Taxi to the ISS – the Andromède Mission

R. Ewald & C. Haigneré

Astronaut Division, European Astronaut Centre (EAC), Cologne, Germany

With the arrival of the first ISS expedition crew in November 2000, the permanent presence of humans in near Earth-orbit continued, taking over from what the Russian Mir space station had demonstrated for almost fifteen years previously. The way in which operations onboard ISS are conducted owes a great deal to inherited Mir experience, but many of the things happening now in orbit are quite new and are providing new opportunities also for the European astronauts.

Introduction

The French-Russian Andromède mission in October 2001 proved to be a good example of new ways of fully exploiting the limited human spaceflight opportunities currently available. Called a 'taxi mission', the flight's main purpose was to deliver a new Soyuz spacecraft to the International Space Station (ISS) and take back the old one, which had been attached to the Station since May 2001. In the Mir era, this would also have meant an exchange of the expedition crews, with the old crew returning to Earth in the Soyuz that had brought them up. The internationality of the ISS does not stop with the building blocks and the crews, but also applies to the space vehicles used to ferry the crews and provisions to and from the Station, which also come from several partners. Thus the ISS crews are being ferried up and down on US Space Shuttle flights for most of the Station's build-up phase.

This in turn means that the three crew seats of the Soyuz spacecraft can be used for stays of 6 to 8 days, and sometimes longer, on the ISS. Thus while the first Soyuz taxi flight included a tourist paying for a very special, but completely personal experience, the second Soyuz taxi flight had a programme involving scientific, operational, and educational goals, implemented as part of the European preparation for the utilisation of the ISS. All of these tasks were given to Claudie Haigneré, a European astronaut of French nationality based at the European Astronaut Centre (EAC) in Cologne, Germany. The French space agency CNES took the lead for this mission, with the French Government paying through a bilateral agreement with Rosaviakosmos for the provision of the flight and the payloads.

Figure 1. Traditions and official meetings punctuate the days before launch for the flight and the back-up crew. From left to right, Koseev, Afanasiev, Haigneré, Zalutin and Kushelnaya.

Figure 2. Three hours before launch, the functioning of Claudie's spacesuit is checked under pressure in the launch position

Letter from the Andromède Astronaut

November 2001

The Andromède mission was successfully completed just a few weeks ago. In recognition of the fact that the astronaut on board is just one link in the chain, scientific, technical and general debriefings will be conducted in the near future to disseminate useful information to all those who contributed to the success of the mission.

I am deeply grateful to the French, Russian, German, Spanish, and European-integrated scientific teams who devoted so much time and energy to developing excellent protocols to take advantage of the space environment for their particular scientific fields. I greatly appreciated the expertise of the operational and technical teams, the priceless presence of the EAC Flight Surgeon throughout all phases of the mission, and the availability and competence of the teams of engineers supporting the different phases of the mission and training, from CNES in Toulouse (CADMOS), and from ESA at EAC in Cologne and in Star City.

I would like to offer my thanks also for the friendly and professional relationships with my colleagues, astronauts and cosmonauts from Russia, NASA and especially the European astronauts at the Mission Control Centres in Russia and USA. I felt completely integrated with all the personnel and their teams and prepared for our common goal: working in space for the progress of science and in preparation for the future steps taking humans further into space. I was really happy and honoured to represent the European Astronaut Corps and ESA in space. It gave me great satisfaction to work in so harmonious an international atmosphere, with a multi-cultural crew, with two Mission Control Centres, and with the capacity to interact with the ground teams in the event of non-nominal situations occurring. The functionalities of the ISS are already very wide-ranging even in this early phase, even if it is not always easy to coordinate the schedules of the visiting and the increment crews. That also means that for so short a mission as mine, it was difficult to find enough personal time to enjoy the sights and the exceptional experience of my stay there.

We have certainly learned a lot, but we still have a lot to learn. Personally, I already feel ready for the next step. I am therefore very pleased to see new European missions and projects being scheduled for the near future aboard the International Space Station !

Claudie Haigneré

The training

In Claudie Haigneré, an experienced astronaut was chosen for the mission. She had already made a 16-day flight to Mir in 1996 and had served as back-up astronaut for three other missions, including training for a long-term stay onboard Mir involving an EVA (Extra-Vehicular Activity). She is also the only woman to have received the Soyuz Return Commander qualification, involving special training in returning the Soyuz safely to Earth in an emergency situation with an incapacitated crew.

Nevertheless, as pre-mission training is also aimed at bringing a crew together, she started courses for her latest mission in January 2001 at the Cosmonaut Training Centre in Star City, Russia. With her were two Russian colleagues: Victor Afanasiev as Soyuz Commander, a veteran of now five space flights, and Konstantin Koseev as Flight Engineer 2, a newcomer in space. Together, they travelled to France to familiarise themselves with the experiments to be conducted during the mission. At a stop-over on the occasion of the Le Bourget Airshow in Paris, the Andromède crew and their back-ups met a large number of the European astronauts and a Shuttle crew that had just returned from space. During a visit to the Johnson Space Center (JSC) in Houston, the crew was also introduced to the US segment of the ISS. For the final launch preparations, Claudie and her Russian colleagues travelled to Baikonur in Kazakhstan.

