Manned Spaceflight and Microgravity

Programmatic Overview

The major event of the year was the approval, at the Ministerial Council in Brussels in May, of the Initial Phase of the European participation in the International Space Station (ISS) Exploitation Programme. Ministers allocated a financial envelope of 346 M€ for 'Early Activities' to be committed in 2000 and 2001, and a provisional envelope of 334 M€ for the following three-year 'Second Step', and decided to open a new Programme Slice for European participation in the ISS Crew Return Vehicle Programme (CRV). By end–1999, subscriptions to this Programme Slice amounting to approximately 58 M€ had been received from Belgium, France, Germany, The Netherlands, Spain, Sweden, and Switzerland; Italy had made known its intention to participate to a value of approximately 30 M€. The ESA CRV contributions will be bartered with NASA in exchange for reimbursable services necessary to carry out the European utilisation of the ISS and this level of contributions ensures a significant role for Europe in this important co-operative programme with NASA.

At the same Ministerial Council Meeting, the extension of the EMIR-2 programme was also approved with an envelope of 98 M€, of which about half is available from present contributions, thus ensuring the continuation of ESA's microgravity activities for the next two years.

Agreements with Other Organisations

The amendment of the Columbus Launch Barter concerning re-engineering of Node 3 for the ISS, was agreed between ESA and NASA and should be signed early in 2000. Following this, the related changes to the ESA/Italian Space Agency (ASI) arrangement on Nodes 2 and 3 will be formalised through an Exchange of Letters.

During the year, NASA informed ESA of the deletion of the requirement for the second of the two Cupolas foreseen in the ESA/NASA Barter Arrangement for the transportation of ESA payloads. As a result, signature of a revised ESA/NASA Implementing Arrangement is now expected in the first quarter of 2000.

Columbus Module flight-unit primary structure in fully welded configuration, at Alenia in Turin (I)

A Memorandum of Understanding between ESA and NASA concerning co-operation on the X-38 project, the pathfinder and demonstration programme for the CRV, was concluded in July 1999.

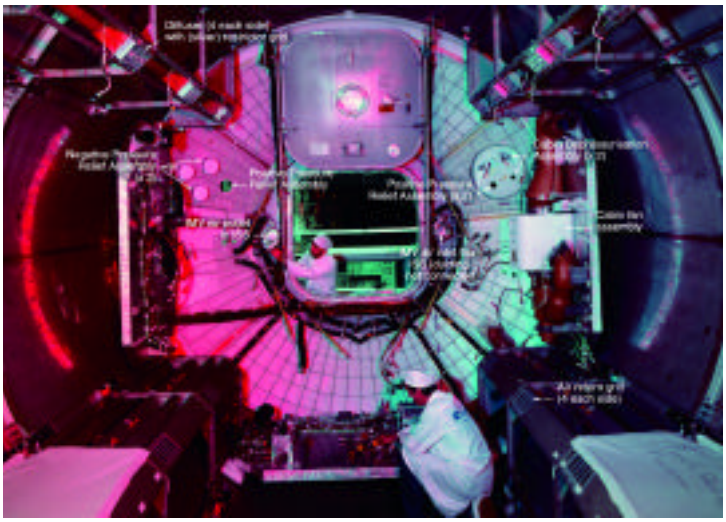
The Automated Transfer Vehicle (ATV) Integration Contract, under which the Russians perform technical work related to ATV/ISS interfaces and the accommodation of ATV-related hardware in the Service Module, was signed by all parties in July.

The final text of the Crew Code of Conduct for the ISS was agreed in late-1999 and formal approval by the ISS Multi-lateral Co-ordination Board is now expected in the first quarter of 2000.

Technical Activities for Various Programme Elements

Columbus

Assembly of the Columbus Electrical Test Model and the initial phase of system functional testing were successfully completed. All equipment and subsystem-level Critical Design Reviews (CDRs) were completed, and equipment and subsystem-level qualification testing is ongoing.



The ECLSS partially installed in the MPLM engineering qualification model

Some problems were encountered in the development of the Data Management subsystem, and the overall Columbus development schedule was reworked to accommodate the resulting schedule delay at subsystem level.

Manufacturing of the primary structure for the flight unit was completed, and formal transfer of this hardware from the MPLM Programme to the Columbus Programme was initiated in line with the associated Barter Arrangement between ESA and ASI.

Continuing delays in the ISS Assembly Sequence will require a re-assessment of the Columbus development programme planning and the planning for the installation of the ESA Payload Racks being developed under the Microgravity Facilities for Columbus (MFC) Programme.

