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Changes in Columbus Operations and Outlook to Long-term Operation Phase

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CHANGES IN COLUMBUS OPERATIONS AND OUTLOOK TO LONG-TERM OPERATION PHASE

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ABSTRACT

Since the activation of Columbus on 12 February 2008 three years of busy and partly challenging operation have been performed by the Columbus FCT. The last year was mainly driven by the ground segment schedule to update the control rooms and servers to adapt the ground systems with software and hardware development. Starting with the control room K3 new workstations, new monitoring and command software as well as a new Voice Communication System (VoCS) have been installed, tested and brought into operations. Meanwhile also K4, the main control room at Col-CC, is completely renewed and used for operations. The last step to follow is the update of the backup control room K11 which has been performed for February/March 2011. Besides the scheduling of the ground events around the most important activities on board, the proficiency training of the FCT was a major challenge of the Columbus flight control team. For the first time the flight controllers have to be trained on a completely new system, i.e. the VoCS, during ongoing operations with all constraints due to shift plan and operation preparation work. This experience will be used for the training for future add-ons, changes and upgrades as well as for the setup of continuous proficiency training for upcoming years. Despite the quite low attrition rate in the Flight Control Team at Col-CC a continuous replacement of flight controllers takes place. The training for the new flight controller is well established and continuously adapted to the current needs. Nevertheless the knowledge of the long-term flight controllers has to be kept on the current level of experience and the way how operation is done. Hence a knowledge database has to be set up for use by the flight controllers and as a basis for the establishment and extension of the proficiency training of the FCT (see [10]). During the ULF5 (STS-133) flight in February 2011 the WOOV8 valve of the Columbus Thermal Control System is the next major challenge of the Col-FCT, because this the first major on-orbit maintenance of the Columbus TCU including a necessary rack tilting. The paper will give an overview of the achievements and highlights of the last year and concentrate further on the operational goals and constraints of the next years as well as the first preparations on the planned ISS operations until 2020.

Introduction

After the interagency agreement of this year to continue the ISS operations until at least 2020 a new perspective has been opened to the ISS community: Not only the maintenance of the on-board equipment until their end-of-lifetime is the major part of the work of the control centers but also the planning, preparation and replacement of major parts of the modules is coming into the focus of the teams.

This results in a focus shift from the more near and medium term tasks to at least partly to more longterm tasks to ensure the life of the module, i.e. the Columbus module over the next 10 years.

The first result of this new approach was the removal of one of the WOOVs (Water On Off Valves) in February 2011 which was brought back to Earth with ULF5 for inspection and analysis. The plan is to replace at least some of the WOOVs in Columbus by newly designed valves with improved capabilities.

In the last year a major upgrade of the ground systems of the Columbus Control Center has been performed because most of the subsystems were in use since the Eneide Mission in 2005. After supporting the flight control team during the Astrolab mission with Thomas Reiter in 2006 (see [1] and [2]) the subsystems are used continuously for Columbus Operations (see [6] and [7]). Since 2008 the Industrial Operations Team (IOT, see [3] and [5]) operates, monitors and maintains this ISS element at Col-CC. Now the Columbus Control Center has already made a big step forward for a long-term operations period until at least 2020.

Next European Astronaut on ISS

After Frank de Winne who served as commander of ISS in 2009 ESA Astronaut Paolo Nespoli flew to the Space Station in December 2010 with Soyuz 26. This nearly 6 month with a European Astronaut on board ISS means increased responsibility for the Col-CC team and more work to prepare the necessary products to support Paolo Nespoli. The positive side was the close contact to the astronaut before, during and after the flight offering a lot of possibilities to learn from the work with the astronaut and to improve our skills for upcoming missions.

