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The Newsletter of the Directorate of Manned Spaceflight and Microgravity

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Directorate of Manned Spaceflight and Microgravity
Direction des Vols Habité et la Microgravité

A Promising Start to 2002

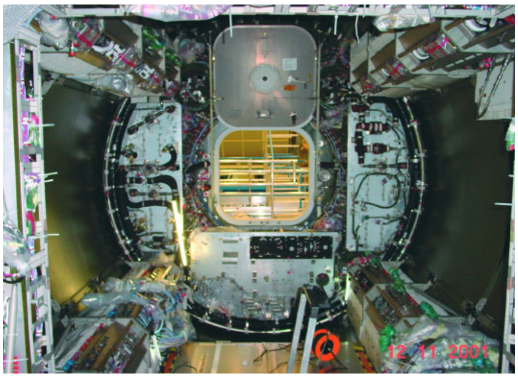
Jörg Feustel-Büechl
ESA Director of Manned Spaceflight and Microgravity

I want to highlight two very important milestones for this year. Firstly, the final integration and test of our Columbus laboratory for the International Space Station began at Astrium GmbH in Bremen (D) following the arrival in September of the Pre-Integrated Columbus Assembly (PICA) from Alenia Spazio in Turin (I). I believe that we have a masterpiece of European engineering here, and I am delighted with the progress so far. We should be seeing some very real advance on Columbus by the end of 2002 and look forward to its status then.

Secondly, I had the opportunity on 15 January to review the course of the Automated Transfer Vehicle (ATV) project at Les Mureaux (F), together with our team and the industries involved in the project under prime contractor EADS-LV. The progress is quite remarkable when we remember the difficulties of last year. All in all, I think that the technical achievements so far are satisfactory. One important demonstration of this progress is the arrival of the ATV Structural Test Model in ESTEC's Test Centre, where it will undergo testing during the whole of this year. In parallel, the preparation of a number of crucial items for the ATV Critical Design Review is underway. This should lead to a positive conclusion of that extremely important review early in 2003 so that we can then expect ATV's maiden launch in 2004.

There are two other major events that we are looking forward to this year. The first is the Soyuz taxi flight to the Space Station of ESA Astronaut Roberto Vittori, planned for 27 April. This is a very important flight not only for Roberto, who is making his first spaceflight, but also because it demonstrates yet another concrete example of European/Russian cooperation. This flight is sponsored by the Italian space agency (ASI) and the Italian Air Force.

The second event is the Soyz taxi flight of Frank De Winne in November. This will be the first flight of the latest Soyuz-TMA spacecraft and, like Roberto, Frank has the important role of Flight Engineer on his first mission. This



Interior of the Columbus module. (Astrium)

crew position is a crucial factor in the success of the improved Soyuz vehicle. This flight is sponsored by the Belgian Government. These are two important astronaut missions for the year. Although we would have liked full ESA missions, I believe that the way in which such missions are organised is basically acceptable, and fulfils the goals of having our European astronauts flying into space. We in ESA are indeed very keen to continue these beneficial and fruitful ventures with the Russians.

We continue to make important progress with our payload facilities. The Microgravity Science Glovebox (MSG) will soon be launched on STS-110/ISS Assembly Flight #8A in April, followed by the first 'Minus Eighty degree centigrade Laboratory Freezer for ISS' (MELFI) model on STS-114/ULF-1 next January. MSG will provide the ISS with its unique and multidisciplinary laboratory support capabilities. It can handle a wide variety of materials, house investigations into combustion, fluids and biotechnology, and accommodate servicing of harware that needs a controlled working environment. With MELFI, ESA and European space industry have developed new technologies and integrated them in a new concept for a space freezer. For the first time, the scientific community will have permanent large-volume cold storage in space.

We also have the Shuttle STS-107 mission currently planned for July. That will carry a number of ESA payload elements, including APCS, ARMS, Biobox, Biopack, ERISTO, FAST and Com2Plex. The first Foton-M flight is planned for October, with ESA payload elements FluidPac, Stone and Biopan offering further flight opportunities for experiments. I really feel that this wide spectrum of payloads represents a remarkable achievement for European industry.

We expect to continue with significant advances in our technical work during 2002. This, I believe, is a very important factor for cooperation not only within Europe but within the whole Station partnership. Nevertheless, we are still far from finished with our overall question to the US on the subject of Station crew-size. In early February we saw NASA present their financial budget for 2003 and, for the first time, we saw in clear terms the 'US

Roberto Vittori (foreground) and Frank De Winne during their Soyuz Flight Engineer training.

ATV STM testing at ESTEC. Above: in the Large European Acoustic Facility. Facing page: with (from left) Director General Antonio Rodotà, Head of MSM Manned Spaceflight Programme Department Alan Thirkettle, Mr. Feustel-Büechl, ESA Director of Administration Daniel Sacotte and ATV engineer Geoffrey Beckwith.

Core Complete' proposal with a crew of only three, instead of the seven we have long expected. I can only repeat what I said in the last issue of *On Station*, and we have forwarded that view to our American partners: we are extremely concerned about this development, and would like to emphasise that NASA and the US should stick to their commitments of the January 1998 Inter-Governmental Agreement and the associated Memoranda of Understanding.

This is not just a legal issue but, more importantly, a political issue. We want to have a Space Station that fulfils our expectations and justifies the enormous amount of tax-payers' money that has been flowing into the programme. The restricted operational capability offerred by a Space Station with a crew of only three will not fulfil the utilisation expectations that we all had and that we still aim for. We foresaw that, building on our occasional flight opportunities with Spacelab and Spacehab, we would have a permanent and fully outfitted laboratory in orbit available 24 hours per day, 365 days per year for research and applications projects. Furthermore, it would be operationally comparable with a ground laboratory, where researchers could go to do their work at any time. This purpose will certainly not be fulfilled with a crew of three and therefore we see, as Europeans, an urgent need to redress the situation, especially on the US side. To this end, our Chairwoman of the ESA Ministerial Council, Mrs. Edelgard Bulmahn (D) has recently seen the new NASA Administrator, Mr. Sean O'Keefe, and other high-level US representatives to insist that they keep to their original commitments. ■

ISS launches planned for the next 12 months.

Flight #	Launch	Element/Task	Vehicle/Mission
25: 7P	21 Mar 02	Logistics (Progress-M)	Soyuz
26: 8A	04 Apr 02	S0 Truss/Mobile Transporter	Shuttle STS-110
27: 4S	25 Apr 02	Taxi Flight (Roberto Vittori)	Soyuz-TM34
28: UF-2	06 May 02	Expedition-5 Crew/MPLM	Shuttle STS-111
29: 8P	14 May 02	Logistics (Progress-M)	Soyuz
30: 9P	22 Jul 02	Logistics (Progress-M1)	Soyuz
31: 9A	01 Aug 02	S1 Truss	Shuttle STS-112
32: 11A	06 Sep 02	Expedition-6 Crew/P1 Truss	Shuttle STS-113
33: 10P	07 Oct 02	Logistics (Progress-M)	Soyuz
34: 5S	04 Nov 02	Taxi Flight (Frank De Winne)	Soyuz-TMA
35: ULF-1	16 Jan 03	Expedition-7 Crew/MPLM	Shuttle STS-114

ESA-related flights for the next 12 months.

March: Maser-9 sounding rocket

March: 32nd Parabolic Flight Campaign

April: Soyuz taxi flight with ESA Astronaut Roberto Vittori

May: Microgravity Science Glovebox (MSG), aboard Shuttle STS-111/UF-2, for installation in Destiny; MPLM Leonardo

July: STS-107 with ESA payloads APCS, ARMS, Biobox, Biopack, ERISTO, FAST, Com2Plex

July: 5th Student Parabolic Flight Campaign

August: X-38 free-flight

October: Foton-M1 with ESA payloads FluidPac, Stone, Biopan, SCCO, Photo II, Aquacells, Biofilter, 3 student/outreach experiments, material science experiments in the Russian Polizon (2x) and German Agat (2x) furnaces, biological experiments (2x) in the French IBIS facility

September: 33rd Parabolic Flight Campaign

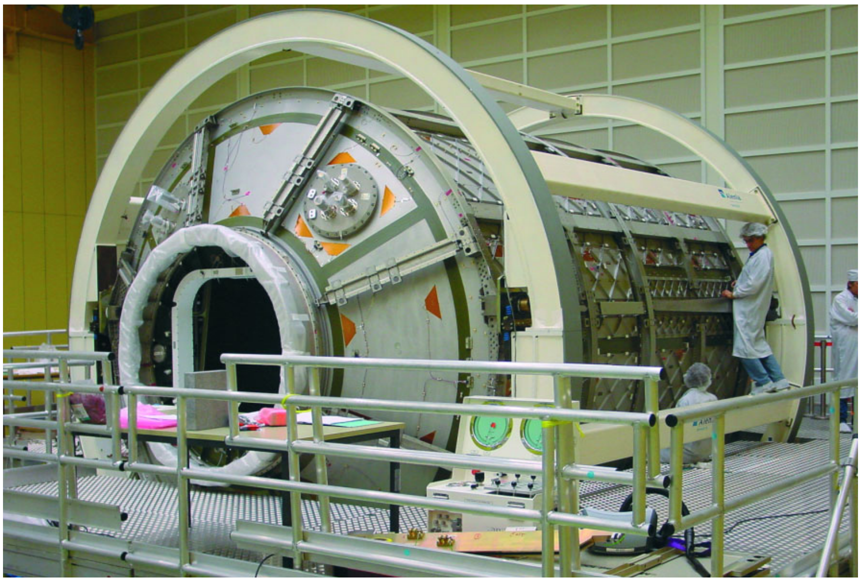
November: Soyuz taxi flight with ESA Astronaut Frank De Winne

November: X-38 free-flight

January 2003: MELFI; Pulmonary Function System, part of HRF-2 for Destiny, on Shuttle STS-114/ULF-1; MPLM Raffaello

March 2003: Maxus-5 sounding rocket

March-April 2003: 34th Parabolic Flight Campaign



The Columbus module at Astrium in Bremen.

