

Manned Spaceflight and Microgravity

Programmatic Overview

During the year a total of thirteen assembly and logistics flights were made to the International Space Station (ISS). The US 'Destiny' Laboratory, the Space Station robot arm 'Canadarm 2', the Russian Docking Compartment 'Pirs' serving as an additional docking port for Russian vehicles, and the new 'Quest' airlock allowing space walks without a Space Shuttle docked to the Station, were assembled. The first two European astronauts, Umberto Guidoni and Claudie Haigneré, and the first ESA ISS payload were flown to the ISS during 2001. In total, four Multi-Purpose Logistics Module (MPLM) flights carried experiment and storage facilities, and by the end of the year the fourth Expedition Crew was installed onboard the ISS.



In February, NASA reported a potential US\$ 4 billion cost overrun for the Space Station, resulting in the cancellation of the Propulsion Module. An independent (ISS Management and Cost Evaluation, IMCE) task force performed an external review of the NASA ISS programme and its report recommended that, at least temporarily, the size of the ISS crew should be reduced from seven to three and the deferral of some elements accordingly, such as the Habitation Module, Node-3 and the Crew Return Vehicle (CRV). ESA submitted its reaction to the IMCE report to the NASA Advisory Council, confirming that Europe would maintain its commitments to the programme and expects the United States to do likewise. Now, ESA and the other International Partners are searching for options to enable the ISS to have a full crew complement as early as possible, consistent with the programmatic limitations that all Partners are experiencing.

The in-orbit configuration of the International Space Station in December

With the concerns induced by this US situation in mind, the ESA Council Meeting at Ministerial Level in Edinburgh (UK) in November approved the Period-1 funding for the ISS Exploitation Programme, but blocked about

60% of its firm funding until October 2002, pending clarification of the ISS budget situation in the USA. The ISS Studies, Technology and Evolution Preparation (STEP) Programme, with subscriptions from three ESA Member States, and the European Programme for Life and Physical Sciences and Applications utilising ISS (ELIPS), with subscriptions from 12 ESA Member States, were both approved in Edinburgh.

Agreements with Other Organisations

In July, a Multilateral ISS Commercialisation Working Group was established and mandated to develop a common policy amongst the ISS Partners.

The Non-Partner Participation Task Force reached agreement on the process to be applied for non-partner participation in ISS activities, whilst the ISS Multilateral Crew Operations Panel finalised a document defining the ISS Crew selection criteria for both expedition and visiting ISS crews.

The Exchange of Letters relating to the ESA/CSA co-operation on the Microgravity Vibration Isolation System (MVIS) for ESA's Fluid Science Laboratory (FSL) was formally completed and entered into force on 6 February.

The ESA/NASA Cooperative Research Agreement relating to the European Modular Cultivation System (EMCS) was finalised.

A Charter covering co-operation between CNES, NASDA and ESA on a long-term bed-rest study was agreed between the three parties and signed on 7 March.

ESA, CNES and DLR finalised a trilateral cooperation agreement on Cardiolab as a contribution to the European Physiology Modules (EPM) facility for the ISS.

The Arrangement between ESA and ASI concerning the Advanced Protein Crystallisation Facility (APCF) flight opportunity was signed 15 March in Paris.

The ESA/ASI Arrangement on co-operation for the STS-100 mission to the ISS with U. Guidoni was finalised and signed on 23 February.

An Arrangement between ESA and CNES concerning ESA astronaut Claudie Haigneré's participation in the Andromède mission to the ISS in October was concluded.

A Framework Agreement between ESA and Rosaviakosmos on ISS Taxi and Increment flight opportunities was signed and an Exchange of Letters between ESA and ASI took place relating to the high-level terms and conditions applicable to an ASI-sponsored Soyuz Taxi Flight; ESA, Rosaviakosmos, RSC-Energia and ASI signed a related protocol. An ESA astronaut of Italian nationality, Roberto Vittori, was assigned as flight engineer for this Taxi Flight opportunity, currently planned for April 2002.

A Soyuz Taxi Flight opportunity was negotiated with Rosaviakosmos for a flight to the ISS for the Belgian astronaut Frank de Winne, foreseen for November 2002.

ESA and NASA agreed on an interim extension of the Shuttle Mission Specialist Training Agreement for the ESA astronauts, assigned to the NASA astronaut corps at Johnson Space Center (JSC), pending negotiation of a broader agreement that should provide better prospects for regular flight assignments for the ESA astronauts concerned.

