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number 3, july 2000

on station

The Newsletter of the Directorate of Manned Spaceflight and Microgravity

in this issue

European Space Agency
Agence spatiale européenne

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

We Are On Our Way!

Jörg Feustel-Büechl
ESA Director of Manned Spaceflight and Microgravity

Zvezda Launch Successful

The most important events recently for everyone involved in the International Space Station were the launch of the 'Zvezda' Service Module on 12 July and the docking with the Station on 26 July. Zvezda brings with it increased stability in the overall Space Station assembly sequence. For ESA in particular, the launch was important for three European aspects. The European onboard Data Management System (DMS) is working well – the Russians tell us it is operating flawlessly and that they are very pleased with the system. Our Automated Transfer Vehicle (ATV) will use Zvezda to dock with the Station beginning in 2003 so the launch is a decisive step forward for us. Last, but not least, is the use of Zvezda as an experiment platform, especially for our early experiments. We already have two under preparation: 'Matroshka' will measure radiation absorption by humans in space, particularly during spacewalks, and the Global Time System (GTS) commercial experiment will allow the synchronisation of ground-based clocks as well as many other time-dependent services.

The launch was monitored by ESA from Baikonur, Moscow and – premiered for its very first live occasion – the Erasmus User Center here at ESTEC. A Heads of Agency meeting followed in Moscow, with all participants in the International Space Station programme echoing their pleasure at the success.

And what comes next? There will be a number of Station launches later this year, with the most notable taking up the first crew at the end of October or early November. As this 'Expedition-1' is the first permanent crew, it is the beginning of manned operations and utilisation of the Space Station.

Further coverage of Zvezda's launch is provided on p6 of this issue, in the *Recent & Relevant* news pages.

Space Station Exploitation Programme

The Exploitation Programme for ESA comprises two elements: industrialisation of operations and the commercialisation of utilisation. We have been working these issues since the Brussels Ministerial Conference in May 1999 and have made good progress in both.

A crucial step for the industrialisation of operations was the high-level commitment from the Astrium (D)-led industrial group. The group comprises all the major players in the development of our Space Station elements: Alenia Aerospazio, Matra Marconi Space (now part of Astrium), and Aerospatiale Matra Lanceurs. We were very pleased to see that the ESA Council in March endorsed our approach to this industrialisation of operations. Following the Industrial Policy Committee (IPC) meeting in June, the procurement process has begun and I am pleased to say that the IPC is highly satisfied with and unanimously agrees with our procurement approach. We are now entering into the proposal preparation phase with a view to having a contract ready before the actual Exploitation Programme starts on 1 January 2002.

We have also made good progress with commercialising Station utilisation, although the situation here is more heterogeneous. Awarding financially beneficial contracts to industry is one thing, but expecting industry to generate the money is far more difficult. It will consequently take some time to come up with the right approach, so we are looking at the following three routes.

The first would award the commercialisation contract to a commercial agent or business developer. For that, we launched a Call for Interest in June (see the *Recent & Relevant* news pages) that should produce positive results. The second would award it to the industrial operator and combine it with the industrial operations contract. The third route is to do the job within the Agency through several industrial contracts. This could be a bridging solution if we are not ready to make a decision by the end of this year. Why the end of this year? Because we have promised the Council to come forward with a concept for commercial utilisation by then so that it will be in place when the Exploitation Programme begins in 2002.

ATV Progressing

ESA has contracted with Arianespace for the launch of nine ATVs: one development flight of Ariane-5 with ATV, and eight operational flights fulfilling our obligations to contribute to Station operations. That contract was signed in June (see the *Recent & Relevant* new pages) and will eventually be folded into the industrial operations contract. It was important to sign it now in order to safeguard the development launch in 2003/2004. A major goal has been achieved by combining the benefit of an early maiden launch with the economies of scale from purchasing nine launches. The contract is certainly the biggest ever signed by the Agency – more than € 1 billion. It also supports Arianespace in their promotion of Ariane-5 and its place in the commercial launcher market.

As far as ATV development is concerned, we are now in a critical period with the Preliminary Design Review planned for conclusion in October. ATV, as an extremely complex and demanding project, requires the full attention of industry and the Agency. This is accentuated by the ever-increasing interest from the International Partners in ATV's vital role in servicing and reboosting the Space Station.

European Astronaut Centre Anniversary

We celebrated the tenth anniversary of EAC in Cologne (D) on 17 May in the presence of all our astronauts (see the article beginning on p3). I must say that this was a wonderful event. It showed that EAC is now fully established. We have concluded agreements with DLR and CNES and should soon do so with ASI, with the goal of consolidating our forces for implementing the technical tasks at EAC. We now have some 60 people in EAC, including 16 astronauts, preparing for the Space Station era and we will soon see the arrival of the first training tools for our astronauts and the International Partner astronauts. We expect that the centre will satisfy our Station obligations and needs. In addition, we are always looking for further bilateral flight opportunities with the Americans and the Russians before Station assembly is complete.

Crew Rescue Vehicle Status

Europe's contribution to the Crew Rescue Vehicle (CRV) is developing in a very positive way. Although we were not certain when we began last year of achieving even a € 40 million contribution, we are now approaching a very satisfactory € 150 million. More and more interest is being shown in the practical aspects of reentry technology within CRV. We hope to consolidate the contribution situation very soon in order to establish solid European participation under a barter arrangement with NASA. The CRV has a very special role as a lifeboat – it will be needed as long as there is a Space Station in orbit. It will also allow Europe to develop reentry technologies, important not only for CRV but also for future manned spaceflight and launcher projects.

Industrial Day

ESA will be holding an Industrial Day on 20 September for the European industrial participants to continue discussing progress on the Space Station programme. In addition to the progress reports, this year's theme will be 'Transition from Development to Exploitation – A Challenge for Industry and ESA'. We plan to cover the event in *On Station* #4 later this year.

Starting Point for Space

ESA's European Astronaut Centre

Introduction

The roots of ESA's European Astronaut Centre (EAC) reach back to 1977 when the Agency's first four astronauts were chosen, after a pre-selection process by the Member States, to train for the Spacelab-1 mission. After that highly successful multi-disciplinary international mission landed in December 1983, US President Ronald Reagan announced the Space Station project and invited the active participation of Europe, Japan and Canada. Europe simultaneously began its own ambitious programme encompassing the Columbus Programme with the Attached Pressurised Module for the Space Station, the Man-Tended Free-Flyer, the serviceable Polar Platform and the manned Hermes spaceplane.

As EAC enters its second decade of training astronauts, On Station writer Graham Biddis reviews its history and capabilities...

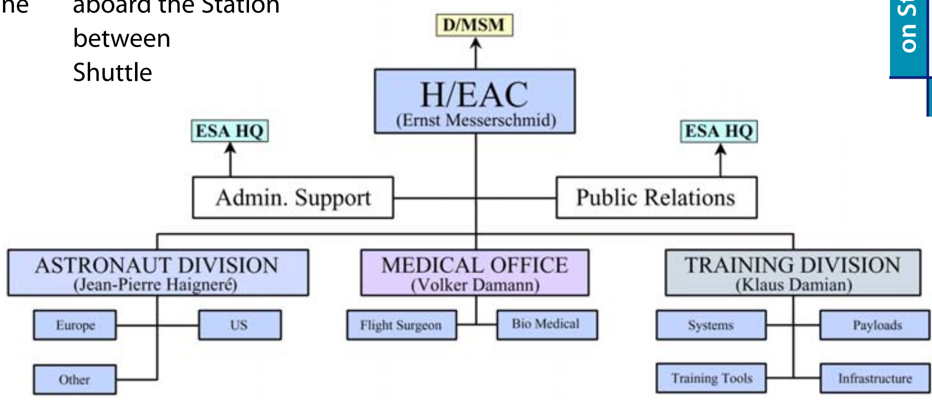
In order to satisfy this long-term need for astronauts, ESA established the EAC in Cologne (D). The Centre was formally created in May 1990, when the Host Agreement was signed between ESA and the German national authorities.

EAC rapidly became the home base for all European astronauts following the selection of six astronaut candidates in 1992. Hermes, Free-Flyer and Polar Platform had been cancelled by then, and EAC focused on supporting ESA astronauts assigned to Space Station precursor missions aboard Shuttle/Spacelab and Mir. The training programme was developed in close cooperation with NASA and Russia's Gagarin Cosmonaut Training Centre, and initially applied to the payload training for the Euromir-94/95 missions.

Integration of the Member State national astronauts into a single European astronaut corps, started in 1998, is now complete with the roster of 11 flown astronauts and five rookies. EAC's staff total will be almost 60 by the end of this year when the integration of national agency staff that began in March is completed. The German, French and Italian space agencies will contribute up to 30 seconded staff.

EAC Training Division

The Centre provides basic, advanced and 'increment-specific' training. Basic training is the responsibility of each International Space Station partner for its own astronauts, and for ESA this is performed at EAC. Advanced and increment-specific training on ESA space elements (Columbus and Automated Transfer Vehicle) and payloads will be provided at EAC for all ISS astronauts. Specific training on ESA elements and payloads for Space Station 'increments' (the periods aboard the Station between Shuttle visits) will centre on EAC for ISS crews. EAC training will begin about 2 years before Columbus launch in 2004, with about 70 ISS astronauts graduating each year.



ESA astronaut assignments and collateral duties

Jean-François Clervoy (F)	JSC: ISS display integration in Space Station Operations Branch
Claudie André-Deshays (F)	EAC: Microgravity Facilities for Columbus, supports medical operational and life science activities within D/MSM
Pedro Duque (E)	ESTEC: supporting the Module Project Division for Columbus
Reinhold Ewald (D)	EAC: supporting the training system build-up for ESA elements and payloads
Léopold Eyharts (F)	JSC: Mission Specialist training; collateral duties on Russian vehicles (Soyuz/Progress) and ISS Flight Crew Systems
Christer Fuglesang (S)	JSC: prime Support Astronaut for 2nd Station crew
Umberto Guidoni (I)	JSC: training for STS-100 Multi-Purpose Logistics Module flight (February 2001)
André Kuipers (NL)	ESTEC: Microgravity Payloads Division, coordinating scientific development inputs for MARES and ARMS
Paolo Nespoli (I)	JSC: Mission Specialist training; collateral duties in computer-based training, onboard training and system tests on ESA elements and payloads
Claude Nicollier (CH)	JSC: EVA Instructor in EVA Branch
Thomas Reiter (D)	EAC: supporting ERA and ATV projects
Hans Schlegel (D)	JSC: Mission Specialist training; collateral duties in mechanical, structural systems and crew equipment
Gerhard Thiele (D)	EAC: mission control capcom in JSC astronaut corps
Michel Tognini (F)	JSC: ISS Robotics Branch supporting MBS and ERA
Roberto Vittori (I)	JSC: Mission Specialist training; collateral duties in Shuttle system upgrades
Frank De Winne (B)	ESTEC: X-38/Crew Rescue Vehicle projects in human engineering and man-machine interfaces

ARMS: Advanced Respiratory Monitoring System. ERA: European Robotic Arm. EVA: Extra-Vehicular Activity. JSC: NASA Johnson Space Center. MARES: Muscle Atrophy Research.and Exercise System. MBS: Mobile Base System (for ISS robot arm) NASA Johnson Space Center.