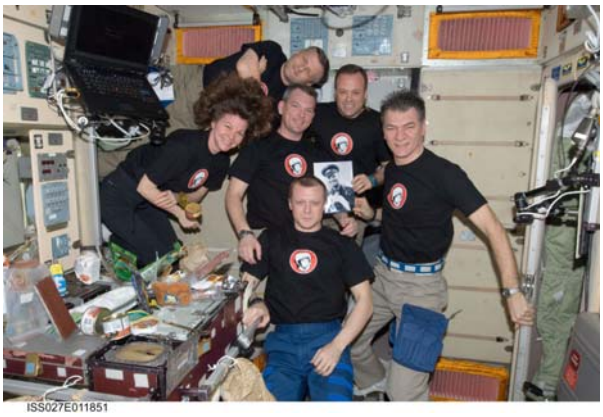

Fig. 1: Paolo Nespoli with his crewmates at 50th anniversary of Yuri Gagarins space flight (Credits: NASA)

The highlights of the work of Paolo Nespoli in Increment 26 and 27 were the work with the Geoflow experiment, the commissioning and first recordings with the ERB-2 camera, 3D-Space (see Fig. 5), support to ATV-2 docking and replacement of the WOOV8 valve by a manifold as well a PAO event with Pope Benedict XVI.

Paolo Nespoli returned to Earth on 24 May 2011 with his two crewmates Dmitry Kondratyev and Cady Coleman. Undocking and de-orbit went as planned and Soyuz 25 landed in Kazakhstan on 24 May on 2.26 GMT (see Fig. 2).

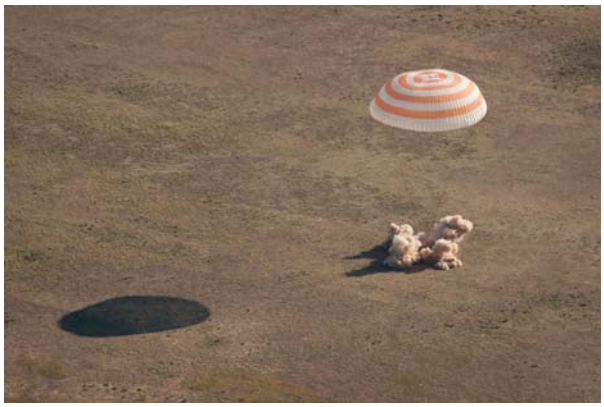

Fig. 2: Landing of the Soyuz 25 crew in Kazakhstan (Credits: NASA)

WOOV Replacement

One of the most challenging events during the last year was the WOOV-8 (Water-On-Off-Valve) replacement. This valve is controlling the water flow through the heat exchanger between the Columbus water based TCU and the USOS ammonia based system. During regular maintenance the WOOV 8 is closed and opened again to ensure the movability of the valve. Unfortunately in autumn 2009 the valve was stuck open and even a manual override was not successful (see [7]). During this activity it was realized that some suspect material was found on the outside of the valve. Hence, it was decided that the valve will be replaced and the valve will be brought back to Earth for inspection.

As there were only a small number of shuttle flights offering sufficient return capability for the WOOV the replacement has to take place within short time frame. Instead of using the spare valve on board a new manifold was made which is sufficient because WOOV8 is in open position during

nominal operations. On 27 February Paolo Nespoli performed the replacement and the valve was brought back to Earth with STS-133 on 9 March (see [9]). The results of the inspection will help to ensure a continuous operation until 2020.

System Maintenance Activities

The main task of the Columbus Flight Control Team is the monitoring, commanding and maintenance of the Columbus Module. While the monitoring and commanding task can be mostly performed by the FCT alone, the maintenance tasks are often combined crew and ground activities. In the last 12 months a continuous flow of known and new maintenance activities have been performed to ensure that all capabilities of the module are permanently available and full support for payload operations can be given. Among the different tasks the examples of protective and corrective maintenance given below provide a good overview on the variety of work to be fulfilled by crew and FCT.

One of the regular tasks which have to be performed in Columbus by the astronauts up to now is the smoke detector cleaning. The two cabin smoke detectors are located in the cabin air return loop, to be able to detect a combustion process in the ventilated cabin area. Unfortunately also dust and dirt is transported by the return air, which could not be removed completely by the installed filters. To reduce the frequency of smoke detector cleaning an additional filter has been designed and brought to ISS with STS-134. On GMT173 (22 June 2011) the return grid sensor housing (RGSH) was cleaned by Ron Garan and an additional filter called AORG was installed. It is expected that this new filter will reduce the amount of dirt on the smoke detectors and will reduce the amount of on-orbit crew time to keep Columbus operable.