Aurora

A European Roadmap for Solar System Exploration

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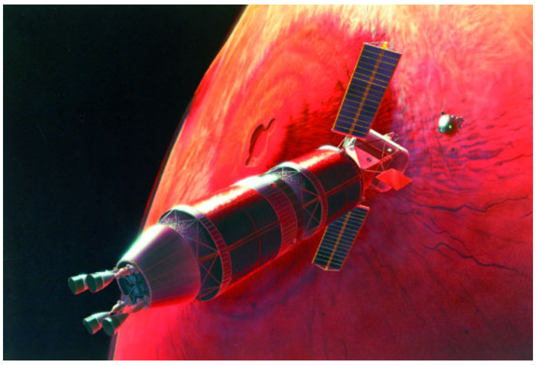
Aurora is a long-term initiative for robotic and human exploration of the Solar System, in particular where there promises to be traces of life. In a first 3-year preparatory period, preliminary mission assessments and technology roadmaps are being developed...

The 'European Strategy for Space', endorsed by the ESA Council and the European Union Council for Research asks for a European approach to 'explore the Solar System and the Universe...' and to 'prepare for the next step in human space exploration, the exploration of the Solar System.' Based on this mandate, ESA decided towards the end of 2000 to begin the 'Aurora' initiative for planetary exploration. The activity, cutting across ESA Directorates, culminated in a new programme proposal describing the objectives and approach leading to a long-term mission framework for robotic and human exploration.

At the leading edge of science and technology, a manned mission to Mars would be a major project, requiring the International Space Station (ISS) and possibly Moon as a testbed and stepping stone. Why explore Mars? With an atmosphere sometimes showing weather and circulation patterns similar to those of Earth, and with 'dry river' valleys suggesting an earlier environment suitable for sustaining life, the planet is an extremely rich target. It touches upon geology, geophysics, geochemistry, atmospheric physics, climatology and biology.



Interplanetary transport. (NASA)

Aurora is Europe's response to this challenging goal – a long-term exploration programme in coordination with European and international partners. It is a roadmap for robotic and eventually human exploration that will generate a large number of science and technology spin-offs. By its nature, Aurora is a multi-disciplinary programme, across many sectors of science, technology and space. As an envelope programme, Aurora will formulate and then implement a European long-term plan for exploring the bodies of the Solar System, particularly those holding promise for traces of life.

An important milestone for Europe was reached at the Ministerial Council in Edinburgh (UK) in November 2001, which adopted a proposal by the ESA Director General for an initial 3-year preparatory period for Aurora. As an optional programme with a currently subscribed financial envelope of €14. 1 million, Aurora is subscribed to by France, Italy, Belgium, Switzerland, UK, Austria, Spain, The Netherlands, Canada and Portugal. Other countries have expressed their interest and may join later. The contributions will help to secure the long-term vision and interests of Europe in such a demanding but appealing enterprise.

The Aurora Programme covers two main components:

The Definition Component includes programme planning and definition of the European framework for exploration, activities selection, scientific support, pre-Phase-A and Phase-A mission studies, along with future human missions architecture, generic technology pre-development work, scientific and instrument definition, as well as public awareness activities. Aurora's 3-year preparatory period funds only this Definition Component.

The Development Component includes mission and technology development Phases-B/C/D/E. For technologies, this is when the mission-specific developments or demonstration activities take place. Operations and exploitation are included, as well as any related infrastructure developments. They will be implemented in the most efficient way to reduce costs and improve scientific and technological yield by combining ESA and national efforts, and in cooperation with other international organisations.

Two classes of missions are foreseen:

Flagship, major missions driving towards soft landing or sample return from other planets, and eventually a manned mission;

Arrow, cost-capped, rapid-development missions to demonstrate new technologies or mission approaches, or to exploit opportunities for payloads on European or international missions.

Mars, the Moon and near-Earth asteroids will be explored in a natural sequence, summarised as remote sensing from orbit, robotic *in situ* exploration and sample return for detailed analyses, leading to a soft landing by a manned vehicle.

The following technology areas were identified as enabling a wide variety of manned and robotic exploration missions:

- automated guidance, navigation & control,
- micro-avionics,
- data processing and communication,
- entry, descent and landing,
- crew aspects of exploration,
- exploiting local resources,
- power generation, conditioning and storage,
- propulsion (space transportation, ascent, descent),
- robotics and mechanisms,
- structures, materials and thermal control.

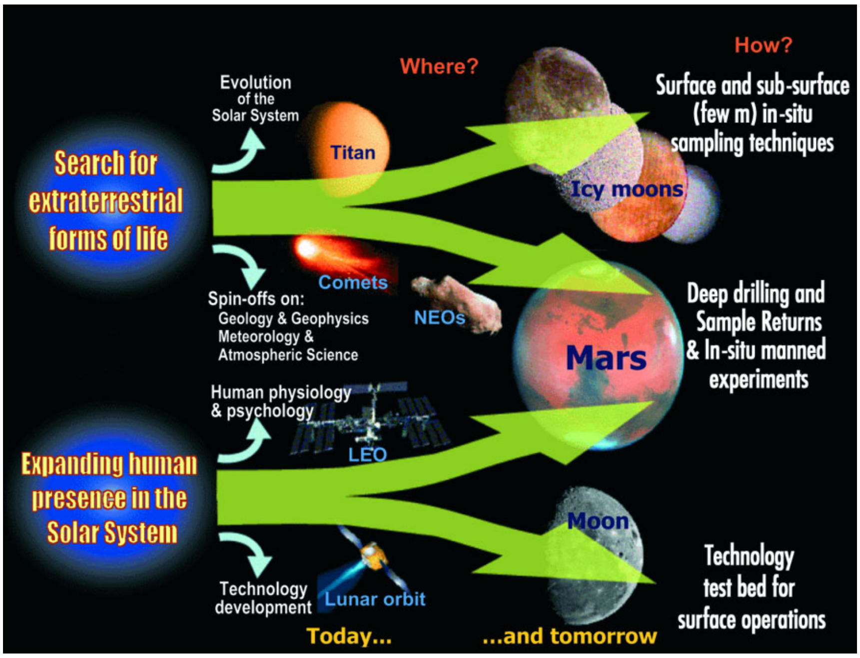
For human exploration, Aurora will undoubtedly benefit from the International Space Station in terms of technology validation and lessons-learned. However, the specific requirements for long-duration planetary missions mean that additional key technologies need to be developed and validated through realistic demonstrations:

- efficient interplanetary fast transfer,
- regenerative crew life-support systems,
- health care at remote locations,
- techniques to cope with human isolation and confinement,
- crew radiation protection in transit and on a planetary surface,
- spacesuit technology for planetary surface extravehicular activities.

To promote innovation, a network of European and Canadian academics is being set up to generate new mission ideas and advanced concepts. Also, the interests and capabilities of non-prime contractors and small- and medium-sized enterprises are taken care of via the Arrow missions and the programme's large technology component.

Aurora is being pursued in coordination with European and international partners, including agencies, industry and research institutes. Experience with the Space Station programme clearly shows that the best cooperation is between equal partners. Aurora will provide the missions and technologies for Europe to become a credible partner in the international effort for exploring the Solar System.

Check the Human Spaceflight website for more information:
http://www.esa.int/export/esaHS/ESACVG0VMOC_future_0.html



Aurora exploration goals.

The Erasmus Virtual Campus

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What is the Erasmus Virtual Campus?

The Virtual Campus at ESTEC's Erasmus User Information Centre is designed to bring people together, increase their collective knowledge and facilitate cooperation between them. It is structured very much like a campus in the physical world. Think of it as a city with places and buildings connected by streets. While some buildings may be open for all visitors, others have a restricted access for members only. There is a Library and an Archive. There is a Forum for discussion and for meeting new people, an Amphitheatre for lectures and presentations and a Coliseum for events.

The Erasmus Virtual Campus is becoming an increasingly important tool for space users...

The Virtual Campus also provides the foundation for creating and operating Virtual Institutes in selected scientific areas.

What are the principal functions?

Firstly, the Campus is an information portal. It eases access to information that is stored elsewhere and difficult to find. Secondly, the Campus is itself an information provider. It is a warehouse for validated and up-to-date reference information. It packs this information into appropriate boxes, describes the contents on top and stores the boxes in a structured way on shelves where they can easily be found.

Thirdly, the Campus is a broker. It helps to make the ideas and projects of people known to others, and helps people to interconnect. Fourthly, the Campus is a cooperation facilitator. It provides information and communication tools that allow research teams to work on a common research project even though they are geographically separated.

Who are the users of the Virtual Campus?

The target audience for the Campus are European scientists and engineers who are interested, or already involved, in the utilisation of the orbital and ground facilities managed by ESA's Directorate of Manned Spaceflight and Microgravity, or for which this directorate can provide access. These facilities cover the European elements of the International Space Station (ISS), the US Space Shuttle, Russian Foton capsules, European Maser and Maxus sounding rockets, parabolic flight campaigns with the Airbus A300, drop towers and selected ground facilities for research in life sciences and physical sciences.

The Erasmus Virtual Campus is thus open to a large potential user community:

- scientists interested in the above facilities for their research activities;
- project engineers and managers involved in developing, building or operating these facilities;
- scientists and engineers in the European User Support and Operations Centres (USOCs) who deal with the utilisation of these facilities;
- politicians who decide on research activities and who want to obtain information on the objectives and results of the work performed in these facilities;
- students in search of reference material for their university studies or of information and guidance in their personal career choices;
- public and private education institutions

and exposition centres that focus on the popularisation of science and technology activities in space;

– laypeople and media representatives with an interest in research and high-technology subjects.

Why do these people need a Virtual Campus?

The research projects using the ISS or other facilities under ESA responsibility often unite people from different scientific disciplines and professional corporations. These teams are usually international, with their members spread around Europe. Becoming familiar with each other's discipline, sharing existing knowledge, working from different locations with the same reference documentation and jointly working on proposals is a constant occupation of these teams. The Virtual Campus makes their lives easier, in particular by reducing the drawbacks of geographical separation.

Thanks to its information and communication tools, the Campus provides interactive information exchange and a higher degree of interaction among team members than was possible previously using classical one-to-one information and communication tools.

What are the main tools and services?

Internet site The core product of the Campus in its triple function as an information portal, an information content provider and an information broker is the Internet site *www.spaceflight.esa.int/users*. It is a resource of validated up-to-date reference information for scientists and engineers.

Document Server By promoting cooperation, the Campus allows its members to store documents of common interest and share them among team members.

Photo and Video Archive The shared storage of and access to photo and video files is operational. The distribution of video files using streaming video is almost ready. This will make the Archive particularly attractive for tele-education activities.