ESA's astronaut corps (from left): Schlegel, Guidoni, De Winne, Thiele, Fuglesang (obscured), Ewald, André-Deshays, Clervoy, Tognini, Nicollier, Vittori, Eyharts, Duque, Reiter, Kuipers and Nespoli.

EAC's training facilities include a training hall, a neutral buoyancy facility, physical fitness rooms, classrooms, supporting model workshops, trainer control rooms and refreshment areas. The complex will be progressively outfitted with a Columbus Trainer incorporating high-fidelity man-machine interfaces with simulated functionality, standalone training models for Biolab, Fluid Science Laboratory, European Physiology Modules, European Drawer Rack and European Stowage Rack, and a high-fidelity mechanical Columbus mockup with Orbital Replacement Units for realistic maintenance training. ESA's Automated Transfer Vehicle (ATV) training facilities will also be hosted at EAC for crews to learn how to handle the pressurised cargo, along with the ATV rendezvous and docking simulator for pilot training.

The neutral buoyancy facility will allow scuba-diving astronauts to gain experience moving Station experiment racks around in simulated weightlessness. The water tank has already seen active service preparing for space walks and practising the deployment of solar wings on the Mir station.

17 May 2000: Head of EAC Ernst Messerschmid begins the 10th anniversary celebration of the European Astronaut Centre.

EAC also provides astronauts with computer-based training to use when they are away from home base or in space. The portability standards between the various Station partners for this are now being assessed multilaterally. Multi-point video teleconferencing facilities continue to support the 'teletraining' that began with the preparations for ESA's two flight aboard Mir.

EAC Medical Office

The Medical Office provides a wide spectrum of crew support. It is responsible for medical issues during crew selections and astronauts' active careers, and provides the annual medical examinations for continuing flight certification. The infrastructure supports the astronauts and their families with, for example, nutritional advice, physical fitness regimes and human behavioural training for long-duration missions. During tours of duty aboard the Station – lasting about 3 months – family teleconferencing and counselling will be provided.

EAC has three certified flight surgeons who represent the Agency on the various Space Station medical boards. The flight surgeons have a valuable role in closely monitoring astronaut health during hazardous operations and when the crew is subjected to, for example, life sciences experiments. Based at the Mission Control Centres, they act as ground-based ombudsmen for the crew with the scientists and payload operators. They are presently based in Cologne but, when the Station is occupied, they will spend extended periods in JSC and Star City as part of the consolidated ISS Crew Surgeon Team.

The Biomedical Engineers bridge the gap between the centre's medical and engineering activities. Their knowledge of flight vehicle systems and operational medical practices enables them to provide 'backroom' support to the flight surgeons during astronaut training and missions. In addition, they coordinate all medical documentation and the medical operations interfaces with the ESA internal and external offices.

With the growing need for better communications in the Station's global environment, especially for onboard operations, EAC is regularly reviewing new technologies, including telemedicine, secure data access to medical data and secure global medical data transport, through cooperative activities with all Station partners. Medical technologies from ground-based clinical environments continue to be assessed for onboard application.

EAC and its astronauts will increasingly be employed in transferring related innovations to terrestrial applications in health care and physical fitness promotion.

EAC Astronaut Division

The Astronaut Division is responsible for the flight assignment, collateral duty assignment, proficiency maintenance, career planning and support for each astronaut during training, mission and post-flight activities. The current assignment of each astronaut is shown in the table.

Exciting Outlook for EAC

EAC is evolving towards an operational centre to provide training for the Station's European contributions in synchronisation with the ISS build-up. By combining experienced staff from ESA and Member State national agencies, and serving as the home base for the European astronaut corps, EAC is becoming an important entity within the manned space world. This multi-national team provides an excellent basis for future European and international manned missions to the International Space Station and, later, into deeper space.

Scenes...

from...

the 10th...

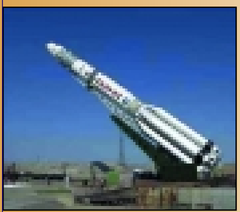
anniversary...

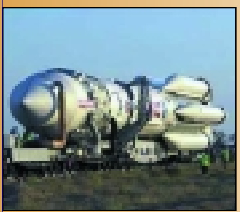
celebration.

Recent & Relevant

New Star in Orbit

Assembly of the International Space Station can now continue apace following the successful docking of the Zvezda ('star') Service Module on 26 July. Zvezda is the first fully Russian Station element and is the cornerstone for the early permanent occupation of the complex. As a result of the new module's arrival, the first long-stay crew is expected aboard by early November. Zvezda's 'brain' is ESA's Data Management System (DMS-R) which, ultimately, will perform overall control of all Russian station elements, and guidance and navigation for the whole Station. Zvezda is also carrying hardware for the first European experiment aboard the Station: the Global Time System will broadcast accurate time and data signals to users on Earth.





Zvezda was launched on 12 July at 04:56 UT from the Baikonur Cosmodrome, Kazakhstan aboard a Proton-K rocket. It was released 580 s later by Proton's third stage into an initial 185×356 km orbit inclined at 51.6° to the equator. For the next 6 min, Zvezda automatically deployed the Kurs rendezvous/docking system and Lira communications system antennas, released the solar wings (which immediately began tracking the Sun) and activated the power, thermal, command & data handling, communications and life support systems.

During Zvezda's first four passes over the Russian ground stations, controllers in the TsUP Mission Control Centre in Korolyov, near Moscow, first verified that all systems were working properly and then oriented the module to minimise propellant usage while allowing the solar arrays to gather sunlight. They reconfigured Zvezda's attitude sensors and activated its star trackers.

Two test-firings of the manoeuvring engines during 13 July showed that Zvezda was ready to begin the long journey to the waiting Zarya/Unity complex in its 376 km orbit. The first two major rendezvous burns using the two 3070 N main engines were made on 14 July. Beginning at 05:09 UT, the orbit was raised to 183×358 km and then, starting at 05:44 UT, to 269×361 km. The firings were so accurate that a correction burn scheduled for 15 July was not required. Attitude control continued to be provided by 16 of the small, 130 N thrusters.

On 17 July, final tests verified the full operation of the software that manages Zvezda's guidance system. Routine cycling of the five batteries began; the final three will be delivered by September's Space Shuttle mission. Zarya on 18 July practised the final two orbits leading up to docking using its Kurs automatic control system. For this final approach, Zarya was the active partner.

Zvezda made its first correction burn on 20 July, firing the two main engines for 15 s to change its orbit to 290×361 km. A day before docking, it manoeuvered to the docking orientation and the solar arrays rotated into their docking attitude. The Kurs rendezvous system was activated on 25 July and, with Zarya in control, the Station caught up with Zvezda. Docking came at 00:45 UT 26 July. It then took about 25 min for the hooks and latches on the two modules to close fully for the hard mating.

Over the next 16-24 hours, mission controllers planned to monitor the air pressure between the modules to ensure an airtight seal, and then began the work to transfer control of most Station functions from Zarya to Zvezda. In particular, Zvezda assumed responsibility for attitude control and reboost. Soyuz, Progress and ESA's Automated Transfer Vehicle will dock with its aft port. Many of the systems aboard Zarya are deactivated and this first module now provides primarily propellant storage and equipment stowage.

What happens next? Zvezda's success means there will be a rapid sequence of missions in the near future. The first supply ferry, Progress-M1, is planned for launch on 6 August from Baikonur, docking with Zvezda 2 days later. Shuttle mission STS-106/2A.2b will dock with Unity in September to continue preparations for the first permanent crew. They will also unload the Progress. STS-92/3A in October will deliver the first Truss section (Z1), four Control Moment Gyros and a second conical docking adapter. The first dedicated Station crew of William Shepherd (Expedition Commander), Yuri Gidzenko (Soyuz Commander) and Sergei Krikalev (Flight Engineer) will appear aboard the Station's first Soyuz in early November. This 'Expedition-1' crew will stay aboard for about 4 months, activating Station systems and the first experiments, and making the first

Zvezda launch: TV coverage from ESTEC's Erasmus User Centre.

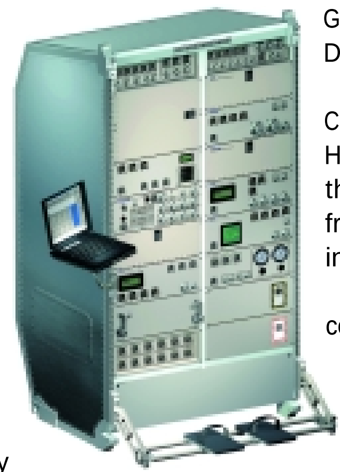
Recent & Relevant

spacewalks from Zvezda's forward airlock. STS-97/4A in November will add the first pair of giant solar arrays, paving the way for STS-98/5A in January 2001 to attach the first science module: Destiny. STS-102/5A.1 in February 2001 will carry Europe's Multi Purpose Logistics Module with supplies and experiment racks for Destiny. The Expedition-1 crew will return to Earth aboard that Shuttle, swapping with the Expedition-2 crew of Yuri Usachev, Susan Helms and Jim Voss. The Soyuz craft will remain attached to the Station as a lifeboat. ■

Do You Want to See the Space Station? Then go to *http://www.heavens-above.com/* and it will show you when the Space Station is next visible from your location.

EPM Set for Next Phase

ESA's European Physiology Modules (EPM) facility began its Preliminary Design Review at the end of July, aiming to begin Phase-C/D in February 2001. EPM is one of ESA's four major research facilities being developed under the Microgravity Facilities for Columbus (MFC) programme, to be launched to the International Space Station aboard Columbus in late 2004. It provides the infrastructure and science modules for numerous experiments on human physiology in weightlessness, initially for neuroscience, the cardiovascular system, bone and muscle physiology, and endocrinology and metabolism. These science modules can be replaced by new units during the Space Station's lifetime. The first set is being funded by ESA and national space agencies and research institutes from France, Germany, Italy and Denmark.



