esa

number 18, november 2004

on station

www.esa.int/spaceflight

The Newsletter of the Directorate of Human Spaceflight, Microgravity & Exploration

in this issue

European Space Agency
Agence spatiale européenne

Directorate of Human Spaceflight, Microgravity & Exploration
Direction des vols habités, de la microgravité et de l'exploration

Farewell MSM – Hello HME

Jörg Feustel-Büechl
ESA Director of Human Spaceflight

Development of the Columbus ground segment is progressing satisfactorily, and the recent System Validation Test #2 has been completed. This demonstrated the good data communications between the European payloads integrated in Columbus in Bremen, through the European ground network to the Columbus Control Centre in Oberpfaffenhofen, as well as selected Facility Responsible Centres. Further 'delta' testing is foreseen early next year following the integration of the external payloads onto the Columbus External Platform Facility and, again, with the ground segment. This testing will be repeated just before shipping Columbus to the Kennedy Space Center in preparation for launch. In September, all of the ESA payloads were removed from Columbus following completion of integrated testing. They have now been returned to their developers for upgrading.

Columbus Qualification Review #2 is planned for 4 November. This is a major Agency/industry milestone leading to the formal conclusion of the Columbus development programme. Unfortunately, the recent hurricanes in the southern US seriously damaged the Shuttle processing capability and, as a result, the return to flight of the Shuttle has been delayed from March/April 2005 to May/June 2005. But we still expect Columbus to be attached to the Station by the end of 2006.

Testing of the NASA/Boeing Human Research Facility rack in Columbus has been successfully accomplished. Data paths that are used solely by US payloads in Columbus were checked and no major problems were found.

In ATV, there have been regular high-level meetings between ESA, CNES and industry in order to take stock of the critical items, and good progress has been made. Of particular note is the ATV software (Version 2.2) that has now been finalised

The ATV Flight Operations Readiness Review of 28-29 September 2004 at the ATV Control Centre in Toulouse confirmed the readiness of the operational products and facilities needed for the first vehicle, 'Jules Verne'. The meeting was chaired by Robert Castle (Director, NASA Mission Operations) and Susan Creasy (Manager, NASA Mission Integration and Operations). Also attending were Mark Geyer (Manager, NASA Mission Integration), Victor Blagov (RSC-Energia Chief Flight Director), Alan Thirkettle (Manager, ESA ISS Programme) and Bob Chesson (ESA Head of Operations Department).

Right: ATV 'Jules Verne' in the ESTEC Test Centre.

and has already undergone around 3000 verification checks. However, there is still more software to be delivered. Integration of the ATV hardware at ESTEC is going ahead smoothly, with mating of the main elements prior to environmental testing. This begins with electromagnetic compatibility testing in mid-November and then acoustic testing in early 2005. Launch is targeted for mid-October 2005. See the ATV article on pp14-15 for further details.

An informal handover ceremony of the Cupola from Alenia to ESA took place on 6 September in Turin. The Cupola was then shipped to KSC and the formal ESA to NASA handover is being prepared. See the Cupola article on pp18-21 for further information.

A Preliminary Authorisation To Proceed statement has been agreed between ESA and Roskosmos for the Italian Soyuz flight carrying ESA astronaut Roberto Vittori in April 2005. The PATP is the precursor for the formal contract. Meanwhile, Roberto's training and experiment preparation are both well underway.

Negotiations for the first European long-duration astronaut mission aboard the ISS are well in hand. Thomas Reiter and Léopold Eyharts are in training for this flight of about 3 months.

NASA/Lockheed Martin engineer Mary Trenolone working with the Human Resources Facility in Columbus. Completed in October, the test showed that the NASA HRF rack is compatible with the European module. (V. Koehne)

During September, the Programme Board met for the very first time at the EAC in Cologne and agreed the decision schedule for the future exploitation and ELIPS package. ELIPS is our 'European Programme for Life and Physical Sciences and Applications utilising the ISS' and other means. A science symposium was subsequently held to mark the retirement from the Agency of Ulf Merbold, ESA's first astronaut. The symposium was kicked-off by John Young, who commanded the first Shuttle (1981) and first Spacelab (1983) flights. This was followed by the *Night of the Astronauts* at the Cologne Arena, with 32 active and former astronauts presenting themselves with brief biographies of their space experiences to an audience of 5000. Apart from an impressive 3-D laser show, a live link with the Station allowed the Expedition-9 crew of Gennadi Padalka and Mike Finck to answer questions from the audience.

As this is my last *On Station*, I would like to thank all my staff and colleagues, and partners in Space Agencies, industry and research organisations for a very gratifying experience during my 10.5 years of responsibility for human spaceflight and life and physical sciences in ESA. I have certainly seen many major steps in human spaceflight, beginning with the EuroMir-94

and -95 missions that demonstrated our ability to work harmoniously with the Russians. This was complemented in 1995 by the acceptance of the ISS and Microgravity Facilities for Columbus programmes presented at the Ministerial Conference in Toulouse. These programmes provided stability for our efforts and has stood the test of time. In 1998, we saw the successful mission of the Atmospheric Reentry Demonstrator (ARD) on Ariane-503, with the capsule landing exactly as planned. Also in 1998, we saw the creation of a unified European astronaut team at the European Astronaut Centre in Cologne, bringing together astronauts from different national Agencies under one roof. I also enjoyed in 1998 the beginning of Station operations, with the Zarya module followed in 2000 by Zvezda carrying the ESA Data Management System, which is still working flawlessly. In June 2002, the first European-developed payload, the Microgravity Science Glovebox (MSG), was added to the US Destiny laboratory aboard the Station. Many other deliveries have since been successful. Since 1994, 636 scientific and applications-oriented experiments have been performed on 21 parabolic flight campaigns 17 sounding rocket flights, nine Spacelab/Spacehab missions and aboard the ISS. Among 24 European astronaut flights, I witnessed seven missions, from Umberto Guidoni to André Kuipers.

And, now, I have another career in ESA, looking after the organisation of the General Budget from 1 November and will be based in Paris at ESA Headquarters.

I have really enjoyed the cooperation with my highly professional and motivated colleagues, and I wish my successor an equally gratifying period of office as Director of Human Spaceflight, Microgravity and Exploration. ■

Hello HME

Daniel Sacotte

ESA Director of Human Spaceflight, Microgravity & Exploration

I have the privilege of leading this new Directorate and bringing together Space Station, Microgravity and Exploration. Six months ago, I was asked by our Director General to lead the Agency's exploration activities, and we convinced the Member States to participate in a new Preparatory Programmme for Exploration: Aurora. This Preparatory Programme is on track and will provide the basis for decisions at the next Ministerial Council, expected in late 2005.

In parallel, most of the key elements for the Space Station have nearly reached completion under the direction of my predecessor, Jörg Feustel-Büechl. Columbus is close to readiness for launch and it is one of my priorities to push for that launch as soon as possible. ATV is well on track and we are pretty confident that it will be launched on schedule.

Now the priorities are to maximise use of these superb developments and prepare for the future. Of course the present conditions are less than ideal: retirement of the Space Shuttle is planned for around 2010 and then of the ISS in about 2015, together with our own constrained budgets for 2005 and 2006. So the Agency has to look at the future and provide opportunities for European scientists up to at least 2030. The approach will be decided at the next Ministerial Conference. This should provide the cornerstone for future European exploration. It is also a goal of this initiative to bring 'Space' to European citizens – particularly young people – showing in concrete terms how we all benefit from this European investment.

So we have demanding times ahead of us but I fully expect we will create an exciting and fulfilling Programme. ■

Delta: A Dutch Milestone

A Major Step for Dutch Spaceflight

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Introduction

The Dutch Soyuz Mission 'Delta' of 19-30 April 2004 was a major milestone for Dutch human spaceflight. For a spaceflight, the public interest was almost unparalleled in Dutch history: TV programmes carried daily reports and major newspapers sported front-page articles for days in a row. Not since the first Dutch astronaut, Wubbo Ockels, went into space in 1985 on board the US Space Shuttle did space play such an important role in Dutch public life. In this article, I would like to highlight some aspects of the mission.

The Delta mission has had a major impact on The Netherlands ...

Official crew portrait (from left): Michael Fincke, Gennadi Padalka and André Kuipers.

Possibilities and Options

In general, space activities and space policy are only infrequently the 'right stuff' for newspaper headlines or the TV evening news. Generally, only the industries, scientists and policymakers directly involved discuss the issues.

What are the issues? Let me just mention a few that are important from the policy perspective. How can we make human spaceflight more directly beneficial to life on Earth? Can the benefits be achieved in other ways? What should the balance be between manned missions and robotic missions? What should the role of human spaceflight be for exploration missions to other planets?

For weeks, they were a matter of public debate. We hope that the flight of André Kuipers has stimulated an awareness in Dutch society for the possibilities open to us, and for the choices to be made.

Historical Perspective

André's flight has a long history. In a sense, it goes back to the ESA Ministerial Conference in The Hague in 1987. At that meeting, ministers approved the Ariane-5, Hermes and Columbus programmes as three major building blocks for Europe in space, laying the foundation for European participation in the International Space Station. As part of that effort, it was foreseen that Europe would build up a European astronaut corps. At the time, there were only three ESA astronauts, Claude Nicollier, Wubbo Ockels and Ulf Merbold, in addition to a number of national astronauts. In 1990-91, a selection process was started for the new corps, first at the national level and then at the ESA level. André Kuipers was one of the five Dutch national candidates proposed to ESA; in ESA's subsequent selection he ended up on the reserve list, because – owing to the cancellation of the Hermes programme – the Agency had to reduce the number of astronauts to be selected from the original 12 down to six.

However, André got another chance, when the European Astronaut Corps was established in 1998. He was selected in the second round, together with Belgian astronaut Frank De Winne.

Unfortunately, as time went on, few flight opportunities came along because of the slowdown in Shuttle flights and the delay in launching Columbus. ESA decided to propose at the Ministerial Council in Edinburgh in 2001 an Additional Flight Opportunities programme involving launches with Russia's Soyuz. However, the programme did not receive the required funding support from several of the larger member states, which had their own national Soyuz launches lined up. At around the same time, ESA and the member states were discussing a new Astronaut Policy document, which was to set the principal guidelines for the European Astronaut Corps. I had the pleasure of serving as chairman of that committee. One of the major items of debate was the issue of how to conduct national missions, and in particular the division of roles of ESA and national organisations. This document was eventually approved by the ESA Council in June 2002.

Despite the tight schedule, André performed an impressive series of experiments.

Dutch National Decision-Making

Following the Edinburgh decision not to fund the Additional Flight Opportunities programme, plans were made to gain approval for a Dutch national mission with André Kuipers. The first steps were taken in December 2001, and in the following months the arguments were put on the table and a network was set up to enable such a mission. The prime arguments were:

- the importance of the medical-scientific and industrial-technological experiments;
- the experience to be gained by Dutch institutions and industry in innovative research and implementing such a mission;
- the interest to be generated among young people for science and technology;
- the resulting national and international public focus on space and its benefits.

In close coordination with ESA, these arguments were put forward, and in November 2002, the Dutch ministers of Economic Affairs and of Education, Culture and Science decided on joint funding and implementation of the flight. An agreement was negotiated with ESA, and signed in July 2003 by ministers Laurens-Jan Brinkhorst and Maria van der Hoeven, and on the ESA side by Jörg Feustel-Büechl, Director of Manned Spaceflight and Microgravity.

Lunching with Station residents Alexander Kaleri (left) and Michael Foale.

Preparations and Implementation

Although some work had been under way before the Dutch national decision of November 2002 , time was still short, in particular to prepare the experiments. Still, an impressive package of research was put together in close cooperation between ESA and the Netherlands (see the following articles).

During the first half of 2003, an unparalleled number of activities had to be undertaken, involving the principle investigators, Dutch industry led by Dutch Space of Leiden (which set up the Dutch Soyuz Mission Project Office) and a team of coordinators led by Dutch Mission Manager Dr. Ruud Roos. Together with an ESA team led by Mission Manager Aldo Petrivelli, they ensured that the experiments achieved their milestones and were ready for the flight.

The launch of the unmanned Progress ferry on 29 January 2004, which delivered the large majority of the experiments to the Station, was a major achievement for the team. As the launch date for the Soyuz launch itself approached, publicity in the Netherlands heightened, reaching a peak in the early hours of Monday, 19 April 2004, when dozens of media organisations descended on ESTEC and the adjoining Noordwijk Space Expo for the live coverage of the launch in Baikonur.

In Baikonur itself, a delegation of some 20 VIPs, two dozen friends and relatives of André, and dozens of reporters, witnessed the suiting ceremonies, visited the launch pad and then moved to the viewing stand to see André and his Russian and US colleagues Gennadi Padalka and Michael Fincke reach for the sky. ■

Delta: Crew Report

11 days in Space

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Delta was packed with demanding but enjoyable activities for André Kuipers...

Preparation

Most of my work in the Gagarin training centre in Star City centred on the Soyuz spacecraft and the Russian part of the ISS. Lessons on the systems were followed by flight-oriented lessons. Practical sessions in the Soyuz simulator confronted us with all possible malfunctions and emergencies. Three months before the flight, my final crewmembers were confirmed as commander Gennadi Padalka and NASA flight engineer Mike Fincke.

To be able to return the Soyuz alone, I trained extensively on a computerised simulation and in the centrifuge. I practised taking laser distance and speed measurements in case we had to make a manual approach to the Station. Survival training, parabolic flights, language training and sports were all part of the training schedule. A session in Houston showed me how to operate the Microgravity Science Glovebox and to handle emergencies in the US part of the Station.

Although 80% of my training was to qualify as a flight engineer, 80% of my work during the flight was to perform experiments. Experiment training was done mostly in Russia, but the Heat and Arges experiments (see p13) required an MSG simulation in Houston.

