Visiting the ISS – by Taxi

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Introduction
The primary goal of the Taxi missions is to replace the Soyuz lifeboat attached to the ISS before its 6-month warranty expires. A fresh Soyuz is delivered by a crew of three, who stay aboard the ISS for about a week and work alongside the resident Expedition crew, before returning to Earth in the ‘old’ Soyuz.

In mid-2001, the Italian space agency, ASI, and ESA negotiated a contract with the Russians to use one of the Soyuz seats for an Italian astronaut within the framework of the ESA/Russian agreement on cooperation in manned spaceflight. ESA astronaut Roberto Vittori trained as the Soyuz flight engineer and was launched on 25 April 2002 aboard Soyuz-TM34 from the Baikonur Cosmodrome, together with Commander Yuri Gidzenko and Spaceflight Participant Mark Shuttleworth. Docking with the ISS after 2 days, he spent 8 days onboard. On 5 May, the crew returned safely in Soyuz-TM33, in which ESA astronaut Claudie Haigneré had reached the Station more than 6 months earlier.

Training
Roberto’s background as a distinguished test pilot in the Italian air force and his 3 years of Shuttle Mission Specialist training at the NASA Johnson Space Center in Houston were excellent preparation for the mission. He began training in August 2001 at the Gagarin Cosmonaut Training Centre at Zvezdny Gorodok (‘Star City’), near Moscow. Training was initially alongside ESA astronaut Frank De Winne, who was preparing for his October 2002 Taxi flight. The first lessons were with the assistance of an interpreter, which made the 3.5 m³ of the Soyuz interior very cramped indeed during practical work. Eventually, of course, Russian-language courses meant that both ESA cosmonauts could dispense with the interpreter’s services.

The Russians have extensive experience in training crews for spaceflights so, even on such a tight schedule, they delivered the required courses for Roberto. His role was that of Flight Engineer, sitting to the left of the Commander, and in charge of the flight computer, the engines and the propellant system, among others. He supported the Commander in all the flight phases, including the ascent, the orbital manoeuvres, the approach and docking to the ISS, and finally the undocking and return in the swapped Soyuz. The Flight Engineer has to

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Yes, it is possible to visit the International Space Station (ISS) by taking a taxi, if the ‘taxi’ is a full Soyuz spacecraft and the training qualifies you for the flight. The third ISS Taxi mission flew in April/May 2002 and, as with the second Taxi mission in October 2001, a European astronaut was again onboard.

Figure 1. Yuri Gidzenko (foreground) and Roberto Vittori training in the Soyuz simulator at Star City
handle several life-support system elements, planning and controlling the careful exploitation of the limited Soyuz resources.

Commander Gidzenko was already well-known to ESA from the highly successful and harmonious EuroMir mission in 1995, when he spent half a year aboard Mir with ESA astronaut Thomas Reiter. Yuri and Roberto were accompanied by Mark Shuttleworth, a South African citizen, who flew on the basis of a commercial contract with the Russian Space Agency and partner organisations. After the tourist flight in 2001 of Dennis Tito, the ISS Partners agreed on a set of rules for non-professional astronauts. A minimum of training and safety rules was defined, together with health requirements to avoid endangering the rest of the crews.

**Days 1 & 2**

Today, the crew settled into a flight routine aboard Soyuz-TM34, reporting every 90 minutes to the Moscow Flight Control Centre. A small orbital correction during the 17th orbit went according to plan to catch up even faster with the Space Station. Life on Soyuz between communication passes and manoeuvres is quite spartan: no hot drinks or food, just canned food, a sip of tepid water and some fruit juice in tubes. But, as a transport vehicle, it fulfils its role perfectly.

**The experimental programme**

Though the amount of European research hardware aboard the Station is growing, the time for training and collecting life-sciences baseline data is a bottleneck for performing the experiments. So the set of experiments taken by Roberto Vittori into space on his ‘Marco

**Day 3**

Finally, after 2 days in the cramped 10 m³ cabin, the large Station appeared in the periscope in front of Yuri in his centre seat and on the small video screen. The docking went perfectly - completely automatic and on time. Hatch opening and a warm welcome by the ISS Expedition crew was certainly unforgettable. From TsUP, the ESA Director of MSM, Jörg Feustel-Buechel, talked with Roberto and the Expedition-4 Commander, Yuri Onufrienko, during the first teleconference shortly after docking.
Polo’ mission reflected the very short lead time. For example, there was no time to train him in the use of the large units like the Human Research Facility, installed in the US Destiny laboratory. So the set had to be limited to three life-science experiments through ASI, a number of ground experiments and – a first for ESA – a commercial venture called BMI, a blood measuring instrument. Intospace of Hannover (D) acted as ESA's agent for this commercial undertaking.

