

**IAC-12.B3.4-B6.5.1**

**Development and Implementation of a  
new Columbus Operations Setup**

**D. Sabath\*, G. Söllner\*, D. Schulze-Varnholt<sup>+</sup>**

\* DLR, Oberpfaffenhofen, Germany

+ Astrium GmbH, Friedrichshafen, Germany

**63<sup>rd</sup> International Astronautical Congress,  
1 – 5 October, 2012  
Naples, Italy**

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## DEVELOPMENT AND IMPLEMENTATION OF A NEW COLUMBUS OPERATIONS SETUP

### Author

D. Sabath, DLR, Oberpfaffenhofen, Germany, Dieter.Sabath@dlr.de

### Co-Authors

G. Söllner, DLR, Oberpfaffenhofen, Germany, Gerd.Soellner@dlr.de

D. Schulze-Varnholt, Astrium GmbH, Friedrichshafen, Germany, Dirk.Schulze-Varnholt@astrium.eads.net

### ABSTRACT

After four years of continuous Columbus operations since February 2008 and the end of the Shuttle era in July 2011 the operations concept of ISS and also Columbus has to be partly reshuffled. Despite the last years when tool upgrades and hardware renewals were in the focus of the team now a reorganization of the Flight Control Team itself has to be started.

In parallel to the ongoing operations work which has to ensure a running Columbus module with minimum impact, the FCT has developed a new setup of the on-console and off-console team. This is partly driven by a growing efficiency of the FCT due to their experience on console but mainly to ensure the feasibility and affordability of the project during the long-term operations period until at least 2020. The year 2012 is a pure preparation year laying the basis for the changes to come in the years after. The first implementation of the new setup on console is planned for 2013. Nevertheless the new concept will be full established in 2015, only. Due to the reduced resources foreseen in the new concept there will be a lot of influences on the performance of the flight control team and on how operations is done at Col-CC when the new concept is implemented. Nevertheless the necessary tasks of the Col-CC FCT will be performed during transition and after the final implementation of the concept.

Besides this big preparation work to be done in 2012 also the normal operations work has been performed with rack tilting, exchange of hardware, a major software upgrade of the Columbus module and support of the payload operations in Columbus.

The paper will give an overview of the achievements and highlights of the last year and concentrate major change in the setup of the Columbus FCT which is one of the preparatory tasks for the planned ISS operations until 2020.

### Introduction

Looking back on the 2008 the Columbus flight control team has now more than four year experience in operating Columbus. A lot of task

which were extraordinary at the beginning are now standard tasks and can be done in the normal work flow. On the other hand new tasks have been added, e.g. WOOV replacement and encapsulation which was not planned before the launch. Hence, the operation of the Columbus module always offers new tasks and excitement on new challenges waiting for the flight controllers and the supporting teams.

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After the major upgrade of the ground systems of the Columbus Control Center have been performed in the last years the focus is now on restructuring the flight control team to ensure cost efficient and reliable operation with small limitations, only. Meanwhile Col-CC has a long experience in manned space operations starting with the Eneide Mission in 2005 and the support of the Astrolab mission with Thomas Reiter in 2006 (see [1] and [2]) and then from 2008 onwards with Columbus operations (see [6] to [9]). Since then the Industrial Operations Team (IOT, see [3] and [5]) operates, monitors and maintains this ISS element at Col-CC. Now the next step is the adaptation of the Flight Control Team of the Columbus Control Center to the changed boundary conditions to ensure the long-term operations period until at least 2020.

### **European Astronaut André Kuipers on ISS**

On 21 December 2011 the next ESA astronaut André Kuipers was launched to orbit in Soyuz 29 capsule from Baikonur. He arrived at the ISS on 23 December together with his crew mates Oleg Kononenko and Don Pettit (see Fig. 1). After about two months they learned that they will have to stay 6 weeks longer in orbit due to a delay in the launch schedule of the subsequent Russian Soyuz capsule. Hence, André Kuipers and his crew mates had to stay until 1<sup>st</sup> July 2012 until they could go back to earth.