The public attention in The Netherlands for the mission was enormous. There were PR activities almost every day, which demanded a substantial amount of my time, but was well worth it because it generated a very positive attitude towards spaceflight.

Physiology and biology measurements before the flight were to be compared with those taken during and after, so several sessions were held in Star City and Holland to collect baseline data. In fact, some tests were only ground-based.

Medical examinations became more frequent as the flight neared, with our crew surgeon making sure that all the procedures and data collections were safe and according to the rules.

After the final preparations and ceremonies in Star City, the prime and back-up crews travelled to Kazakhstan for the last week in quarantine. During the final days, we prepared documentation, selected personal items, performed physiological training, attended traditional activities, met our families and generally relaxed.

Launch and Docking

The launch on 19 April, with its peak 3 *g* acceleration, was smooth. It was just like training, but this time without any emergencies! Everything happened as it should. We were all impressed when the fairing was discarded and we could see our blue planet shining in the black Universe. After only 528 s Soyuz was travelling around the world at 28 000 km/h and a height of 220 km. We fired the thrusters to begin raising the orbit and start our 2-day journey to the Station at its 400 km altitude. We could then remove our suits, use the toilet and have something to eat. I began some biology and education experiments.

Approaching the Station, we donned our suits again because of the potential for collision. The computer used the radar to approach automatically from below as we closely monitored the screens in case we had to take over. But everything went smoothly and we docked automatically without problem.

Station Activities

Commander Michael Foale and Alexander Kaleri warmly welcomed us aboard the ISS, followed by a TV session with officials in mission control. After emergency briefings and transfer of my seatliner and suit to Soyuz TMA-3, we moved the scientific equipment from our Soyuz to several locations in the Station.

Floating was a pleasure, but working in weightlessness was sometimes troublesome. Finding equipment, setting up experiments, fixing every single item and watching out that nothing floats out of a box all costs much more time than on Earth. Most experiments were a one-man operation, although Gennadi helped when needed and my NASA colleagues helped with the MSG. Every day was fully packed, partly because we had several technical problems that required repeat runs, troubleshooting, consultation and relocating equipment. But I am delighted that in the end we managed to perform all the experiments.

Learning to live in weightlessness takes some time. Physical adaptation, washing with wet towels, procedures for using the toilet, sleeping without feeling a bed, and orientation are all different and do not come without effort. The meals were social events, with a choice between tasty Russian and American food, cans or aluminium bags that could be heated, or freeze-dried food and drinks.

The crew interaction in the Station was very good, and communication with the many ground stations, including EAC and ESTEC, went well. There were radio-amateur contacts and phonecalls with ESA colleagues, family and friends. Every morning brought a press conference. A big event was the live start and finish of the Seeds in Space experiment with many schools.

Return

The last day was busy – all experiments had to be closed down and data carriers given to Soyuz commander Kaleri, who carefully stowed them in the capsule. Several experiments had to be closed down or even performed at the last moment because of temperature sensitivity of the samples.

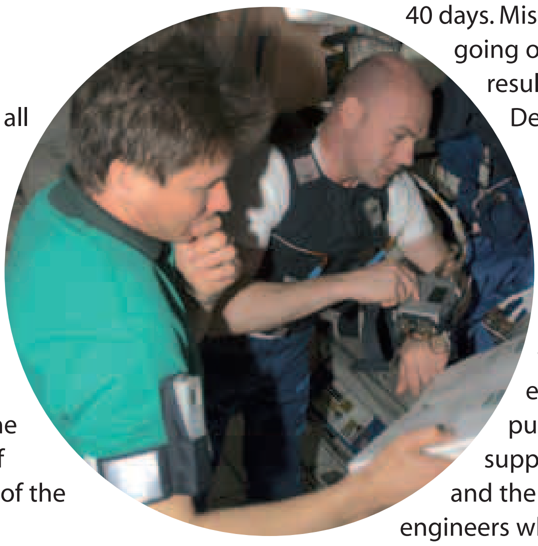
Working with Arges in the Microgravity Science Glovebox.

The main engine ignited as planned and soon the blackness of space turned to orange and the *g*-forces climbed to 4 *g* as sparks flew by. In the denser layers of the atmosphere, the sound of rushing air was very strong, until the parachutes opened and shook us violently for 20 s. We eventually hit the steppe, cushioned by retrorockets firing at a height of only 1.5 m. I was the first to enter TMA-3 at Baikonur as back-up to Pedro Duque for the Cervantes mission, and now I was the last to leave it. It was a good ship.

We were all in good condition. We were carried to a medical tent, where our examinations included testing for orthostatic intolerance (p11). Meanwhile, ESA personnel secured the critical biological samples in cool boxes.

We were flown in helicopters to the airport and, after the official Kazakh welcome, a plane returned us to Star City for 2 weeks of recovery and debriefings. But the work was not over – my baseline data collection went on for 40 days. Mission debriefings are still going on and the first scientific results will be presented in December.

The Delta mission, my first spaceflight, was a great success thanks to the many dedicated people who worked hard on it. And I am delighted that it had such a positive effect on the general public, who provide the support for space exploration and the future scientists and engineers who make it happen. ■



Adjusting the SUIT experiment with Gennadi's help.

Delta: Mission Report

Facing The Challenge

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The combined success rate of all experiments was 85%.

The Challenge

At the time of the first preparation meeting in December 2002, it was evident that the Delta mission presented challenges. The many experiments were still in the early stages of preparation, and the overall schedule was extremely tight for a flight expected in October 2003. This was another sponsored mission, in this case by the Dutch government, with Sponsor's and ESA's ambitious expectations and different objectives requiring harmonisation. The *Columbia* disaster on 1 February 2003 delayed Delta by 6 months and added the Increment crew rotation to the mission objectives, exchanging the new Expedition-9 for the returning Expedition-8. Though Delta was contractually conceived for a visiting taxi crew to swap the Soyuz spacecraft, that goal was realised as part of a much more constraining crew swap.

Planning and managing the Delta mission was a major challenge ...

Organisation

A major discussion at the beginning was how the Mission Team would be structured. The final organisation had mission integration and operations being carried out by the ESA Team, and the preparation of experiments and their interfaces to the Mission Team by the National Organisation. This had a Dutch Mission Manager, two Dutch Science Coordinators (one each for life and physical sciences) and the Dutch Project Office industrial team to support the payload developers directly. This Dutch organisation worked closely with the ESA Mission Team. During realtime operations, both teams worked in a joint control room in the Erasmus building at ESTEC, together providing mission coordination and science support.

There was also the Steering Committee, consisting of ESA and the National Organisation, to control the mission's overall development. It included high-level management and representatives of the Mission Team, including the ESA Mission Manager, Dutch Mission Manager Crew Office representative and Mission Scientist.

The Soyuz approaches for docking.

Delta Experiments

In addition to creating the organisation to implement the mission, it was also necessary to reduce the large number of experiments initially proposed to a level that could be conducted effectively during the mission. This was not an easy task because we had to satisfy the demanding and different requirements of the various disciplines: human physiology, physical science, technology, education, commercial and

Performing the SUIT experiment.

public relations. Some experiments were eliminated, but other activities were added later on, mainly for education and PR. André Kuipers commented on his return that he found it difficult to cope with the high workload, despite the fact that the experimental programme had been very carefully planned and timelined. The previous taxi flights had increased expectation of what could be achieved during these short missions. Odissea had 21 flight activities and three on the ground; Cervantes included 21 flight and two ground, plus the delivery of hardware spares. Delta aimed at 28 investigations: four were conducted by the resident Station crew before and after the Soyuz flight, three were performed by them during the Soyuz visit, and one was ground-based. André himself was directly involved as a subject in a number of physiology experiments.

Meeting the Challenge

Preparing for the mission was like combining a number of different projects on a single road leading to the flight. Each project has its own organisation and team that, most of the time, wants to deliver its own items to Soyuz and have direct and exclusive control over this process. In practice, of course, this is not feasible. In reality, a project must deliver to a professional team that integrates and runs the experiment efficiently and effectively. This is the mission integration and operations team that is taking shape within ESA, developing infrastructures, organisation, experience and a strong team spirit, thanks to the opportunities offered by the Soyuz missions.

One of the key milestones along the Delta highway was the final work carried out at the Baikonur launch site. During this critical phase, there is a heavy reliance on expert engineers to complete the work perfectly. There is definitely no room for tourism here, or immediately after landing. Final preparation of the biology experiments, in particular, overcame the sometimes severe limitations of the local facilities.

Delta was the first mission to activate experiments during the 2-day Soyuz flight to the Station; several biology experiments ran in the two Kubik incubators. Although the Kubiks performed well during this part of the mission, they later sufferred several difficulties during Station operations. A centrifuge failure in one resulted in a lengthy period of frustrating ground-based troubleshooting. And then one biology experiment was 'lost' during storage after the flight. Despite these problems, the combined success rate for all of the experiments flown was 85% (including the successful conclusion of the Expedition-9 experiments after André's departure).

The Soyuz docked to the nadir port of the Zarya module.

The Future

The lessons learned from the Soyuz missions tend to focus on what went wrong and what can be improved, so we sometimes take for granted what went right. The Soyuz missions have allowed ESA to push the envelope and to optimise the science return from such brief flights; Delta showed us the limits of what can be achieved. It is already significant that ESA's integration and operations team now expects a high rate of success for each mission. The Soyuz taxi flights are a unique opportunity for ESA to acquire operational experience rapidly and to develop expertise for future operations aboard the Columbus laboratory. The lessons learned from Delta, coupled with those from the other four taxi flights (Andromede, Marco Polo, Odissea and Cervantes), provide a solid foundation for building future ESA manned spaceflight operations. ■

Delta: Science Report

Preliminary Science Results from the Delta Mission

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Analysis of the results from Delta's experiments is producing a wealth of information ...

Introduction

The Delta mission is now some 7 months behind us, so it is perhaps time to have a first look at the scientific results. It can take up to a year until the first results are submitted to scientific journals, but direct contact with the scientists means that some preliminary conclusions can be presented here.

In general, Delta's science experiments covered three main disciplines: biology, human physiology and physics. In addition, Delta also hosted a large number of successful technology and educational experiments (it is hoped these will be covered in the future).

Biology

Five of the six biological experiments used the new Kubik incubator, designed specifically to culture and process biological cells within the tight constraints of a Soyuz mission. Although Kubik is compact and relatively light, it nevertheless offers the full range of biological research, with a 1 *g* reference centrifuge and late access.

Unfortunately, there were several technical problems with Kubik's experiments. The investigation is still under way and it is too early to draw conclusions. It is clear that various factors contributed to the problems, including restricted access to cooling air.

As a result, only ICE-first and Sample were completed without problems. The others returned only samples of inferior quality and are regarded as totally lost.

ICE-first

ICE-first studied the nematode *Ceanorhabditis elegans*. The handy thing about this worm is that its entire genome is known through genetic sequencing. This makes it very amenable for an in-depth study of the influence of weightlessness and the space environment, and makes it possible to extrapolate the results to other living organisms, including humans. In particular, ICE-first looked into the effects of radiation, muscle atrophy and muscle development, ageing, genomics, gravity sensing and apoptosis (programmed cell-death).

All the samples were successfully processed during flight and were returned to the international team (France, US, Japan and Canada) for analysis. Since this involves rather complicated techniques, no concrete results are yet available.

Flow

Flow studied bone demineralisation in weightlessness (akin to osteoporosis) in osteocyte bone cells. In particular, it tested whether early onset of bone demineralisation can be detected by specific markers such as nitrous oxide gas production. Unfortunately, Flow was not properly activated and no results were obtained. Nevertheless, ground experiments have since demonstrated that sharp peaks of NO production can indeed be observed under specific circumstances. The possibility of reflying Flow is therefore under serious study by ESA.

Tubul

Tubul looked at the influence of gravity on cell shape, elongation and division and, in particular, on the spatial organisation of microtubules, which form the backbone of plant cells. Tragically, Tubul was completed on the Station and good results would have been

Working with a Kubik incubator.

obtained but for the inadvertent post-flight freezing of the cells. This made them unusable for the advanced analysis required for this type of research. However, visual inspection and counting of the harvested cells show that the cells grew as expected, which implies that the microtubule system was functional under weightlessness. The experiment can be repeated without modification so an early reflight is being sought.

Actin

The experiment aimed at a more fundamental understanding of the way gravity interacts with mammalian cells. In that sense, it is a counterpart to Tubul. Actin is the major constituent of the cytoskeleton, which performs roughly the same functions in mammalian cells as microtubules in plants. It provides structure and a pathway for transporting signals from the cellular membrane to the nucleus, where it initiates the expression of its genes in response to the stimulus provided. The theory is that gravity is important in determining the 3-D structure of this cytoskeleton, so cellular responses to stimuli under weightlessness may be different.

Many experiments are necessary to prove this, and 'Actin' looked in particular into the synthesis and decomposition of the cytoskeleton. Unfortunately, it was not activated in flight. It will refly on the Maser-10 sounding rocket in March 2005.

Kappa

A major challenge in medicine is the increase in autoimmune diseases such as allergies, inflammatory bowel disease, asthmatic disease and rheumatoid arthritis. Current immunosuppressive treatments are only able to deal partially with these diseases. Weightlessness is known to induce immunosuppression, but the underlying mechanism is unknown. The aim of Kappa was to identify this mechanism in the hope of finding novel avenues for inducing immunosuppression in patients.

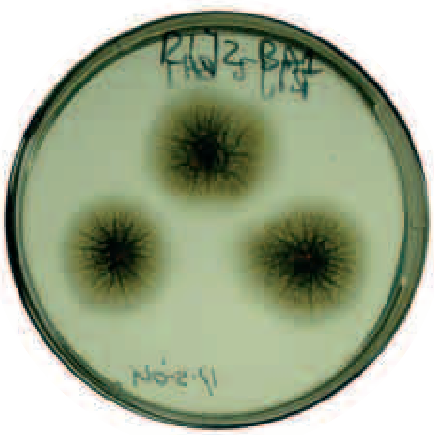
Unfortunately, Kubik's problems meant that the experiment was not carried out. Reflight is planned on Maser-10.