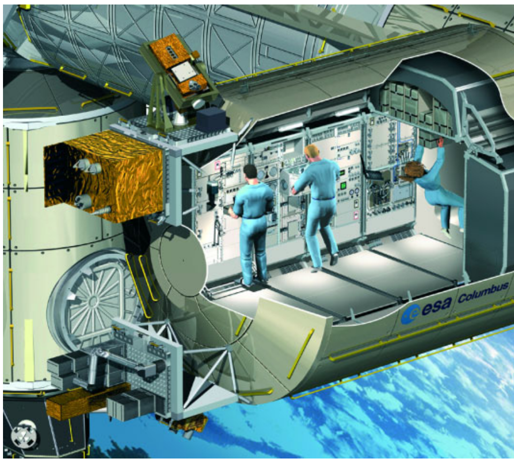
Remote Working Sessions The Campus is setting up a dedicated server and procuring the licences for tele-conferencing and tele-education to work with the software and firewall environments of the participants. This will allow geographically separated research teams to work remotely and interactively using Word, Powerpoint and Excel files and to speak to each other through the Internet. The efficient combination with other communication tools, such as satellite communications, 3D television and the network that links the USOCs with ESA, makes this form of remote cooperation attractive to potential users.

Chat and Discussion Forums The Campus organises chat sessions and discussion forums with a broader audience – and the general public – through the *www.spaceflight.esa.int/users* Internet server.

Video Production and Broadcast Facilities The ISS User Information Centre is equipped with a TV studio and the resources for producing video films (including 3D). Its own satellite television uplink/downlink facility can be used for live events and lectures.

Lectures and Events The ISS User Information Centre has a 120-seat auditorium that can be used for Campus lectures. The lectures can also be broadcast live to Europe via satellite and Internet streaming video. The same tools and resources allow a wider distribution of ISS launch and in-flight events, in particular for those with scientific or educational links, to a number of European viewing sites. The USOCs are expected to play a key role in this network of viewing sites. Commercially funded user-support centres like ALTEC in Turin (I) and BEOS in Bremen (D) have been invited to become part of the network of viewing sites. As a second step, the network would be extended to research institutes and organisations, universities, other space agencies, industrial companies and education and popular science centres. ■

ESA's ISS External Payloads



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Introduction

We usually think of astronauts aboard the International Space Station (ISS) performing experiments inside the laboratory modules, but *external* payloads offer experiments in the space environment with the major advantages of long duration exposure and return to Earth for examination.

European investigators are preparing to exploit the external research opportunities provided on the Columbus module...

ESA is equipping the Columbus module with the External Payload Facility (CEPF) to accommodate research payloads. It is a framework mounted on the module's end-cone and provides power, data and command links. The Station's robot arms will install the payloads delivered by the Space Shuttle. The External Payload programme consists of two elements: early utilisation (before Station assembly is complete) and routine exploitation (after assembly completion).

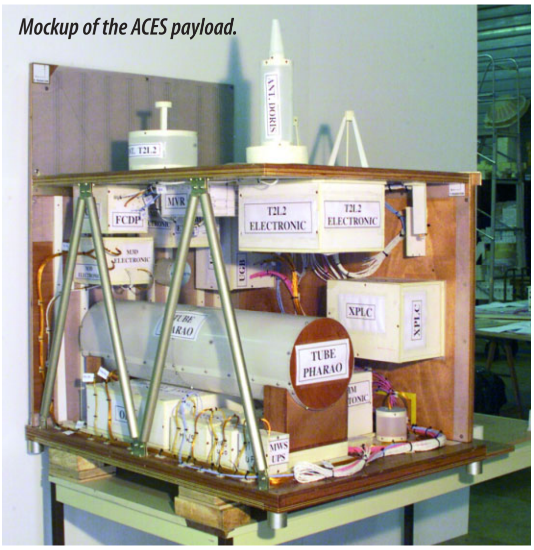
External Payloads for Early Utilisation

ESA negotiated the right to fly external payloads during the Station's early utilisation phase, for a period of 3 years. Each payload is mounted on an adaptor able to accommodate small instruments and experiments totalling up to 227 kg. Following an Announcement of Opportunity and peer review, five payloads were selected, of which four entered development. They were originally planned to use the NASA external sites but will now be located on Columbus in 2005-2006.

Atomic Clock Ensemble in Space (ACES)

The fact that time can be measured very precisely – far better than any other physical parameter – is a technological asset of great importance. This is the essence of ACES, which will test a new generation of atomic clock in space. The 'cold atom' clock, PHARAO (Projet d'Horloge Atomique par Refroidissement d'Atomes en Orbite), developed by CNES (F), and SHM (Space Hydrogen Maser), developed by the Observatory of Neuchatel (CH), will be characterised and compared in a microgravity environment.

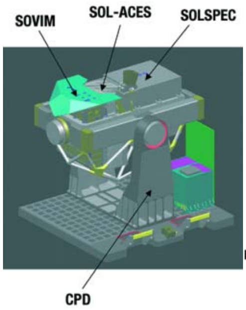
Experiments include high-precision time and frequency transfer, atmospheric propagation, high-precision geodesy, global network synchronisation and fundamental physics.



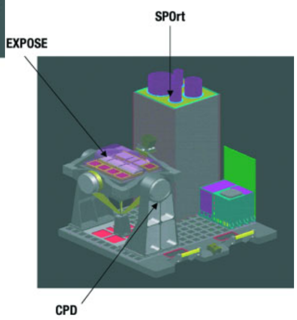
Mockup of the ACES payload.

SOLAR

SOLAR will measure the Sun's output with unprecedented accuracy. Apart from contributing to solar and stellar physics, knowledge of the interaction between the solar energy flux and Earth's atmosphere is of great importance for atmospheric modelling, atmospheric chemistry and climatology.



The SOLAR instruments are mounted on a Coarse Pointing Device to track the Sun.



The EXPORT configuration.

SOLAR's three instruments will measure the solar flux across a wide spectrum:

- SOVIM (SOlar Variable & Irradiance Monitor), covering near-UV, visible and thermal-IR, developed by the Observatory of Davos (CH);
- SOLSPEC (SOLar SPECctral Irradiance measurements), covering 180-3000 nm at high spectral resolution, developed by CNRS (F);
- SOL-ACES (SOLar Auto-Calibrating EUV/UV Spectrophotometers) measures the extreme-UV and UV regime at moderate spectral resolution, developed by the Fraunhofer Institute (D).

The instruments are mounted on a multi-purpose Coarse Pointing Device (CPD), which tracks the Sun as it compensates for the Station's orbital motion.

EXPORT

EXPORT carries two independent instruments. EXPOSE is an exobiology facility developed by ESA. It studies the photo-processing of organic molecules, the survival of micro-organisms in space and the effect of unshielded solar-UV on organic molecules and micro-organisms. EXPOSE is also mounted on a CPD, to point the 12 sample compartments at the Sun. SPOrt (Sky Polarisation Observatory) is an astrophysical instrument, developed by CNR (I), to measure celestial polarisation in the unexplored microwave frequency range of 20-90 GHz. SPOrt goals include the first polarisation map of the Galaxy at 22, 32 & 60 GHz and all-sky measurements in the cosmological window (90 GHz) with unprecedented sensitivity.

EuTEF

The European Technology Exposure Facility (EuTEF) is a programmable, multifunctional, fully automated system. The modular architecture provides uniform interfaces for instruments– up to seven instrument modules can be accommodated and operated simultaneously. Five instruments are under development:

- TRIBOLAB, a tribology testbed developed by INTA (E);
- PLEGPAY, a plasma electron gun payload developed by LABEN (I);
- MEDET, the Material Exposure and Degradation Experiment on TEF, developed by CNES/ESA/ONERA/University of Southampton;
- DEBIE-2, a space debris detector developed by ESA (the first is flying on the Proba satellite);
- FIPEX, the Flux Probe Experiment developed by the University of Stuttgart (D).

EuTEF will initially accommodate five experiments.

Future Payloads

After about 3 years, this first batch will be replaced by new payloads now being studied. EUSO (Extreme Universe Space Observatory) and Lobster are approved by the Agency's Science Programme to begin Phase-A studies this year. EUSO would detect extreme-energy cosmic rays and the high-energy cosmic neutrino flux. Lobster is an all-sky monitor in the soft X-ray band, using six lobster-eye telescopes to provide wide-angle imaging at 0.1-3.5 keV. RapidEye is an ISS commercialisation payload approved by the Manned Space Programme Board. It will observe man-made structures for agriculture applications and insurance verification.

Conclusion

The Columbus external facilities offer the opportunity for classical space science and technology experiments in a diverse array of disciplines. They will enhance the Station's return without significantly increasing the infrastructure cost by exploiting automated operations, with almost no crew intervention (a very expensive and limited resource). Three payloads are already in the detailed design and manufacturing phase (EuTEF, EXPORT, SOLAR) and ACES is planned to begin Phase-C/D this year. Phase-A activities begin soon on EUSO and Lobster, accompanied by the Phase-B of RapidEye. ■

ISS Assembly of XEUS

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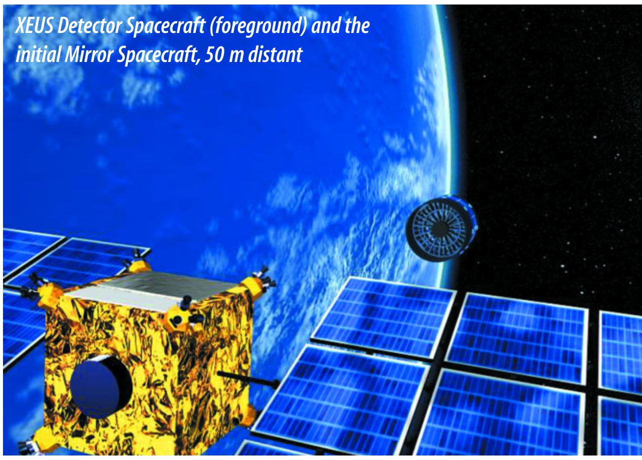


XEUS Detector Spacecraft (foreground) and the initial Mirror Spacecraft, 50 m distant

Introduction

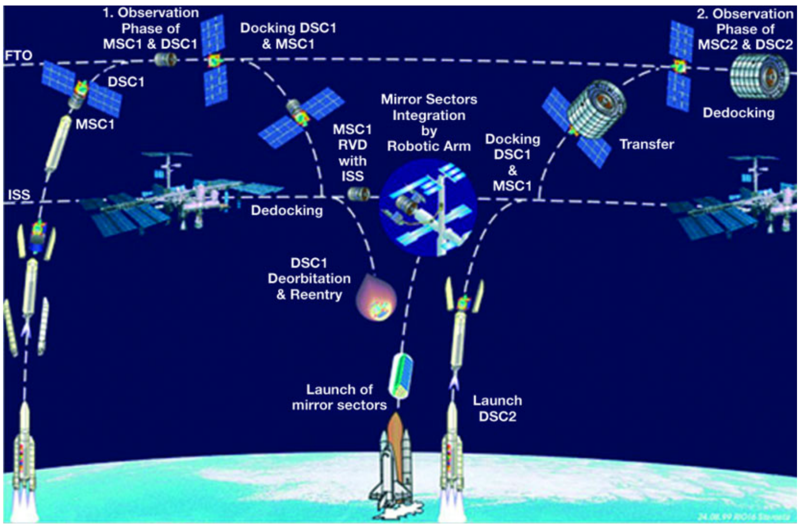
Providing in-orbit assembly services for visiting large science satellites is an attractive new utilisation area for the International Space Station (ISS). A prime but demanding candidate is XEUS (X-ray Evolving Universe Spectroscopy), a revolutionary mission to study black holes and the most distant X-ray emissions in the early Universe.

