EAC Trains its First International Astronaut Class

Hans Bolender, Loredana Bessone, Andreas Schoen & Hervé Stevenin
Astronaut Training Division,
European Astronaut Centre (EAC), Cologne, Germany

EAC's first international astronaut ISS advanced training class, photographed in front of the Columbus module. From left to right: S. Furukawa (NASDA), S. Wilson (NASA), P. Nespoli (ESA), T. Reiter (ESA), P. Duque (ESA), K. Wakata (NASDA), L. Eyharts (ESA), T. Doi (NASDA), N. Stott (NASA) and A. Hoshide (NASDA)

After several years of planning and preparation, ESA's ISS training programme has become operational. Between 26 August and 6 September, the European Astronaut Centre (EAC) near Cologne gave the first ESA advanced training course for an international ISS astronaut class. The ten astronauts who took part – two from NASA, four from Japan and four from ESA – had begun their advanced training programme back in 2001 with sessions at the Johnson Space Center (JSC) in Houston and at the Japanese Training Centre in Tsukuba.

During their stay in Cologne, the ten astronauts participated in a total of 33 classroom lessons and hands-on training sessions, which gave them a detailed overview of the systems and subsystems of the Columbus module, the Automated Transfer Vehicle (ATV), and the related crew operations tasks. They were also introduced to the four ESA experiment facilities to be operated inside the Columbus module. After their first week of training at EAC, the astronauts were given the opportunity to see the flight model of the Columbus module being integrated at the site of ESA's ISS prime contractor, Astrium in Bremen. The second week of training at EAC included hands-on instruction on the Columbus Data Management System (DMS) using the recently installed Columbus Crew Training Facility.

In preparation for the first advanced crew training session at EAC, two Training Readiness Reviews (TRR) were conducted there in June and August. These reviews were supported by training experts and astronauts from NASA, NASDA and CSA (Canada), who were introduced to ESA's advanced training concept and the development process, and then analysed and evaluated the training flow, content and instructional soundness of lessons and courses, as well as the fidelity of the training facilities and the skills of the ESA training instructors. The International Training Control Board (ITCB), made up of representatives from all of the ISS International Partners and mandated to control and coordinate all multilateral training for ISS crew and ground-support personnel, testified to ESA's readiness to provide Advanced Training by declaring the EAC TRR successful.

The completion of this first training course was therefore a good opportunity for the Astronaut Training Division to assess the status of its training programme. The comments and recommendations of the training experts and the astronauts who took part have been carefully evaluated and the results are being fed back into the on-going training development process.

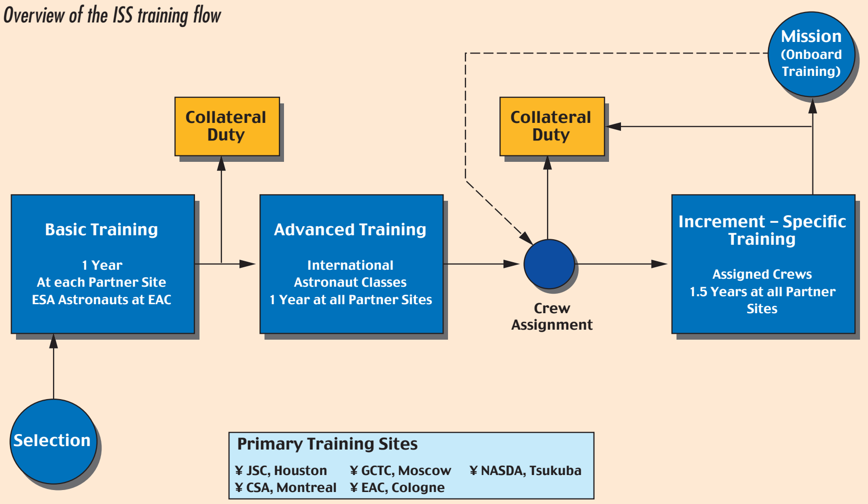
The ISS Training Flow

The multilaterally agreed ISS training approach consists of three consecutive phases: Basic Training, Advanced Training and Increment-Specific Training.

The Basic Training, which takes a year, is provided independently by each ISS International Partner for its own astronauts. The next two phases of training are designed for international astronaut classes and are implemented at all International Partner training sites. During these so-called 'multilateral training phases', each Partner is responsible for providing training to all ISS astronauts for those elements that it is contributing to the Space Station Programme.