Environmental Control and Life-Support Sub-System (ECLSS) for the Multi-Purpose Logistics Module (MPLM)

All development activities were successfully completed during 1999. Qualification at all levels was successfully completed and all remaining flight hardware was delivered to the MPLM Programme.

Cupola

After some initial difficulties, the Structural Test Article forging was successfully manufactured. Manufacture of the Cupola mock-up was completed during the first half of the year, and the first Crew Station Review involving NASA astronauts was successfully conducted. Following NASA's deletion of the second Cupola, the revised technical-requirements baseline was successfully negotiated and agreed with NASA in November, and industrial activities were revised accordingly.

Nodes 2/3

Manufacture of the Node Structural Test Article is now nearing completion. The detailed design of Node 2 is well advanced, and flight equipment manufacturing has been initiated. As a result of further design and outfitting changes initiated by NASA, a significant redesign of Node 3 was required during the year. A Configuration Design Review for this Node against the new requirements baseline was successfully conducted, and detailed design activities were restarted.

The ARD after recovery from the Pacific Ocean, at Aérospatiale in Bordeaux (F)

Automated Transfer Vehicle (ATV)

The technical-requirements baseline for the ATV was subject to significant changes during the year as a result of extensive efforts to consolidate ATV interfaces with the Russian Segment of the ISS. The introduction of these changes into the ATV design caused some delays in the design definition work that must be completed prior to the Preliminary Design Review (PDR), which has now been rescheduled to start in early–2000. Preliminary Design Reviews (PDRs) for the Propulsion and Reboost, Spacecraft Structure, and Integrated Cargo Carrier subsystems were completed successfully.

Work under the ATV Integration Contract, which was already initiated in December 1998 under a Preliminary Authorisation to Proceed (PATP),

is progressing satisfactorily and the Software Requirements Review (SRR) was successfully completed in November.

Arianespace proposed a new Ariane-5 launch-vehicle configuration (Ariane-5 Versatile) for the ATV, which would use a re-startable EPC Upper Stage. This configuration has significant benefits for the ATV, and has been selected for ATV missions.

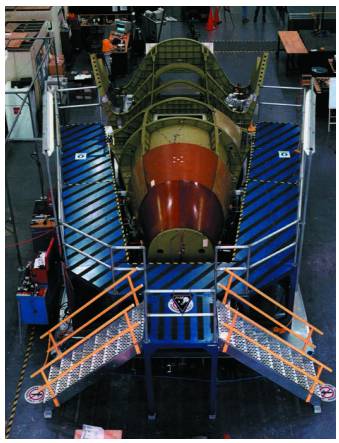
Atmospheric Re-entry Demonstrator (ARD)

Initial results from the evaluation of the data obtained from the successful mission in 1998 confirmed the nominal performance by the ARD during all of its mission phases.

X38/Crew Return Vehicle (CRV)

All European hardware scheduled for delivery and integration into the NASA X38 Orbital Test Vehicle (V201) during 1999 was delivered on time and successfully integrated into the vehicle.

Three X38 drop tests from a B52 aircraft were carried out successfully during the year. In the third test in July, the ESA-provided Guidance, Navigation and Control (GNC) software was used for the parafoil descent phase.



The V201 space-test X38 prototype under assembly at NASA's Johnson Space Center

Initial time-critical activities were initiated with industry in September in order to meet the overall CRV schedule. The full suite of work to be undertaken by European industry should be initiated in the first quarter of 2000.

Data Management System - Russia (DMS-R)

Solutions to a problem with the ERC32 Revision B chip and a 'boot' problem with the Fault Tolerant Computers were implemented during the year. The launch date for the Russian Service Module in which the DMS-R is installed has, however, been delayed due to the failures of two Russian Proton launchers.

DMS-R Fault-Tolerant Computers installed in the Russian Service Module

European Robotic Arm (ERA)

In 1999 the ERA Critical Design Review (CDR) was successfully completed, as were system-level thermal-vacuum heat balance tests using the Large Space Simulator at ESTEC. Delivery of the flight model to Russia is now expected to take place early in 2001. Although later than planned, this is still consistent with the need date for ERA, which is tied to the launch of the Science & Power Platform (SPP), now foreseen no earlier than March 2002.

Ground Segment and Operations

The planning of activities for the Columbus and ATV Control Centres has been aligned with the related launch dates, and definition activities continued throughout the year.

The Columbus Functional Crew Trainer Phase-C/D was initiated and is proceeding to plan, and the System Requirements Definition Phase for the ATV Trainer is being prepared.