EPM will host a set of replaceable physiology research modules. (ESA/D. Ducros)

EPM will be collocated in Columbus with NASA's Human Research Facility so that experiments benefit from the combined instrumentation.

The industrial consortium developing EPM is led by OHB Systems (D). The Critical Design Review is planned for November 2001, followed by the Final Acceptance Review in November 2002. ■

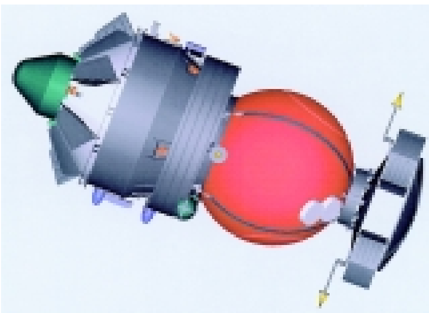
New Foton Mission

ESA's Microgravity Programme Board gave the go-ahead on 27 June to book 355 kg of the payload capacity on Russia's next Foton mission, planned for the end of 2002. This will be the first time that the Agency has purchased all of the non-Russian capacity on a Foton mission. While the Board was reaching its decision, the technical details of the improved Foton-M spacecraft were being revealed in Samara, Russia, during an international Bion/Foton conference attended by some 75 engineers, scientists and project managers, including a delegation from ESA.

Foton-M1's manifest will build on the success of last year's Foton-12 (see *On Station* #1 pp12-13; #2 pp17-19) by flying the 200 kg FluidPac/TeleScience combination (fluid physics), the 27 kg Biopan exposure facility (biology) and up to 7 kg of standalone experiment packages. A new version of the Stone simulated meteorite samples will be carried on the heatshield. An Announcement of Opportunity (AO) for the Biopan and Stone experiments is expected to be released in September (*www.estec.esa.int/spaceflight*). FluidPac's four experiments have already been approved: BAMBI, ARIEL, DAGOBERT and SIMBA.

As on Foton-12, ESA's payload will be accompanied by the Ibis automated biological incubator from CNES and the Agat materials science furnace from DLR. With the flight costs paid by ESA, Ibis and Agat will host up to 50% of ESA-sponsored experiments.

ESA has reserved more than half of the payload capacity of the first Foton-M mission. (TsKB/Progress)



The 7 kg standalone capacity is allocated to student experiments selected through ESA's Outreach programme. An AO will be released in September (*www.estec.esa.nl/outreach*) for experiments to fly on ESA's parabolic aircraft in June 2001 before final selection for Foton.

Foton-M is being developed by TsSKB/Progress of Samara as an upgrade of the generic Foton recoverable spacecraft that completed 12 successful missions in 1985-1999. The modification goals include increased payload mass (600 *vs.* 500 kg) and power, longer flights (3 *vs.* 2 weeks) and improved microgravity quality: residual accelerations will be 10^{-5}-10^{-6} *g* throughout the flight. If those design goals are achieved, Foton-M will offer an unparalleled environment that satisfies even the most demanding of researchers. ■

Recent & Relevant

ISS Commercialisation

ESA took a major step on 16 June towards commercialisation of the International Space Station (ISS) when it released two Calls for Interest aimed at creating an organisation to market Europe's commercial allocation and to share in the generated income. The Calls are targeted at distinct market segments. The *Commercial Research and Technology Development* element is aimed primarily at space and research companies operating in the space and microgravity fields. The *Innovative Markets* element emphasises sponsorship, advertising, entertainment and education. The goal here is to attract communications, sponsorship and multimedia companies in developing the unique opportunities offered by the ISS offers in terms of image, brand visibility and public interest.

An ISS Information Day at ESTEC's Erasmus User Centre (EUC) supported the release of the Calls for Interest, attended by companies from both market segments. ESA astronaut Pedro Duque helped to describe the Space Station, its facilities and the EUC, adding his own experiences in space and a virtual reality tour of the Station.

ESA astronaut Pedro Duque (right) describes what the Space Station offers to potential commercial developers.

This event marks the first time that ESA has publicly declared its intention to create strategic partnerships for commercial exploitation of the Station. Business proposals were due in by the end of July, to be followed at the end of the year with high-level commitments from invited organisations, and kick-off the ISS Commercialisation Programme in 2001.

The Information Day also saw the creation of a forum among participating companies, promoting interactions that should generate detailed proposals covering a wider range of commercial activities.

The ISS Commercial Development Organisation could be a single entity or a more complex structure such as a Consortium, a Joint Venture with other industrial or semi-industrial entities, or a Public-Private Partnership. As the R&D and innovative sectors likely require different knowledge and expertise, more than one Business Developer may be appointed. If so, ESA may appoint a Business Development Coordinator to act as the Agency's sole interface.

The companies that have already expressed interest include Alenia Aerospazio, Astrium GmbH, BEOS AG & Co.oHG Space Operators, Bikker, Carlo Gavazzi Space, CMP Cientifica s.l., D3 Group GmbH, ESYS, Intospace GmbH, Kesberg, Bütfering & Partner, National Aerospace Laboratory (NL), OHB System GmbH, Publicis Consultants, Space Channel and Verhaert.

The Calls for Interest and company contact details are available at:

www.estec.esa.int/spaceflight/isscommercialisation

ATV Launch Contract

ESA and Arianespace signed a contract in June worth more than EUR1 billion to launch nine Automated Transfer Vehicles (ATVs) to the International Space Station over a period of 10 years. Following the maiden flight in late 2003, ATVs will be launched every 15 months to resupply the Station, boost its orbit and remove waste.

Currently under development by a consortium led by Aerospatiale Matra Lanceurs of Les Mureaux (F), the ATV will be Europe's payment 'in kind' rather than in cash for its 8.3% share of the common ISS operating costs. The nine ATVs will be produced and operated by European industry under a single ESA contract to be awarded in 2001. This contract will later include the launch services contract.

The 20.75 t ATV will be launched by the Ariane-5 Plus version of the heavy-lift launcher, equipped with the reignitable EPS upper stage, directly into a 300 km circular orbit inclined at 51.6°. From there, ATV will use its own propulsion system to reach the 400 km orbit of the ISS and dock with the Russian Zvezda Service Module. The cargo can include up to 5.5 t of dry cargo in the pressurised carrier, 840 kg water, 100 kg air, oxygen or nitrogen, 860 kg propellants for Station refuelling, and 4 t of propellants for its own engines to provide Station reboost and attitude control during the 6-month attachment. At the end of its mission, ATV can remove 5.5 t of waste for disposal during the destructive reentry.

The launch contract for nine ATV missions was signed on 7 June at the ILA2000 air show in Berlin. Centre is ESA Director General Antonio Rodotà, left is Director of ESA Manned Spaceflight & Microgravity Jörg Feustel-Büechl, right is Arianespace Chairman/CEO Jean-Marie Luton. (Arianespace)

Maxus Payload Approved

The experiments for the Maxus-5 suborbital microgravity mission were approved by the Agency's Microgravity Programme Board at its meeting on 26/27 June. The five experiments are: 'Drop Dissolution and Marangoni Migration' (R. Monti, I); 'Crystallisation Kinetics of Silicalite-1' (J. Martens, B); 'Vibrational Phenomena in Inhomogeneous Media' (P. Evesque, F); 'Gravisensitivity and Graviperception Mechanism of Characean Rhizoids and Protonema' (Braun, D); 'Biological Gravity Dependence by Way of Microtubule Reaction-Diffusion Processes' (J. Tabony, F). Maxus-5 is planned to be launched from Esrange in November 2002. The construction of Maxus-4 is underway for launch in April 2001. See pp16-17 for coverage of the latest microgravity mission. ■

'Tubulin' Publication

The results of the intriguing 'Tubulin' experiment on Maxus-3 (described in *On Station* #1, pp24-27) were recently published in the authoritative *Proceedings of the National Academy of Science* (vol. 97, #15, pp8364-8368, 'Microtubule Self-organization is Gravity-dependent', C. Papaseit, N. Pochon & J. Tabony). The experiment demonstrated – for the first time – the gravity-dependency of a reaction-diffusion structure. This finding provides a clue as to how living cells sense the lack of gravity in space. ■

ISS Biomedical Contract

ESA and researchers from academia and industry signed the contract on 3 May for a health research project that will develop a space bioreactor for research aboard the International Space Station (ISS) into biomedical applications. At the ceremony, held in the Erasmus User Centre at ESTEC, Mr Jörg Feustel-Büechl, ESA's Director of Manned Spaceflight and Microgravity, pointed out that "This is the first in a series of almost 50 contracts for application-oriented research projects that involve the ISS."

A bioreactor is used for growing bacteria, yeast or animal cells and, more recently, for tissue. The new bioreactor will be designed specifically for cultivating medically-relevant mammalian cells, tissues and organ-like structures, with particular emphasis on vessels and cartilage. Space research may be instrumental for the breakthrough in tissue engineering – the microgravity environment may provide much better conditions for obtaining proper 3D cell structures.

The modular space bioreactor for medically-relevant organ-like structures was proposed by a European scientific and industrial research team under the coordination of Prof. Augusto Cogoli from the Swiss Federal Polytechnical University (ETH) Zurich. It will be essential in clarifying the cellular and molecular

Mr Jörg Feustel-Büechl (left) and Prof. Augusto Cogoli sign the contract for the first in a series of almost 50 new projects in ESA's Microgravity Applications Promotion Programme.

mechanisms responsible for cell aggregation and differentiation control mechanisms, and in obtaining better pseudo-organs for possible clinical uses.

The modular space bioreactor project is one of almost 50 microgravity application projects for the Space Station that ESA expects to initiate in the near future. They will use the Station to obtain application-oriented data that provide deeper insights into Earth-based industrial processes or be used in numerical simulations. The availability of the Space Station means that examining specific applied-research questions in that unique environment may be, in the long term, rewarding for industry.

The modular space bioreactor project is sponsored by ESA's Microgravity Applications Promotion Programme and is funded jointly with the participating scientific research institutes and industry. A major aspect of this MAP Programme is the setting up of Europe-wide teams and networks involving partners from academia and industry to work together on industrially-relevant research. The aim is to initiate concrete industrial projects in which terrestrial research with industrial objectives and commercial funding, together with the participation of researchers from scientific institutes, are supported by ESA, including the sponsoring of space flight opportunities and associated ground-based activities.