Russian specialists were contracted to develop the procedures and to support the experiments. ASI and ESA staff provided the necessary inputs and followed the progress during the flight in close cooperation with their Russian counterparts.

Life aboard the Station
With the arrival of a Taxi crew at the ISS, public interest focuses for a few days on this outpost in space. It should not be forgotten that, since November 2000, the Station has been continuously inhabited and the assembly work has been in full swing. So, even for Yuri Gidzenko, part of the first ISS expedition crew, life onboard was very different from his experiences of November 2000 – March 2001. Destiny, the US laboratory module, has enlarged the volume of the Station and its operational capabilities, the Canadian robot arm has become active, and new communication and data downlinks have been added.

For each Taxi crew and, even more so, each Expedition crew, the training programme has to be highly individual. Though crew interaction is essential for the success of the activities squeezed into the 8 days aboard the Station, the crews hardly have time to get to know each other on the ground beforehand and therefore have to improvise to a certain extent when meeting onboard. The activities of a Taxi crew are mostly orchestrated by the Moscow control centre, TsUP, in close coordination with the Station lead mission control centre in Houston, MCC-H. The activities are then finalised and integrated into a daily activity plan for both crews, called ‘Form 24’. Details of the activities and updates to the procedures for the next day are linked up as 10-15 radiograms every day. The crew convenes in the evening and goes through the next day’s activities, before reiterating the plans in the Daily Planning Conference. Roberto by contract counted as a Russian crewmember and therefore worked under the authority of the onboard Commanders and the Moscow flight directors.

Life in the Control Centre
The interaction of the ESA/ASI support group with Roberto followed the lines described above for planning and communication with the whole ISS crew. The main means of interaction were the two Daily Planning Conferences, when all responsible centres on both sides of the Atlantic joined in a space-to-ground teleconference to clarify changes to the preliminary planning. Whenever the crew called down throughout the day with specific problems or questions, the calls were monitored and answered as quickly as possible by voice call or in a radiogram. When time allowed, written information was given in both official ISS languages: English and Russian.
The Russian experts in TsUP freely included their operational colleagues from ESA’s Astronaut Centre in their daily work, reviving the friendly experience of the many flights with European astronauts on Russian spacecraft.

With Taxi crews, exchanges are made during communication passes over Russian territory, when the Station is in line-of-sight of Russian ground stations, using VHF channels. Matching crew awake and work time (following GMT) and the actual orbital times of these passes meant that only three or four useful passes per day remained for information exchange or even TV downlinks. Here, a new characteristic of today’s Taxi flights became evident: the presence of a paying customer with a strong interest in publicising his stay aboard the Station with the help of video coverage. By far most of the longer VHF passes with video connection were used by Mark Shuttleworth for broadcasts from space. Being blocked by TV events, these passes could not be used for reports on the experiments or system activities. ESA and ASI had the two remaining slots for TV events with the crew and Roberto.

Better checked twice

The main task of a Taxi crew is accomplished when the new Soyuz docks to the Station. Access to a rapid-return vehicle for the Expedition crew is then assured for another
200+ days. Taking the ‘old’ Soyuz craft back to Earth allows items and experimental results to be returned, although the capacity of this small spacecraft is very limited. Finding safe storage places in containers located at almost unreachable places in the innards of the Soyuz capsule is a near-nightmare. This is still the part of the mission when, despite all the careful planning, the Soyuz Flight Engineer, working closely with the Commander, has to be creative. As a result, the 2 days before undocking are mostly freed of other activities for both of them so that they can focus on reactivating their return Soyuz after its long period of storage, checking it out and packing it with material requiring safe return. In addition, some Station rubbish is stored in the disposable Orbital Module, to burn up in the atmosphere on the way down. Every item stowed in the many tight locations is checked and double-checked to avoid expensive oversights.

The next Taxi
While the analysis of the experiment data that Roberto acquired during his flight is in full swing, the next ESA astronaut is preparing for lift-off. Frank De Winne will take the Flight Engineer position in the first uprated Soyuz-TMA spacecraft in October. The lead time for his training and the progress of deliveries to the Station will allow him to use the Microgravity Science Glovebox (MSG). This ESA-built facility was bartered with NASA and delivered to Destiny in June by the STS-111 mission. The demanding number and characteristics of the experiments mean that the flight’s funding organisation, Belgium’s Office of Scientific, Technical and Cultural Affairs (OSTC), has asked ESA’s Directorate of Manned Spaceflight and Microgravity to set up an organisation for handling the experimental programme.

Communication links between the ISS Partners are improving all the time and more services of the Interconnected Ground Segment (IGS) for European participation in the Station are becoming available. This network will provide support and monitoring functions from ESTEC, EAC and the Belgian user centre for Frank while he is aboard the ISS.

As always, the Taxi, Shuttle and Expedition crews rely on the close and motivated cooperation of the international teams on the ground and in space for their success.