XEUS will be the most powerful X-ray observatory ever launched. Following a first phase of observations, it will visit the ISS to grow even larger...

The sensitivity requirements demand a telescope diameter of 10 m, with an effective area of more than 30 m^2. The observation and resolution requirements call for a focal length of 50 m. The solution is two spacecraft flying in formation, with the initial configuration (XEUS1) launched into a 600 km orbit by a single Ariane-5 some time after 2010. The slowly spinning mirror spacecraft (MSC1) houses X-ray mirrors spanning a 4.5 m-diameter, their baffles, two docking ports and an attitude control system. The detector spacecraft (DSC) hovering 50 m away hosts the focal plane instrumentation, coolers, a single docking port, and an attitude and orbit control system. An active laser range-finding system provides alignment accuracy of better than 1 mm^3 and *post-facto* reconstruction to <100 µm with respect to the MSC.

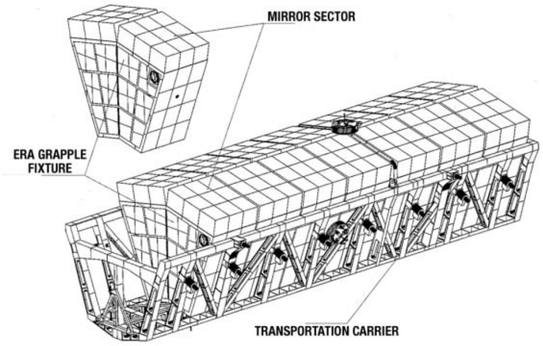
The DSC includes an orbital transfer motor, which – after about 5 years of observations – allows it to dock with the MSC and for the pair to transfer to the ISS for expansion and refurbishment into the much larger XEUS2.

XEUS/ISS mission scenario.



The ISS Assembly of XEUS2

The innovative mission scenario requires a radically new in-orbit assembly scenario. For assembling MSC2, the 12.4 t core MSC1 docks with Zvezda's aft port at the ISS. Eight new mirror segments, each 3.2 m high, 1.5 m wide and weighing 1.6 t, are delivered to the ISS in a single Shuttle flight, using a 12.9 m-long transport carrier (TC), weighing 15.8 t when loaded. The TC is transferred by the Shuttle/ISS robot arms to Zvezda (via intermediate parking on top of the Z1 Truss, where up to 800 W provides mirror thermal control). The mirror segments are then unloaded one by one by the European Robotic Arm (ERA) and attached to MSC1. Using the arms limits spacewalks to the final assembly steps and verification. The empty TC may leave the ISS aboard the same Shuttle after 11 days. The 11.2 m-diameter MSC2 has a final mass of 25 t.



Eight mirror segments will be launched in the Transport Carrier.

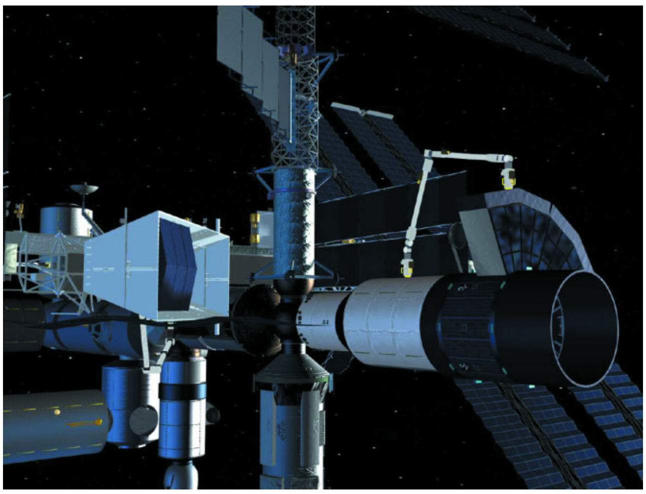
The detector spacecraft is deorbited and replaced by DSC2 offering the latest instrument technology.

The Challenges

The TC as a single logistics item requires detailed analysis:

- the loaded TC's length and mass are at the limit of the Shuttle's capability;
- the availabilities of the Z1 Truss for cargo storage and of a cargo adapter on it have to be confirmed;
- the loaded TC far exceeds the documented standard mass and centre-of-gravity constraints of a cargo adapter for worst-case ISS accelerations during reboosts and dockings. Avoiding these manoeuvres should make the excess load acceptable for the short TC parking periods.

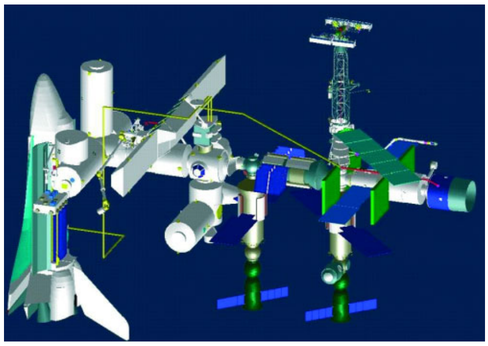
Extensive use is made of the ISS robotic facilities for assembling MSC2. The long robotic transport from the Shuttle to Zvezda – across the whole ISS – is a complex and critical activity. The Shuttle robot arm (SRMS) hands off the TC to the Station's Canadian arm (SSRMS) on the Mobile Base System. The SSRMS parks the TC on top of the Z1 Truss, and relocates



ERA adds mirror segments to create MSC2.

itself to Zarya. It then holds the TC above Zvezda so that ERA can extract a mirror segment. This TC transfer is critical and close to the feasibility limit of the ISS geometry. ERA then transports and installs the segment, repeating the process until MSC2 is complete. The empty TC is returned to the Shuttle by the reverse sequence.

Conclusions



XEUS will be demanding robotically: the yellow line traces the TC's path.

Driven by the high scientific desire for missions of the importance and complexity of XEUS, the concept developed for assembly using the ISS appears technically and operationally feasible, though challenging:

- the defined XEUS mission milestones fit within the Station's projected life;
- the Shuttle and ISS are capable of satisfying the needs of XEUS logistics, rendezvous & docking, and robotic assembly;
- MSC2 assembly can be performed robotically, with a minimum of EVA support;
- by far the dominant ISS resource for XEUS is crew time: 209 man-hours, about a third of ESA's annual share.

However, some assembly steps are either beyond normal ISS operations or come very close to the limits of the baseline Shuttle and Station capabilities, e.g. for:

- TC upload in one Shuttle launch;
- TC parking on top of the Z1 Truss;
- robotic handoff from SSRMS to ERA.

In addition, the ISS needs some relatively minor upgrades: payload storage (Z1 Truss adapter) and an additional ERA basepoint on the Zvezda. Also, ERA's handling of payloads in the lateral direction has to be confirmed.

In general, the Station's overall design proved capable of efficiently supporting in-orbit assembly of large spacecraft and 'visiting vehicles'. Only comparatively minor upgrades and improvements of the present technical baseline are required to support large-scale assembly missions.

XEUS, an ambitious mission with major challenges for the scientific community and industry, will likely become a truly global mission with international collaboration at a significant level, involving many of the partners already teamed in building the ISS. Further information on XEUS can be found at:

http://sci.esa.int/home/xeus/ ■

SPOE Standard Payload Outfitting Equipment for European Payloads on the ISS

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ESA has developed a set of standard equipment to outfit the European payloads for the International Space Station...

Introduction

In 1996, the Space Station Utilisation Division at ESTEC began the development and procurement of a set of standard equipment to support the European payloads for the International Space Station (ISS). The Standard Payload Outfitting Equipment (SPOE) programme now supplies a suite of standard items central to all ESA payloads destined for the ISS. The Microgravity Science Glovebox (MSG), to be delivered by the UF-2 mission to the US Destiny module in May, is the first using SPOE elements – it carries the complete set. The integration of SPOE items in other payloads is under way.

When SPOE development began, the Station interfaces were still evolving, so a key objective was to insulate ESA's payloads by absorbing the effects of changes in centrally provided equipment. This has proved particularly successful in the area of data handling, where significant modifications have been absorbed without affecting the payloads. The SPOE concept triggered new challenges for traditional ESA contracts, including: the production of recurring items of ground and flight hardware; their storage, handling and multiple delivery to users; the sustaining engineering and user-support services stretching over a significant time.

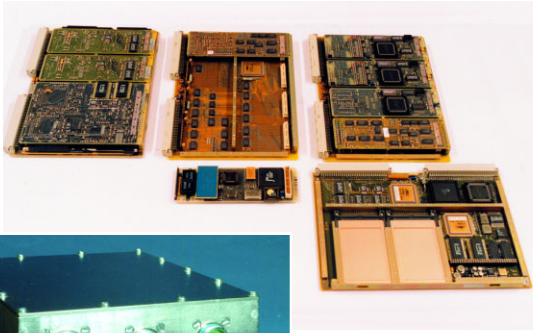
Once ESA had identified the key items to be provided as part of SPOE, a number of procurement decisions were made. Technologically interesting items such as the Avionics Air Assembly (AAA), the Remote Power Distribution Assembly (RPDA) and the Standard PayLoad Computer (SPLC) were selected for development and qualification by European industry. The International Standard Payload Rack (ISPR) was bartered from Japan. The Rack Main Switch Assembly (RMSA), the Smoke Detector Assembly (SDA) and the complete set of standard connectors for the Payload Rack/Laboratory Module interface on the Utility Interface Panel (UIP) were bought from the US.