Prof. Cogoli and his scientific-industrial team proposed the space bioreactor project in response to ESA's first Announcement of Opportunity (AO) for Physical Sciences and Biotechnology. This 1998 AO for Space Station research proposals produced 145 responses, substantially exceeding expectations. After a review by independent peers, 6 proposals were rated as 'outstanding', 26 as 'highly recommended' and 30 as 'recommended'. Of these, 31 dealt with application-oriented research, including thermophysical properties of liquid metals, advanced foams, biological tissue culturing, osteoporosis and combustion processes. ■

Space Station Synergy

The Synergy between Columbus, MPLM, the Nodes and ATV's Carrier

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The Columbus primary structure is inspected in the Torino plant by the D/MSM team.

Introduction

Europe's major participation in the International Space Station offered ESA and the Italian space agency (Agenzia Spaziale Italiana, ASI) the opportunity for developing common subsystems for their pressurised modules, thereby reducing costs. The Station's redesign allowed the agencies to harmonise the top-level requirements for Columbus, the Multi Purpose Logistics Module (MPLM), Nodes-2 and -3, and the pressurised Carrier of the Automated Transfer Vehicle (ATV).

Common development of major Space Station elements is optimising the cost to Europe…

For these four important Space Station elements, the agencies and prime contractor Alenia Spazio have worked hard to optimise their design commonalities even though they have totally different purposes:

- ESA's Columbus pressurised laboratory is aimed primarily at materials science, fluid physics and life sciences research;
- the reusable MPLM will be carried by the Space Shuttle as an ASI/NASA bilateral venture for delivering and returning supplies and materials, attached to the Station for up to 6 months;
- Nodes-2 and -3, developed under an ESA/NASA barter arrangement, will connect the Station's pressurised modules and house life support, EVA and robot arm controls;
- ESA's ATV logistics vehicle, launched by Ariane-5, will deliver research and system equipment, gases and propellants, and then burn up in the atmosphere carrying Station waste.

Alenia Spazio is responsible for the design and production of modules totalling about 40% of the Station's pressurised volume.

Node-2 uses half of the MPLM shell. Columbus is in the background, at left.

With the aim of harmonising the basic requirements of these four projects, the specific design methodologies for their equivalent subsystems and components were evaluated, including the use of the same technologies, tooling and procedures. The entire spectrum of potential commonality was investigated. From the beginning of Space Station redesign, 'commonality' became an imperative, bearing in mind that extending any part of one project into another would produce substantial benefits.

Based on this approach, under an ESA/ASI agreement, Alenia and Columbus prime contractor Astrium made a substantial effort to revise the designs of the MPLM and Columbus modules in order to adopt common items and subsystems, and consequently to substantially reduce the development and qualification costs.

In addition, significant effort has been made on simplifying the design of the internal subsystems for all the projects in order to maximise the volume and mass available for the payloads. Although it is physically the Station's smallest laboratory, Columbus offers the same payload accommodation and services as the others.

The Savings

The first important consequence of the similarities between the projects was the adoption of common design approaches for the primary structures, thermal insulation systems and most of the internal environmental control equipment for all of the related pressurised compartments. MPLM was considered to be the base project for deriving those subsystem designs for Columbus, with the goal of transferring them with as few modifications as possible. In fact, MPLM's primary structure has been almost fully used for Columbus, with only a few local changes in the forward cone and in the thickness of the cylindrical shell. In exchange for this structure, ESA has provided to ASI the Environmental Control and Life Support Subsystem (ECLS) for MPLM (p4, *On Station* #2; ESA BR-143 'Supporting Life') Several of those ECLS items, such as the cabin air diffuser, depressurisation assembly and positive/negative pressure relief assembly, have also been adopted for Columbus without further qualification, after proof that their original requirements meet or exceed those of the laboratory.

The experience gained from the design and development of MPLM, plus the integration and verification of the two Flight Units already delivered to NASA, has created remarkable benefits for the other projects. The acquired know-how is allowing common utilisation of analytical tools and documentation, adoption of the qualification approach by 'similarity', and optimisation of the projects' integration and verification processes – generating a cost-saving that would have been impossible to achieve otherwise. This Columbus/MPLM synergy has saved about EUR70 million of taxpayers' money – or about 10% of MPLM's programme cost and a similar level for Columbus. The Columbus primary structure was completed in January and successfully tested in February.

The MPLM primary structure also forms the basis for the two Nodes and ATV's pressurised Carrier. For the Nodes, half of the cylinder length is being fully used, along with the fittings for the Shuttle cargo bay interface. The other half has been redesigned to host the four radial docking ports. Node-2's primary structure will be completed in October and finish testing in December, for the fully integrated and tested Node to be delivered to NASA in March 2002. Among other items, ESA is providing the Nodes to offset the Columbus launch cost aboard the Shuttle. European industry is thus developing hardware for the Station using ESA funds, rather than ESA paying NASA in dollars for the Columbus launch.

ASI President Sergio De Julio (left) and ESA Director General Antonio Rodotà sign the formal transfer of the Columbus and MPLM hardware on 14 April.

The ESA/ASI agreement has also fostered an increasing use of common subcontractors for the Columbus and Node electrical harnesses and Mechanical Ground Support Equipment (OHB, D) and thermal control subsystems (Microtecnica, I). These synergies will continue into the operational phase in terms of integration, payload operation and logistics activities.

For ATV, MPLM's length is halved to 3.9 m. The aft cone is modified to interface with ATV's propulsion section and the forward cone is modified to accommodate the Russian Docking System (see p20 *On Station* #1, December 1999). The Structural Model is in final assembly and will begin its qualification campaign in late 2000. The first flight unit will be delivered to Aerospatiale in November 2002; eight flight units are currently planned.

By the end of the Space Station programme, Alenia Spazio will have built 18 related primary structures (three dedicated to qualification). This approach of reducing costs by using common items wherever possible has kept these projects within budget and released financial resources for new activities. ■

MPLM provided the primary structure for Columbus.

Further information on the space activities of Alenia Spazio can be found at *http://www.alespazio.it*

Dipping into Microgravity

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ESA's latest campaign of parabolic aircraft flights was completed successfully in May. This 28th campaign was organised by ESA to prepare microgravity experiments for sounding rocket and International Space Station flights.

ESA's series of parabolic flights continues to prepare experiments for rocket and Space Station flights

International teams conducted 11 experiments: seven in physical sciences, three in biology, and one with crew support equipment.

The Airbus A300, flying out of Bordeaux-Mérignac (F) airport, completed 97 parabolas over 4 days, each time generating about 20 s of microgravity. The 27 previous campaigns have produced more than 2650 parabolas and almost 15 h of weightlessness for 360 experiments since 1984.

ESA astronaut Andre Kuipers (right) testing the Mirsupio crew pouch supervised by EAC engineer Frits de Jong.

Physical Sciences

'Hydrodynamics of wet foams' (B. Kronberg, Institute for Surface Chemistry, Stockholm, S; M. Adler, CNRS, Paris, F) studied different foams and tested a new method of creation by injecting carbon dioxide into liquids. Foam generation cannot be tested on the ground because the bubbles collapse too rapidly. Researching stable foams in microgravity is helping to produce lighter materials without compromising structural behaviour – clearly of interest to car and aircraft designers, for example.

'Interfacial turbulence in evaporating liquids' (J.C. Legros, Brussels University, B) studied the 3D temperature in evaporating ethanol arising from the turbulent motions at the liquid-gas interface. It also tested the cell filling method. This is one of the recommended experiments of ESA's Microgravity Applications Promotion Programme (*On Station* #2, p.7)

The Swedish Space Corporation designed the hardware for these first two experiments in preparation for their respective flights on the Maxus-4 (March 2001) and Maser-9 (November 2001) sounding rockets.

'Vibrational phenomena in inhomogeneous media' (P. Evesque, Ecole Centrale, Paris, F; D. Beysens, CEA, Grenoble, F; Y. Garrabos, CNRS, Pessac, F) investigated the effects of vibrations in weightlessness on the inhomogeneities in 2-phase fluids and granular matter. Three cells were axially vibrated at 5-100 Hz. This is one of the recommended experiments for the Fluid Science Laboratory aboard Columbus.

'Liquid diffusion model experiments with the shear cell technique' (G. Frohberg & A. Griesche, Berlin Technical University, D; G. Matthiak, DLR, Köln, D) continued an experiment flown on the Russian Foton-12 in September 1999. The diffusion coefficients of liquids are difficult to measure on the ground because of convection induced by gravity. In microgravity, diffusion coefficients can be measured by separating parts of the long capillary cell after diffusion. This shearing was investigated on different cell designs. One cell was tested to prepare for the German Advanced Titus facility that will fly on the Russian segment of the Space Station.

The 'Study of synthesis of carbon species in microgravity' (J.P. Issi, J.C. Charlier & J.M. Beuken, Louvain University, B) investigated the synthesis of new forms of carbon (Fullerenes, nanotubes and diamonds) via a strong electric discharge between two graphite electrodes. Similar experiments on previous parabolic flights have shown that the synthesis of these carbon forms is somehow improved. In addition, better artificial diamonds were produced on the ground than those by standard industrial processes.

'Recrystallization of tungsten filament' (R. van Wijk & P. Dona, Philips Eindhoven, NL) looked at the causes of filament sagging in bulbs, which reduces light output and lifetime. This is one of the first experiments conducted directly by an industrial company in weightlessness and shows the potential of applied research and development in microgravity.

'Laminar diffusion flames representatives of fires in microgravity environments' (P. Joulain, CNRS, Poitiers, F; J.L. Torero, Maryland University, USA) continued a series of parabolic flight, sounding rocket and drop tower combustion experiments to characterise the structure of laminar diffusion flames in microgravity. Flames in the absence of natural convection, which removes hot gases from the combustion site in favour of cold gases, allow diffusion transport to be studied. An ethane flame in a forced air flow was observed using advanced diagnostics techniques such as spectroscopy and particle image velocimetry. It should provide the scientific basis for evaluating material flammability in microgravity, allowing fire risks aboard manned spacecraft to be reduced.

Biology Experiments

Bones tend to degrade in the elderly on Earth and in astronauts on long spaceflights. 'Real time physiological and molecular biological measurements of osteoblast-like cells' (D. Jones, Marburg University, D; Vander Sloten, Leuven University, B) investigated osteoblasts, responsible for bone tissue regeneration. Bovine bone cells were mechanically strained and observed by optical diagnostics in order to determine the role of the intracellular calcium.