ESA's main contributions to the ISS, for which EAC therefore provides crew training, are the Columbus module, including the four ESA payload racks (EDR: European Drawer Rack, FSL: Fluid Science Laboratory, EPM: European Physiology Module and Biolab: Biological Laboratory), and the Automated Transfer Vehicle (ATV).

Overview of the ISS training flow



Basic training

This first training phase for newly recruited astronauts focuses on providing the fundamental knowledge, attitudes and skills needed by a professional astronaut. It includes an introduction to space activities (organisations and current programmes), spaceflight fundamentals (e.g. engineering, and life and biomedical sciences) and space systems and operations (e.g. US Space Shuttle, Soyuz and ISS, incl. ESA contributions). It also fosters the development of the basic skills considered necessary for future astronauts, such as scuba-diving training in preparation for Extra Vehicular Activities (EVAs), media skills for pubic-relations purposes, and Russian language training.

Advanced training

This also lasts a year and provides a more in-depth understanding of ISS systems and subsystems, payloads and payload support systems, transport vehicles and related operations. It focuses on generic ISS onboard tasks and the interactions with the ground control centres, and thoroughly prepares crew members for their first flight assignment. As new elements, payloads and capabilities are added to the ISS, the content of the Advanced Training curriculum is augmented to reflect the current Station configuration. It is organised around generic crew jobs and thus includes some specialisation in terms of robotics skills, EVAs or other foreseen tasks. A crew member completing the Advanced Training is immediately eligible for assignment to a range of missions.

Increment-specific training

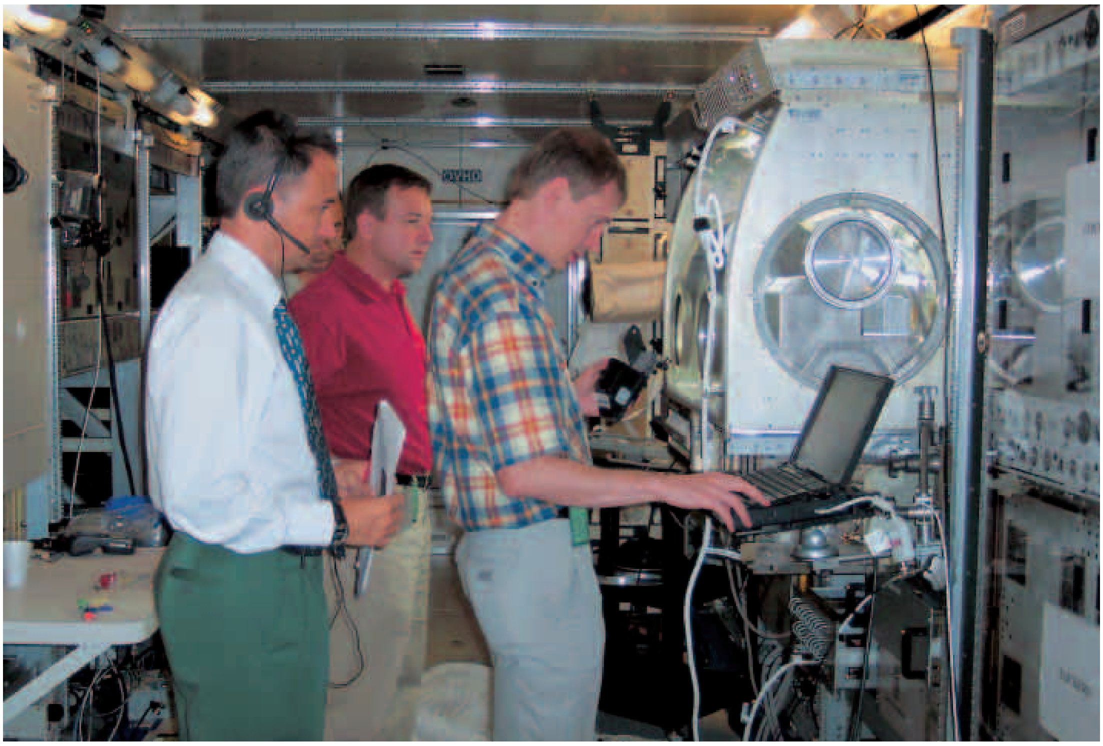
This final training phase lasts 18 months and its primary objective is to prepare the prime and backup crews assigned to a specific ISS flight for performing all of the activities planned for that particular flight Increment. This includes standard operations and maintenance tasks for systems and payloads, as well as such preventive maintenance as exchanges of Orbital Replaceable Units (ORUs) or particular assembly tasks like the activation and checkout of new ISS elements.