The Industrial Consortium

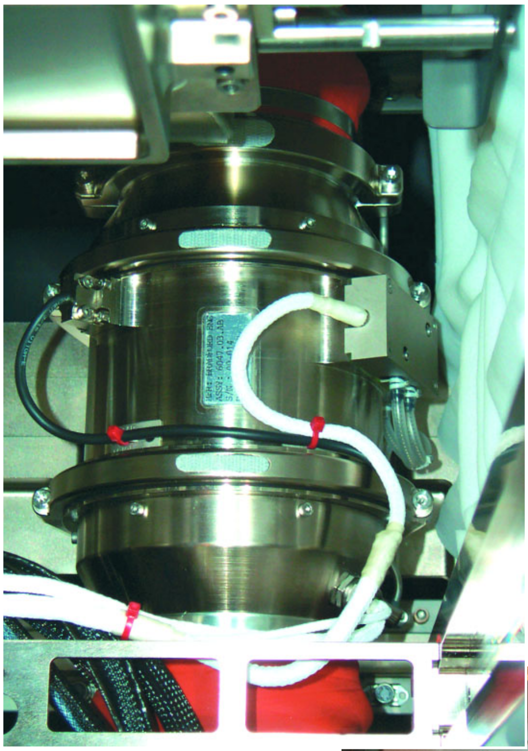
Astrium-SI (D) headed the SPOE Industrial Consortium as Prime Contractor. Besides the traditional management and system engineering responsibilities, the Prime was also in charge of identifying subcontractors and harmonising the requirements. On the technical side, the Prime developed a common approach across all the SPOE items and validated them for the different laboratory modules, in particular for the interface definition, product assurance requirements and qualification approach. As a result, the bulk of SPOE activities is governed by one common set of Quality Assurance & Safety documents and by a single, Prime-generated, Interface System Document towards the hosting modules. The subcontractors for the AAA and RPDA are, respectively, Bradford Engineering (NL) and Carlo Gavazzi Space (I).

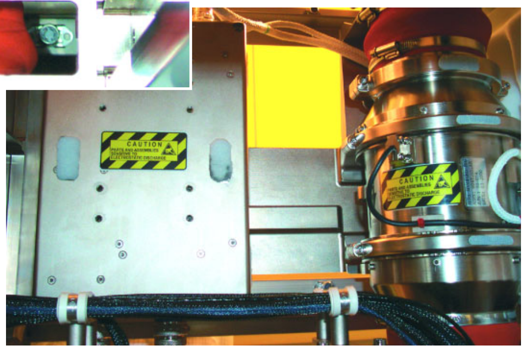
Standard Payload Computer (SPLC)

The SPLC is a standard set of boards and matching housing that can be assembled to



The Standard Payload Computer.





AAA installed in the MSG flight model.

meet the data-handling needs of most payloads. Owing to the openness of the design, special interface requirements can be resolved by adding user-developed boards. About half of the current projects rely on SPOE's standard boards, with the rest combining standard boards with specific developments.

The SPLC is qualified for internal and external payloads and is configurable for either Columbus or Destiny. The software package, to handle the interfaces between the payload and system, was a major part of the development. It was pre-tested on the NASA reference facilities in Houston, with the result that the MSG data-handling acceptance proceeded without error – a first for ISS payloads. Similar Columbus pre-testing is in progress on the rack-level test facility at Astrium in Bremen (D).

The SPLC is accompanied by Electrical Ground Support Equipment that simulates the US and Columbus data management systems with very high fidelity. As MSG experience showed, this significantly reduces the number of hidden interface errors that are usually found only during formal qualification testing.

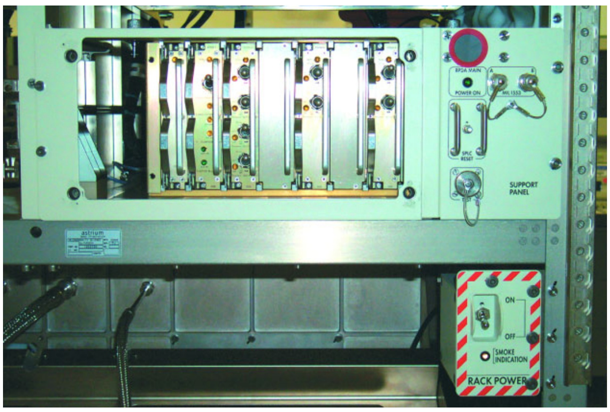
Avionics Air Assembly (AAA)

The AAA dissipates the residual heat inside a rack by air ventilation and forces the required air ventilation around the Smoke Detector head. AAA comprises an air/water Heat Exchanger, a Fan Unit to force the airflow through it and the electronics (E-Box) to control the fan propeller speed. It can dissipate 1200 W at 190 kg/h, 200ºC, water flow and 220 m^3/h, 380ºC, airflow. Complying with the ISS cabin noise limits was an extremely challenging design driver. The MSG version meets the 'NC 40' requirements – again a first – by means of additional acoustic absorbing material in the rack.

Remote Power Distribution Assembly (RPDA)

The RPDA distributes up to 6 kW among its rack elements from the Station's power system. Modular, it can accommodate two mandatory Exchangeable Standard Electronic Modules (ESEMs) for control and internal power supply plus up to six selectable ESEMs, able to provide 120 Vdc or 28 Vdc. Each RPDA power outlet can be remotely controlled and is protected against overcurrent/shortcircuit. A baseplate provides cooling.

RPDA installed in the MSG flight model.



Additional Items

The SDA and the complete set of connectors accommodated on the rack UIP were acquired commercially. The SDA is available in two configurations, suitable for accommodation inside the rack open space or inside the duct connected to the AAA. Its sensor head, based on light backscattering, detects typical smoke particles. The RSMA switch turns off the ISPR power feed via the Columbus or Destiny power control system during maintenance. It contains an LED for indicating a smoke alarm.

Qualification

The SPOE items developed in Europe, particularly the RPDA and SPLC, were qualified using a realistic worst-case. The results can be used by the different SPOE customers 'as is' if their configuration comes within the reference envelope, or extending them 'by similarity' beyond the reference case. The qualification process was completed by submitting SPOE items to the MSG safety reviews.

The ISS Exploitation Phase

An integral part of the SPOE concept is the provision of centralised spares and software maintenance over the lifetime of the payloads. For all SPOE items, users are able to call on immediate replacement of ground and flight units without having to buy and maintain individual stocks. Software changes are centrally coordinated so that modifications are implemented and validated on a reference version, which is then distributed to individual users. This provides significant savings compared to maintaining several individual project implementations. The SPOE activity is coordinated via databases, accessible to all users via *www.spoe.de*. SPOE maintenance is now being aligned with the ISS Exploitation Programme, where it will be merged with similar requirements from other elements of the Columbus system.

MSG uses the full set of SPOE. Flight Model testing at Astrium.

While this approach will satisfy existing payloads, a strategy is necessary for new payloads in order to counter component obsolescence brought about by the extremely long periods of ISS utilisation. This problem is particularly acute for the SPLC, where there are already difficulties in component availability. As this also applies to the Columbus system computers, a possibility under study is to upgrade the SPLC design with a view towards a common solution for all future computers aboard Columbus.

Conclusions

Through SPOE, the Agency has avoided repetitive developments of common items, and the payload integration process has been significantly eased by ensuring homogeneous quality of the end products, together with a reliable set of interfaces. As with any form of standardisation, it is impossible to cater for all the peculiarities of individual payloads and some compromises have been necessary. This may result in adaptation costs for individual payloads but these are more than compensated for at an overall programme level. The SPOE programme has been a considerable Agency undertaking, with many technical and programmatic challenges. The development phase is completed and the majority of items have been delivered. With the completion of MSG verification testing at the Kennedy Space Center, we are well on the way to achieving our objectives.

ESA-developed Payloads using SPOE

Project	*SPLC*	*AAA*	*RPDA*	*ISPR, RMSA SDA, etc*
ACES	X			
Biolab	X		X	X
CPD	X			
EDR	X	X	X	X
EMCS	X	X	X	X
EPM	X	X	X	X
EuTEF	X		X	
FSL	X	X		X
Hexapod	X			
MELFI				X
MSG	X	X	X	X
MSL	X			X
PCDF	X			

ACES: Atomic Clock Ensemble in Space. CPD: Coarse Pointing Device. EDR: European Drawer Rack. EMCS: European Modular Cultivation System. EPM: European Physiology Modules. EuTEF: European Technology Exposure Facility. FSL: Fluid Science Lab. MELFI: Minus Eighty degree Lab Freezer for ISS. MSG: Microgravity Science Glovebox. MSL: Materials Science Lab. PCDF: Protein Crystallisation Diagnostics Facility.

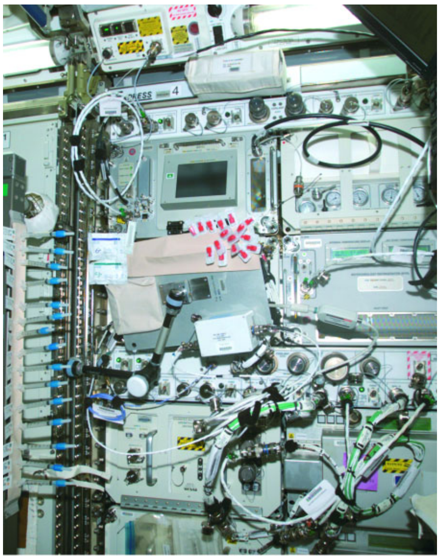
Acknowledgements

The authors express their appreciation for the highly motivated dedication of the Industrial Consortium that made the standardisation possible. Special thanks go to our colleagues in ESTEC: T. Sgobba, W. Freihoefer, R. Bureo, A. Ciccolella, J. Wolf, G. Colangelo, G. Simonelli and H. Van Der Meij. A final word goes to the MSG Industrial Team, who contributed significantly to the SPOE activities by acting as a constructive first user.

The Destiny Research of Expedition-4

Graham T. Biddis
On Station Contributing Writer

During their occupation of the Space Station since December 2001, the Expedition-4 crew has been performing a wide range of scientific investigations...