'Effects of gravity at biomolecular level' (P. Vanni, Florence University, I) and 'Lipoxygenase activity in microgravity' (M. Maccarrone & A. Finazzi-Agrò, Rome University, I; G.A. Veldink & J.F.G. Vliegenhart, Utrecht University, NL) investigated the role of microgravity in enzyme catalysis reactions to complement previous experiments in the EMEC (Effect of Microgravity on Enzyme Catalysis) module on the Maser-7 sounding rocket in 1996, refurbished for this campaign by Officine Galileo. The lipoxygenase enzyme plays important regulatory roles in all living cells, from plants to animals.

Crew Support Equipment

The 'Test of the Mirsupio crew support pouch' by engineers from the European Astronaut Centre used a multi-purpose crew equipment pouch worn around the waist to help astronauts in their daily lives in orbit. ESA astronaut Jean-Pierre Haigneré used an early version aboard Mir. This improved version was validated for use aboard the Space Station.

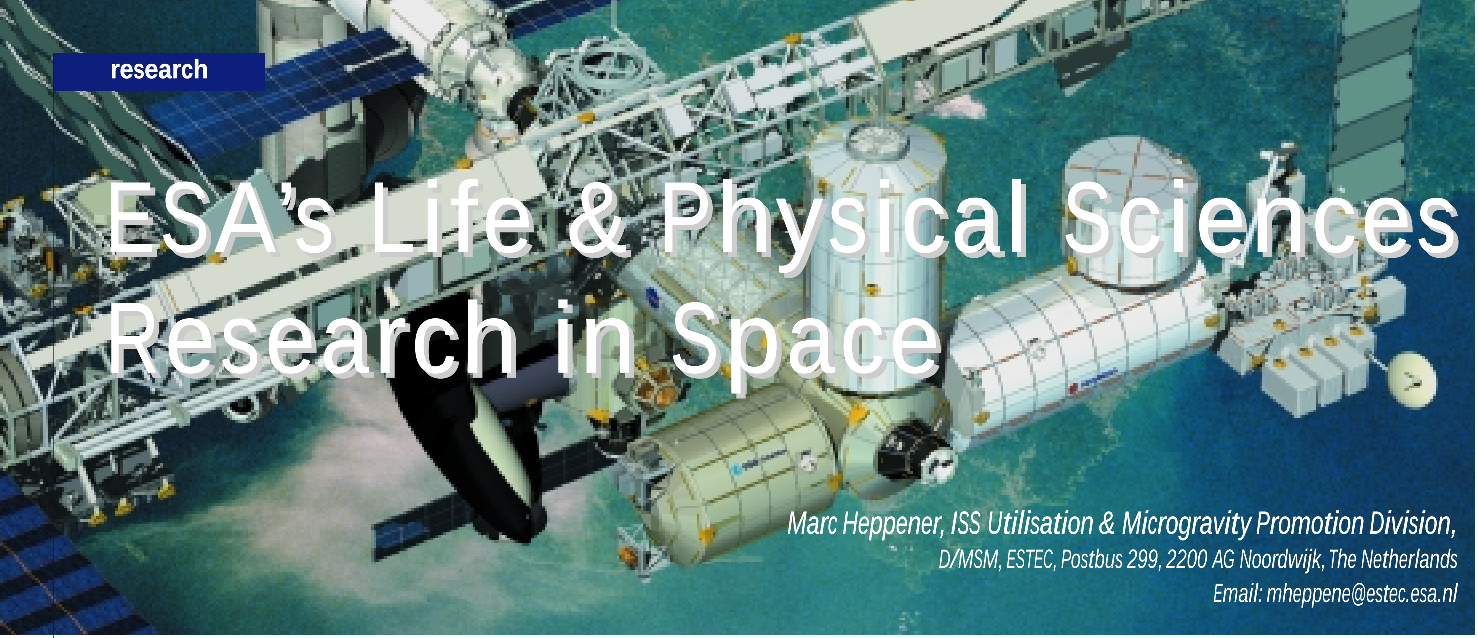
The Future

ESA's 29th parabolic flight campaign is scheduled for November 2000 with experiments in life and physical sciences, this time focusing on physiological and medical experiments. Over the next 4 years, ESA will run two campaigns annually. Scientists are regularly invited (*http://www.spaceflight.esa.int/parabolic*) to submit proposals for review and selection by peers.

Scientists from the Univ. of Rome and engineers from Officine Galileo conducting the enzyme catalysis experiments with the EMEC module.

Engineers from Philips testing a new bulb filament design.

*The Airbus A300 flew its 2000th parabola during the campaign's second sortie. Coordinators Vladimir Pletser (ESA, **left**) and D. Thierion (CNES, **right**) congratulate Novespace Directeur General J.P. Fouquet in front of the commemorative plaque.*



ESA's Life & Physical Sciences Research in Space

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Introduction

In the past 15 years, the quality of research in life and physical sciences in space has progressed to the present high level. At the same time, the field has expanded beyond fundamental research to add applied research, with principal applications in health research and improving industrial processes.

ESA is currently promoting application-oriented research in space. Research programmes by pan-European teams with significant industrial contributions are being initiated. Common objectives are being established with the 5th and 6th Framework Programmes of the European Comission (EC) and with the basic research objectives as defined by the European Science Foundation (ESF).

Applied research is now a strong element of ESA's Life & Physical Sciences activities...

The Quality of Research

ESA has undertaken life and physical science experiments in space since the mid-1980s. They involved mainly fundamental studies on the influence of gravity on living systems, such as cells, organisms and humans, and organic and inorganic materials, mostly in the liquid state. In the early days, experiments were often phenomenological and the development of adequate research facilities adapted to the new environment of spaceflight was still in its trial and error phase. As a result, it was often difficult for the researchers to gain recognition in the scientific community at large for their pioneering work. A recent statistical survey on the number and quality of life sciences papers has shown (see graph) that this situation has significantly improved over the last 15 years. Today, the average quality of a space life sciences paper, as measured by the impact factor of the journal in which it appeared, is almost 50% higher than an average non-space life sciences paper. It can be safely assumed that the physical sciences enjoy a similar positive situation.

The increase in quality of the research is attributable to two factors. Firstly, since the early 1990s, ESA has applied a rigorous peer review system in which independent peers judge proposals on their scientific merits. This system has been acclaimed by ESA delegations, the ESA advisory groups, the peers and the scientists themselves – even when their proposals were rejected. Since 1997, the Announcements of Opportunity and the resulting peer reviews in Life Sciences have been coordinated internationally. All proposals received worldwide are reviewed under one system and judged on scientific excellence. A similar arrangement for the Physical Sciences will be implemented in 2000.

A second explanation for the increased quality in research is the improved availability of flight opportunities in the last decade. With numerous flights of Spacelab, Spacehab, sounding rockets and Russian manned and unmanned systems, the 1990s strongly improved on the preceding decade, which was greatly troubled by the Challenger accident in 1986.

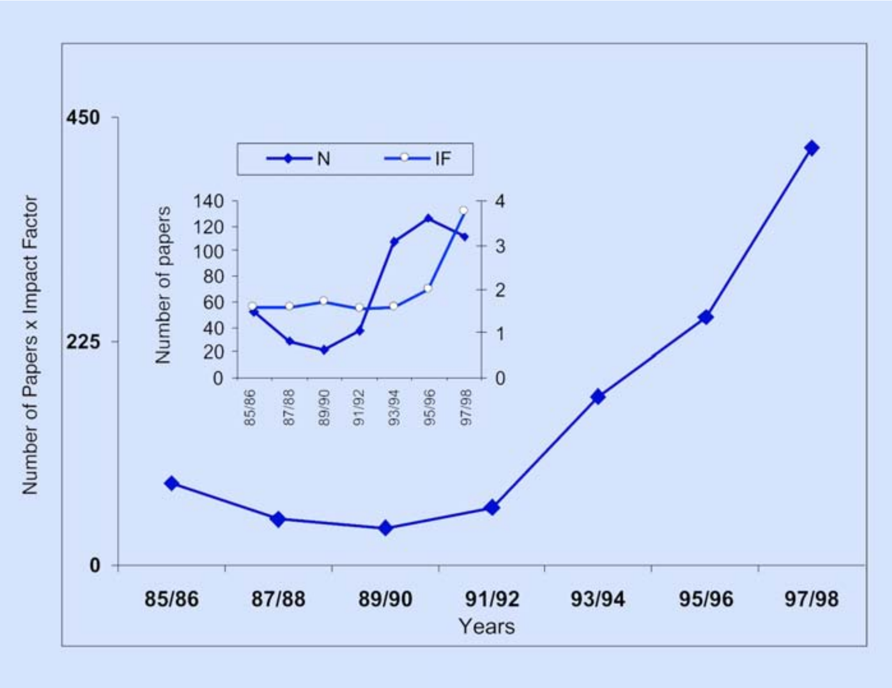
Still, counting the number of experiment-hours, the total available experiment time is small when compared to what will be available on the International Space Station. The Station will offer the continuous access and repeatability of experiments that are essential in attracting new scientists and commercial customers to exploit the possibilities of research in space.

As in any other discipline, the onset of a new technique needs first to be incorporated and accepted by its user community before application-oriented research or commercial use can be considered. For research in space, this period has been relatively long, mainly as a result of the scarcity of flight opportunities. Nevertheless, several research themes with application potential have emerged. ESA's implementation of its new programme element was based on exploiting these themes.

The New Elements

In 1995, the ESA Ministerial Council in Toulouse approved a proposal to promote application-oriented research aboard the Space Station. An important first step was setting up Topical Teams mixing scientists from

The quantity and quality of papers published on space-related European life sciences research has increased remarkably in recent years.



academia and industrial R&D laboratories. They focused on identifying common interests and developing concrete suggestions for application-oriented research. The second step incorporated application-oriented research in ESA's AOs for Life and Physical Sciences. The first such new-style AO was issued in 1998. Important new elements are that the AO:

— deals with basic and applied research;
— calls for research programmes, rather than proposals for individual flight experiments;
— calls for teams with a European dimension, rather than individual Principal Investigators;
— strongly suggests inclusion of partners from non-space industries in the teams;
— offers ESA funding for applied research programmes.

The last element is fundamentally new for ESA, which has never before funded the experiments themselves.

The response to this first AO, which dealt with Physical Sciences and Biotechnology, consisted of 145 proposals – substantially exceeding initial expectations. After a review by independent peers, six were rated as Outstanding, 26 Highly Recommended and 30 Recommended. 31 of the 145 were application-oriented, including:

— thermophysical properties of liquid metals;
— advanced foams;
— biological tissue culturing;
— osteoporosis;
— combustion processes.