An Agreement was reached by the ISS Multilateral Crew Operations Panel on 'Principles Regarding Processes, Standards and Criteria for Selection, Assignment, Training and Certification of ISS Crew Members'. This Agreement covers the selection and training requirements, as well as the certification and assignment procedures for ISS increment crews as well as Shuttle and Soyuz visiting crews with professional and non-professional astronauts.

Technical Activities for Various Programme Elements

Columbus

The system Critical Design Review final board was successfully held in January. Hardware manufacturing and integration of the Pre-Integrated Columbus Assembly (PICA) continued, leading to the PICA's delivery to the prime contractor in Bremen on 27 September. Formal qualification testing on the electrical test model was started and progressed well. The first ESA/NASA bilateral test on data-communications exchange between Columbus and the rest of the ISS was successfully completed.



Delivery and unpacking of the Pre-Integrated Columbus Assembly (PICA) in Bremen (D) in September

Cupola

Qualification pressure testing on the Structural Test Article (STA) was completed and the STA system modal-survey test, the neutral-buoyancy test, and the second 1-g mock-up demonstration were



performed successfully. The re-design of the shutter panels, requested by NASA to improve resistance to orbital debris/meteoroid impact, was also performed and compensation for the related additional costs agreed with NASA. Subsequently, the System CDR and Safety Review I/II were completed successfully. Following the projected NASA cost overrun for the ISS, the Cupola launch date is under review.



The Cupola modal-survey testing

Nodes-2/3

The flight-unit Node-2 pressure-test campaign and system-level modal-survey test were successfully performed and the System Design Review 2 (SDR-2) was successfully conducted. The Node-2 overall delivery to Kennedy Space Center (KSC) is now scheduled for November 2002, with the launch in February 2004. Again, following the projected NASA cost overrun for the ISS, the Node-3 launch date is under review.



The Node-2 primary structure

The Node-2 modal-survey test configuration (internal view)



Automated Transfer Vehicle (ATV)

As a result of the conclusions emanating from the Preliminary Design Review (PDR) in December 2000 and contractual negotiations with industry, and to expedite the technical decision process for the implementation of the design decisions taken at the PDR, it was decided to collocate the ESA project team at the prime contractor's site and to change the prime contract from a fixed-price to cost-reimbursement basis.



The Automated Transfer Vehicle (ATV) structural and thermal model at ESTEC (NL)

In parallel with these management actions, work progressed on the structural and thermal model. The Cargo Carrier and spacecraft were delivered to and assembled at ESTEC and the first environmental test (acoustic) was successfully conducted in December. Integration of the spacecraft electrical test model started in October and manufacture of the flight equipment is also in progress in Industry.

X38/Crew Return Vehicle (CRV)

European hardware and software were delivered for integration into the X38 Space Test Vehicle (V201). Besides a pallet drop test performed in Yuma in the USA, two drop tests of the prototype X38/V131R vehicle from a B52 carrier aircraft were successfully conducted in 2001. These latest flights demonstrated that the aerodynamic handling qualities had been significantly improved since an earlier flight in November 2000, during which there was a serious instability. The corrective actions were largely based on wind-tunnel and computational-fluid-dynamics analyses performed in Europe.

Early industrial tasks of the CRV development phase, including aerodynamics, material qualification for the CRV hot structures, International Berthing Docking Mechanism (IBDM) mechanical design and display technique development, were continued. The industrial proposal for the full CRV design and development activities up to the Critical Design Review (CDR) was received, evaluated and negotiated, and initial tasks were released thereafter. Following NASA's request to ESA to extend the European participation in the CRV, as part of their ISS cost-overrun mitigation, several options were discussed, but were put on hold pending resolution of the approach to be taken by the United States. Meanwhile, as the US Congress has approved a US\$ 40 M budget line for X38 continuation in 2002, ESA participation will continue as planned.



The X38/CRV parafoil descent in December

Data Management System - Russia (DMS-R)

The installation of all DMS components on board the 'Zvezda' module have been completed and the in-orbit operation of DMS-R is problem-free.

Following the arrival and docking of the US 'Destiny' Laboratory at the ISS, a major software reconfiguration was completed so that both 'Zvezda' and 'Destiny' will function in a co-operative mode to perform guidance, navigation and control of the entire ISS for the operational lifetime of the Station.

Negotiations with European industry and the Russians on the long-term engineering support for DMS-R are ongoing. The ESA DMS-R services will be used as partial payments for the procurement of ATV operational services from the Russians.