Sample

Sample dealt with the detection and identification of microorganisms aboard the ISS. In particular, it studied the composition, physiology and possible adaptation of microbial communities in weightlessness.

The first aim was to evaluate which microbial species could undesirably develop under the growth conditions of life support systems in manned spaceflights. The astronaut took 104 samples from 35 different specific sites in the ISS and his own body. The swabs are being screened for microbes through culturing on growth media and molecular analysis of the microbe DNA. The preliminary results show that bacteria, fungi or yeasts were cultured from 14 of the sites. DNA has been isolated in the swabs and is being checked for potentially pathogenic microbes.

Sample's second aim was to investigate how microbial species adapt to weightlessness, focusing on the adhesive abilities of the model bacterium *Escherichia coli*. The bacteria were transported to space in a special container, allowing them to grow under microgravity. Preliminary results indicate no significant change in adhesion ability after growth in space, although an increase was hypothesised.



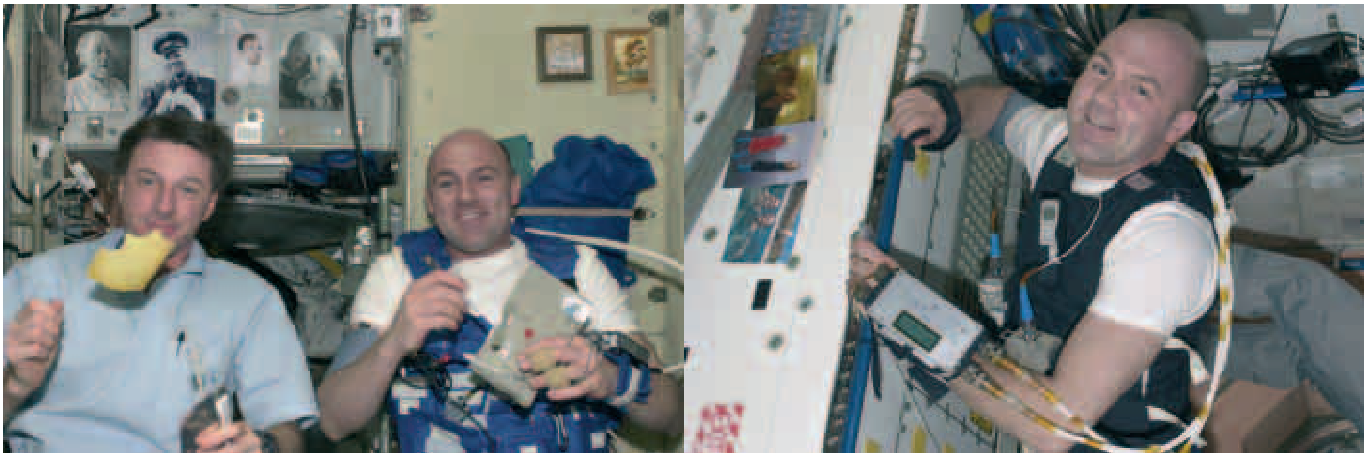
Fungi cultured from samples obtained in space for the 'Sample' experiment.

Physiology

In total, five experiments were carried out in human physiology. Of all space experiments, these most obviously require astronauts. As the Delta experiments clearly demonstrate, they are highly relevant for medical research on Earth. They are a prime example of how research in space can benefit our lives on Earth.

Heart

Astronauts returning from space suffer from varying degrees of orthostatic intolerance – the inability to stand upright without dizziness or fainting. Although this adaptation to microgravity has been studied extensively, it is still not possible to predict fully or prevent its occurrence. In Heart, astronauts underwent a set of orthostatic challenges before and after flight. Tolerance post-flight is determined via a 10-minute standing test.



André and Mike Foale at lunch in ISS. André is wearing the Circa equipment for continuous blood pressure recording.

Of course, such studies produce meaningful results only with a sufficient number of test subjects; Delta means that data have now been compiled on five. They clearly suffer reduced tolerance after flight, shown by increased blood pressure variability during the standing test. The next step is to develop a model that can predict orthostatic intolerance for individuals through specific tests. This model will benefit long-term bed patients.

Circa

In healthy humans, blood pressure has a circadian rhythm; blood pressure at night is 10-20% lower than during the day. This 24-h variation is considered a sign of good health; there is increased morbidity when nightly decreases in blood pressure are abolished in hypertensive patients. Circa investigates whether this circadian rhythm alters in weightlessness.

Intermittent measurement of blood pressure was obtained round-the-clock before, during and after flight. André has produced the first pressure recordings at intervals over a 24 h period in space. The investigators were specifically interested in the transition from wake to sleep; this was successfully recorded. As in the other physiology experiments, more test subjects are needed before solid scientific conclusions can be drawn.

Muscle

Lower-back pain is one of the most common diseases on Earth, with 80% of people suffering from it at some stage. It is not, as generally believed, a problem of old age, but rather it affects people in the prime of life. Consequently, it is an important medical problem with obvious economic impact. It has been noted that astronauts suffer rather frequently from lower-back pain. The Muscle experiment asked the astronaut to fill in a questionnaire on occurrence, type and other aspects of lower-back pain. For this and other information, it was a significant advantage that André is himself a medical doctor.

The questionnaire answers support the biomechanical model developed by the scientific team. This includes the recorded complaints as well as the countermeasures practised by André. Of course, the results of a study with a single test subject should be interpreted with reserve, and should be consolidated with follow-on studies of astronauts staying aboard the ISS for several months. Future studies could have a large impact on flight countermeasures and the treatment of patients on Earth.

MOP (Motion Perception)

Astronauts have mentioned close similarities between the symptoms of space sickness (space adaptation syndrome, SAS) and the symptoms experienced after a 3 g centrifuge run (sickness induced by centrifugation, SIC). This suggests that transition from 3 g to 1 g provokes the same effects as from 1 g to 0 g, implying a general vestibular adaptation mechanism to changing g-levels. MOP aimed at gaining insight into the process of vestibular adaptation to g-transitions by investigating several vestibular parameters before and after a 1 h centrifuge run.

With Delta, ten astronauts have now been tested both in the centrifuge and in space for their susceptibility to SIC and SAS, respectively. A positive correlation was found: four astronauts were susceptible to both, and six were not. This supports the hypothesis that SIC and SAS share an underlying mechanism. The vestibular tests showed that postural stability decreased after the centrifuge run in one SIC-susceptible subject and was unaffected in the other non-susceptible subject.

OLP

This experiment provided insight into the equilibrium system under weightlessness by looking at a specific property of the visual system: the orientation of Listing's Plane (OLP). This plane is orthogonal to the two main eye-movement directions of up-down and left-right. The tilt of this plane is a measure of the correlation between head and eye movements, which in turn is determined by the equilibrium system, in particular the otholiths in the middle ear.

The Eye-Tracking Device, developed by DLR, was used for the first time in space during Delta. Measurements were taken before, during and after flight, showing a clear change in

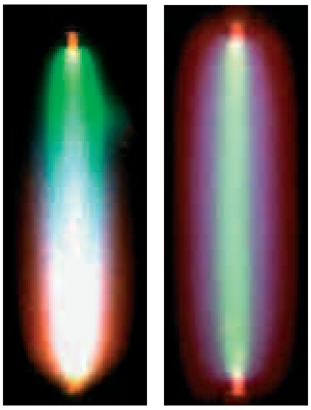
Listing's Plane under microgravity, slowly returning to normal in the days after landing. This indicates that, contrary to general opinion, the eye-movement system is influenced by changes in gravity conditions. The results support the concept that the otolith-mediated gravity signal acts as a central reference for sensorimotor and possibly other body systems.

Physics

Both of Delta's physical science experiments made use of the Microgravity Science Glovebox (MSG) as a versatile platform offering power, communication, cooling, video and containment. This and the experiments' semi-manual nature allowed the rapid development of specific hardware. Both projects addressed problems with a significant industrial interest; hardware and experiment preparation was partly funded by industry. This again demonstrates that the scientific research on the ISS has moved beyond the realm of purely fundamental issues and now encompasses applied and pre-competitive R&D topics.

Arges

Arges focused on high-density discharge (HID) lamps, which provide a very bright light for their size. This makes them popular for lighting roads, stadiums, factories and the like. New applications are being developed and a serious amount of research is under way to optimise their design. In



Axial demixing observed in Arges: (left) on the ground; (right) its absence in space.

André working on the Arges experiment in the Microgravity Science Glovebox.

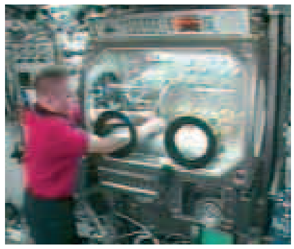
particular, two disturbing phenomena need further study: the demixing of the salt mixture that determines the output spectrum, and helical instabilities of the plasma in the electrical field. Both effects show a clear gravity-dependence. The spectrum of an HID lamp is different when operated in a horizontal or vertical position, whereas the demixing itself also influences the helical instabilities.

Arges consisted of 20 HID lamps mounted in a carousel and observed with a video camera (to study the helical instabilities) and a spectrometer (to observe the demixing effects). Each lamp had different electrode design and gas/salt composition. All the lamps were sequentially operated at different power levels. The design and selection of the lamp properties were first tested in a parabolic flight campaign, which proved extremely useful in determining the optimal configurations to observe the desired effects in weightlessness.

Arges was totally successful; all the planned measurements were made and the data delivered to the experimenters. Even during the experiment, the results were very surprising. Whereas the instabilities were expected to be shaped as a rotating helix, they appeared to be a singly bent stationary curve. Analysis indicates that the rotation is caused solely by convection and that the curvature comes from self-generated magnetic fields. For one condition, residual gravity caused a very slow rotation. As expected, the axial demixing did not occur during Delta, so the radial demixing can indeed be studied undisturbed. The analysis of the spectra is well underway.

In terms of economic benefits, the scientific team calculates that the improvement in lamp efficiency from this study is significant. For Holland alone, this translates to a reduction in energy consumption of some €30 million/year. This assumes the current volume of HID-lamp sales. With upgraded HID lamps, this figure will rise, coming to include household applications.

Heat



Mike Fincke is seen via video carrying out the Heat experiment in the Microgravity Science Glovebox.

The experiment tested the efficiency of grooved heat-pipes in various regimes of heat inputs. Heat-pipes are used rather extensively in space to transport heat from equipment to cooling systems. The principle resembles that of ordinary household refrigerators, and is based on evaporation, cooling and transport of a volatile liquid. However, unlike on Earth, the liquid is transported by capillary forces, allowing operation in weightless.

Unfortunately, the thermal coupling of the Heat equipment and MSG's cold plate was not optimal. Even a modest input power generated unexpected high temperatures and the equipment switched off automatically. The problem was pretty well analysed during Delta, but there was no time to correct it. However, Expedition-9's Mike Fincke modified it and ran it flawlessly on 5-6 September; the investigator declared that all runs were completed normally and all the expected data were received. ESA is grateful to Mike Fincke, who worked in his free time, and to the motivated and supportive NASA team. Analysis of the data is now under way. ■

'Jules Verne' Takes Shape

The First ATV Begins its Final Tests

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ESA's Automated Transfer Vehicle is on the home straight of its long journey to the ISS ...

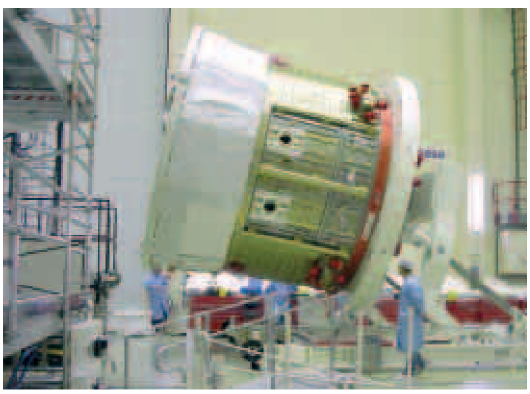
Introduction

After years of hard work and completion of the Critical Design Review in June 2003, the *Jules Verne* first flight model of the Automated Transfer Vehicle (ATV) has been at the ESTEC Test Centre in Noordwijk since July 2004. Following integration, it will undergo an extensive test campaign until June 2005. It will then be shipped to Kourou for a mid-October 2005 launch.

The *Jules Verne* Test Campaign

The main event after the arrival at ESTEC of *Jules Verne*'s two elements (Integrated Cargo Carrier and Spacecraft) was the integration and testing of the Russian Electronic Control System (RECS), which was delivered at the end of July 2004. RECS will control the Russian docking and refuelling systems that were installed in the Cargo Carrier by Alenia in Torino (I) in July/August 2003 before the ICC was transferred to EADS Space Transportation in Bremen (D).

In addition, the Russian Kurs transponder was integrated in early September 2004. The radar-based Kurs will communicate with its active counterpart on the Station's Zvezda module for independent monitoring of ATV's approach from 4 km to about 100 m (see *On Station* 11, December 2002, pp17-19).



The Jules Verne spacecraft at ESTEC ready for mating with the cargo carrier.

The basic integration work, including retrofitting some equipment because of last-minute design modifications and/or component alerts, was completed by the first mating of the Cargo Carrier and the Spacecraft in mid-October.

Jules Verne will then undergo a sequence of environmental and functional tests, such as:

- electromagnetic compatibility tests in October 2004;
- System Validation Tests in conjunction with the ATV Control Centre (Toulouse, F) and NASA's Tracking & Data Relay Satellite (TDRS) at the end of November 2004 and in May 2005;
- acoustic tests in January 2005;
- thermal-vacuum tests in March-April 2005;
- guidance & navigation closed-loop tests in April-May 2005.

The goal is to have all ESTEC activities completed during the first half of June 2005.