A second, Life Sciences, AO was issued in September 1999. The 40 proposals are under review. If the statistics of the first AO apply, then 40-50 proposals in total will be initiated.

An important aspect is the funding status of these programmes. ESA funding per project was announced as 300 keuro per year maximum, scaled by an 'application factor' as identified by the peers. Other parties ready to fund these projects were mainly the proposing institutes themselves, National Agencies and the industrial partners. The overall statistics read as follows:

ESA	9.2 Meuro	35%
Institutes	7.6 Meuro	29%
Industry	6.9 Meuro	27%
Third parties	2.4 Meuro	9%
Total	*26.1 Meuro*	

Funding from National Agencies is excluded from these statistics because these data are not yet fully available. What is extremely gratifying to see is the leverage of the funding provided by ESA. Also, the contributions by industries, which include some important European companies, are substantial. Even taking into account that the industrial contributions are mainly in-kind or in-house activities, the interest of European industry is clearly evident.

Towards the European Research Plan

The approach described above will be pursued further in the coming years. ESA is beginning a dialogue with the ESF and EC to define common objectives in fundamental and applied research. Research priorities will be set around themes like Health, Nutrition and Ageing, Energy and Environment, and Improvement of Industrial Processes. Together with inputs from the various National Space Agencies, a truly user-driven European Research Plan will be the end result. This Research Plan will be presented to the next ESA Ministerial Council in 2001. ■

Texus Successes

ESA's Participation in Texus-37 & Texus-38

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Introduction

ESA's four successful experiments aboard the Texus-37 and -38 sounding rockets launched in March/April 2000 from Esrange near Kiruna in northern Sweden were the latest in the long series of suborbital microgravity missions. So far, ESA has funded 75 experiments from eight Member States: B (15), D (17), E (6), F (11), I (6), NL (7), S (8) and UK (5), or about 3.1 t of scientific payload on Texus missions since Texus-6 in May 1982. This reflects the important role of sounding rocket missions for microgravity research, both in preparing for longer duration and manned missions and also in carrying out independent investigations.

The recent dual Texus launches again highlighted the importance of suborbital microgravity research...

The TEM-SEN-3 module studied flame-spreading in microgravity. Samples were burned in the large central combustion chamber, surrounded by the three gas bottles, the infrared camera (black unit, bottom right) and the two optical CCD cameras (twin white cylinders). Inset: a sample is ignited. The other two samples can be seen to the left and right, with their ignition filaments.

Texus-37

The single ESA-funded module accounted for about 29% of the scientific payload. The other four experiments in three modules were funded by the German Aerospace Centre (DLR). Texus-37 was launched on 27 March, 4 days behind schedule because of strong winds. The biological samples were returned only an hour later to the scientists at the launch site by helicopter, followed minutes later by a second helicopter with the recovered payload.

Texus-38

This 100%-ESA mission flew on 2 April, 2 days behind schedule, again because of strong winds. All of the scientific data was telemetered to the ground before the main parachute failed to open and the payload thumped back down into the snow at 85 m/s. Although the horizontal impact meant it was not completely destroyed, most of the hardware cannot be reused. This was the first failure of the recovery system after 43 successes for European microgravity launches covering 37 Texus, 2 Maser and 4 Maxus missions. The failure investigation showed that the main parachute was never pulled out of its container because the tow-line from the drogue parachute was not properly attached by the US manufacturer.

The ESA-funded Experiments

Texus-37: Critical Velocities in Open Capillary Flows

(Dr. Dreyer, ZARM, Bremen, D; new module TEM 06-24, developed by Astrium, Bremen, D)
Capillary vanes are used in satellite tanks to supply propellant to thrusters for attitude control, but there is a point (critical flow

The launch of Texus-38.

velocity) where the flow path collapses or liquid is ingested at the outlet. Measuring this critical velocity is difficult on the ground because flows only a few mm long can be achieved, but on Texus-37 a steady flow of silicon oil with a viscosity of 0.65 cSt was established between two parallel glass plates 5 mm apart and 50 mm long. The flow was then increased slowly to find the critical value for that length. The open capillary was observed by two CCD cameras, and the flow speed measured by injecting small air bubbles.

Texus-38: Signal Transduction in Osteoblasts
(Prof. Jones, Philipps-Univ., Marburg, D; new module TEM 06-25, developed by Astrium, Bremen, D)
Investigating whether the calcium release by bone-forming cells is affected by microgravity is important for understanding the lose of bone mass in astronauts. The free calcium of osteoblast cells loaded with 'fura-2' fluorescent dye was accurately measured by two photometers recording the fluorescence (405 nm & 490 nm) triggered by an ultraviolet (345 nm) laser. As mechanical stress (e.g. physical exercise) increases calcium generation, the second part of the experiment subjected the cells to pressure pulses. This time, the 'oregon green' fluorescent dye was excited by a 473 nm crystal laser and observed with a fluoresence microscope.

Texus-38: Flame Spreading under Forced Flow Conditions
(Prof. Tarifa, Univ. of Madrid, E; modified module TEM-SEN-3, developed by Astrium, Bremen, D and Sener, E)
Little is known on how fires would spread in a manned spacecraft, where there is no convection and low airflow. Flame spreading along solid fuel samples in very slow laminar gas flows (1, 1.5, 3 cm/s) was observed by optical and infrared cameras, and the temperatures measured by thermocouples. Two gas mixtures with different oxygen contents were used: 10% O_2/90% N_2 and 40% O_2/60% N_2. Each of the three hollow plastic cylinders – 80 mm long, 6 mm diameter – was ignited by an electric heating wire.

Texus-38: Droplet Evaporation
(Prof. Gökalp, CNRS Orléans, F; new module TEM-EVA, developed by Astrium, Bremen, D)
n-Heptane droplets were vaporised in two independent ovens in order to probe the behaviour of propellant droplets in car, aircraft and spacecraft engines. Improved understanding will lead to more efficient designs. The experiment was run in realtime by the investigators – one for each oven – working with joysticks at their launch-site consoles. The most critical step for each was creating the droplet, by establishing a liquid bridge between two small syringes, which were then quickly rotated apart. The droplet was held on a 0.1 mm-diameter glass fibre and moved into the hottest part of the oven – one heated to 400°C, the other to 600°C. The pressure for each was controlled between ambient and 50 bar.

Droplet vaporisation was studied in the two ovens (the large cylinders near the top) of TEM-EVA, seen here in the Esrange integration hall. Inset: an n-heptane droplet evaporates under weightlessness in the 400°C oven.

All four experiments ran successfully and interesting scientific results can be expected. For the future, the 100% ESA-funded Maxus-4 (April 2001) and Maser-9 (November 2001) are under construction, and the payload for Maxus-5 (November 2002) was approved in June (see this issue's Recent & Relevant news pages). Maser-10 is planned for 2003 with 80% funding by ESA.

The battered payload module of Texus-38 is returned to Esrange. Fortunately, all of the scientific data were relayed to the ground before impact.

ESA's Laboratory Support Equipment Programme

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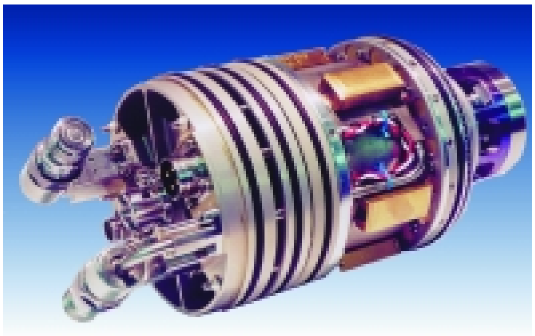


The 'Brayton Machine', working at 90 000 rpm, generates the –80°C for MELFI.

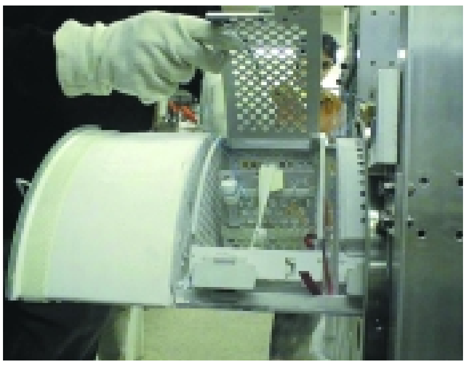
The ESA Laboratory Support Equipment (LSE) Programme covers the development of the 'MELFI' and 'MSG' multi-user facilities to support experiments in biology, life sciences, physiology, materials science and fluid science, together with the development of the Hexapod pointing system for external payloads. By providing these three to NASA under the ESA/NASA Memorandum of Understanding for Early Utilisation, the Agency has gained early access for European users to the Station before the Columbus laboratory becomes available in 2004. Through this barter, ESA can use three external payload sites on the Station Truss for 3 years and the equivalent of 1.5 internal equipment racks for 1 year, plus two ESA astronaut flight opportunities. The investment is in developing European technology, rather than spending European taxpayers' money in the USA.

The Agency's development of research hardware will provide European users with early access to the Space Station

A MELFI flight unit is also being provided to Japan's NASDA space agency, in return for 12 International Standard Payload Racks (ISPRs).

MELFI

The Minus Eighty (Degrees Celsius) Laboratory Freezer for ISS (MELFI) is a fully integrated rack facility, hosted in an ISPR, to condition, freeze and store life sciences and biological samples aboard the Space Station. MELFI will also be used to transport frozen specimens to/from the Station flying fully powered inside the Mini-Pressurised Logistic Module aboard the Space Shuttle. The four MELFI units being built will each fly a mission of up to 2 years.



MELFI: a dewar is open with a speciment tray pulled out.

The –80°C is generated by a centralised cold engine working on the Brayton thermodynamic cycle using nitrogen gas as the cooling fluid. The turbine runs at up to 90 000 rpm.

MELFI began Phase-C/D in January 1997, went through the Preliminary Design Review (PDR) at end-1997 and the Critical Design Review (CDR) at end-1998; it is now in the middle of its qualification campaign. The major subsystems and equipment are undergoing qualification tests, while the system-level tests will begin in mid-2000. The industrial consortium is headed by Matra Marconi Space (F), now part of Astrium.

ESA will deliver the first MELFI to NASA in about March 2001 for launch inside MPLM on Space Shuttle mission UF-1 to the Station, currently planned for about August 2001.