European Robotic Arm (ERA)

The ERA Phase-III Safety Review, held with the NASA Safety Review Board, was successfully completed. The flight model completed its structural qualification programme and at year's end was undergoing functional qualification testing at the prime contractor. Testing of the qualification model was also still in progress. However, work on the Mission Preparation and Training Equipment (MPTE) experienced some delays, which impact the ERA system-level schedule.

Funding for the development of the Russian Science Power Platform (SPP) that will accommodate ERA had not yet become available, causing a significant delay in ERA's launch. The earliest possible date currently envisaged is in 2005/2006 and it was therefore decided put all activities following the Acceptance Review on hold.

Ground Segment and Operations

The detailed definition of the Columbus and ATV Control Centres culminated early in the year with their System Requirements Reviews (SRR). Advanced procurement activities for critical Control Centre subsystems/equipment were subsequently authorised, and Requests for Quotation (RFQs) for both Control Centres were released.

Following the successful completion of the SRR for the ATV Crew Trainer in February, the industrial proposal was solicited and received and is currently under evaluation.

The Preliminary Acceptance Review (PAR) of the Mechanical Configuration (Meco) of the Columbus Crew Trainer was successfully conducted in November and the hardware was then shipped to the European Astronaut Centre (EAC) and to NASA.

Space Station Utilisation Preparation and Promotion

The most advanced ESA-provided utilisation-related hardware items for the ISS are the Microgravity Science Glovebox (MSG) and the -80°C Brayton-cycle-cooled freezer (MELFI). The MSG was delivered in November to NASA for a launch in May 2002, and MELFI is undergoing final testing and will be delivered in time for a launch in early 2003. In exchange for these deliveries, NASA will provide flight opportunities for two major ESA payloads in the 'Destiny' laboratory and five payload assemblies as external payloads on the ISS.

In concert with the development of the respective payloads, integration contracts are now in place for two experiments on the Russian part of the ISS (Global Transmission Services and Matroshka), for five Columbus payloads (three MFC Facilities, the European Drawer Rack and an on-board Stowage Rack) and for four external payload assemblies carrying space-science, technology and fundamental-physics experiments.

For the Life and Physical Sciences Facilities, the replies to further Announcements of Opportunity issued to the science community were evaluated in 2001. The highest rated experiments were selected for flight and their integration into the available facilities is now being studied in detail.

Also in support of experimental programmes to be carried out on the ISS, some 40 Microgravity Application Promotion (MAP) projects are in progress, with application-interested industries working closely with scientists



The Microgravity Science Glovebox (MSG) flight unit



The -80°C Freezer (MELFI) flight unit

already experienced in microgravity research. Some of these projects have already progressed such that experiments on sounding rockets and other opportunities (Foton, Spacehab) are being prepared for flight in 2002.

Ground-based preparatory activities took place in the form of bed-rest studies to provoke effects like muscle atrophy, bone demineralisation and other symptoms, which are also caused in space by exposure to microgravity. These studies develop and test the appropriate countermeasures.

The ISS User Information Centre at ESTEC in Noordwijk further consolidated its role as the source for validated reference information on the utilisation of the ISS by European users. This information is being made available through databases that can be accessed externally by interested users.

The setting up of a network of User Support Operation Centres (USOCs) in ten Member States that will support decentralised ISS payload operations, under the overall coordination by the Columbus Control Centre, is also in preparation.

Space Station utilisation on a global scale was presented and reviewed at the ISS Forum 2001 conference in Berlin in June, with the participation of the five ISS Partners. It was organised and sponsored by ESA, together with the host country's space agency DLR.

Exploitation Programme

In line with the modified ATV development programme, the previously planned procurement of the first ATV production unit was placed on hold, with only advanced batch procurements of EEE parts and selected equipment so far authorised.

The industrial tasks for the Early Activities were adjusted to cover only the most urgent procurement and definition activities needed to safeguard the exploitation planning schedule.

The main industrial contractors have agreed on the main modalities of the legal entity as the formal contractor vis-à-vis ESA for the industrial operator contract. This proposal is currently under evaluation by the Agency.

In view of the US situation and the decisions taken at the ESA Ministerial Council in November, it was considered premature to place a single industrial operator contract, and for reasons of prudence the transition phase was therefore extended and the full Request for Quotation will be released to industry at a later date.

Commercialisation

Selected pathfinder projects for commercialisation were further defined and the first project entered its development phase.