After installation of the MARES rack in spring 2010 it was realized that the operations of the MSG rack is partly restricted due to the space needed during operations MARES. Hence, it was decided to move the MSG rack to Destiny and the open spot was filled with a ZSR (Zero-G Stowage Rack). This will increase the stowage capability in Columbus. Nevertheless it is planned to fill the space again with an experiment rack in one of the upcoming increments.

Beside these major tasks a lot of routine maintenance activities like valve cycling, leak checks, water sampling and check of the OPA levels in the water loop were performed in the last year as well as the regular water loop refill operations carried out by ground and crew several times now. Among other activities a recovery of a CLSW failure, a CMU reboot and a recovery from a false fire alarm were done as well as some PWS reboots, which are investigated in more details at the moment.

Payload Operations Support by Col-CC

One of the major experiments in Columbus in 2011 was the re-run of the Geoflow experiment (see Fig. 3). The Geoflow-2 experiment was brought to space with ATV-2 and installed in the FSL rack by Paolo Nespoli on 27 February 2011. The performance of the FSL rack and the Geoflow experiment put some problems to the teams in MARS, E-USOC and at Col-CC but in a combined effort most of the flaws could be resolved and a complete set of experiment runs has been performed up to now by MARS and E-USOC supported by Col-CC. The next weeks will be used to fill some gaps in the experiment envelope to improve the results even more.

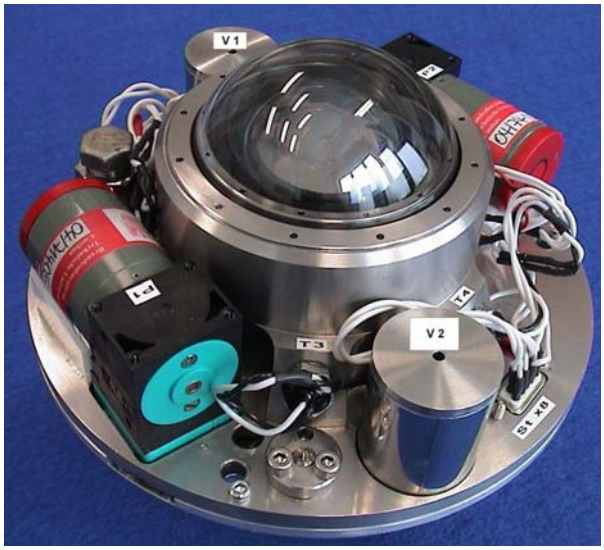

Fig. 3: GEOFLOW Experiment in FSL (Credits: NASA)

Another exiting experiment was the commissioning and first use of the ERB-2 camera (see Fig. 4.) ERB-2 is a HD stereo camera which could provide 3D videos of the Columbus and the other module.

Paolo Nespoli performed commissioning test with the camera and filmed e.g. a fly-through the Columbus module. Meanwhile also live-stream pictures from ERB-2 are possible, giving a totally new insight in the ISS for people on ground.

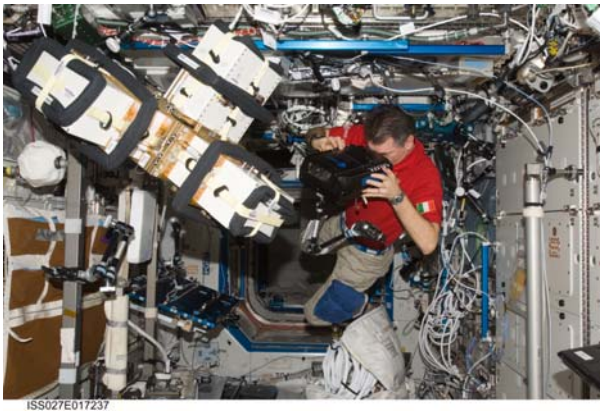

Fig. 4: Paolo Nespoli films the Altea Shield experiment with the ERB-2 camera. (Credits: NASA).