MELFI characteristics

Volume: 300 litres total in 4 independent dewars (minimum configuration 1 dewar at –80°C; 2-4 dewars in combinations of 3 modes: below –68°C, –37°C to –23°C, +0.5°C to +6°C. Temperatures maintained for 8 h without power

Sample storage: cell culture 1-10 ml, fluids (blood, media, etc) 1-500 ml, tissue 2-10 ml, whole specimens 10-500 ml

Cooling time (from +23°C to –68°C): 2 ml 18-25 min; 10 ml 44-56 min; 500 ml 460 min

The MELFI Training Unit, delivered in June, shows the four dewar drawers at bottom.

MSG characteristics	
Work volume for experiments	255 litres
Largest access dimension	40 cm diameter
Experiment Power	+120 Vdc, +28 Vdc, ±12 Vdc, 5 Vdc
Cooling	up to 200 W by air; up to 800 W by cold plate

The Training Unit for the Microgravity Science Glovebox was delivered in July to NASA's Johnson Space Center.

MSG

The Microgravity Science Glovebox (MSG), also housed in an ISPR, accommodates materials science, combustion, fluid science and crystal growth research. The sealed glovebox environment, with the class 100 000 cleanliness level achieved by continuously circulating and filtering the air, means that MSG is particularly suited to handling hazardous materials in a manned vehicle. It provides a large working volume with resources for flexibly handling experiments, either by direct crew intervention or automatically for prolonged periods.

MSG's Phase-C/D began in January 1997, went through PDR at end-1997 and CDR at the beginning of 1999. Hardware manufacture and flight and ground software development are underway. System-level qualification tests are planned to begin by the middle of this year. MSG's industrial consortium is headed by DaimlerChrysler Aerospace (D), now part of Astrium.

MSG will be delivered to NASA by the end of 2000 and, like MELFI, will be launched on UF-1 for installation in the Station's US Laboratory. ESA made its first rack-level hardware delivery to NASA in August 1999 when it handed over the MSG Ground Unit, which is being used to verify experiment interfaces and protocols as well as in-orbit operations. The Training Unit was delivered in July 2000.

Hexapod

Hexapod will point its payload at the Earth with high accuracy and stability whatever the Space Station's attitude. NASA's Stratospheric Aerosol and Gas Experiment (SAGE III) is its first payload, to monitor the global distribution of aerosols and gaseous constituents in the atmosphere.

The Hexapod/SAGE mechanical configuration is extremely compact. SAGE is mounted on Hexapod's top ring flange and extends down among the six actuators in order to minimise the volume and the moment of inertia of moving parts. Hexapod's lower platform is mounted on a wedge, to provide the 7° offset for optimising SAGE's field of view. The assembly will be mounted on a nadir-pointed Express Pallet Adapter on the Station's Truss.

Hexapod's Phase-C/D began in February 1998 and went through PDR in May 1999 and CDR in June 2000. The industrial consortium is headed by Alenia Spazio. Hexapod will be delivered to NASA in mid-2001 for launch on Shuttle mission UF-3 to the Station in late 2003. ■

Hexapod will carry an atmospheric monitoring instrument. (Alenia Spazio)

Hexapod characteristics	
Degrees of freedom	6
Pointing range	±8°
Pointing accuracy	± 90 arcsec
Pointing stability	9 arcsec/s
Pointing rate	1.2 deg/s
In-orbit life time	5 years
Payload assembly mass	35 kg
Payload envelope	340 x 340 x 740 mm
Hexapod mass	110 kg

Return to Earth

An ESA astronaut shares his space experiences

ESA astronaut Gerhard Thiele flew his first space mission in February as part of the STS-99 Shuttle Radar Topography Mission (SRTM) that provided the raw data to create 30 m-resolution digital topographic and radar maps of 80% of the Earth's surface. On Station took the opportunity to talk with Dr Thiele at ESA's European Astronaut Centre in Cologne, Germany at the conclusion of the crew's European tour.

ESA astronaut Gerhard Thiele shared his STS-99 experiences with On Station contributor Graham Biddis…

Working on a laptop during STS-99. (NASA)

Would you outline the major mission goals of your flight?
The purpose of the mission was to generate the first 3-dimensional map of the Earth's main land masses between 60°N and 57°S. We now have terrain information with an altitude accuracy of about 10-15 cm for every 30 m along the ground.

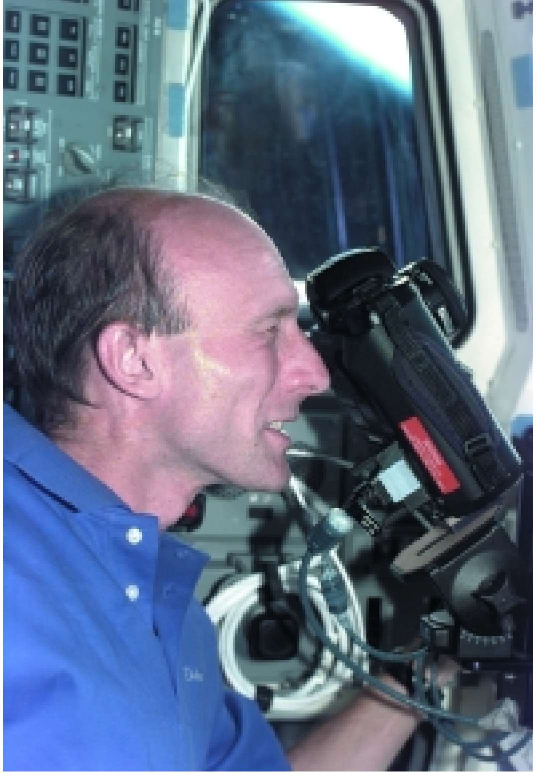
Juggling in weightlessness is not so easy... (NASA)

STS-99 was your first flight. What were your experiences of the first few hours and days in weightlessness?
I was extremely cautious because, as you know, astronauts have experienced adaptation problems to weightlessness. I was very fortunate that mine were very mild – probably because I was so careful. In the first few hours, you need to stay upright and orient yourself in the same reference frame as the Orbiter's. The most amazing thing to me was that, just within 3 or 4 days, you adjust not only to weightlessness but you even forget what it is like in gravity!

Your role in STS-99 was as a member of the European astronaut corps with specific responsibility for the European-built radar system. As Mission Specialist-1, what were your other 'personal' responsibilities?
Well, as MS-1, I was sitting on the flight-deck behind the pilots for launch. If everything goes normally, that means that you do nothing but observe. If there is a malfunction, then you are the guy who keeps the 'big picture' in looking ahead and monitoring which systems are still active. MS-1 provides the system status to the pilots and the flight engineer sitting next to you, including potential impacts of further failures.

The SRTM crew had to be able to perform a spacewalk in the event of hardware problems. Can you give us some insight into your EVA training?
Every Shuttle crew has a contingency EVA team in case something happens that needs external attention – even if it is not planned. Let's say that the Ku-band antenna, which is one of the antennas for communicating with the ground, refuses to return to its stowage position at the end of the mission. You have the option to jettison it, but it is an expensive piece of equipment, so you prefer to bring it back home. And that means a spacewalk to stow it manually.

Apart from these usual Shuttle contingency tasks, our mission was equipped with this 60 m-long radar mast that could have presented



Gerhard checks an Earth target through the camera viewfinder on the Shuttle's aft flight deck. (NASA)

some problems – we might have had to do EVAs to deploy or retract it manually. And we came pretty close to the manual retraction because of the problem we had closing the mast canister lid! We could not close it on the first attempt but that was not a total surprise. But it closed OK at the second go and we did not need a spacewalk.

Are there any specific issues from your mission training where you can pass on significant 'lessons learned' to your colleagues?

Well, one that I would recommend to first-time flyers – as I was on that mission – and if you are MS-1 sitting on the flight-deck during ascent, is that you want to get to know the Shuttle systems by heart. And if you are also a contingency EVA astronaut, don't underestimate the time that you need to spend on it in order to become proficient. On top of all that, I was 'payload lead' for my shift, so I had to have an in-depth knowledge on everything that had to do with the radar in order to take decisions in conjunction with the ground team. Of course, that means you have to spend a tremendous amount of time learning the subject! So I would say that you must start as early as you can and don't hold back on a single opportunity because the time constraints can be just overwhelming.

STS-99's multi-national crew included US, Japanese and European astronauts. Did you notice any cultural differences in training for and flying this mission?

There were definitely some cultural differences between the crew members. Very simple things like eating – Japanese food is very different from European food, for example. But there was never a significant difference on our mission that would not have arisen if it had been an all-American crew or that I introduced into the team because I was a European. I just didn't see anything like that!

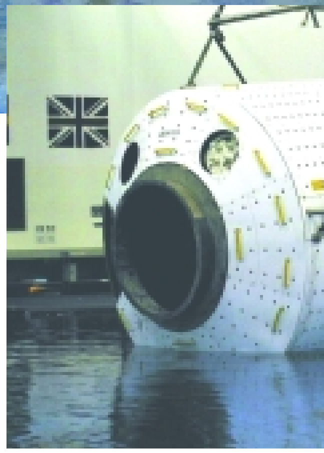
Training with NASA astronaut Janet Kavandi. (NASA)

Following your experience supporting Spacelab D-2 mission operations and now your STS-99 experience, is there a particular area where your background could really make a future contribution?

Definitely yes! And I think it shows in my new job assignment after STS-99 – I will be a Capcom (capsule communicator or Mission Control Center crew interface) for Shuttle mission control. My experience as an Alternate Payload Specialist during D-2 will certainly be an asset. It was very beneficial already in communicating with our STS-99 radar experts who were sitting in a separate Radar Payload Operations Control Center, very similar to our Spacelab POCC. Having experienced the communication process at both ends, on the ground and onboard, will certainly help me in my new job.

Taking a meal break...(NASA)

Focus on ESA's Houston Office



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The ESA Houston Office (EHO) at NASA's Johnson Space Center in Texas owes its existence to the International Space Station (ISS) but its ancestry stretches back to the Spacelab liaison office at NASA's Marshall Space Flight Center in Hunstville, Alabama in the late 1970s under Jan Bijvoet. After that design phase, liaison offices followed at the Johnson Space Center for interface definition and then at the Kennedy Space Center for Spacelab integration into the Space Shuttle.