Figure 3. Months of intensive training on systems and payloads help to make a good crew: from left to right, V. Afanasiev, K. Koseev and C. Haigneré.

Onboard the ISS

In preparation for the incoming Andromède flight, the ISS Expedition Three member and Soyuz pilot Deshurov first had to 're-park' the Soyuz spacecraft from a docking node at the FGB module to another at the end of the newly arrived Russian PIRS airlock and docking port.

The Soyuz launch, the chasing of the ISS in orbit, and the docking to the newly freed port went flawlessly for Claudie and her colleagues. She proved her capabilities by being the first female and non-Russian flight engineer to

Figure 4. The Soyuz TM 31 spacecraft attached to the PIRS docking port and airlock.

occupy the seat to the left of the Commander – another 'first' in Soyuz history. The hatches between the two spacecraft were opened on 23 October, to the sound of applause from a large French delegation back on Earth led by French Prime Minister Lionel Jospin, who was watching the event from the TsUP Control Centre in Moscow.

The same night the personal items belonging to the two crews were transferred from one Soyuz to the other. Claudie set up her quarters 'around the corner' in the 'Quest' airlock compartment, a late addition to the ISS for sorties with the US space suit. There she fixed her sleeping bag to a wall and arranged some often used equipment around her. The long-term crew, who stay for up to six months on board the ISS, is given priority use of the 'cabins'. A busy programme of activities followed, with the two crews working through their planned timelines for the next eight days.

The in-flight programme

Claudie immediately started her flight programme, which consisted largely of experiments prepared by French and other international groups.

Figure 5. The shirt-sleeve environment on-board the ISS is ideally suited for experiment work

Life-science experiments

COGNI – investigated the changes in perceived spatial orientation of the astronauts by means of a computer and geometrical patterns displayed on the screen. After a virtual ride through a complicated tunnel system, the astronaut had to reproduce the navigation pattern.

Cardioscience – took up elements of investigations performed on the Mir space station, such as anambulatory registration of pulse, ECG and other physiological signals.

Biology

AQUARIUS – provided a ride into space for embryos and tadpoles of two amphibic species, Xenopus frogs and Pleurodelus salamanders, to anlyse the development of their graviperceptive organs. Their swimming behaviour in space was filmed and the data gathered will be evaluated, also with the help of school children. In a third experiment, yeast cultures were grown in space and analysed after return to Earth.

Earth observation

Lightning and Sprites Observations (LSO) – intended to clarify the nature of puzzling light emissions in the upper layers of thunderstorm clouds by observation from the ISS.

IMEDIAS – an Earth-observation experiment that will complement satellite observations with digital photographs taken by astronauts of specific problem areas on Earth where desertification, deforestation, and other processes are occurring.

Physical sciences

GCF Protein Crystallisation – made use of weightlessness to grow larger-than-on-Earth protein crystals for later X-ray diffraction analysis.

PKE – the Plasma Kristall Experiment – is a German-French-Russian collaboration to investigate the surprisingly ordered structures that micro-sized particles ('dust') show when left in a plasma without the influence of uncompensated gravity. One of the first active experiments to be conducted onboard the ISS, it opened the laboratory in space to a new group of researchers in fundamental physics.

Technology, operational aspects

SPICA-S – assessed the influence that the radiation environment inside the ISS has on electronic components by exposing such equipment and documenting its functioning.

EAC – the European Astronaut Centre's set of experiments provided a pouch container

(‘Mirsupio’) for in-orbit use, to contain in weightlessness small objects that would otherwise behave rather like a bag of fleas. With the help of medical questionnaires, the astronauts’ mood changes and sleep quality were assessed, which are important indicators of stress and the astronauts’ ability to cope with the demanding work day.

Education

As the mother of a four-year old daughter, Claudie especially wanted to address children and their curiosity when demonstrating the environment of the Space Station and the effects of weightlessness. Her message was communicated in live television transmissions and interviews to various venues where young people had been assembled to learn more about space and its exploration. This also involved active participation by the children and students in the evaluation of some of the experiments, for example AQUARIUS with the yeast and the tadpoles.

Special events

In a series of television links with the ISS, the political and international dimensions of this great space endeavour were highlighted. France’s political support for and interest in the mission were well demonstrated in TV links and interviews with Claudie. A link with the highest representatives of the European Union culminated in the presentation of a floating 1 Euro coin, serving as visible proof of the growing unity within Europe.