ATV Flight Segment Qualification

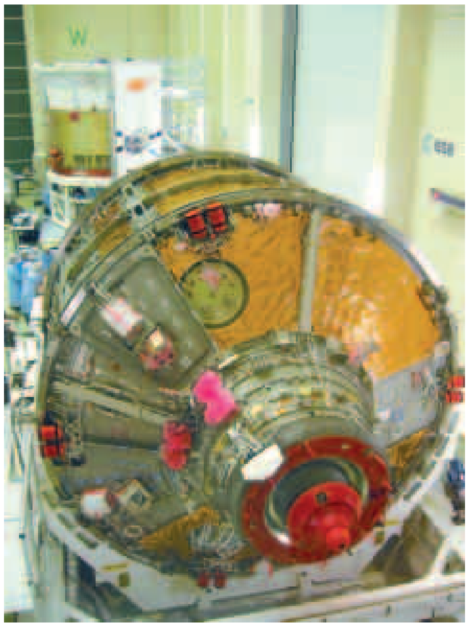
Qualification of ATV's mechanical and thermal control systems were achieved through:

- the Structural Thermal Model test campaign in 2001-2002;
- the ICC dynamic tests in 2003;
- static tests on the Spacecraft and ICC structures, completed in 2004;
- mathematical modelling and analyses.

ATV's job includes boosting the Station's decaying orbit.

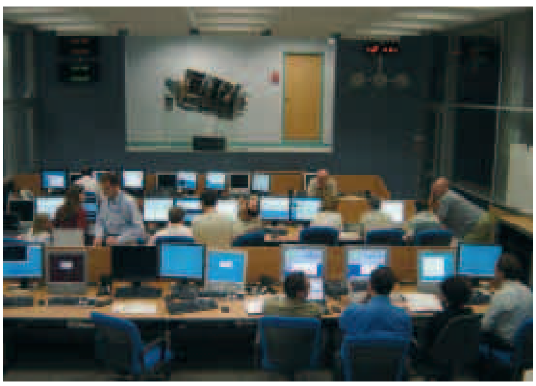
Ground Segment and Operations

Development of the ground segment is the responsibility of CNES in Toulouse, while preparation for ATV operations is managed by an ESA team in Toulouse. The Control Centre infrastructure is complete and all operations products are almost ready. So far, several System Validation Tests (SVTs) have checked communications between *Jules Verne* sitting in ESTEC and the ATV Control Centre via TDRS, Artemis and the ground network controlled by the Columbus Control Centre at DLR Oberpfaffenhoffen (D).



The Integrated Cargo Carrier of Jules Verne at ESTEC. The red covers protect the Russian docking system.

But the most difficult part is still to come: qualification of the whole system, which requires the Functional Simulation Facility (FSF) in Les Mureaux during the first half of 2005. FSF fully simulates the ATV and its environment using numerical models and hardware in the loop. The driving factor is the availability of the ATV Flight Application Software (FAS), fully proved on the Software Validation Facilities. The first FAS version with all the software elements (FAS V2.2.1) became available in August 2004. FAS V2.2.2, incorporating late changes and bug corrections, will be delivered in January 2005 to be used for ATV's formal qualification process. Qualification will be concluded by the System Qualification Review Board in May 2005.



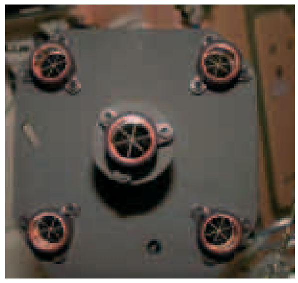
ATV Control Centre control room during an SVT test.

ISS Russian Segment Upgrade

In order to be ready for *Jules Verne*'s arrival at the Station, several hardware and software upgrades have been made or planned as part of the Integration Contract with Russia. New optical targets were installed by EVA in July on the rear of Zvezda to support final ATV approach. The Crew Control Panel for ATV was delivered by an unmanned Progress cargo ferry in August, along with an upgraded SIMVOL TV monitor and a modernised GPS receiver. Antennas for proximity communications with ATV were installed before launch. Still to be launched and mounted on Zvezda are:

- the Proximity Communication Equipment is currently under acceptance and compatibility testing in Moscow;
- a new camera, CCD-based. Its reduced sensitivity to the Sun in its field of view will increase the range of ATV docking opportunities.

In addition, a new version of Zvezda's software (v7.03), to support ATV operations such as refuelling and reboost, through Zvezda's computers will be uploaded before the end of this year.



New laser reflectors were added to Zvezda in August.

The Next Step

Following completion of the above activities and acceptance of all the mission elements (flight segment, ground segment, operations products and cargo), ATV *Jules Verne* will finally go through the 'Certificate of Flight Readiness' process before launch and docking with the International Space Station in October 2005. ■

ATV Ahoy!

Crew Training for the First ATV

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Introduction

The Astronaut Training Division at the European Astronaut Centre (EAC) is now training the first ISS crew that will work with ESA's Automated Transfer Vehicle (ATV). ISS Expedition-12 will be launched in October 2005 aboard Soyuz-TMA 11S for a 6-month stay on the ISS. In addition, negotiations are under way with Roskosmos and NASA to launch Thomas Reiter (backup: Léopold Eyharts) in December 2005 on the Shuttle for a 3-month stay on the ISS. During their mission, the first ATV, *Jules Verne*, will dock with the Station. The prime (Bill McArthur & Valeri Tokarev) and backup (Jeff Williams & Alexander Lazutkin) Expedition-12 crews will each receive 2 weeks of ATV training at EAC during March-May 2005. The ATV training dates for Reiter & Eyharts have still to be decided.

The first ISS crew to train at EAC is learning how to handle the maiden ATV ...

Last summer, the Astronaut Training Division finalised the ATV courses and lessons, the ATV facilities and the certification process for its ATV instructors. ATV crew training focuses on four main aspects:

– ATV Core Block (5 hours). Introduction to ATV and its mission. Overview of ATV systems, focusing on safety and main crew operations;

Simvol Display produced by the ATV Crew Trainer of the approaching ATV. The display includes an overlay of data needed for crew monitoring during approach and docking.

– Rendezvous & Docking and Undocking & Departure (31 hours). Introduction to the crew monitoring concept, monitoring items and criteria, crew commands, familiarisation with the crew man-machine interface, control panels and displays. Hands-on training includes a wide variety of ATV or ISS malfunctions that affect the rendezvous & docking or undocking & departure;

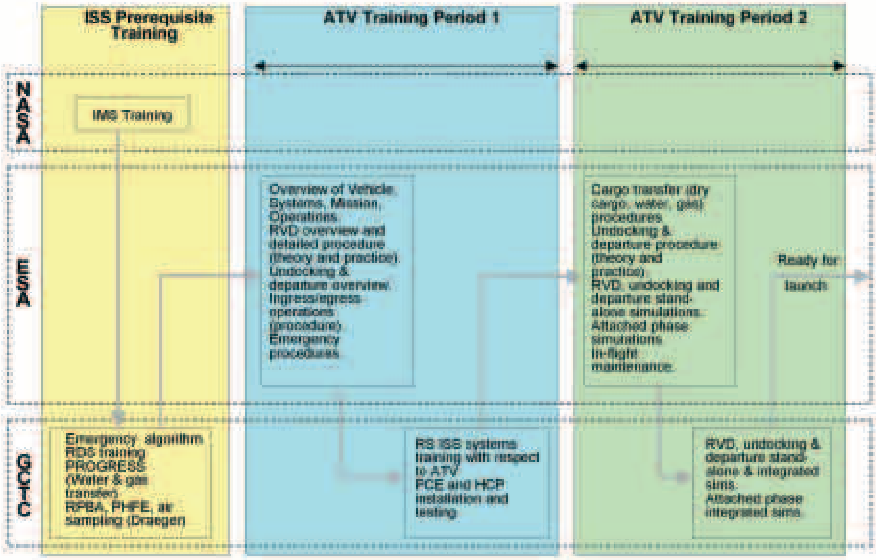
– ATV Attached Phase Operations (15 hours). Focuses on principal functions when ATV is attached to the ISS, including cargo and stowage management, transferring dry cargo, water and gas, loading waste into ATV; inflight maintenance tasks and ATV system monitoring during attached operations;

– ATV-specific Emergency Training (1 hour). Training for ATV-specific tasks and procedures in case of emergencies such as fire or depressurisation during docked operations. This will be repeated in an integrated simulation with the Russian onboard system during 'complex training' in the Gagarin Cosmonaut Training Centre (GCTC) at Star City near Moscow.

ATV Onboard Training

It is important for the crew to refresh their skills aboard the Station. A simulator for ATV rendezvous and departure training is being developed for the crew to work with. In addition, they will be able to use a computer-based training program for attached phase tasks to refresh their knowledge before starting with the real operations. Shortly before ATV's launch, the crew will be briefed on the latest flight timeline, the vehicle's trajectory and the final demonstration and test programme. This briefing will be supported by computer-based briefing material uplinked in advance. The overall onboard ATV training programme has

ESA astronaut Jean-Francois Clervoy works on the ATV rendezvous & docking training with an ESA instructor in the Zvezda Mock-Up in EAC.



The ATV crew training flow for the various international training sites for the Expedition-12 crew.
HCP: Hardware Control Panel
IMS: Inventory Management System
RDS: Russian Docking System
PCE: Proximity Communication Equipment
PHFE: Pressure High Flow Equipment
RPBA: Russian Portable Breathing Apparatus
RVD: Rendezvous & Docking

been agreed by the Onboard Training Working Group, a subgroup of the International Training Control Board.

ATV Training Team

The ATV training team consists of EAC training engineers and an instructor team under an EADS prime contract that involves SAS and Alenia. In the past 2 years, the team has readied and constantly updated a total of 50 ATV crew training hours.

Three Training Dry Runs involving Russian, American and ESA crew and training experts from all ISS Partners were performed at EAC between July 2003 and April 2004 to prepare for the arrival of Expedition-12 in March 2005. Some ATV courses, requiring special Russian hardware, and some proficiency training hours, will be provided by our Russian counterparts (GCTC, RSC Energia). The first of two Training Dry Runs was made in Russia at the end of May 2004. During all these Dry Runs, the training products, the facilities and the ATV instructors were evaluated and the ISS Partners testified that they were ready for training the first crew.

ATV Training Facilities

Two main ATV training facilities at EAC are being used during the first expedition crew training: the ATV/Service Module Mock-Up (AMU/SMMU) and the ATV Crew Trainer (ACT-Lite).

The AMU/SMMU is a 1:1 mechanical replica of the Russian Zvezda Service Module (SM) with the attached ATV integrated cargo carrier – ATV's pressurised part. It allows the crew to train on integrated SM and ATV operations tasks like cargo, gas and water transfer, stowage and inventory management and emergency responses. It is also used to train for exchanging ATV equipment in case of inflight maintenance.

The ACT-L is a high-fidelity simulator of ATV behaviour during rendezvous & docking and undocking & departure. It simulates the video image of the approaching ATV and all the alphanumeric displays monitored by the crew either as data overlays on the video picture itself or on a separate ATV display on the SM laptop. The whole training set-up of the Russian SIMVOL display, the ATV control panel and the SM laptop is identical to the flight system. The training instructors can insert a wide variety of malfunctions and disturbances that force crew reaction. All the commands from the instructors and crew are recorded in a report file for detailed evaluation afterwards.

International Training Coordination

In discussion with the NASA-chaired Expedition Training Requirements Integration Panel, the ATV training content and flow is harmonised with the training programmes of the other ISS Partners, and the ATV crew training time budget is agreed. The detailed planning for Expedition-12 training was prepared in close coordination with NASA's International Training Integrators. This includes sequencing the training between NASA, GCTC/RSCE and EAC, taking into account prerequisite training provided by other Partners, down to the detail of crew travel planning.

Developing the training programme for an entirely new space vehicle was a challenging task, mastered in close cooperation between the training team, the ATV operations team and our Russian counterparts. ■

The ATV Training Team with ESA, NASA and Russian crew and training experts during a training dry run at EAC in April 2004.

Window on the Universe

The Challenges of Cupola Manufacturing, Assembly & Verification

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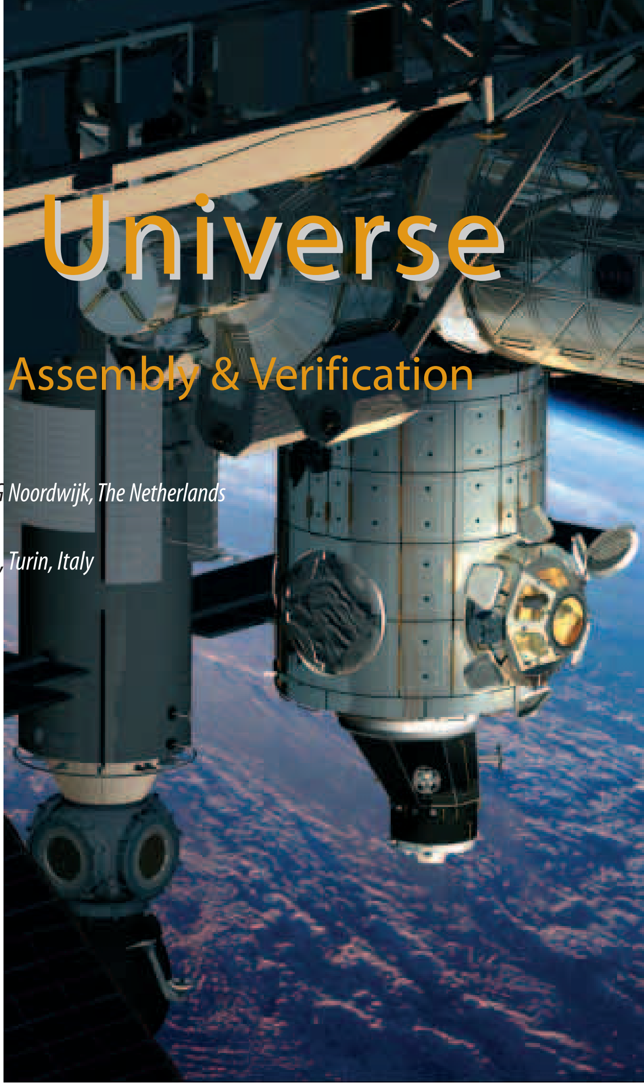


The Cupola will face forward from Node-3. (ESA/D. Ducros)

Introduction

Initially being developed by Boeing as part of the US segment of the Space Station, the Cupola was cancelled by NASA in 1993 to save money. NASA and ESA in 1997 began discussing a barter, in which ESA would deliver the Cupola in exchange for the Shuttle launch and return of five external payloads and 70 kg of Columbus internal payloads. The signature of the agreement in October 1998 brought the Cupola back into the ISS.