The training conducted at the International Partner's sites focusses mainly on single ISS elements or modules. Other so-called 'Multi-Segment Training' is performed at the Space Station Training Facility (SSTF) in Houston. As well as addressing on-board activities like emergency procedures, it also provides interface training for the on-board crew and the mission controllers at the various control centres. The training of individual crew members is tailored to the tasks assigned to each of them in the Crew Qualification and Responsibility Matrix (CQRM) for each ISS Increment.

The Training Challenges

Several factors combine to make the ISS crew training activities more complex and hence more challenging than any training programme that EAC has previously undertaken:

- The multinational nature of the ISS programme results in a large number of interfaces, calling for extensive and intensive consultation and coordination between the Partners.
- The decentralised training at sites around the World calls for carefully harmonised training concepts to avoid omissions or repetitions.

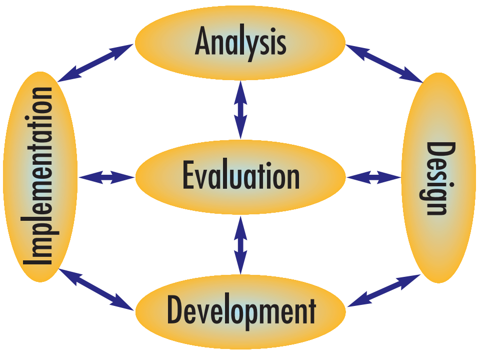


The ODISSEA crew, who visited the ISS on a Soyuz taxi flight in October 2002, receiving ISS training at the SSTF facility in Houston. ESA astronaut Frank De Winne (right) and his Russian crew mate, Yuri Lonchakov (centre) during their experiment training on the ESA Microgravity Science Glovebox (MSG), supervised by the EAC Training Coordinator, Hervé Stevenin

– The limited crew training time available dictates the use of the most effective training concepts in order to achieve the training objectives as quickly and as straightforwardly as possible, especially when dealing with astronaut classes consisting of crew members with diverse cultural and professional backgrounds.
– The different crew task and qualification level assignments require the training programme to be tailored to the actual tasks and responsibilities of each crew member.
– Last but not least, the training programmes for Increment crews have to be harmonised with those for the Shuttle and Soyuz crews who visit the ISS, to ensure that all of them can work together safely and effectively onboard the Space Station.

ESA and its International Partners have taken up these challenges, implementing a variety of measures and initiatives in order to provide highly skilled crew members capable of working safely and efficiently in the ISS environment.

The ISS Partners have agreed on using the same approach to training development, resulting in a harmonised training concept and structure. The underlying philosophy of the approach, relying on an Instructional System Design (ISD) based on research in learning psychology and addressing the shortfall between current and required knowledge and skills, is shown in the accompanying figure.



Phases of the Instructional System Design (ISD) approach used for astronaut training development

Payload Crew Training

The payload training is one of three main elements of the ESA-provided ISS training, together with the Columbus and ATV system training, and is a good example of the ISD development principles being applied.

Payload training is being developed for all four ESA microgravity research facilities: the Fluid Science Laboratory (FSL), the European Physiology Module (EPM), a biological research facility called Biolab, and the European Drawer Rack (EDR). EAC is also supporting NASA for the development and implementation of training for the Material Science Laboratory (MSL).

Payload training is founded on three closely interrelated building blocks:
– the payload courseware
– the payload training facilities and training tools
– the payload instructors.

Development of the training courseware has been contracted to an industrial consortium led by Lufthansa Flight Training (LFT), and including SAS (Brussels) and the companies developing the payload flight models for ESA (Astrium, Alenia and OHB). The payload developers are responsible for the on-board task analysis, for defining the training requirements and training manuals, and for developing lessons in close interaction with the payload training model developers. A Curriculum Board headed by LFT elaborates guidelines and standards and co-ordinates the courseware development. The course materials – training manuals, handouts, technical documentation, photos, videos and computer-based training aids – for all payloads are being produced by SAS. A

Steering Board, headed by the ESA Astronaut Division and consisting of representatives from each company involved, oversees the Curriculum Board and the courseware production.