Fig. 1: Andre Kuipers, Oleg Kononenko, Expedition 31 commander and Don Pettit in their Sokol suits (Credits: NASA)

### **System Maintenance Activities**

After the successful WOOV-8 replacement in 2011 and the subsequent inspection and analysis of the hardware on ground it was realized that also the other WOOVs have to be inspected and possibly treated specially. On 14 October 2011 the WOOV 3/4/5 inspection was performed (see Fig. 2). During the inspection Satoshi Furukawa cleaned the WOOVs and insulated the WOOV to avoid contamination in future.



Fig. 2: WOOV 2/4/5 during inspection (Credits: NASA)

The same inspection is planned to be performed for the other WOOVs. The manifold which replaces WOOV-8 since the beginning of 2011 will be replaced again by a new WOOV valve by end of 2012.



Fig. 3: André Kuipers during inspection and cleaning of the CFA ducts (Credits: NASA)

Beside other maintenance work the Columbus CFA inspection and cleaning has to be performed. It was monitored that the performance of the CFA

were slowly degrading and therefore the CFA cleaning was prepared. On 22 and 23 February André Kuipers together with ISS commander Dan Burbank open the CFA ducts, inspected and cleaned the ducts and reassembled the parts (see Fig. 3). The CFA checkout after the inspection shows that the cleaning was successful and the CFA performance was back to nominal.

On 6 July 2012 the master MMU2 failed and automatic reaction initiated the slave MMU1 to resume operations which has been performed several times during the last four years. Nevertheless during rebooting of the MMU2 it was detected that the Solid State Disk of the MMU2 shows some defects and was not usable anymore. As each MMU has two SSD available an R&R had to be developed to bring MMU2 back to operational. The first approach was to perform a hardware exchange of the SSDs which would have needed up to 3 hours of crew time. In parallel an alternative strategy was established by the engineering team. A new feature in the onboard software uploaded during Cycle 13 software upgrade (see below) offers the possibility to re-configure the MMU software wise to access the second SSD as boot disk. After intensive ground testing with positive results this approach was chosen and the procedure was executed on 24 July. After booting of MMU2 from the second SSD and re-alignment with MMU 1 the redundancy was established again.

### **Payload Operations Support by Col-CC**

Besides the Columbus system monitoring and maintenance activities (see previous chapter and [11]) Col-CC is also providing payload operations support the USOCs and to POIC. The main task of the Columbus laboratory is the support of experiment therefore a small number of experiments out of the whole experiment set can be mentioned here, only. After several large and long-lasting experiments like Geoflow or PCDF, which have been performed in the last years a larger number of short running experiments were schedule in the preceding months

One of the experiments which has already been performed by several astronauts is NeuroSpat (see Fig. 4) with CADMOS as the responsible USOC. NeuroSpat investigates the ways in which crew members' three-dimensional visual & space perception is affected by long-duration stays in weightlessness.



Fig. 4: André Kuipers performs the Neurospat experiment (Credits: NASA)

To get ready the Biolab rack for the next experiments planned for the upcoming increments a series of maintenance activities of the rack have been prepared and performed by MUSC. Fig. 5 shows André Kuipers supporting a Biolab Health check in Columbus which was one of several planned activities with this rack in the last months. When all maintenance activities are finished in a few months, Biolab will be again available for experiment support in Columbus.



Fig. 5: André Kuipers support a Biolab Health check (Credits: NASA).

Nevertheless also small experiments sometimes need extra effort to produce good results: Together with the astronauts and cosmonauts also the samples of the ESA experiment ROALD-2 (Role of Apoptosis in Lymphocyte Depression 2) was flown into space with Soyuz 29. This experiment has to be performed shortly after launch of Soyuz 29 because of time constraints for the samples and needs therefore a careful planning by the USOC CADMOS and Biotesc as well as by Col-CC. Fig. 6 shows André Kuipers working with the ROALD-2 experiment in the KUBIK-3 thermostatic container.



Fig. 6: Andre Kuipers works with the ROALD-2 experiment in KUBIK-3 (Credits: NASA)

### Adaptation of Columbus FCT

After the decision to keep the ISS and Columbus in operation until at least 2020 a major review of the way how to operate Columbus over this long period took place. Taking into account the given boundary conditions and resource constraints for the upcoming years all groups involved in Columbus operations have to adapt the way to work including the Columbus Flight Control Team.