Express Rack 4 (NASA).

Introduction

This review summarises the research activities aboard the US Destiny laboratory by the Expedition-4 Crew, who arrived on 5 December 2001 aboard STS-108/UF-1 and are expected to depart in June 2002. The crew of Yuri Onufrienko (Commander), Carl Walz and Dan Bursch (Flight Engineers) inherited a number of experiments from their predecessors (*On Station* #7, December 2001, pp20-23).

The Expedition began with two 'sortie' experiments that remained aboard STS-108. The **Avian Development Facility** was activated shortly after docking for its 36 Japanese quail eggs to incubate. The embryos were then fixed for post-flight examination. Bird embryos are useful biological models for observing changes in cardiovascular, vestibular, musculoskeletal, immunological and neurological development in microgravity. The second sortie experiment, the **Commercial Biomedical Testing Module**, examined how well a recently discovered protein reduces bone loss. This potential treatment for osteoporosis is being tested by a biotechnology firm together with a NASA Commercial Space Center, using microgravity to simulate accelerated bone loss on Earth. Twelve lab mice were treated with the osteoprotegerin protein, a potent regulator of bone metabolism, while 12 others were treated with a placebo.

Expedition-4 Commander Yuri Onufrienko.

Inherited Experiments

Expedition-4 inherited a set of experiments from their predecessors. Express Rack (ER)-1 is hosting:

Microgravity Acceleration Measurements System (MAMS) and **Space Acceleration Measurement System II** (SAMS-RTS) Remote Triaxial sensors 1 & 2 to characterise the Station's microgravity environment.

Biotechnology Cell Science Stowage Resupply (BCSS-R), previously in ER-4, supports biological cell culture research. Sub-rack modules provide semi-automated bioreactors, gas supplies, computer control and passive and low-temperature stowage. This cell culture system is an interim platform for cell research until the Biotechnology Facility is delivered.

ER-2 is hosting:

Active Rack Isolation System (ARIS) actively damps out vibrations. The ARIS ISS Characterization Experiment (ARIS-ICE) is testing its performance.

SAMS Interim Control Unit.

Physics of Colloids in Space (PCS-TC1 & -AS) is investigating the colloidal properties of common materials, including food, paints and coatings. A laser illuminates a melted sample for a pair of colour cameras to record images at two magnifications of the arrangements of individual particles as well as the larger structures.

ER-4 is hosting:

Biotechnology Specimen Temperature Controller (BSTC), part of the BCSS, can house 32 tissue culture modules at a carefully controlled 36°C.

The **Gas Service Module** (GSM) and **Biotechnology Refrigerator** (BTR) support the BCSS.

Advanced Astroculture (ADVASC) Support Systems, previously in ER-1, for research into whether seeds can be produced by plants grown from seeds in space.

ER-5 contains no payloads and has been installed in readiness for future uploads.

The **Human Research Facility** (HRF-1) is used to study the physiological, behavioural and chemical changes in humans caused by spaceflight. The **Gas Analyzer System for Metabolic Analysis Physiology** (GASMAP) analyses metabolic function, cardiac output, lung diffusing capacity, lung volume, pulmonary function and nitrogen washout. The **Ultrasound Imaging System** (Ultrasound) provides enlarged 3D images of the heart and other organs, muscles and blood vessels. The **Pulmonary Function in Flight** (PuFF) unit is researching changes in lung anatomy and performance caused by spacewalks or microgravity. The focus is on measuring changes in the evenness of gas exchange in the lungs, and on detecting changes in respiratory muscle strength. Each PuFF session includes five lung function tests.

Deployed Payloads

The following payloads were already in Destiny:

Carl Walz with the WA3 amateur radio antenna.

Interactions for studying crew and crew-ground team relationships during long-term space missions. The crew fills out a laptop questionnaire of their interactions with each other and ground controllers.

Earth Knowledge Acquired by Middle School Students (EarthKAM) uses a digital camera mounted in Destiny's large window to enable thousands of students to photograph and examine Earth from an astronaut's perspective. Via the Internet, they control the camera and post the photographs for public viewing. Since Expedition-3, several new schools in the US have joined the programme, as well as a school in Krefeld, Germany.

HRF Extravehicular Activity Radiation Monitor (EVARM) is a radiation dosimeter badge reader, with 12 (four sets of three) small dosimeter badges, each uniquely identified. Each set will be placed in an EVA suit to measure radiation levels at different body locations.

HRF Hoffman Reflex (H-Reflex) measures the effects of weightlessness on spinal cord excitability. Surface electrodes are applied to the soleus muscle in the sitting position, with the knee at 120° and the foot at 90°. The stimulating electrode (part of the knee brace) is applied behind the knee to stimulate the posterior tibial nerve.

HRF Urine Collection Kit (UCK), a Nomex container housing the Urine Collection Devices (UCD), Ziploc containment bags, towelettes and gauze pads.

HRF Renal Stone for observing changes in renal function and increased risk of kidney stones induced by weightlessness. Beginning 3 days before launch and continuing for 14 days after their return, the crew are ingesting two potassium citrate pills (a proven Earth-based therapy) or placebos daily and collecting urine samples to learn whether the pills are effective.

Yuri Onufrienko photographing the Earth from Zvezda.

The STS-105 crew attached the first experiment outside the Station – **Materials ISS Experiments** (MISSE) – during an EVA in August 2001. Two suitcase-sized packages contain experimental materials for solar cells, radiation shielding, paint, optical materials and lightweight building materials are being exposed to the harsh environment of space for a year before return to Earth for study.

New Payloads

Sub-rack and deployed payloads transferred into Destiny from STS-108 include:

Biotechnology Cell Sciences Stowage system (BCSS) Unit #5 added to ER-1.

Advanced Astroculture (ADVASC) Growth Chamber #2 added to ER-4. This is a follow-up to an Expedition-2 experiment: second-generation *Arabidopsis thaliana* plants are being grown using seeds harvested from plants grown during Expedition-2 (as well as from new seeds). It also formed the basis for a commercial Internet-based education programme.

Protein Crystal Growth Single Locker Thermal Enclosure System units 7 & 8 added to ER-4.

Zeolite Crystal Growth Furnace Units 1 & 2 added to ER-2. ZCG is not expected to be operational during Expedition-4.

The **Microencapsulation Electrostatic Processing System** (MEPS) failed a vacuum test shortly before launch, so it was not moved from the Shuttle.

Descent Payloads

Payloads returned aboard STS-108 in December as Expedition-4 began included:

ESA's **Advanced Protein Crystallisation Facility** (ER-1) grew samples of proteins that are key ingredients in many life processes.

Biotechnology Cell Science Stowage (BCSS) system Units # 1 & 2 from ER-4.

Dynamically Controlled Protein Crystal Growth (DCPCG) experiment from ER-1.

Bonner Ball Neutron Detector (BBND) Unit.

Dreamtime Camera (DMTM) part of a public-private partnership to upgrade NASA's equipment to next-generation HDTV technology.

Expedition-3/4 Overlap Experiments

Walz and Bursch completed their first sessions with the Hoffman Reflex just a day after arrival, repeating the sessions every few weeks to track changes in the human neurovestibular system.

The Protein Crystal Growth Single Thermal Enclosure Unit #10 was activated early on, followed later in the Expedition by Unit #7. The crew activated Cellular Biotechnology research by injecting cells into 32 nutrient containers, placing them in an incubator and then periodically removing nutrient solution for analysis and re-injection of fresh growth fluid.

The first Interactions questionnaires were completed.

Expedition-4 Tended Experiments

Photography targets were uplinked for the Crew Earth Observations research programme, including industrialised South Africa, Angolan biomass burning, eastern Mediterranean dust and smog, Patagonian and Andean glaciers, and wake clouds and von Karman vortices in the Canary Islands. Walz and Bursch completed their third session with the Hoffman Reflex experiment at the turn of the year. Before and after two EVAs, they performed the PuFF experiment. The Zeolite Crystal Growth furnace unit was installed and checked out. The crew completed checkout of EVARM: data from the radiation badges were downlinked to the ground. Walz and Bursch completed the first session of the Renal Stone experiment, including collection of urine over a 24-hour period and diet monitoring.

Early in February, a Guidance, Navigation and Control (GNC) computer crash in Zvezda allowed the Station's attitude to drift slowly. As a result, the solar wings could not track the Sun and their power output fell drastically. The crew turned off science experiments, backed-up Station systems and shut down non-critical subsystems. NASA's main antenna could not be aimed at the relay satellites, losing US telemetry. The crew could communicate with ground controllers only when the Station was passing over Russian ground stations in Central Asia. The computer was restarted after 2.5 h and Station orientation was restored after another 2 h. It took less than 6 h to return power to sensitive payloads, and normal operations were achieved within 24 h.

EarthKAM was activated a week earlier than planned to provide a full four days operation without communications outages. Initial problems with a voltage converter were overcome.

During their normal maintenance checks, the crew noticed and removed an ice buildup in the Biotechnology Refrigerator containing several cell science samples processed earlier in the mission and now awaiting transfer to Earth

Expedition-4 Untended Experiments

In December, the MAMS recorded the STS-108 undocking, helping scientists to plan experiments that require a vibration-free environment. Research operations resumed early in the Expedition with SAMS and ARIS-ICE, and PCS completed a 48 h run. Untended operations continued with a pair of protein crystal-growth experiments. Around the middle of the Expedition, the PCS colloids experiment team expanded its research to build fractal structures over 5 weeks using a colloidal gel. Fractal gels are of interest to manufacturers and materials specialists on Earth. A primary mechanism for degradation of motor oil is the formation of fractal clusters of soot. Another example is the ageing and spoilage of food. Later, the team concluded its 120 h reexamination of the crystallisation of the AB6 binary colloid. The colloid experiments will be extended into Expedition-5. ■

Bursch (left) and Onufrienko perform maintenance.

For information on ISS science activities, check the website at: *http://www.scipoc.msfc.nasa.gov/*

Teach Space 2001

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> *In October 2001, ESA invited 160 teachers to ESTEC for Teach Space 2001, the first International Space Station Education Conference in Europe...*

Teachers from 20 countries, including all 15 ESA Member States, as well as the Czech Republic, Hungary, Russia, Canada and the US took part in Teach Space on 26-28 October 2001. A wealth of information was exchanged on how space is being used in education, representing the wide variety of nationalities and the different subjects and education levels taught.