The payload instructors have already undergone an introductory training phase at EAC and have participated in Instructor Training Courses at NASA-JSC and at EAC, familiarizing them with the methods and techniques of Instructional System Design. The development of training lessons and materials forms part of their on-the-job training and counts towards their instructor certification.

Hands-on training on the Data Management System (DMS) in the Columbus Trainer at EAC during the Advanced Training in August 2002

Columbus Crew Training

This training prepares the crew to monitor, operate and maintain the Columbus module's systems and subsystems.

During the *Advanced Training*, the astronauts are familiarised with the technical layout of the module, its characteristics and capabilities, and the operational concepts and modes. They receive knowledge-based training on the different systems and subsystems, their components, functions and redundancies. Special attention is paid to the Data Management System (DMS) – as seen from a crew operations perspective – which is a central element of the Columbus module. Working with crew displays, navigation within those displays, and the monitoring and commanding are other key elements in this training phase. The concept, locations, functions and maintenance of the Orbital Replaceable Units for Columbus are also covered. This knowledge-oriented part of the training is concluded with instruction in the Columbus operational modes. After completing this course, the crew begin hands-on training in the Columbus Crew Trainer.

The content of the *Increment-Specific Training* for the Columbus systems is driven by the overall activity plan for the particular ISS Increment and the tasks assigned to the various crew members. Major topics in this training phase are the preventive/corrective maintenance planned during the Increment, the day-to-day onboard activities to be performed using the various onboard tools, and understanding how the different ISS elements function together. During the Multi-Segment Training in Houston, the crew train to operate the Station as an integrated system. This includes the emergency training that the crews need to handle such emergencies as fire, rapid depressurisation or toxic spills.

Aside from the technical and operational content, team-building is an important element of the Increment-Specific Training.

ATV Crew Training

The ATV training focuses on three major areas: rendezvous and docking, cargo operations, and emergencies.

As the ATV docks automatically with the Station – monitored by the ground controllers and the crew – intervention possibilities during rendezvous and docking are rather limited. The crew can, however, monitor the approaching vehicle on video and via the data on their onboard displays to check that it is on a safe trajectory. If not, they can intervene to halt the approach and command the vehicle to a safe and collision-free orbit. This training is therefore very important for overall Station safety. The close interaction between the onboard crew and the ATV ground controllers in such situations is fostered during integrated simulations involving the ATV Control Centre and the ATV Crew Trainer (ACT), located at EAC.

The ATV will re-supply the ISS with a wide range of dry cargo, water, gases and fuel. Experience with the MIR space station and the first ISS Increments has shown that the complexity of cargo operations/handling can often be underestimated. After familiarisation with the basic ATV cargo operations, crews will therefore be trained to handle the actual cargo complement to be flown on the particular ISS Increment. When unloading cargo from the ATV and re-loading it with trash, for example, care has to be taken to keep the vehicle's centre of mass within a certain range to allow safe un-docking and departure from the Station.

The ATV emergency training covers all types of events, including potential emergencies specific to the ATV and ISS 'generic' emergencies that could have an impact on the ATV. The overall ATV training programme being conducted at EAC will therefore ensure safe and efficient operation of the ATV by the ISS crews.

Evolution of ISS Crew Training

A major issue for the ISS training community is the constant evolution of the ISS Programme, reflecting changing boundary conditions as well as learning from in-flight operational observations and post-flight crew feedback. As the Station grows and more International Partners have to provide their training, the requirements become more stringent and crew training time becomes an ever more critical resource. This makes careful harmonisation and integration of training flows to achieve greater efficiency and effectiveness of the overall training programme, exploiting synergies and reducing redundancies, an absolute necessity.

One of the training team's future tasks is therefore to develop a process for the distribution of training time to the Partners based on exact Increment training requirements. Crew feedback after flights also indicates a need to redefine the operational relevance of different areas of the training, which also implies a higher degree of fidelity for the training facilities.

Conclusion

As a result of the decision to delay the launch of the Japanese Experiment Module for the ISS to 2006, ESA will be the next International Partner to launch its ISS module. Changes being made to the Assembly Sequence also indicate that the Columbus launch, planned for October 2004, will no longer be a crew-exchange flight, but most likely a visiting-Shuttle flight. The Increment crew onboard the ISS when Columbus arrives will have already arrived in July 2004.