During the ISS Forum 2001 conference in Berlin, the access rules of all Partners and the ESA, NASA and Rosaviakosmos tariffs for commercial utilisation of the ISS were published, and the first commercial contract, between ESA and Intospace for an amount of 2 MEuro, was signed.

At the ISS level, a Multi-lateral Commercialisation Group (MCG) was established and is currently preparing the Programme Guidelines for commercial ISS utilisation.

The principles of the Co-operation Agreement between ESA and Industry were finalised and approved unanimously by ESA Council. Industry formally offered (in writing) a contribution, in kind and in cash, in excess of

30 MEuro. Following the postponement by the Ministerial Council of the decision on the Programme for Commercial Utilisation Preparation, which was to fund the ESA contribution to the co-operation, discussions with Industry were initiated to decide how to proceed further. Some industries stated their strong interest in speedy implementation of the co-operation despite the postponement of the programme decision.

The European Investment Bank declared its intention to provide ESA with a credit facility of up to 50 MEuro for supporting commercial ISS utilisation projects. Follow-up activities in response to this offer will be initiated shortly.

Microgravity Programmes

EMIR Programmes

In April, the Maxus-4 sounding-rocket flight from Esrange in Sweden successfully performed seven fluid-physics and material-science experiments.

Parabolic-flight activities continued with two successful flight campaigns of 90 parabolas each, during which 23 experiments were conducted, including a growing number of student experiments. The experimental programme using the ZARM Drop Tower facility in Bremen (D) continued, focusing on combustion research.



The multi-user Advanced Protein Crystallisation Facility (APCF) was flown on the ISS between August and December carrying seven experiments. The protein crystals produced are under evaluation.

Preparatory activities for the Shuttle/Spacehab STS-107 microgravity research mission, which will carry six ESA microgravity facilities with 37 experiments in life and physical sciences, continued. Preparations for the Foton-M1 Russian retrievable capsule mission in October 2002, which will include the re-flights of the ESA multi-user facilities FluidPac and Biopan with 13 experiments, also continued.

New developments in the EMIR Programme aiming for flights on the ISS were maturing. Design and safety reviews were successfully completed, engineering models were being manufactured and tested, and the first experiments were selected for flight.

As a result of international Announcements of Opportunity in the Life and Physical Sciences, a database of 229 'outstanding' or 'highly recommended' peer-reviewed experiment proposals was established. Based on this database, some 15 Phase-A and Phase-A/B studies were being performed or initiated within the EMIR Programmes. These studies are preparing the basis on which payload facilities will be selected for future development under the European Programme for Life and Physical Sciences and Applications utilising the International Space Station (ELIPS).

The Microgravity Facilities for Columbus (MFC) Programme Development of the engineering models for the Biolab, the Fluid Science Laboratory (FSL) and the Materials Science Laboratory (MSL) was completed in 2001.



The Maxus-4 sounding-rocket launch from Esrange (S)

The Advanced Protein Crystallisation Facility (APCF) prior to launch in August

The Fluid Science Laboratory (FSL) engineering model



A Crew Evaluation for the MSL was successfully completed and the Canadian Space Agency's (CSA) Microgravity Vibration Isolation System (MVIS) subsystem, which will be integrated into the FSL, is in an advanced stage of development.

The engineering model of the European Physiology Modules (EPM) is under development, and the flight model of the ESA Pulmonary Function System (PFS), to be launched in the NASA Human Research Facility-2 (HRF-2), was delivered to NASA. It is worth noting that with PFS development, new diagnostic technology has become available that will be used for commercial medical applications on the ground.



The Biolab engineering model

Flight model manufacturing for Biolab, FSL and MSL was initiated.

A co-operative Phase-A/B study with DLR (D) on the Materials Science Laboratory using the Electro-Magnetic Levitator (MSL-EML) was initiated.

ISS Education

From 26 to 28 October, approximately 160 teachers from 20 countries, including all 15 ESA Member States, as well as the Czech Republic, Hungary, Russia, Canada and the United States, participated in the first International Space Station Education Conference in Europe, 'Teach Space 2001'. This event was organised to stimulate teachers to adopt space as a tool for teaching and for teachers to encourage ESA to take on a more active educational role.

The feedback provided by the participants is currently being evaluated in order to understand the educational systems in Europe better and thereby create ISS educational material that can be exploited in all interested schools.



Teachers discussing educational activities with ESA staff during one of the working group sessions of Teach Space 2001



Teach Space participants in the User Information Centre, between mock-ups of the Zvezda module and the Columbus Laboratory