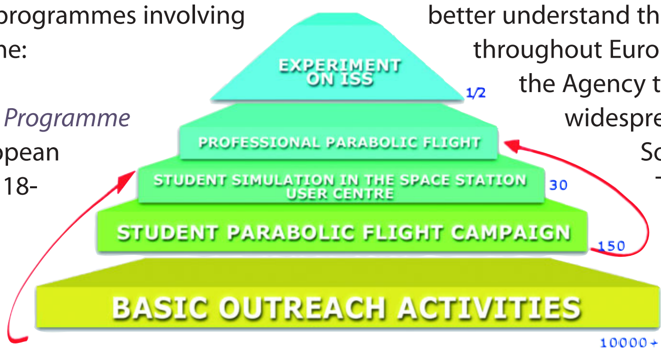
Space as a Theme in Education

The Agency is increasingly aware of the importance of space as a theme in education. ESA depends on a highly talented and skilled workforce – and its future members are sitting in today's classrooms. Space as a theme has many fascinating angles that can be applied to subjects taught at primary- and secondary-school levels. These approaches can give students that extra stimulus to be active participants and be fascinated by their subjects.

Educational Programmes

The International Space Station (ISS) is an ideal tool for teaching science, mathematics, technology, engineering and many other disciplines. For this reason, ESA has launched two educational programmes involving the ISS programme:

The *ISS Education Programme* addresses European students aged 18-27 years. In particular, it makes use of the ground



facilities and services of the Space Station, allowing about 13 kg of experiments to fly on Europe's European Columbus laboratory each year. The Programme can be represented by a pyramid structure, where the activities are initially addressed to tens of thousands of students, of which a small number will end up with access to experiments aboard the ISS.

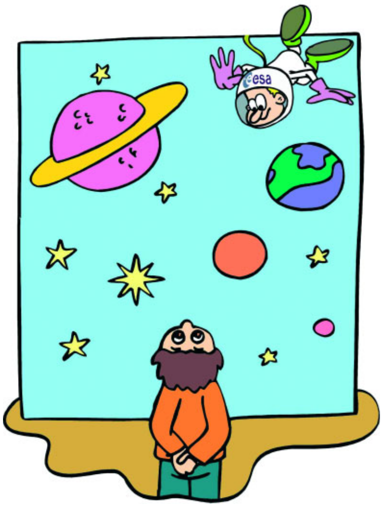
The *Teach Space* initiative focuses on pre-university students (aged 6-18), and was launched at Teach Space 2001.

Teach Space 2001: Teacher Requirements

Teach Space 2001 was organised to stimulate teachers into adopting space as a tool for teaching, and for them to encourage ESA in taking a more active role towards education. The busy conference programme included introductions to several ESA activities, such as life sciences and space exploration, as well as presentations on the world's largest cooperative civil space project – the International Space Station. Through workshops and questionnaires, teachers were asked about their country's specific educational requirements, as well as their needs in incorporating space into their specific subjects. ESA is studying this information to better understand the education systems throughout Europe, which will help the Agency to create material for widespread use.

Some conclusions from Teach Space 2001 are:

– European teachers in all disciplines are



enthusiastic and eager to use space as a teaching tool;
- curricula are, in general, not flexible enough. Space can be taught only as an optional course or as a supporting element to existing curricula;
- schools/teachers have no access to funding;
- the formal education structures and organisations (Ministries of Education, local education authorities, etc) need to be improved. A network must be established between teachers and schools, supported by a selection of publications and input from other organisations, such as planetariums and museums;
- teachers need simple, practical, modular, European material that can be applied to their lessons;
- ESA needs a pool of teachers/consultants to adapt material for schools.

Sponsors

The Teach Space 2001 sponsor initiative aimed at matching ESA's budget for the event with sponsor benefits. Space companies received a personalised letter inviting them to join; eight responded positively and exceeded the sponsorship target of €50 000. The sponsors were: Astrium, Alenia Spazio, Contraves, OHB, SENER, ALTEC, HE Space Operations, and IntoSpace. Astrium and Intospace participated in the conference.

2002: Focus on Education

During 2001, Human Spaceflight education activities focused on gathering input from teachers. This was an important first step. To maintain the momentum and the interest of teachers, we hope to shift the focus this year towards the production of educational material.

Specific projects by teachers for teachers form the basis of ESA's first publication, the Teach Space 2001 conference proceedings (ESA SP-491). Teachers, space enthusiasts and companies responded to an Open Call for space project proposals. More than 40 were received and, after careful consideration, ten projects were selected for presentation at the event. The book is available from late March and can be bought for €20 from Frits de Zwaan at +31 71 565-3405 (or fax +31 71 565-5433; Frits.de.Zwaan@esa.int)

In addition to working on 'content', building on the input and contacts established in 2001, the Agency is continuing existing activities such as the student parabolic flights.

Part of the Teach Space 2001 workshop.

The following activities are planned for this year:
- Teach Space Educators Forum on the Human Spaceflight website;
- creation of an ISS Education Kit, including material that can be used by teachers in primary or secondary schools to incorporate space and human spaceflight in their lessons;
- SUCCESS#2: a second student contest for experiments aboard the ISS;
- World Space Week event at the ISS User Information Centre in ESTEC (October);
- ISS Web Marathon: allowing the public to participate in Q&A's with ESA staff.

We hope to create ESA Human Spaceflight educational material in the near future built on teachers' input, and we look forward to receiving further comments and suggestions (send them to Barber.Uijl@esa.int).

Check the Human Spaceflight website for news and details on upcoming educational events:
http://www.esa.int/export/esaHS/education.html

MSG Ready for Launch

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ESA's Microgravity Science Glovebox completed final testing at the Kennedy Space Center in February and is now ready to begin its journey to the International Space Station...

Introduction

The Microgravity Science Glovebox (MSG) will be the first European rack facility to be launched to the ISS. It will fly on the STS-111/UF-2 mission and from May it will equip the US Destiny Laboratory. This glovebox can handle a wide variety of materials, house investigations into combustion, fluids and biotechnology and accommodate minor repairs and servicing of hardware requiring a controlled working environment. The development included a long and complex verification process, leading to the final certification for flight readiness.

MSG at KSC.

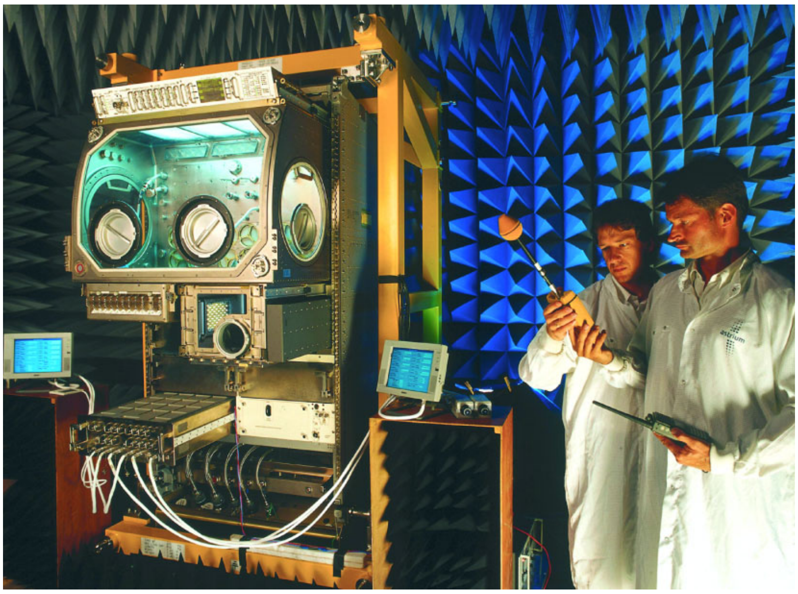
The Verification Process in Two Steps

The process included the verification of both the science requirements, controlled by the MSG System Requirements Document, and the ISS Interface requirements, controlled by the Pressurised Payload Interface Requirement Document (IRD). While the first document was already consolidated at the beginning of Phase-C/D, the IRD and the associated verification programme evolved in parallel to the project development. A second important aspect, peculiar to MSG and the MELFI freezer, was the lack in Europe of suitable interface emulators. This forced division of the verification flow into two parts:

- the European verification process, mainly devoted to environmental and performance testing at the payload developer sites;
- NASA's process at the Kennedy Space Center (KSC), aimed at testing the physical, electrical and software interfaces.

The Testing in Europe

European verification was supported by dedicated interface emulators, complemented by the ESA-provided Test Equipment for Payload Development, which includes the Water Servicer and the Power Supply Emulator. NASA provided the Suitcase Test Emulator for Payloads and the Common Video Interface Unit. In addition to this hardware available in Europe, an early Data Handling verification test was performed in the ISS laboratory of NASA's Johnson Space Center, where generic ESA Standard Payload Computer Basic Software was tested for compatibility with Destiny's payload Multiplexer-Demultiplexer. European processing included tests at the prime contractor site (Astrium-Bremen) and at



MSG testing at Astrium.

subcontractors (Bradford Engineering and ATOS-ORIGIN, The Netherlands; Verhaert Design and Development, Belgium).

The Processing Flow at KSC

The overall flow of KSC activities for MSG – typical for ISS payload processing – can be characterised as:

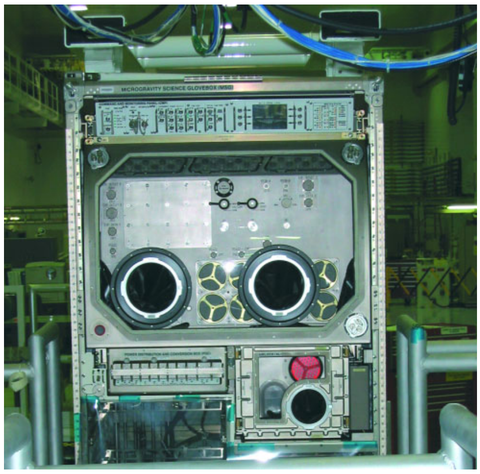
- preparatory technical interchange meetings (about a year before hardware shipment);
- flight hardware and ground support equipment shipping from Europe;
- KSC reception inspection;
- changeout of flight rack from IHI (Japan)-type rackstand to Boeing (US)-type;
- rack and ground support equipment setup in offline laboratory; post-shipment functional checkout test;
- offline testing with Payload Rack Checkout Unit;
- online testing with Payload Test Control System;
- decable review and rack closeout;
- complementary stowage item activities (optional);
- rack integration in Multi-Purpose Logistics Module (MPLM).