The refurbishment of the Biolab rack was carried on to make the rack ready for the next planned experiments. Col-CC supported MUSC the responsible USOC in Cologne in this challenging task. On 26 April 2011 the HAM radio equipment was installed in Columbus. Now the Columbus module provides the astronauts the possibility to talk to amateur radio users all over the world.

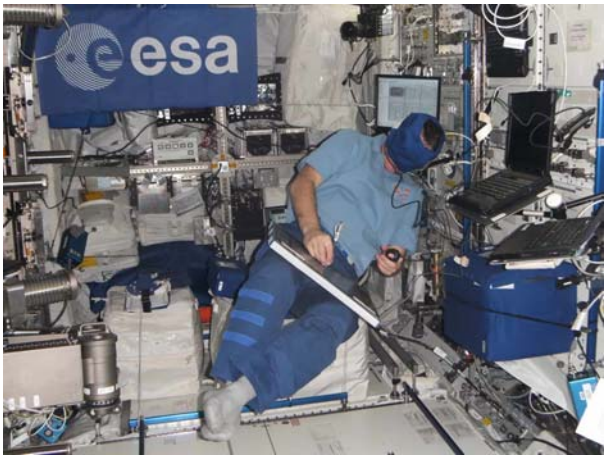

Fig. 5: Paolo Nespoli performs the 3D-Space experiment in Columbus (Credits: NASA)

Among many other experiments like Altea Shield CARD, Passages, Genara was performed in the EMCS in Columbus to investigate the gravity sensing of plants. Col-CC also support the SOLO experiment for measuring the salt input and the effects on a human body in µ-gravity conditions as well as the 3D Space experiment (see Fig. 5) to investigate the change of human perception in space. Both are longterm experiments which need data from several astronauts to produce significant results

To measure the radiation in Columbus the DOSIS experiment was installed in the module in summer 2009 and permanently operated until June 2011. It was de-installed and brought down to earth with ULF7. It now planned to relocate Tissue Equivalent Proportional Counter (TEPC) temporarily to Columbus for radiation measurement in this module. For experiments like SOLO, NEUROSPAT, Genara and CARD several ESA and NASA assets in Columbus were used to run the full chain of experiment steps. The coordination between the different USOCs in Europe, the POIC in Huntsville and the crew onboard ISS was performed by Col-CC flight control team.

Since summer 2008 Col-CC supports B-USOC by taking over the monitoring of the SOLAR external payload if it is in the so-called “idle” mode. This releases B-USOC from a 24/7 shift scheme during that phase that the small team at B-USOC can concentrate on the monitoring and commanding of the external payload in the active phases. Comparable to this approach Col-CC also monitors the STDO (Station Development Test Objectives) Vessel-ID during most of the time to avoid unnecessary night and weekend shift at the responsible N-USOC in Norway. Col-CC is open to support more experiments using a similar concept if it is feasible for Col-CC and wished by a USOC.

Col-CC Ground Segment activities

In parallel to the support of Columbus operations the ground segment team at Col-CC is also responsible for the communication lines needed for ATV operations. Hence, the Col-CC GCT was highly influenced in the preparation, the launch, docking, undocking and re-entry of ATV in spring / summer 2011. ATV was loaded with new experiments, e.g. Geoflow-2, spare parts and food, which was highly welcomed on board. The docking was not only monitored by the astronauts on board ISS (see Fig. 6) but also by an exited Flight Control team at Col-CC.

Despite this high workload for the ground segment in the first half of 2011 the refurbishment of the subsystems at Col-CC was carried on. The Flight Control Team at Col-CC is using the new VoCS in operations since Dec. 2010 after a intensive checkout has been performed. In the last months all European users of the VoCS like USOC and ESC were step-by-step transferred to the new system allowing to stop the usage of the old VoCS beginning of August 2011.