Another ESA contributions to the International Space Station is delivered to the launch site ...

Following the €20 million contract award in December 1998, Alenia improved and matured the Boeing design and then built and verified the Structural Test Article and the flight unit.

Although the Cupola is a small element and appears to be rather simple, its development, construction and verification presented a number of unprecedented challenges.

Cupola Description

The Cupola will be installed on Node-3's radial forward port to provide external views for controlling the robotic operations of the Space Station Remote Manipulator System (SSRMS), and monitoring crew spacewalks and the berthings of Japan's cargo carrier, the H2A Transfer Vehicle. In addition, it will allow scientific observations of the Earth and celestial bodies ... and offer a prime location for the crew to relax. Its role in maintaining the psychological health of astronauts on long mission is priceless.

The Cupola is a truncated hexagonal pyramid – the closest shape to a spherical dome given the technical constraint of flat window panes. The one circular and six trapezoidal windows offer a full hemispherical view on the Station, Earth and Universe. At 80 cm diameter, the circular window will be the largest ever flown in space. The window design is highly sophisticated, incorporating two glass pressure panes to maintain the cabin pressure and resist the internal pressure load. The top window is 3.18 cm thick. Normally, only the inner pane takes the pressure load, with the outer pane redundant. A glass scratch pane protects the inner pressure pane from damage by crew activities, while a glass debris pane protects the outer pressure pane from EVA activities and micrometeoroid and orbital debris impacts.

When not in use, the Cupola windows are further protected from meteoroids and orbital debris by external shutters, manually operated from inside the Cupola.

Internally, the Cupola provides all the mechanical, electrical, video and audio interfaces for the Robotic Work Station and Audio Terminal Unit that controls the SSRMS arm and communications with the rest of the Station, the ground, the Shuttle and spacewalkers. It provides a shirtsleeve environment for up to two astronauts, using water cooling and air circulation from the Node.

tolerance to defects such as scratches and imperfections is difficult. The analysis itself was the responsibility of NASA because all the glass was US-supplied, as per the barter agreement, but the final inspection of the surfaces to characterise all existing defects and ensure they do not exceed the maximum size assumed in NASA's analytical prediction was the responsibility of Alenia. The difficulty was that there is no sophisticated instrument to detect or measure the defects. Each square cm of the surface had to be visually inspected to map the defects, together with their type, length and depth. This was a long and tedious exercise given the 15 m^2 involved. Special lighting was used to reveal to the naked eye surface defects as shallow as 0.015 mm – and to be certain that none was missed.

Nor was cleaning the glass a trivial task. The scientific experiments impose severe optical requirements on the eight surfaces of each window assembly. This was particularly important for those surfaces that became inaccessible after assembly. Dust is difficult to identify and remove under normal light; wiping with a clean cloth was unsatisfactory because dust is electrostatically attracted by the glass and redeposited near the wiped area. Ensuring the required cleanliness in all lighting conditions took a range of inspection techniques, including UV light, and multiple cleaning methods involving, for example, silk brushes

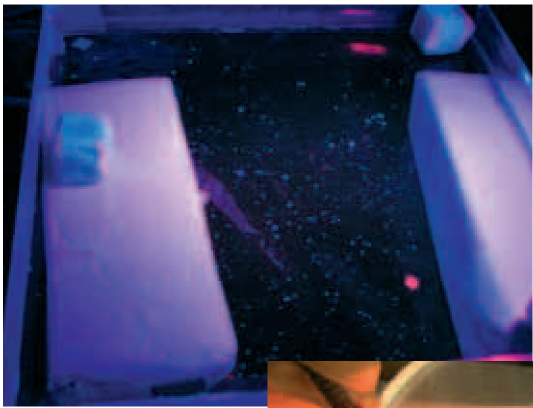
Highlights of Construction and Verification

At first glance, the Cupola is much smaller and simpler than the sophisticated Columbus, Node-2 and MPLM modules already built by Alenia. But the windows are unique to the Cupola and *they* provided the main challenges.

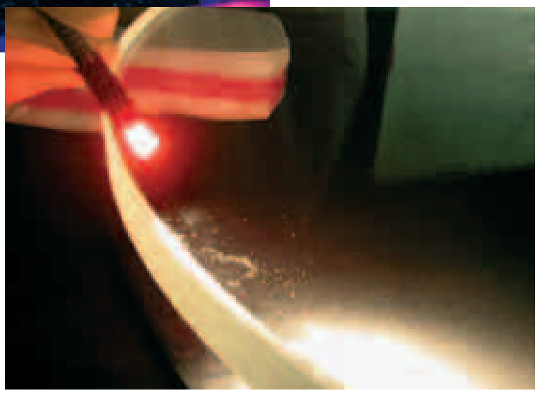
Manufacturing the dome part of the primary structure was the first challenge. In order to minimise the stress in the window glass by deformation of the primary structure under internal pressure loads, the aluminium dome had to be up to 50 mm thick. Unlike the original Boeing design, which used several aluminium forgings welded together, Alenia opted for a single forging because welds are always troublesome, especially on such thick aluminium. Indeed, the distortion of welded parts under stress is much more difficult to control and can lead to leaking windows. However, the single-piece approach is also difficult owing to the size and shape of the forging. With the help of VSG (D) and Ratier (F), Alenia produced a dome of outstanding quality.

Window construction began with a highly detailed inspection of the glass to ensure its structural integrity for the Cupola's lifetime. Glass is a brittle material and assessing its

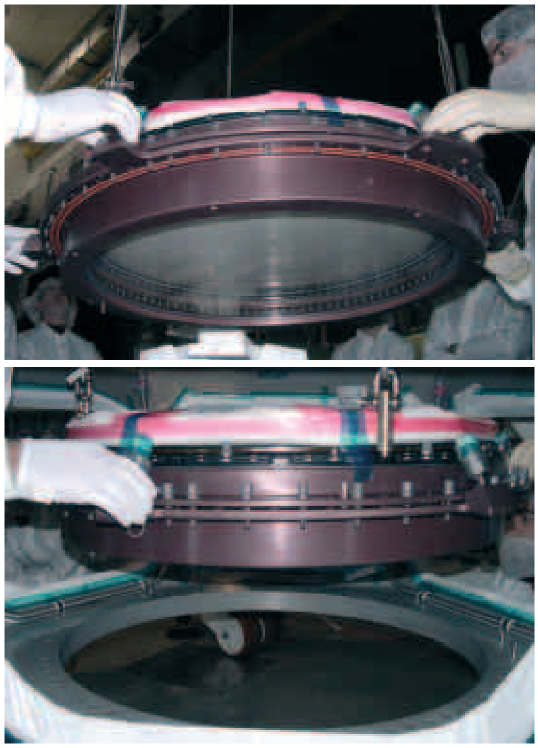
The forging for the dome structure, and after machining.



Checking glass cleanliness under UV light.



Inspecting the glass for the circular window.



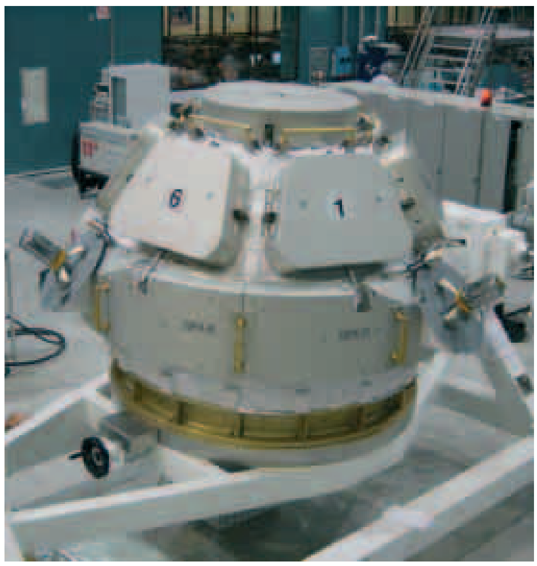
Ready to install the top window assembly, weighing more than 100 kg.

and air guns. All these inspections and cleaning techniques were combined in a precise order within the window assembly procedure to achieve an optimum level of cleanliness for the whole window unit.

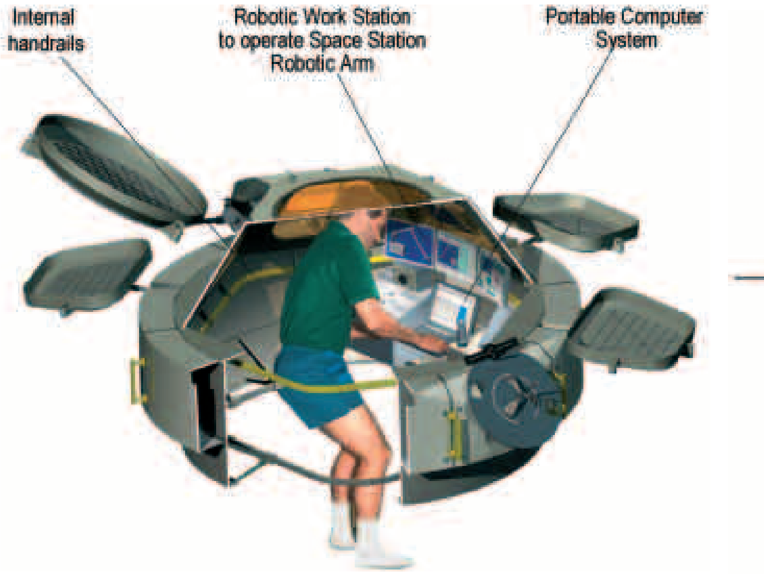
Once assembled, the windows were integrated on the Cupola. The weight of a window (more than 100 kg for the top unit) and the awkward access required special tools to be developed. In the event, the installation went very smoothly and with minimal risk to the hardware.

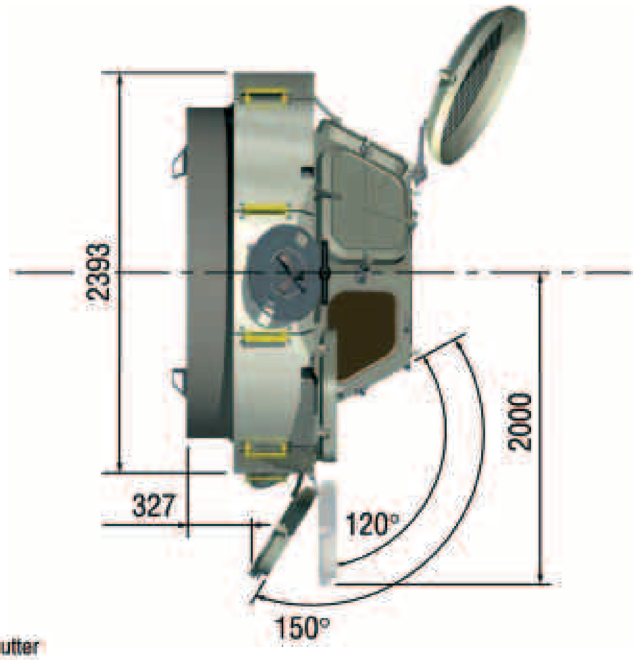
The final challenge was verifying the Cupola's airtightness. Leak tests of the seals were performed directly after the addition of each window. It was time-consuming because each window has 11 seals in order to meet the specifications for seal redundancy and on-orbit maintenance. Each seal was leak-tested separately and compared with its allocated budget. This was the moment of truth: a bad design or poor workmanship would have jeopardised the whole project. The Cupola's stringent leak limit is 3.6 g of air per day, so

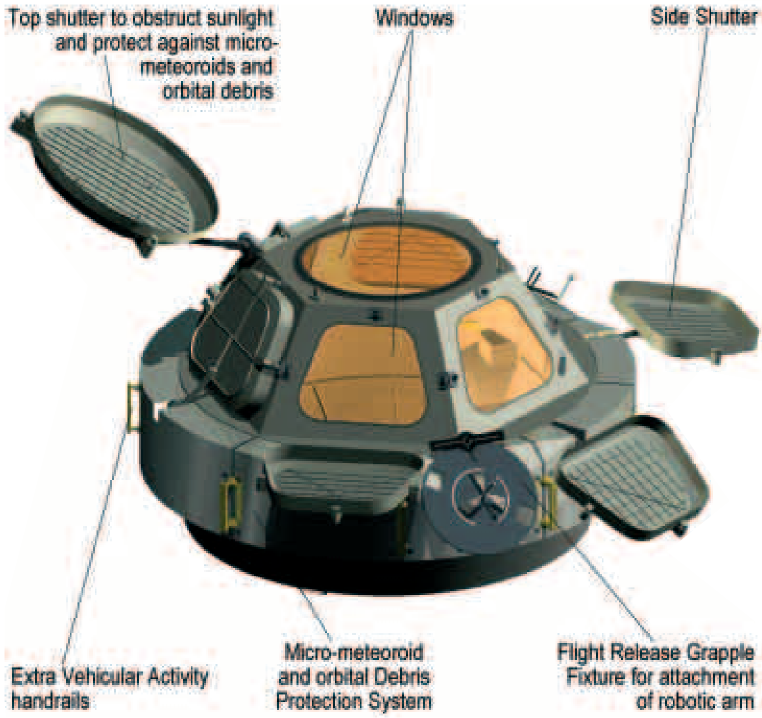
Testing the pressure integrity of the whole Cupola.