The PRCU/PTCS Testing

After Acceptance Review #1, performed at Astrium in October 2001, MSG was shipped to KSC. There, after the post-shipment checkout, it was subjected to the offline tests by the Payload Rack Checkout Unit (PRCU). This is located in NASA's Space Station Processing Facility and provides high-fidelity electrical and mechanical simulation of the available resources in orbit at rack level. In the PRCU testing, MSG was still under the direct control of Astrium, who shared test responsibility with the NASA Marshall Space Flight Center (MSFC) team. The offline tests were very successful – MSG holds the record as the fastest rack through software tests. Offline testing was completed just before the end of 2001.

On 8 January 2002, ESA/Astrium and NASA MSFC handed MSG over to the KSC team, who started the online tests. These are performed at the Payload Test Control System (PTCS). This facility is similar to the PRCU but operations control is from a remote user room, rather than by direct rack access. It allows end-to-end testing, including verification of the operational procedures. The activities are strictly under procedural and quality control by the KSC authority.

The Integrated Testing



Despite problems with some MSG hardware malfunctions and the late readiness of the PRCU and PTCS, MSG completed all rack level testing after 2 weeks and was ready for final rack/experiment integrated testing. The NASA science experiments (In-Space, Solidifcation Using a Baffle in Sealed Ampoules [SUBSA] and Toward Understanding Pore Formation and Mobility Investigation [PFMI]) were integrated inside MSG and the integrated rack functionality was checked. This last test was completely outside of ESA/Astrium responsibility.

Finally, on 14 February 2002, all test activities were concluded. The rack is now awaiting final preparations for integration inside MPLM Leonardo before loading into the Space Shuttle.

MSG is the first European rack facility to have completed the verification programme, setting the standard for future ISS payload development. ■

Recent & Relevant

ESA Astronaut Ready for ISS

Roberto Vittori will become the third ESA Astronaut aboard the ISS when Soyuz-TM34 docks in late April. His 9-day visit includes Europe's first commercial experiment on the Station: the Bloodpressure Measurement Instrument (BMI) for continuously recording bloodpressure and heart rate, based on the commercial Boso TM-2430 PC.

His other three experiments are sponsored by the Italian space agency: Chiro, Alteino and Vest.

The main purpose of Vest is to validate a proposed new range of clothing for living in space. This includes researching and employing new fabrics. The ultimate aim is to reduce the burden on the system by cutting the mass and volume of astronauts' clothing, while making them more comfortable.

Alteino will measure particle radiation in the Station and its effects on the crew's brains. It is the precursor to the ALTEA (Anomalous Long Term Effects in Astronauts) system that will identify risks to the nervous system

ESA Astronaut Roberto Vittori in the Soyuz simulator at the Gagarin Cosmonaut Training Centre, Star City.

with prolonged missions and exposure to radiation. Alteino is a joint project between the Univ of Rome-Tor Vergata, Univ of Geneo, Italy's National Nuclear Physics Institute and the Moscow Institute for Biomedical Problems and the Moscow Engineering and Physics Institute.

Chiro will use two dynamometers to measure the forces exerted by the hand and fingers in grasping objects in weightlessness. The way that upper limbs are used in space reflects some pathological and traumatic phenomena affecting the central nervous system. The results will help to design structures for prolonged missions and to rehabilitate ground patients.

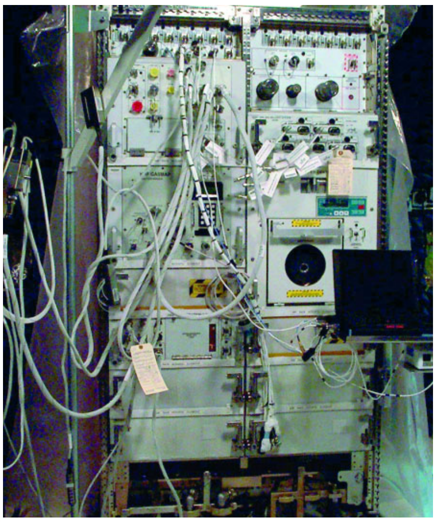
Vittori joined the European Astronaut Corps in August 1998 and immediately began Mission Specialist training at NASA's Johnson Space Center to qualify for Shuttle and ISS flights. In July 2001, he was assigned to a Soyuz taxi mission under an agreement between Rosaviakosmos, ASI and ESA. The following month, he began training as a Soyuz Flight Engineer at Star City near Moscow. ■

For the latest on Vittori's flight:
http://www.esa.int/spaceflight
You can discover when the Space Station is next visible from your location at:
http://www.heavens-above.com

PFS and the Breath of Life

ESA delivered a piece of new technology to NASA in December as part of the ISS Pulmonary Function System (PFS). Developed by the Danish company INNOVISION SA, the new device will analyse exhaled gas from astronauts' lungs and provide near-instant data on crew health. PFS is the first flight hardware developed by the Microgravity Facilities for Columbus (MFC) Programme as part of the European Physiology Modules (EPM) project, originally planned for launch aboard Columbus. Following the great interest shown by NASA, ESA was offered an earlier flight opportunity in January 2003, as part of the second NASA Human Research Facility (HRF) being delivered to Destiny by the STS-114/ULF-1 mission.

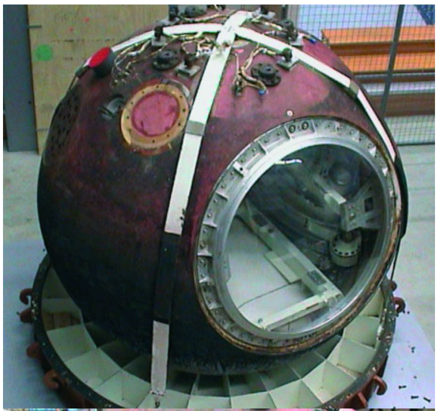
The PFS uses a new approach: photoacoustics, exploiting the property that different gases absorb IR light at different and very precise wavelengths. The new device divides the breath sample into several small test cells, each fitted with a window filter that admits only the exact wavelength of a specific gas. The cells are exposed to an IR source through a spinning chopper wheel. When the hole is in front of the window, the IR energy heats and expands the gas. When the hole has passed, the gas contracts again. A microphone picks up the pulses; their strength accurately measures how much of the specific gas is present. Six different gases can be measured simultaneously, with several measurements being made within a single breath. In addition to the lung function, the data also reveal much about blood flow and the entire cardio-vascular system. ■

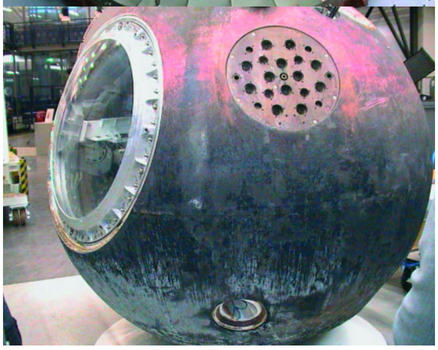


PFS (top left) integrated in the HRF-2 rack.

Recent & Relevant

Foton Capsule at ESTEC





The ISS User Information Centre at ESTEC added a new exhibit to its collection in December: a Foton descent capsule. Marked by its 2500ºC reentry – the scorched heatshield still has a distinctive smell – the Foton-12 capsule is intended to show potential users how payloads are accommodated. Launched in September 1999, Foton-12 included 240 kg of ESA experiments. ESA has been a Foton partner since 1987, and has developed an excellent relationship with the Russian manufacturers and launch teams. The Foton programme provides researchers with access to relatively low-cost weightlessness with a much longer duration than sounding rockets and a faster turnaround than with the ISS. ESA Technical Officer Antonio Verga has worked with Foton for years. 'It's very good value for money. Foton carries a multi-disciplinary payload – anything from biological experiments to fluid physics and technology testing.' Verga hopes that visitors will see it as a potential platform for their experiments. The next mission, Foton-M1, is scheduled for October 2002, and will include experiments designed by student groups from York, Edinburgh and Zurich. Foton-M is an improved version of the spacecraft, with larger battery capacity, enhanced thermal control and increased telemetry and telecommand capabilities. The Soyuz rocket will be equipped with a new third-stage engine, which will provide an orbit with a higher perigee. The more circular orbit, in combination with a more even mass distribution within Foton, will further reduce the residual onboard acceleration. In total, more than 40 experiments in physical sciences, space biology, radiation biology, space dosimetry and meteoritics will be performed:

ESA: FluidPac, TeleSupport, Biopan, Soret Coefficient in Crude Oil (SCCO), Stone and Autonomous Experiments;
DLR: Agat and Keramik;
CNES: IBIS;
Russian industry and institutes: Polizon, Mirage, Sinus-15 and Komparus. ■

NASA Medal Awarded

MSM's Eckart Graf has been presented with NASA's Public Service Medal '*in recognition of his exceptional leadership resulting in unprecedented cooperation between the European Space Agency and NASA in the development of the X-38/Crew Return Vehicle*'. Eckart is credited with reorienting an initial definition study into a hardware programme for the X-38, the prototype for the CRV. Following his initial appointment in 1996 as Crew Transfer Vehicle project manager, in 1998 he became the X-38/CRV project manager.

Eckart is pictured with his wife and Roy Estess, acting Director of JSC. ■

Commercial Camera for ISS

ESA has approved funding for commercial utilisation of the ISS by the 'RapidEye' camera. RapidEye Inc. of Munich (D) plans to place a high-resolution Earth observation camera aboard the ISS by 2005, making it the first commercial user in this business segment. The camera will image major parts of Europe, North America and Asia, enabling the company to offer regularly updated, highly accurate maps. The maps will record changes even in urban areas – new dwellings, streets, roads and bridges. The combination of large-area coverage, high resolution, high revisit rate and low cost will allow the maps to be frequently updated. New consumer services will appear; for example, using the Internet, people will be able to see up-to-date images of their next vacation destination to check for snow coverage, water pollution or their hotel location.

ESA, DLR, RapidEye, Kayser-Threde GmbH and other European partners are working jointly on the project. ESA will partly finance the hardware and organise transport to the ISS. DLR will support camera development. Kayser-Threde will be responsible for the project's technical direction. RapidEye will assume operational control of the camera, process the data and market the images and information services. The system will use a constellation of small satellites enhanced by the ISS camera. ■

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