated testing is foreseen for April 2004. After completion, the facilities will be returned to the payload developers' sites for final processing and storage until final integration into Columbus for launch. This period will be used to further enhance the technical robustness of the flight facilities and to satisfy the latest science user requirements by means of some facility modifications/ upgrades, such as the Microgravity Vibration Isolation System and holographic interferometry for the Fluid Science Laboratory.

Development of the Material Science Laboratory is progressing, with flight-model delivery for integration into NASA's Material Science Research Rack foreseen for mid-2004.

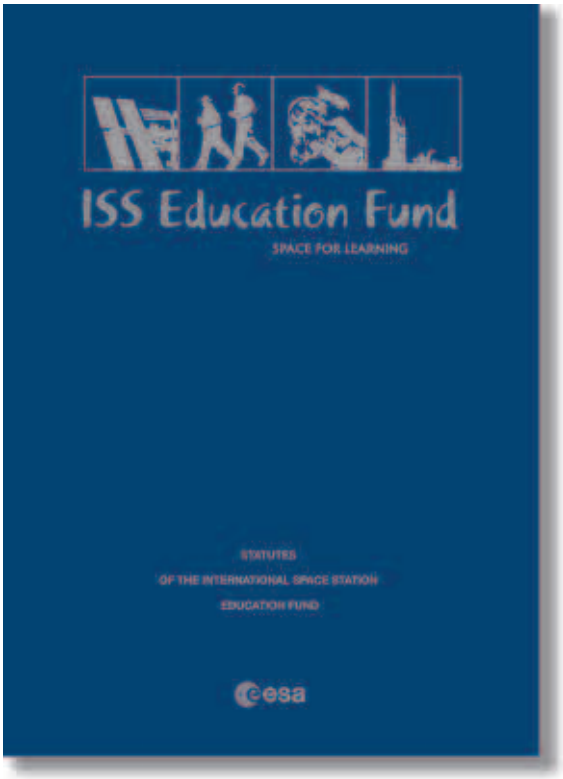
NASA's Human Research Facility HRF-2, including ESA's contribution, the Pulmonary Function System (PFS), had been integrated into the Multi-Purpose Logistics Module, ready for launch in March 2003. However, it was subsequently de-integrated due to the Shuttle launch delay.

Engineering-model testing of the Protein Crystallisation Diagnostics Facility (PCDF) is in progress and flight-model assembly has started. The PCDF will be located in the European Drawer Rack, which in turn will be integrated inside Columbus prior to launch.

ISS Education

In March, a Workshop for Primary School Teachers was held at ESTEC (Noordwijk, NL) to prepare for the development of the ISS Education Kit for Primary Schools. This was followed in May by a Workshop with the secondary school teachers' 'feedback group' to support preparation of the teaching content of secondary-school material. The final version of the ISS Education Kit is a teacher's support tool designed to help capture the imagination of 12-15 year olds. It covers a variety of subjects, mainly in science, and consists of different modules that can be used in a classroom setting, within group exercises, or as homework.

The first ESA web site for primary schools, 'Habla ISS' (in Spanish) was launched on 16 April, and a large number of schools in Spain (13 000) were asked to participate in education activities



The ISS Education Fund

linked with the Spanish Soyuz mission 'Cervantes' to the ISS in October. An educational programme carried out during the mission included two biology experiments prepared by students, two demonstrations of physics principles, VIDEO-2 for video-recording of simple demonstrations of Newton's Laws, and two ARISS radio-amateur contacts between the Spanish ESA astronaut Pedro Duque and primary-school children, winners of the 'Habla ISS' competition, who had the chance to ask him questions.

The ISS Education Fund held its Inaugural Board Meeting at EAC (D) on 28 August, in conjunction with the presentation of the SUCCESS prize to three students who had proposed experiments for the ISS.

ISS Education was represented at the Physics on Stage 3 conference, hosted by ESTEC (NL) in November, which attracted some 450 European science teachers.

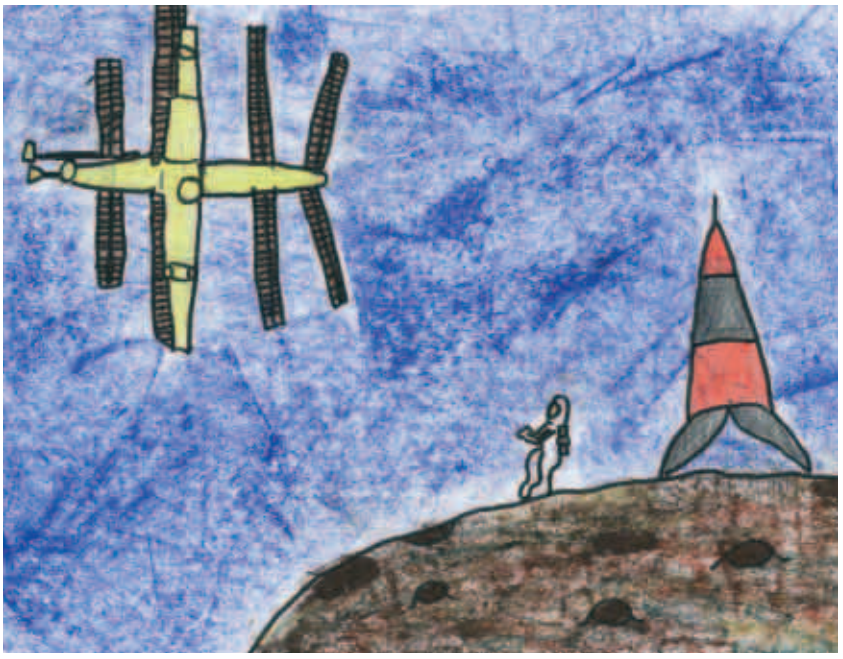
Commercial Activities

A European ISS Business Club was publicly launched at the Le Bourget Air Show on 19 June. The Club's purpose is to help promote ISS commercialisation opportunities among the European business community. Its members include contractors, subcontractors and suppliers in the areas of ISS development, exploitation and utilisation, thus forming a unique industrial network motivated to promote the ISS.

In preparation for selecting one or more commercial agents, a Workshop for potential candidates was held at ESTEC (NL) in February. It was attended by members of the Cooperation Agreement, the USOCs and the Technology Transfer network, and new companies that operate as brokers of R&D in Europe.

ISS branding definition has been completed and the communication plan defined.

Contacts with major European corporations are continuing for Prime and Mission sponsorship, and contacts with Dutch companies for sponsorship of the Dutch Soyuz Mission have been initiated.



A winning painting in the Spanish 'Habla ISS' contest, by 8-year-old children from El Puerto de Santa Maria, Cadiz

The first prototype training for non-professional astronauts has been defined in terms of content, dates and prices.

The Mediet project, to test foods preserved with a novel technology onboard the ISS, has been approved and will be conducted with Russian collaboration.

Preparations for the Future

In preparation for future human-spaceflight programmes, the study activities of the Studies, Technology and Evolution Preparation Programme (STEP), the Human Spaceflight parts of the General Studies Programme and the General Supporting Technology Programme (GSTP) Interim Technology Phase, have been harmonised, and specific enabling technologies have been grouped under three main themes: Robotics, Habitats, and Space Transportation and Re-entry.

An innovative crew restraint was developed in just a few weeks and delivered to the ISS, where Pedro Duque demonstrated its usefulness during the 'Cervantes' mission.

Studies have been performed for new external ISS payloads such as EUSO and LOBSTER. Activities related to ROSITA are currently on hold.