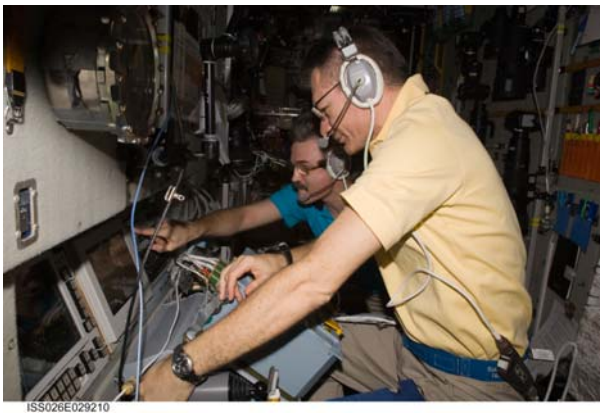

Fig. 6: Alexander Kaleri and Paolo Nespoli monitor the approach of ATV (Credits: NASA)

Also the transition to the new MCS system was carried on. In preparation of the next cycle transition (see below) the first control room K3 has been upgraded to version MCS 4.1 delivered by Astrium and at the moment the upgrade of K4 to the same version is on-going. In parallel the Operations Support tools have been switched from the old SAN to the new SAN (see [8]) in August 2011 ensuring a long-term stability of the system necessary for the now settled operations period until 2020. The goal is to upgrade or exchange the systems with the least possible impacts on operations and to allow for cost reduction in case requirements can be retired or have changed during the last years of operations.

Columbus Onboard Software Upgrade Preparation

As mentioned above the control rooms at Col-CC are already on the way to be prepared for the next software transition, Cycle 13, planned in April 2012. The first control room is equipped with the correct software for the transition and is used by the flight control team to update the database and the ops product to a stage needed to support the transition and to command and control the Columbus module when the new onboard software is running. The FCT is supported by Engineering Support Team (EST) in Bremen in the preparation phase and during the transition, because the onboard as well as the ground software has been developed by Astrium Bremen. It is planned to finalize the preparation work by the end of 2011 and to perform last test at the beginning of 2012. The close cooperation between FCT and EST and the good preparation work will ensure the upcoming Cycle 13 will be performed as smooth the other transitions before.

Lessons Learned and Outlook to long-term operations phase

The Columbus FCT is now well established in the ISS operations community and is looking forward to new challenges coming up in the next years. The first new tasks to be taken over are the responsibility for the planning of crew activities in combined ESA/NASA experiments, which will be started with increment 29/30. While this new task is not so difficult to achieve, the increased crew time for payload activities which will also be available from increment 29/30 onwards will put an additional effort on the team on ground. This crew time was used before for maintenance and assembly task which were planned and prepared by NASA. This offers on the one hand improved capabilities of the laboratory in space on the other side these additional activities on board have to be prepared, planned, coordinated and executed in future.

Fig. 7: Assembly complete of the ISS during STS-134 in May 2011 with Endeavour docked to ISS (Credits: NASA)

On top of this increased payload activities the Columbus module itself has to be prepared for the longer operations time in orbit until 2020. To

achieve this the FCT together with EST has to develop, prepare, and plan measures to ensure that all systems necessary for a safe working environment for the astronauts, for the health of the module and for payload operations are available and in good shape for the longer operations period. This could result in upgrades, repair or exchange of hardware to ensure the reliability of the necessary subsystems until the end of the planned lifetime.

Meanwhile the next European long-term astronauts prepares himself to live and work at the ISS in the next years: André Kuipers in Increment 30&31 and Luca Parmitano in Increment 36&37. This will again offer a lot of opportunities not only for European scientists but also for Col-CC flight controllers to learn more and to get more involved in ongoing ISS operations.

Conclusions

After 3.5 years of Columbus operations it can be stated that the module is running well, but there is continuous surveillance and maintenance - protective and corrective – necessary to keep Columbus and especially the payloads in a healthy status. Hence the flight control team and the engineering support teams are still fully loaded with the preparation, support and execution of such activities. Despite the meanwhile normal 6 person crew on board ISS the offline preparation work in parallel to shift work especially in view of the increased payload activities puts a still high work load on the team.

Nevertheless the FCT enjoys working with the 6 person crew and is using the opportunities offered by the now complete on-orbit infrastructure to the full extent possible.

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