Under this scenario, preparation and implementation of the training for the 1E Shuttle flight and the respective Increment will be a special challenge, not only because it is the first flight-specific training to be provided by ESA, but also because it requires training for one Shuttle crew and one prime and one back-up Increment crew. Moreover, the training for the Increment crews needs to be advanced by three months compared with the original schedule. According to the draft assembly sequence, the first ATV launch is scheduled for the same Increment. In this case, the Increment crews will also have to be prepared for ATV crew operations.

The latest training schedule updates are currently being prepared, and Shuttle and Increment training coordination with the NASA training counterparts has been initiated. The first Increment-specific crew training at EAC can be expected in the last quarter of 2003. Preparations have therefore already started and we are confident that we are on the right track to meet the challenge ! esa

ESA Training Facilities

In order to carry out the ISS training programme, training facilities had to be developed that represent the Station's flight equipment and systems both mechanically and functionally, and which provide the fidelity required by the complexity, specialized nature and safety implications of the tasks to be trained for. The choice of site for those facilities – EAC, Johnson Space Center or the Gagarin Cosmonaut Training Centre – is driven by the need to provide representative training for integrated payload-system and multi-segment operations whilst minimizing travel requirements for the astronauts.

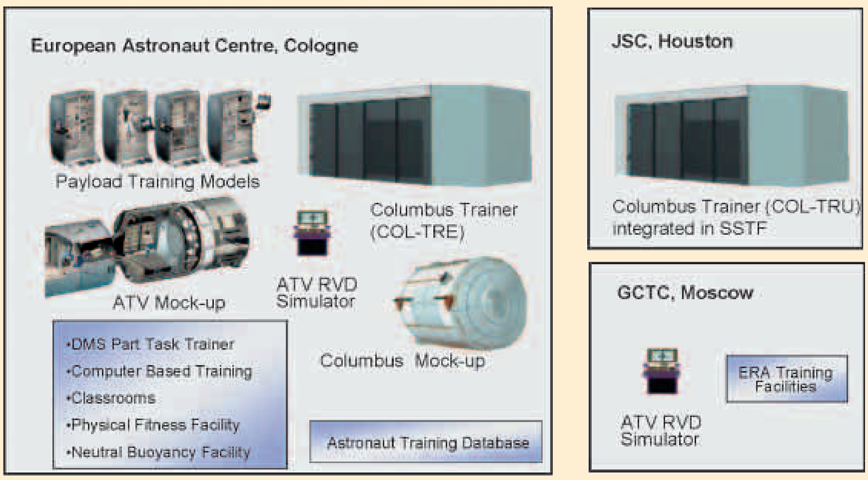
The two almost identical Columbus trainers located at EAC in Cologne and at Johnson Space Center in Houston provide high-fidelity simulation of the Columbus Data Management System (DMS) and its other systems and subsystems, but differ in terms of their simulation of payload/system interaction and of the interface between Columbus and the American in-orbit systems of the ISS.

The Columbus Trainer will soon be supplemented with a Columbus mock-up for crew familiarisation with the module's topology and equipment locations, and training for mechanical tasks, especially preventive and corrective maintenance. It is planned to partially integrate the mechanical and functional simulation to provide realistic training for such complex maintenance tasks as the deactivation, exchange, re-activation and checkout of failed Orbital Replaceable Units.

Interaction with the DMS lies at the heart of Columbus operations. To provide the crews with a clear understanding of its internal architecture, processes, functions and redundancies, a special task trainer is being developed, providing visual animations of DMS components and functionalities, and functional simulations of some dedicated DMS processes.

The automated docking of the ATV to the Russian Service Module is a safety-critical manoeuvre in terms of overall ISS safety. The ATV Crew Trainer at EAC therefore includes a high-fidelity rendezvous and docking simulator which will be used to train crew members for monitoring that critical event. A combined mockup of the ATV and the Russian Service Module is under development and will be delivered to EAC in early 2003. It will be used to train for cargo operations like the unloading of dry cargo, water and gas transfer to the Station, and the loading of trash into the ATV.

The Payload Training Facilities at EAC will be of two different types. The stand-alone Payload Training Models are full-scale mechanical and functional representations of the payload racks, with high-fidelity crew interfaces and maintenance-training capabilities. The Columbus Trainer will be supplemented with simulators for the ESA payloads, fully integrated into their rack positions. These simulators include full-scale representations of the payload front panels, activated by a software simulation model running on a dedicated work station.



The ESA Training Facilities