Installation of the ERA engineering qualification model in the Large Space Simulator (LSS) at ESTEC (NL), for heat-balance testing

Space Station Utilisation Preparation and Promotion

In response to an Announcement of Opportunity (AO) in Physical Sciences, 18 proposals were rated by peer boards as 'outstanding' or 'highly recommended' and identified as Microgravity Application Promotion (MAP) projects. They came mostly from teams with a strong European dimension and included clearly identified industrial partners ready to contribute funding.

Broad agreement was reached regarding the financial support to be given to MAP projects, and funding for 24 such projects was approved late in the year, with ESA providing approximately 35% of the 26 M€ involved. The participating institutes, national agencies,

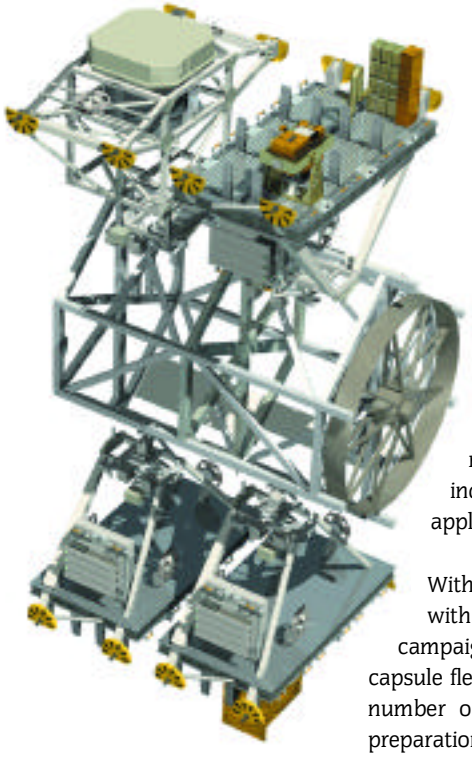
MELFI: the Brayton Cooler cartridge

third parties and industry will provide the remainder. The level of the industrial contribution – more than 25% of the total value of the projects – is a clear indication of European industry interest in utilising the ISS for research purposes.

In the autumn, a high response was received to a new AO, covering Life Sciences Applications, and dealing with biomedical applications and life-support systems.

Important progress was achieved in the area of the Laboratory Support Equipment projects, which are being developed by ESA for NASA under the Early Utilisation and Columbus Module Launch barter agreements. The CDR for MELFI (-80°C freezer) was completed in June and the Laboratory Ground Unit was delivered to NASA in November. The CDR for the MSG (Microgravity Science Glovebox) was closed in February and the PDR for the Hexapod pointing instrument for the NASA-provided SAGE-III experiment was completed in June.

Starboard Truss Section, showing three Express Pallets with their payloads



Launch and deployment of payloads on the exterior of ISS on truss-located Express Pallets is currently foreseen by means of two Utilisation Flights, in 2003 and early 2004:

- ACES, the Atomic Clock Ensemble in Space
- EXPOSE, a multi-user facility for exobiology
- SPORT, the Sky Polarisation Observatory
- SOLAR, a grouping of three solar observation instruments
- EuTEF, the European Technology Exposure Facility
- FOCUS, a multispectral detector of high-temperature events on the ground, such as forest fires or volcanic eruptions.

Microgravity Missions

The EMIR-2 and EMIR-2 Extension

The content of the EMIR-2 Extension programme was agreed in December 1999 and covers the provision of flight opportunities, preparatory activities for ISS utilisation, and general support activities. The Programme will continue the research in life sciences and physical sciences, with an increasing emphasis on industrial applications in the materials-science and biotechnology areas and on applications and societal benefits in the medical and biology domains.

Within the EMIR-2 programme, the Maser-8 sounding rocket flew successfully in May with five ESA microgravity experiment modules on board, and two ESA parabolic-flight campaigns were carried out in June and October. In September, the Russian Foton-12 capsule flew successfully for 15 days carrying the ESA FluidPac and Biopan facilities and a number of autonomous experiments. Development and refurbishment of facilities in preparation for the STS-107 Spacehab flight in early 2001 continued. EMIR-2 also supported the development of experiment facilities to exploit early Space Station flight opportunities.

The Microgravity Facilities for Columbus (MFC) programme

The Phase-C/D development of the Biolab, the Fluid Science Lab (FSL) and Material Science Lab (MSL) continued throughout the year and Phase-B activities on the European Physiology Modules (EPMs) were started.