A lot of option were discussed how to change the flight control team to come to a suitable team structure for the future. In the end the only possible solution was a merger of two control room position to one which lead to a reduced 24/7 team in the Columbus Control Center. The two position to be merged are the DMS/Comms position and the Systems position which are combined in a new 24/7 position called STRATOS (Safeguarding, Thermal, Resources, Avionics, Telecommunications, Operations, Systems). The STRATOS position will take over most of the tasks of the former DMS/Comms and Systems positions but will also incorporate some restrictions in operations which are described below.

After the decision has been made to reduce the flight control team from 4 to 3 permanent positions the work on the new concept started in autumn last year. The new concept included the tasks of the new positions mainly to be taken over from the DMS and the Systems position. Due to the reduction from two persons to one the first restriction is that many tasks cannot be done in parallel anymore. Additionally special tasks like R&R activities cannot be done with one STRATOS alone but need support from a STRATOS specialist. Many other adaptations have to be introduced to allow mostly smooth operations with the new concept.

The next major preparation step is the training of the flight controllers (see also [10]). As only certified DMS and Systems flight controllers will be cross-trained as STRATOS in a first step, some parts of the full flight controller training can be omitted. Nevertheless the knowledge of the other position has to be learned and the new tasks have to be trained in simulations which will take about 7 months according to the current plan. In Fig. 7 the schedule for the cross training can be found. While the preparation for the start of the training of the first STRATOS trainees are nearly finished, the training of 14 STRATOS flight controllers will last until mid of 2015. During this period always at least 2 flight controllers will be in training which will also influence the available resources for on-going operations. It is planned that the first STRATOS is on console by mid-2013 and will take over more and more the tasks of DMS and Systems in the years to come.

### Columbus Onboard Software Upgrade

As mentioned above the latest Columbus onboard software transition, Cycle 13 has been performed in April 2012. First one control room (K3) was equipped with the correct software for the transition and was used by the flight control team to update

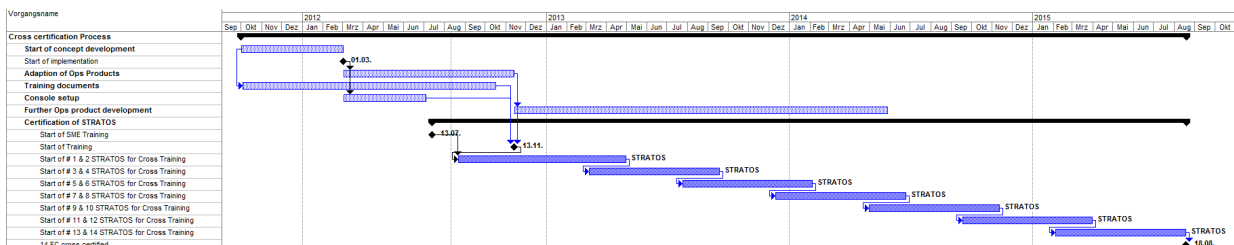


Fig. 7: STRATOS Cross certification schedule

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. Meanwhile the main control room K4 was used for operation with the old ground software until transition. The FCT was 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. After the last tests have been performed in the first quarter of 2012 everything was ready for the transition day. Due to the good preparation by FCT and EST the on-board software transition was running smoothly and the FCT operated the module from K3. After about 2 months the main control room was updated and Col-FCT could resume operation in K4.

#### **Outlook to long-term operations phase**

The Columbus Control Center has performed a major step forward the long-term operations phase by starting the restructuring of the Columbus Flight Control team. The restructuring adapts the Col-FCT to the given boundary conditions and ensures that the Columbus module can be operated for the years to come. Nevertheless some restrictions have to be introduced according to the reduction of available workforce on console.

Besides the training of the FCT which has already started also the control rooms at Col-CC have to be partly refurbished to be adapted for the needs of the new FCT setup. The three control rooms at Col-CC will be changed in the next months ending with the main control room K4 to be ready for STRATOS operation in the second quarter of 2013.

Meanwhile the next European long-term astronauts prepare themselves to live and work at the ISS in the next years: Luca Parmitano in Increment 36&37, Alexander Gerst in Increment 40&41 and Samantha Cristoforetti in 2014/15. 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 more than 4.5 years manned space operations in the ISS context is well established at

Col-CC and many tasks have now a more routine character compared to the years before. Nevertheless the flight control team has now to focus new challenges, i.e. to restructure the team, the setup and the processes to adapt to the new boundary conditions to ensure a long-term operations phase until 2020 and maybe beyond.

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