ESA's office in Houston plays an important role in the Agency's manned space activities

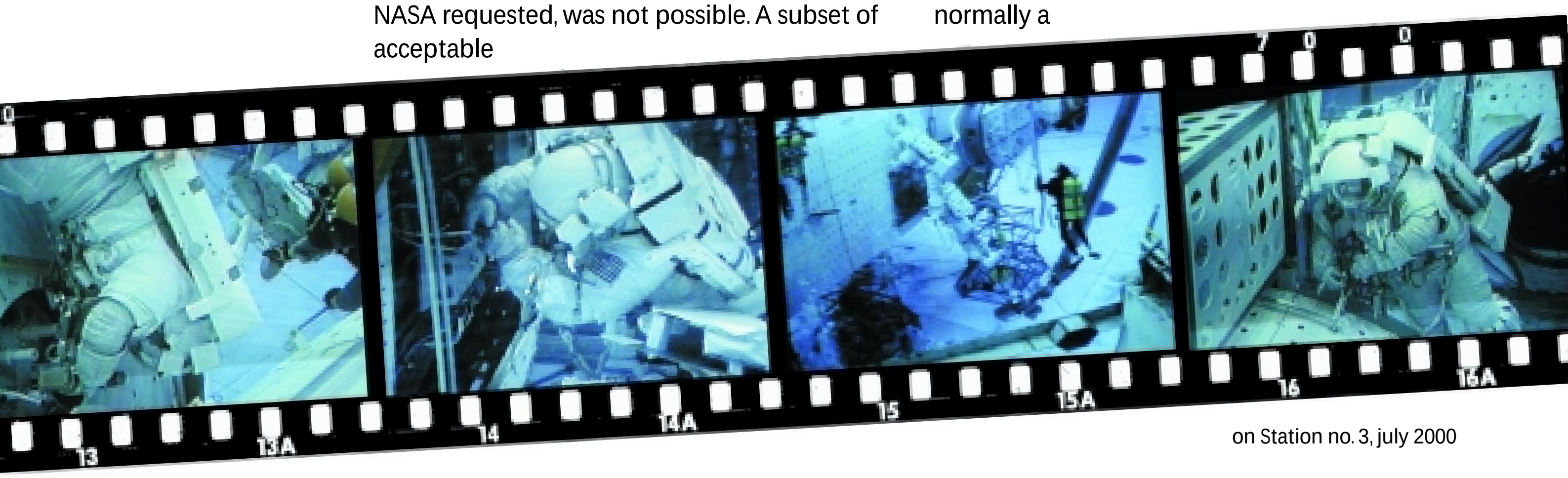
The original Memorandum of Understanding (MOU) between ESA and NASA for cooperation on Space Station Freedom, as well as the current MOU for ISS, foresaw ESA representation at the NASA Space Station Program Office 'to facilitate the working relationships between NASA and ESA'. So the liaison office was installed in 1987 under the direction of Derek Deil in Reston, Virginia, then the seat of the Freedom Program Office. A reciprocal NASA liaison office was set up at ESTEC.

The Reston Office hosted the negotiations for ESA's portion of the Station design requirements for the Columbus module. Signing up to the totality of the Program Design Requirements Document (PDRD), as NASA requested, was not possible. A subset of acceptable requirements was agreed in a 'Joint PDRD' that matched the existing agreements with European industry. However, because the NASA Reston office had no budgetary power over the NASA centres actually implementing the Station Program, ESA's attempts to come to interface agreements with the Marshall, Johnson and Lewis (now Glenn) centres were all in vain.

The greatest Station redesign of all began in 1993 when the Russians joined the programme. The NASA programme office was moved to the Johnson Space Center and, with it, the ESA liaison office. This time, the International Partners' design requirements were documented in individually-tailored Segment Specifications. The contents were still the same, as the contracts with industry had not changed.

EHO Operations

EHO's support to the Manned Spaceflight Programme Department at ESTEC has evolved from helping to negotiate the design requirements, then the interface requirements, and now towards implementation. Defining operations tasks was always part of the support role, but its importance is steadily increasing. Two EHO staff members are now serving as deputy launch package managers – normally a

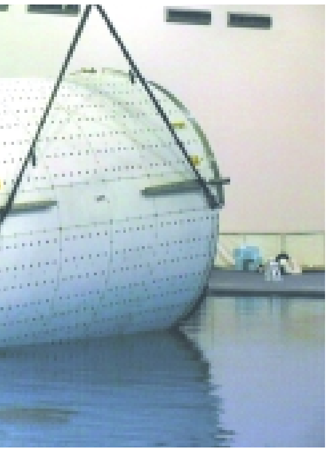


Beginning the spacewalk tests.

Preparing the Columbus mockup for the spacewalk evaluation.

NASA function – for Columbus/Cupola and the Automated Transfer Vehicle (ATV).

The Office's work routine is geared to the Space Station Programme weekly meeting plan. This plan covers weekly meetings of all six secondary boards overseeing all Station activities: payloads; vehicle (the Station); avionics & software; programme integration; mission integration & operations; and robotics integration. The primary board is the Space Station Control Board (SSCB), which is a multilateral control board that derives its mandate from the MOU. The SSCB meets only at important events, usually attended by the International Partners' Programme Managers. In future, keeping up the pace with the ISS assembly, SSCBs will meet more frequently by video-teleconference.



The 'mother of all meetings' is the Friday afternoon meeting (named 'Felicity') chaired by the ISS Program Manager Tommy Holloway, where the achievements and problems of the past week are presented. This meeting is well attended and all NASA centres involved in the programme are connected, so the most detailed questions can be answered instantly.

EHO staff attend meetings as guided by ESA's interests. The overall EHO task is to gather information, report to ESTEC and make the ESA position known to NASA. EHO is actively involved in establishing the ATV Segment Specification and the Interface Requirements Document.

EHO's weekly work culminates – at least from the perspective of the 5-strong team – in providing the Weekly Report to ESTEC.

In addition to the day-to-day work, EHO supports the preparation and execution of joint ESA/NASA tests, especially those at Johnson. The most recent was the Neutral Buoyancy Facility Test for verifying the suitability of Columbus for external maintenance and repair by spacewalking astronauts. EHO assisted in the interface with the project team in Europe and closely followed the fabrication of the Columbus mockup by NASA contractors on site. This close cooperation led to the early detection and correction of an assembly error: the bulkheads were welded to the wrong ends of the cylinder as NASA had assumed that they were identical.

The tests were made on three consecutive days in January. Each day, two suited crewmembers spent 6 h underwater simulating spacewalking tasks. Evaluation of the test results was done in the EVA Assembly Integration and Test Panel, supported by EHO.

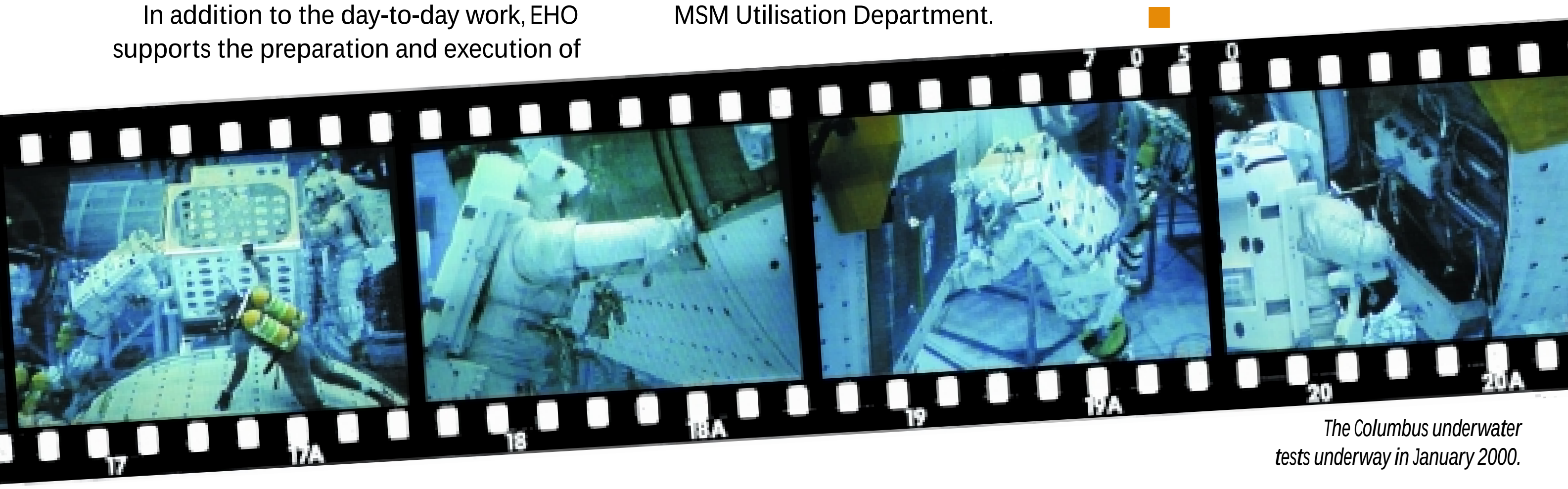
In the future, EHO's emphasis will shift from design and implementation to Station assembly and operations.

EHO Personalities

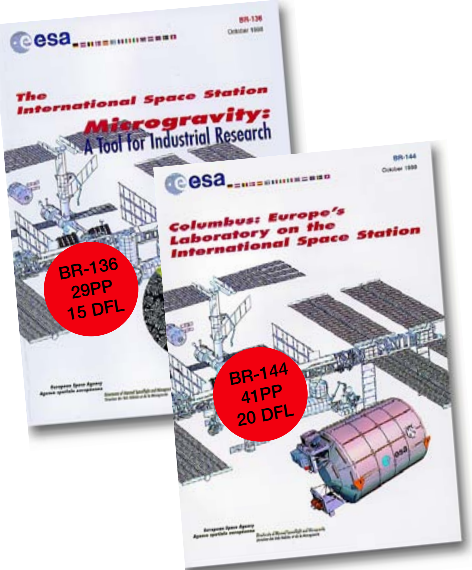
After Derek Deil's retirement in early 1997, Francesco DiMauro took over until summer 1998, when a serious illness led to his untimely death in early 1999. Dieter Lammers headed the office per interim, until Helmut Heusmann was appointed as the Head of EHO in late 1999.

EHO staff (see photo) are seconded from the Manned Spaceflight Programme Department at ESTEC on a rotation basis of 3-5 years. This feature would not be complete without mentioning the support to ESA astronauts at Johnson by Wolf Luettgen and Orazio Chiarenza, seconded from the European Astronauts Centre, as well as contractor Dwight Blair, who supports the MSM Utilisation Department. ■

The EHO team (from left) of Francois Allard, Ulrich Thomas, Helmut Heusmann, local staff member Paige Taylor, and Heinz Wartenberg.



The Columbus underwater tests underway in January 2000.



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On Station

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