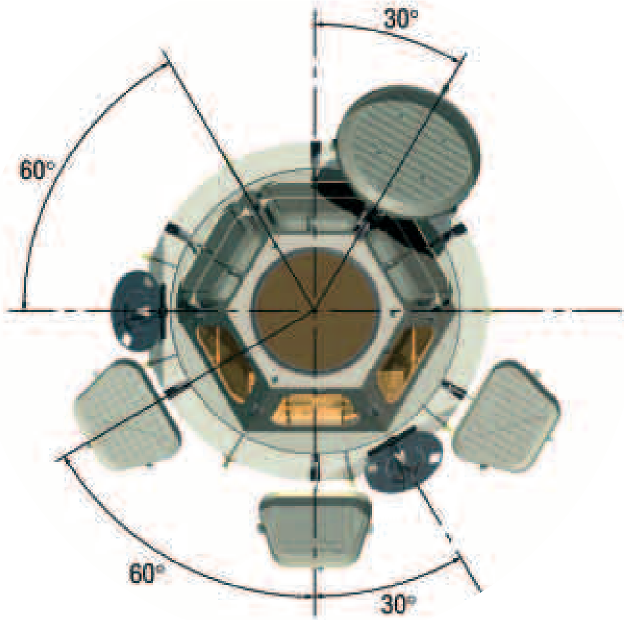


Cupola ready for delivery.







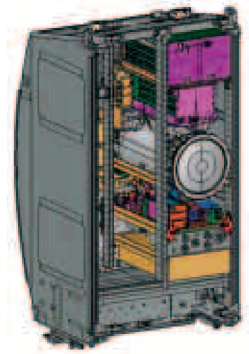


each seal was checked using the most accurate measurement technique available. One side of the seal was bathed with 100% helium at normal pressure, while vacuum pulled on the other side as a mass spectrometer sniffed for leaking helium. The excellent results provided confidence that Cupola is airtight: a test of the whole module showed that the overall leakage is only 10% of the allowable amount.

The Future of Cupola

Cupola arrived at the Kennedy Space Center (KSC) in early October and now, in November, is undergoing the last of its bilateral reviews. Ownership will then be formally transferred to NASA. By the end of the year, Cupola will be returned to its transport container and stored in a KSC warehouse. It will be retrieved in mid-2008 for final pre-launch verification and installed on a Spacelab pallet in the Space Shuttle cargo bay. The latest Station assembly sequence foresees launch in early 2009, assuming a successful Shuttle return to flight in March 2005. Once in orbit, the 1805 kg Cupola will be installed on Node-3's forward port; outfitting will increase its mass to 1880 kg. From there, we are confident that it will fulfil its role for at least its design lifetime of 10 years. ■

Material Progress



ESA's Materials Science Facilities on the ISS

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Introduction

ESA is running two main programmes within its Microgravity Facilities for Columbus Programme for materials science research onboard the International Space Station (ISS):

– the Materials Science Laboratory (MSL-USLab), being developed cooperatively with NASA for the US First Materials Science Research Rack (MSRR-1) in NASA's Destiny module in 2006;

– the MSL-Electro-Magnetic Levitator (MSL-EML), being developed with DLR for installation in Columbus in about 2008.

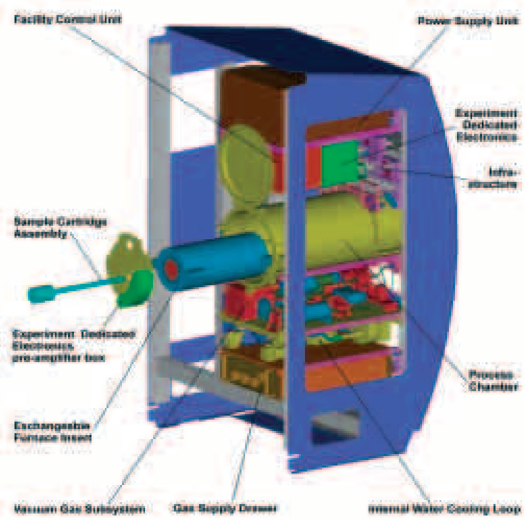
Two ESA facilities will allow fundamental research in materials science aboard the ISS ...

The industrial Prime Contractor for both facilities is EADS-ST, leading two different industrial consortia.

MSL-USLab

This facility supports research into metallurgical solidification, semiconductor crystal growth and measurement of thermophysical properties of materials. Based around exchangeable Furnace Inserts (FIs), it is a versatile, multi-user and multi-purpose facility. Its main element is the Core Facility (CF), a vacuum-tight cylindrical process chamber that houses one FI at a time. The material samples are contained in Sample Cartridge Assemblies (SCAs) inserted in their respective FIs one at a time for processing.

MSL-USLab in MSRR-1: exploded view with Furnace Insert and Sample Cartridge Assembly.



The CF provides an accurately controlled processing environment under vacuum or argon gas, continuous measurement of microgravity levels during processing, and features a high-precision drive mechanism to translate the FI along the SCA, while the latter remains fixed with respect to the vacuum chamber. Besides a low-speed translation ranging from 1 mm per day to 0.2 mm/s, MSL allows fast displacement of the FI for rapid sample cooling (quenching).

An FI has up to eight heaters generating a temperature profile controlled by a dedicated software algorithm, thermal insulation, a water-cooled jacket and a coil system, generating a rotating magnetic field for stirring the liquid material, if required. Two FIs are being developed by ESA: the Low Gradient Furnace (LGF) and the Solidification and Quenching Furnace (SQF). The evolving requirements by the materials scientists can be supported by future *ad hoc* FIs.

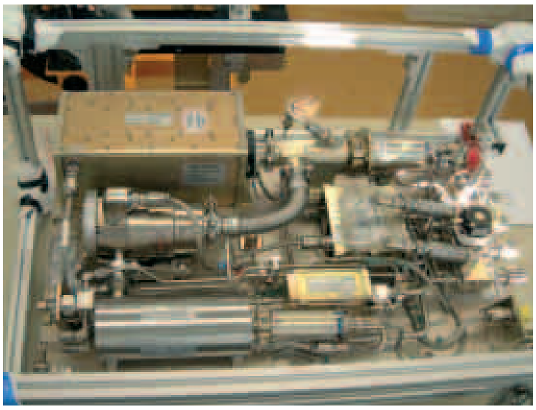
An SCA has a leak-tight tube to contain the sample enclosed in its own crucible, a sensor for process control and safety, and transducers/probes for specific diagnostics.

Experiment samples may include toxic compounds, so a sophisticated safety concept is required: the free volume within the SCA is filled with krypton gas and potential leaks are detected by a mass spectrometer. In addition, the design ensures three levels of containment during processing: SCA hermetic sealing, vacuum chamber hermetic sealing, and vacuum chamber-to-station ambient negative pressure differential.

The other elements of the MSL-USLab provide the resources for operating the facility:

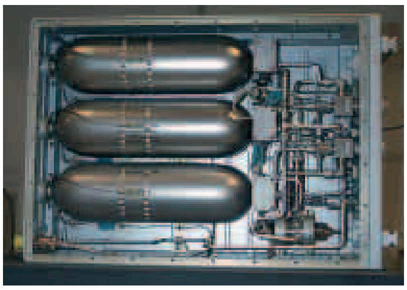
– the Power Supply Unit (PSU) converts, controls and distributes electrical power from the MSRR-1

to, *inter alia*, the FI heaters, the FI coil system, quench drive, and generates up to 100 A current pulses for monitoring of the sample growth;
- the Facility Control Unit (FCU) controls the operation of the facility, performs data acquisition, communication to and from MSRR-1, and converts and distributes power to, for example, the water pump and mass spectrometer;
- the Vacuum Gas System (VGS), includes the mass spectrometer and two turbo-molecular pumps, and provides filling and evacuation of the process chamber and cartridge leak detection;
- the Water Pump Package (WPP), provides circulation of the cooling water;
- argon gas is stored in three bottles in the exchangeable Gas Supply (GS) drawer;
- the Rack Infrastructureto slide in and out the PSU, FCU, CF, VGS/WPP and GS; the heat exchangers, and the vacuum, fluid and electrical power lines to interconnect the PSU, FCU, CF, VGS/WPP and GS through self-mating connectors and self-mating/self-sealing Quick Disconnects.

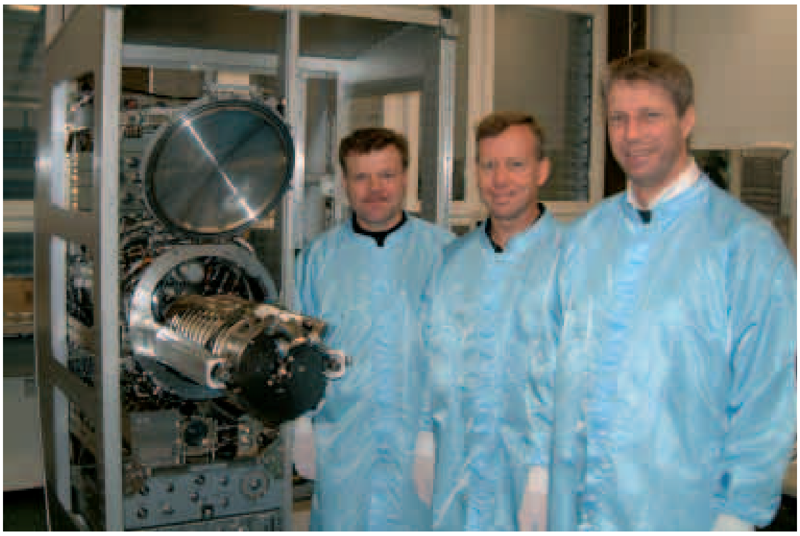


MSL-USLab Vacuum Gas System Flight Model, in its transportation frame.

As standard diagnostics, the MSL-USLab provides monitoring of the experiment sample thermal profile, differential thermal analysis, Peltier pulse marking and shear cell operation. Experiment-dedicated diagnostics can be exchanged on-orbit. Two such diagnostics will be initially available: the Ultra-Sound Diagnostics, being developed within the User Support Programme (USP), and the Seebeck



MSL-USLab Gas Supply drawer Flight Model (bottom view, cover plate off).



MSL-USLab Engineering Model (process chamber lid open, LGF held by the furnace exchange tool) in the EADS-ST laboratory rack during the ESA Crew Review conducted by ESA Astronauts R. Ewald (left) and T. Reiter (right) and NASA's Astronaut S. Lindsey (centre) in December 2001.

and Resistance Measurement Device, developed by CNES under an ESA contract.

Low Gradient Furnace (LGF)

This FI is a Bridgman-Stockbarger furnace, designed mainly for growing semiconductor materials, which requires the generation of accurately controlled, low to medium temperature gradients between two very stable temperature plateaux. For this, an assembly of heaters provides two hot cavities separated by an adiabatic zone. The maximum temperature at the hot cavity heater diffuser is 1673K, the maximum achievable temperature gradient 40K/cm, the thermal stability ±0.02K for temperatures above 1073K.

Solidification and Quenching Furnace (SQF)

This FI is designed for metallurgical research under medium to steep temperature gradients with the option of quenching the solidification front at the end of processing. To meet these requirements, the SQF consists of a heated cavity, a water-cooled chill block and an adiabatic zone between, and the SCA may be equipped with a Liquid Metal Ring (LMR) to enhance the thermal coupling with the cooling zone. In order to freeze the growing interface, the MSL quench drive mechanism can position the furnace/LMR assembly on the solid/liquid interface within 1 s. The maximum temperature at the hot cavity heater diffuser is 1673K, the maximum achievable temperature gradient in the range of 150K/cm, the thermal stability ±0.1K for temperatures above 773K.

High-Temperature Solidification Furnace

It is expected that a high-temperature FI will be developed to serve numerous research projects, including ESA's Intermetallic Materials Processing in Relation to Earth and Space Solidification (IMPRESS), which will be led by ESA and co-funded by the European Commission.

MSL-USLab Sample Cartridge Assembly within its container for ground transportation.

MSL-USLab Status

In December 2003, NASA's Marshall Space Flight Center (responsible for MSRR-1) and ESA (supported by EADS-ST) held a successful Pre-Ship Meeting for the Engineering Models (EM) of the facility and the LGF. The two EMs were then shipped to MSFC, where, further to the flawless post-ship checkouts, preparations for their integration and testing within the MSRR-1 Ground Unit have been started. Activities in Europe are focusing on the Flight Model and the Training Model. Their acceptance by ESA is planned for the beginning of 2005 and the end of 2004, respectively. MSRR-1 launch is projected for mid-2006.

The two Science Reference Models are supporting FI and SCA testing, and will eventually be handed over to the MSL-USLab Facility Responsible Centres (DLR/MUSC for LGF and CNES/CADMOS for SQF) to prepare for and conduct on-orbit utilisation.

MSL-USLab User Support Programme (USP)

The USP will provide the science community with the tools and hardware items required for defining in detail and implementing the individual experiments. It therefore comprises the development of:

- the Thermal Modelling Tool for the LGF, SQF and associated SCAs, which is required for experiment preparation and post-flight analysis;
- the first batch of Experiment SCAs for the research programmes, which were selected from the 2000 Announcement of Opportunity (CdTe Crystals, CETSOL1/2/3, METCOMP, MICAST, RDGS, SETA2, WIS);
- the Ultrasound Diagnostics.

The Materials Science Laboratory-Electromagnetic Levitator (MSL-EML)

This facility is the ISS successor to the TEMPUS (Tiegelfreies Elektromagnetisches Prozessieren Unter Schwerelosigkeit) facility, which successfully operated on the IML-2, MSL-1 and MSL-1R Spacelab missions under DLR contracts.