The renowned Spanish ‘Prince of Asturias Award 2001 for International Relations’ had been bestowed on the ISS, its crews and the ISS Partners. On the occasion of the award ceremony, the ISS crew were linked by TV with an assembly of the highest representatives of the Partner Agencies who had accepted an invitation from HRH Prince Felipe to visit Spain. A moving moment was the farewell call from NASA Administrator Daniel Goldin before giving up his post in November. All in all, Claudie, NASA Station Commander Frank Culbertson, and the whole crew proved to be excellent ambassadors for the peaceful ideals for which the ISS stands.

Help from the ground for the crew

The ISS already in the current state of its build-up is a complex machine, too complicated to be run solely by a three person crew, even given enough training time. So two Control Centres, the MCC at JSC, Houston, and the TsUP in Moscow are constantly in contact with the crew to provide planning, advice and decision support. The initial planning is refined on a daily basis and sent to the Space Station each evening for the following day’s activities. All involved participate via station-to-ground links in two planning conferences per day. Communication with the prime control centre (MCC) is via the TDRSS relay satellites. During passes over Russian territory, the ground stations there can also be used with the help of VHF radio. The French project group at TsUP, including the European astronaut Reinhold Ewald serving as one of the French crew interface persons, had the opportunity to assist Claudie and guide her through difficult parts of the programme, at her request.

Figure 6. Working together in a concentrated way was the key to mission success; here Claudie (left) and her Russian colleague Konstantin Koseev are in the ISS Service Module

A group of scientists had gathered at TsUP to run reference experiments and were eagerly awaiting the data from space. Another group with supporting staff at the CNES User Support Centre (CADMOS) in Toulouse received voice, video and data through permanent lines leased for the duration of the mission. At the MCC in Houston another European astronaut, Michel Tognini, took over as NASA CapCom when the normal workday was coming to an end in Moscow.

Crew medical support during the mission

Soon after Claudie Haigneré had been assigned as a crew member to the Andromède mission, the ESA Crew Medical Support Office at EAC assigned a team consisting of a Flight Surgeon and a Biomedical Engineer to support her throughout all phases of the mission.

The Flight Surgeon, who is responsible for dealing with all mission-related medical issues, supports the medical examination and certification process, monitors potentially hazardous training, supports the launch and landing on site, provides in-flight support from the medical console in the Control Centre, and supports the post-flight rehabilitation process. The Biomedical Engineer is responsible for all

Figure 7. Floating inside the ISS from one job to another. A lot of items have to be unstored, restored, and handled, with the help of the 'Mirsupio' bag for small items

technical aspects related to medical support, and also assists the Flight Surgeon where necessary.

The medical support began with the preparations for the first Russian State Medical Commission meeting, which grants the certification necessary for the cosmonauts to enter training. This initial certification was followed by periodic examinations and some other, more extensive, investigations. Together, the results of these examinations contribute to the final certification for space flight, which is granted via another meeting just prior to the flight and can be considered the final 'go for launch!'

Another of the Flight Surgeon's tasks is to review the scientific protocols and to identify potential inconveniences due to time constraints, stresses induced by the design of equipment, and the level and intensity of the workload. For Claudie's mission, this was done in close cooperation with the EAC Crew Safety Officer. Recommendations were forwarded to the ESA Medical Board for final review and approval.

Testing of operational tools

The Biomedical Engineer had also coordinated the development of operational software dedicated to in-flight crew-operation support known as the 'Medical and Private Instruments Tool' (MaPIT). This tool has integrated medical-operation-specific and off-the-shelf software, allowing easy adaptation to the specific wishes of each crew member whilst still handling the data involved privately and securely. After a series of rigorous tests, MaPIT successfully passed the final-acceptance criteria of RKK Energia.

EAC provided Claudie with the 'Mirsupio', a general-purpose wearable bag for stowage and transport of equipment, consumables, tools and personal items. In coordination with the Andromède management and the NASA Astronaut Office, EAC also provided her with private in-flight e-mail access.

Support from launch to landing

After supporting the launch campaign in Baikonur, the Flight Surgeon moved to the Moscow Control Centre (TsUP) to provide in-flight support. The ESA team had access to a TsUP console and stood ready to respond to any onboard medical problem, in close cooperation with the Russian medical team. At this time, the Biomedical Engineer was located at the CNES User Support Centre, where he was on standby to resolve technical issues in support of the crew member and/or the Flight Surgeon.

For the landing, the ESA Flight Surgeon flew back to Kazakhstan, to assist Claudie as soon as she emerged from the Soyuz capsule. After a quick medical check, she was flown by helicopter to the nearest airport, Karaganda. During the immediate post-flight period, an astronaut has to readapt to living on Earth, which usually involves a short rehabilitation programme. Due to the short duration of the Andromède mission, one week was sufficient for Claudie in this respect.

Figure 8. Safely back on Earth in the Steppes of Kazakhstan