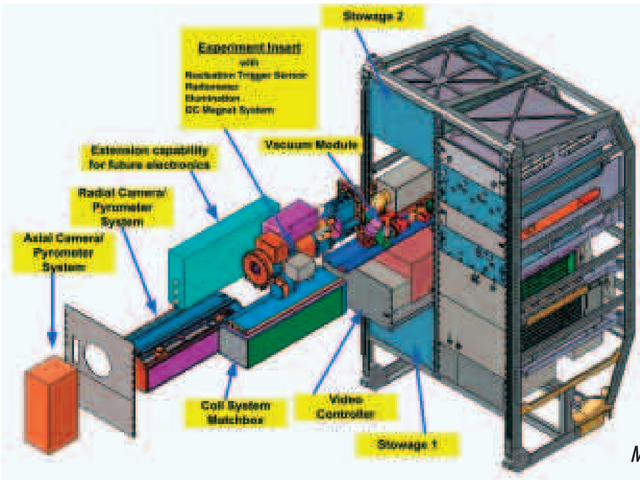
MSL-EML supports research into solidification of under-cooled melts and measurements of thermophysical properties of the molten phase of materials as a function of temperature, which are increasingly required for casting simulation software programmes by Industry. Thanks to this, MSL-EML will also play a significant role in IMPRESS.

The main feature of MSL-EML is that it enables *containerless* experiments on metals, metal alloys and semiconductors. The advantage is that the thermophysical properties (e.g. surface tension, viscosity, heat capacity, thermal expansion, electrical conductivity) of the molten phase of a material can be studied over a very wide temperature range. Especially for very high temperatures or reactive materials, containerless processing inherently excludes reactions with and contamination from the crucible materials, which are always a potential problem with conventional furnaces. Furthermore, all this allows the under-cooling effect to take place: the molten phase can stay liquid for some time even below the melting point. In containerless processing, solidification occurs accidentally or is triggered by touching the under-cooled sample with a needle (which acts as a nucleation site). The resulting solidification speed depends strongly on the degree of under-cooling. This phenomenon can be systematically studied over a wider speed range than with other techniques.

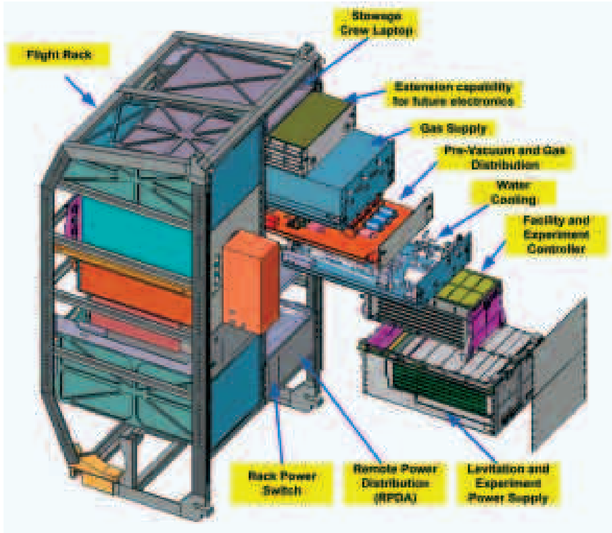
During an experiment, a spherical sample of 5-8 mm diameter is melted, superheated, stimulated while in the superheated and under-cooled melt phase and eventually solidified. Sample positioning and heating are performed by electromagnetic levitation: high alternating currents in a coil system generate magnetic fields that induce eddy currents in the sample that, in turn, heat the sample and generate forces on the sample by interaction with the external magnetic fields. A quadrupole field is used for positioning and a dipole field for efficient heating.

The processing temperature range is 500-2000ºC, and even higher. The processing environment is ultra-high vacuum or high-purity gas atmosphere. During processing, the experiment sample is observed by high-resolution and fast-response pyrometers and by video cameras (either precision or fast).

Based on exchangeable Experiment Modules (EMs), MSL-EML is a versatile, multi-user and multi-purpose facility. Nearly all elements will be extractable with self-mounting interfaces in the back of each. MSL-EML's design is based on an extensive conceptual reuse of the MSL-USLab design for the various support subsystems; this will allow a significant cost reduction.



MSL-EML exploded view.



The experiments are performed in the experiment insert that consists of the vacuum chamber, storage chamber for 15 samples, levitation coil system and motorised vacuum valve that connects the experiment insert to the vacuum and gas supply systems. View ports in the experiment insert allow the observation of sample processing by video and contact-less temperature measurement (pyrometry). The experiment insert can be customised with additional diagnostics like special pyrometers, nucleation trigger sensor and magnetic damping fields.

The other elements provide the resources for operating the facility and executing the experiments:

- the vacuum module contains a turbo-molecular pump, vacuum diagnostics and gas inlet functions;
- the axial and radial camera/pyrometer systems provide video observation and temperature measurement. These elements are optimised for high-precision and high-speed measurements;
- the coil system matchbox allows the adaptation of new developments of the coil system to the levitation power supply module;
- the video controller receives the data from the digital video cameras, transmits them with high compression for downlink and stores them onboard with low compression on removable storage media;
- the facility and experiment controller controls the operation of the facility and of the experiment and operates all communication and commanding channels interfacing Columbus;
- the levitation and experiment power supply converts and distributes power to the levitation coil system and provides all required secondary power to the subsystems;
- the water-cooling unit provides a secondary cooling loop for thermal control of the coil system and all units consuming electrical power;
- the pre-vacuum and distribution module controls the connection of gas, vacuum and venting supply lines to the vacuum module.
- the gas supply unit contains three gas bottles. Stored gases will be argon, helium and a non-flammable mixture of helium and hydrogen;
- stowage compartments are incorporated for a second experiment insert, flight support equipment, an additional axial camera/pyrometer system, and the crew laptop.

MSL-EML Status

Post-Phase B activities to consolidate some aspects of the baseline design established during Phase B were completed within the first quarter of 2004. Within this period, ESA and DLR reached a cooperation agreement on continuation of the development through the funding of a Phase C0 that will be completed by the Preliminary Design Review. The agreement also includes joint EML precursor utilisation activities on parabolic flights and sounding rockets. The Phase C0 is planned to last from the end of 2004 to the end of 2005. MSL-EML launch is expected for mid-2008.

Challenges

The developments of the MSL-USLab and MSL-EML provided several important technical challenges. First of all, the demanding requirements set by the scientists in several cases translated into specific technological developments such as temperature sensors. Then there is the need for performing different types of material research within a single facility; this is achieved through the exchangeability of the FIs and diagnostics devices in the MSL-USLab and of the EM in the MSL-EML. The volume and mass constraints were particularly critical for the MSL-USLab because of its accommodation within MSRR-1: it has to fit within a half standard double-rack and have a mass below 350 kg. Both facilities have to run experiments automatically. With their expected 10-year lives, both facilities have to be modular to allow maintenance and upgrading, and to provide flexibility for evolving scientific research requirements. ■

ISS Education

Update on the ISS Education Fund and Products

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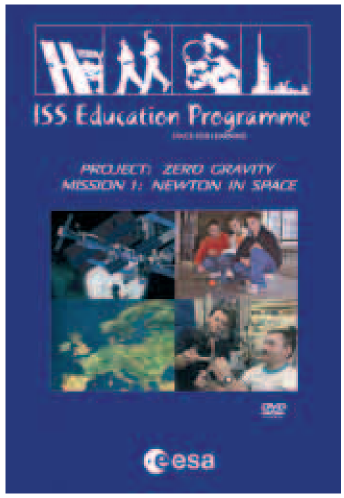

Introduction

The past few months have been a busy time for the ISS Education Fund, with new members joining, products supported by the Fund both under development and about to be launched, and the second annual meeting of the Fund Board. Events kicked off with a group of illustrious individuals joining the Fund: the entire European Astronaut Corps, supported by the Head of the European Astronaut Centre, each pledged their support to the Fund. At a ceremony held at EAC during their biannual meeting, the Astronaut Corps handed over their donation. Education is fundamental to the mandate of ESA and a value held close to the hearts and minds of all, including the astronauts.

The ISS Education Fund is supporting a wide range of products for schools ...

Other organisations across Europe have also realised the benefits of supporting ESA's aim of encouraging more young people to take an interest in science through the medium of space. From Northern Ireland came two organisations: Armagh Planetarium and Action Renewables. The Planetarium is world-renowned and acts as a focal point encouraging individuals, organisations and businesses to benefit from space and spin-off technologies. It is very active in education and has already been a key distributor of the ISS Education Kits into secondary schools. Action Renewables, based in Belfast, is working to raise awareness on climate changes and to promote renewable resources generally.

The German high-technology consulting company Eurospace – active in aerospace, transportation and telecommunications – joined the Fund. From Spain came Oasyssoft, creator of software solutions for the web with their eBD tool, which is fast becoming the market leader in Spain.

Many other organisations – from national space agencies to science centres and government organisations – have provided significant help in-kind to the Fund, promoting and distributing products in collaboration with ESA. Key among these is DLR, which has delivered an ISS Education Kit to each secondary school in Germany.

These organisations are not only helping to encourage interest in science, but are themselves enjoying a variety of benefits as members of the Fund, including marketing, PR and networking opportunities. The ISS Education Programme products are going, on request and through trusted intermediary organisations (often Ministries of Education or national organisations responsible for science education promotion) into no less than a quarter of all secondary schools and into every primary school in the 15 ESA member states, providing high levels of exposure and media awareness for supporting bodies.

DVD Launch

Helped by the money coming into the Fund from individuals and organisations, the ISS Education Programme is continuing the development and dissemination of education products. On 10 September 2004, alongside the second annual Fund Board meeting, the DVD Lesson *Newton in Space* was launched at ESTEC. Over 45 pupils and teachers from three schools in Germany, Ireland and Spain joined the ESA astronauts involved in the filming of the DVD, ISS Board members and key media for an exciting event. The DVD is the first in a series of three that aims to explain basic scientific concepts to pupils aged 12-18 years using demonstrations filmed in space and on Earth, illustrating the differences between the two environments. Ten thousand copies of this first DVD have been produced and will be

Andre Kuipers closing out the GraPhoBox experiment.

available to secondary schools throughout Europe, enough for almost a quarter of all schools in member states.

Space Team

On the same day, Fund individuals and organisations approved the activity plan for the ISS Education Programme. The launch of products supported by the Fund continues, with the next product – Space Team – being made available in its initial English language version later this year. Space Team is a series of online lessons, each using the theme of space, and is a resource for teachers of pupils aged 10-12 years. As each language version is launched, a national competition will be promoted to every single primary school in that country, encouraging pupils and teachers alike to use the lessons on Space Team and to enter the competition to win a live radio contact with the astronauts on board the Station. At the end of the Space Team project, in 4 year's time, almost 24 million primary school pupils will have been given the opportunity to take part. Versions will be made available in most ESA languages.

ISS Education Kit for Primary Schools

In early 2005, the new ISS Education Kit for primary schools will be launched. This is being created as a result of advice given to ESA by teachers at the Teach Space 2003 workshop. The didactical content of the Kit was assessed by another group of teachers at a workshop organised by ESA and held at the Glasgow Science Centre in July-August 2004. Eleven teachers from five ESA member states worked intensively to provide feedback and advice. The finished product will be made available to teachers in more than 41 000 primary schools (about a quarter of all schools) in all member states.

ISS Experiments

Student experiments are a key part of the activities aboard the ISS; two were carried out during the recent DELTA mission. The GraPhoBox experiment should discover if light influences the directional growth of plant roots and if gravity influences the directional growth of plant shoots. Both are exactly opposite to what has been investigated intensively in the past. The BugNRG (pronounced 'Bug Energy') experiment studied the effects of microgravity on the voltage and current of bacterial fuel cells, such as glucose.

Teachers testing the primary school kit.

The Work Continues

2005 will see work continue on educational products, and the launches of new ones. Work to translate, distribute and promote the ISS Education Kit for primary schools and each national version of Space Team will continue. The second DVD Lesson (*The Human Body in Space*) will be released, including footage filmed during DELTA and ground experiments in schools in Denmark, France, The Netherlands and Belgium. Again, 10 000 copies will be provided to teachers in secondary schools. The 3-D Educational Tool will go into development, and work will be underway on the multimedia version of the Education Kit for secondary schools. Finally, the SUCCESS 2004 competition is a contest for university students (up to Masters level) from all disciplines to propose experiments that could fly on the ISS. Registration opened in September 2004; further details can be found on the education website. ■

Keep an eye on our website ***www.esa.int/spaceflight/education*** for updates, product launch dates, national events and advance order forms. If you or your organisation would like to contribute to this effort and to enjoy the range of benefits associated with the ISS Education Fund, contact Fiona.Wilson@esa.int or take a look at our website ***www.esa.int/issef***

What is EAC?

The European Astronaut Centre

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The ESA Astronauts Corps, 2003.

Introduction

The European Astronaut Centre (EAC) is an establishment of ESA in Cologne, Germany. Its main responsibility is to prepare and carry out astronaut operations. Since its foundation in 1990 it has developed considerable expertise within ESA for human spaceflight activities by participating in a number of missions. This role will be significantly extended for the crew operations required for ESA's contributions to the International Space Station (ISS), such as the Columbus module, the ESA payloads and the Automated Transfer Vehicle (ATV).

EAC is responsible for training astronauts to operate ESA's contributions to the ISS ...

EAC is hosted on the premises of the German Aerospace Establishment (DLR) under an Agreement between the German Government and ESA. Following the Integration Agreement in 2000, ESA staff at EAC have been complemented by staff from DLR, CNES and ASI; there is now a team of 65, excluding the astronauts.

EAC's activities cover three main areas: managing the European Astronaut Corps, training ISS astronauts, and medical support. The nature of EAC as a remote centre also requires general, administrative and communication services and liaison functions with ESTEC, NASA and Star City in Russia.

The 1800 m^2 training hall hosts a variety of complex simulators, mockups and standalone training facilities representing all ESA contributions to the ISS.

The European Astronaut Corps

The EAC Astronauts Division (HME-AA), with Michel Tognini at the helm, is responsible for individual astronauts.

ESA member states participating in the ISS programme decided in 1998 to unite their respective astronaut teams with the existing ESA core team to form a single European Astronaut Corps. This integration process was completed in 2002 with 16 astronauts from Germany, France, Italy, Belgium, The Netherlands, Spain, Sweden and Switzerland. Now that some astronauts have left for management, public office or industry positions, the Corps currently consists of 13 astronauts. European experience in human spaceflight now covers 38 flights involving 31 astronauts over 26 years from the different national agencies and ESA.

Six of ESA's astronauts are stationed at different establishments in Europe. Four are at the NASA Johnson Space Center in Houston, where their qualification as Mission Specialists makes them eligible for Space Shuttle flights. Two are in ISS Increment Training. One is training at the Gagarin Cosmonaut Training Centre (GCTC) near Moscow, where the training for a mission usually starts about 10-15 months before a flight. ESA astronauts have achieved Russian qualifications as cosmonaut researchers and Soyuz flight engineers and return commanders.

The EAC Team.

The experience of ESA astronauts in space operations is valuable not only for their involvement in mission support, when they take charge of communications with space crews or prepare and coordinate onboard operations, but also when not assigned to a mission. Recent assignments to other ESA projects included providing feedback for developing and operating hardware and procedures, and participating in strategic development such as preparing the European Union White Paper, the Aurora programme and for Soyuz at Kourou.

The European Astronaut Corps is an ambassador for promoting the benefits of spaceflight. The astronauts communicate this message in countless public-relations activities and scientific lectures, sharing their unique experiences with audiences, helping to shape public opinion towards science in general and spaceflight in particular.

ESA Astronaut Training

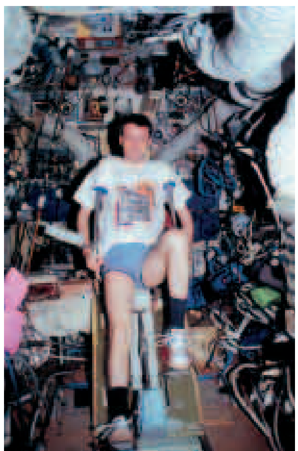
ESA's Astronaut Training Division (HME-AT), managed by Hans Bolender, focuses on ESA's participation in the ISS Programme. The training flow for long-duration flights to the Station consists of three phases: Basic, Advanced and Increment-Specific. Basic Training is provided independently by each international partner for its own astronauts. The other two phases are part of multilateral training, where classes of astronauts from all ISS Partner states travel to all five ISS training sites in USA, Russia, Canada, Japan and Europe. EAC handled its first international astronaut class in August-September 2002.

Each Partner trains all ISS astronauts on its own flight elements and payloads. Thus, ESA is responsible for training on the operation and maintenance of the Columbus systems, the crew interaction with ATV, and the operation and maintenance of all ESA payloads. This training takes place at EAC, where a variety of tools and facilities are available for training, practising nominal operations and learning to detect, analyse and recover from malfunctions and replacing failed onboard equipment.

The Columbus Trainer Europe (COL-TRE) is a simulator supporting hands-on training for commanding and monitoring all systems of the Columbus laboratory. The Columbus Mock-Up (COL-MU) has all the system components with mechanical crew interfaces that the crew is supposed to operate. This includes replacing hardware inflight.

Standalone training models of the four ESA research racks (Biolab, Fluid Science Laboratory, European Physiology Modules and European Drawer Rack) are installed at EAC in special rooms to allow parallel training.

The ATV Simulator provides the ATV and Station characteristics needed for the training on ATV approach, docking, undocking and departure, and on safety actions to command the ATV to hold or abort its approach to the Station and guide it back to a safe distance. In a docked configuration, the ATV and Service Module Mock-Up allow crew training for logistics or emergency activities involving the ATV cargo carrier (see the article on ATV training in this issue).



In-flight exercise: Thomas Reiter aboard Mir.

Astronauts of the 2002 Advanced Training Class performing Columbus System Training on the Data Management System in the Columbus Simulator at EAC in September 2002.

Léopold Eyharts training in Houston.

A team of 20 training instructors provides the ISS crew training for ESA. More than 400 h of crew training is needed to prepare the first ISS crews to activate, check out, operate, monitor and maintain the European ISS modules, vehicles and experiment facilities in space.

In 2004 the Training Division has conducted about 18 weeks of training for astronaut crews, programme managers and ESA and NASA flight controllers. The first ISS crew ATV training will begin in March 2005 for Expedition-12.

Medical Support

The ESA/EAC Medical Office (HME-AM), led by Volker Damann, is responsible for astronaut medical selection and annual medical recertification, as well as for providing astronauts with general medical care, medical intervention for diagnosis and treatment of illness and injury, and emergency medical services.

In order to minimise undesirable health consequences, a programme of comprehensive health care in all mission phases is provided. It includes fitness regimes, nutritional advice and psychosocial support to the crew. During the mission, this programme continues with specific fitness and countermeasure activities, and periodic health and fitness evaluations.

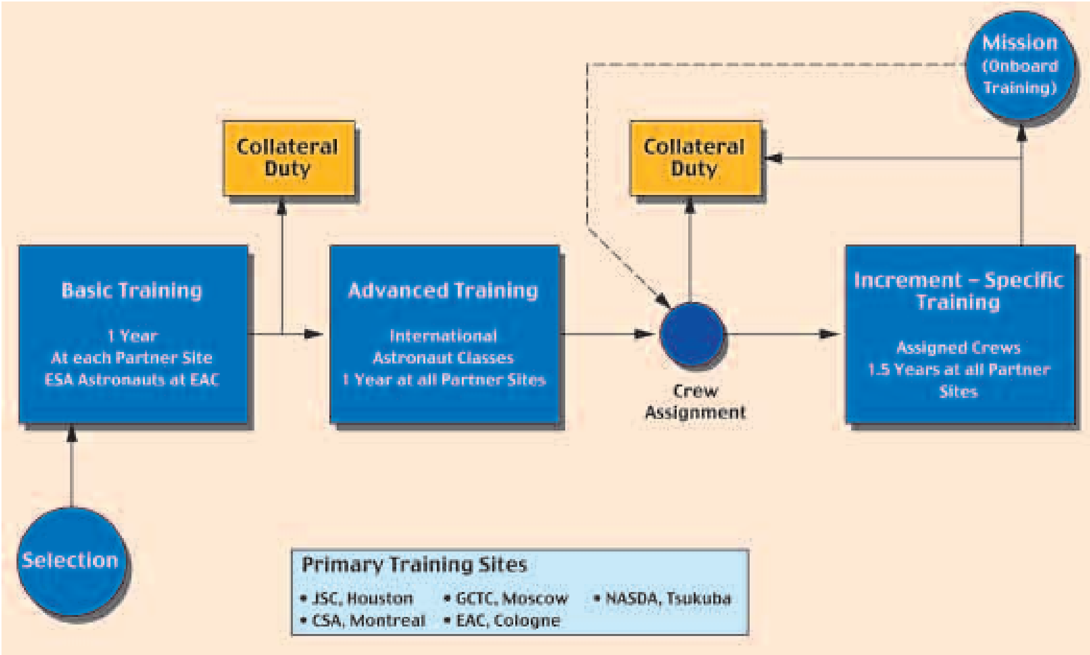
The ISS Medical Group, of which the Medical Office is part, considers an ISS crew as a single team and assigns crew surgeons out of the multinational pool of certified flight surgeons. This crew surgeon follows the crew to all training and mission preparation activities, and provides dedicated medical training to astronauts selected as the Station's onboard Crew Medical Officers.

The ESA Medical Office, which has already provided an Expedition Crew Surgeon to the ISS Medical Group, focuses on supporting real-time operations from the medical control room at EAC. The prime responsibility for the ISS crew lies with the Mission Control Center-Houston (MCC-H). This is where the Expedition Crew Surgeon and his team work primarily to support the missions. The concept is being used on the ESA-Soyuz missions, when ESA Medical Operations monitors in real-time the health status of the ESA crew and of the ISS systems throughout the mission from its consoles at EAC. During mission preparation and operations, a team of biomedical engineers supports the crew surgeons at the different sites.

Management, Public Relations and Liaison

A factor in establishing EAC in Cologne was the manned spaceflight expertise available within DLR. The isolation from other ESA centres, the growing importance of the site and the high visibility of its activities give EAC an important role in relations with Germany, other member states and other countries. The interaction with national authorities is often at high official level. In order to support ESA activities in Russia and the USA, EAC also maintains liaison personnel in Houston and GCTC.

The growth in EAC activities and, specifically,



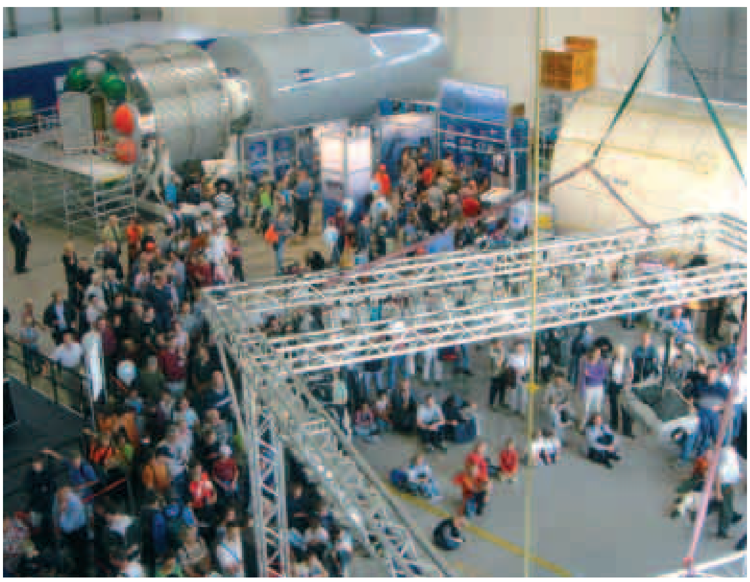
ISS training flow. Collateral duty refers to maintaining fitness and flying proficiency, etc.

the integration of the national astronauts and their national support teams, have necessitated the implementation of corporate administration and communication services driven by staff from ESA's Resources and External Relations Directorates. Together with the Management Support and Coordination Office, they offer EAC management and staff a full palette of services.

New Activities

Following Council decisions, as reflected in the European Astronaut Policy, EAC has begun new activities in health care and education. It is now the hub of the new ESA Health Care Network. Relying on the expertise of EAC, the ESA Technology Transfer Office, the ISS Utilisation and Promotion Division, and the Commercialisation Division, the Network aims to add value to the well-being and healthcare industries in the form of technologies, knowhow, access to research facilities and association of image. Products integrating ESA technologies and knowhow and developed with the support of the Network will be branded using the new ESA Space Solutions trademark.

The Space Learning Centre, to be developed by EAC in association with DLR, is an educational park centred on space and aeronautical activities. It will inform the general public on space activities and their benefit for humankind, provide education and training on aerospace subjects for students and teachers, and facilities for congresses. The running cost will be covered by the Centre's commercial income. A broad spectrum of visitors will enjoy state-of-the-art multimedia presentations, exhibitions, hands-on interactive learning and experiments. Although the intention is to attract people of all ages and background to visit the SLC, there will be a strong emphasis on pupils and students in order to get the 'next generation' involved in sciences in general and space sciences and aeronautics in particular. A goal is for the SLC to develop strong relationships with other European space-learning centres. ■



High public interest: the German Space Day in September 2004 attracted thousands of visitors.

On Station
ISSN 1562-8019

The Newsletter of ESA's Directorate of Human Spaceflight, Microgravity & Exploration

This newsletter is published by ESA Publications Division. It is free to all readers interested in ESA's manned spaceflight and microgravity activities. It can also be seen via the website at http://esapub.esrin.esa.it/

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Languages
- Danish
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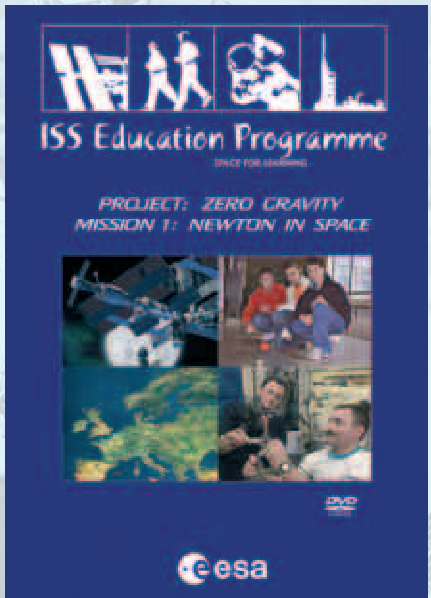
Project: Zero Gravity

Mission 1: Newton in Space International Space Station DVD Lesson available now!



To help capture the interest of youngsters in science, and to support teachers looking for ways to teach the basics of physics, a comprehensive ISS DVD Lesson (the first in the series 'Project: Zero Gravity') on Newton's three Laws of Motion has been created by ESA with the support and input from experts, teachers and their pupils across Europe. Aimed at pupils aged 12-18 years, it has been designed for the classroom and to encourage group exercises.

The DVD includes 11 European languages and comes in a handy DVD case that contains a Teacher's Guide with an explanation on how to use the DVD, a brief introduction to the ISS, interdisciplinary classroom activities related to European curricula, a glossary, further web and reading references, and an evaluation form. Chapters from the Teacher's Guide (classroom exercises, glossary, etc.) can be copied and distributed to pupils.

Secondary school teachers: get your FREE copy of the DVD by signing up at *http://esamultimedia.esa.int/docs/isskit/ISS-dvd-form.html*