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First Experience with New Col-CC Console Setup

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ABSTRACT

On 7 February 2013 the Columbus Flight Control Team achieved five years of continuous Columbus operations. This centenary is on the one side a good opportunity to look back on five successful years but on the other side also a starting point for changes in the way operations is done in future.

Last year the Columbus Flight Control Team started with the definition and implementation of the merger between two important console positions – DMS and Systems – to a new position called STRATOS. Meanwhile the training of the first flight controller is finished and the first shift has been performed on 3 April 2013. In parallel all three control rooms were adapted to the new setup and are available for STRATOS operations as planned.

The first simulations have shown that the new chosen setup is feasible but some fine-tuning was necessary to optimise the work on console. This was done before the first STRATOS shift. Despite these optimization of the on-console tasks the reduction of the 24/7 on-console team from 4 to 3 persons leads to some impacts in the work of the FCT. The transition phase from DMS and Systems to STRATOS will last until 2nd half of 2014 when all DMS and Systems flight controllers are cross-certified and ready for on-console work.

Besides this big preparation work to be done in 2013 also the normal operations work has been performed with rack tilting, exchange of hardware, ground software upgrades and hardware changes, support of the ESA crew member on board ISS and the support of payload operations in Columbus.

Introduction

Looking back to 2008 the Columbus flight control team has now more than five 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. Water On Off Valve (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.

After the decision to reduce the 24/7 console staffing at Col-CC one of the major task of the Columbus Control Center was the restructuring the flight control team to ensure cost efficient and reliable operation with small limitations, only. Based on the long experience of Col-CC 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 [10]) the new concept with FD, OC and STRATOS on console has been

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developed, trained and the first STRATOS flight controllers work from April 2013 onwards. This new concept will to ensure the long-term operations period and will allow to operate Columbus under changed boundary conditions until at least 2020.

European Astronaut Luca Parmitano on ISS

When ESA Astronaut André Kuipers left ISS in December 2012 the next ESA Astronaut was already in the final stage of his training. In the course of his final training steps Luca Parmitano visited Col-CC for a pre-launch tag-up to discuss the upcoming increment and to agree on the cooperation between control center and the astronaut during his stay at the ISS (see Fig. 1).



Fig. 1: Luca Parmitano with Col-CC flight controllers in control room K4 (Credits: G. Zoeschinger)

Luca Parmitano left Earth on 28 May to dock to ISS with Soyuz 35 on 29 May 2013 (see Fig. 2). Already in the first 2 months of his stay on-board ISS he largely contributed to the Columbus operations, e.g. by exchanging the failed Water Pump Assembly 2 (WPA 2) and the maintenance of the Biolab rack (see below). Until his return to earth planned for November 2013 a lot of other tasks are waiting for him and the Columbus Flight Control Team.



Fig. 2: Fyodor Yurchikhin, Luca Parmitano and Karen Nyberg prior to their launch from Baikonur (Credits: NASA)

System Maintenance Activities

After 5 years of operations the probability of a degradation of on-board is rising and the Flight Control Team together with Engineering Support Team (EST) has to be prepared to repair or exchange on-board equipment. One of the first examples is the exchange of the WOOV-8 which has replaced by a manifold in 2011 [10]. To regain full control of the Columbus Thermal Control System (TCS) a newly developed WOOV MKII was brought to the space station by the end of 2012.

On 18 January 2013 Chris Hadfield supported by ISS CDR Kevin Ford successfully performed the replacement of the Columbus Water Temporary Substitution Manifold (WTSM) with a new WOOV Mk II. To access the worksite it was necessary to rotate the ER-3 rack. The new valve was installed without problem and also the checking of the valve using ground commands was successful. After a complete checkout of the TCS system, the TCS and Environmental Control and Life Support System (ECLSS) subsystems were reconfigured to nominal.

During the exchange of the WOOV-8 the astronauts realized that a replacement WOOV-7 was necessary, too. Nevertheless there was no hurry because WOOV-7 was still working well. Hence, a second exchange activity was scheduled

for 23 April 2013 which again asked for tilting Express Rack 3 (ER-3). ISS CDR Chris Hadfield successfully performed the replacement of the Mk I valve in the WOOV 7 location with a new Mk II valve with the additional support of Flight Engineer Tom Marshburn.

On successful completion of the WOOV 7 R&R, Col-CC confirmed good functionality of the new Mk II valve through ground commanding and gave ISS CDR the GO to close out the worksite. After completing the ER-3 rotate up activity, Col-CC returned the Columbus TCS and ECLSS configuration to nominal.

In January 2013 during a routine switching procedure between the two redundant water pumps in Columbus the WPA 2 was not reacting as expected. The investigations starting after this event lead to a high probability of a severe problem with WPA 2. To avoid a complete outage of Columbus active thermal control system (TCS) the trouble shooting has to be performed with great care. After coordination with all involved parties including NASA a test was developed and performed to check the status of the suspicious pump.



Fig. 3: Luca Parmitano prepares the new WPA for installation (Credits: NASA)

To avoid any ripple effect on the running pump WPA 1 and the Columbus TCS, WPA 2 was taken completely out of the cooling system for this test and was tested in a short-cut tubing system to create a small water circuit. After preparation on ground and on board the test was performed but WPA 2 was not reacting and declared as failed. Fortunately ATV-4 was close before launch and a spare pump could be loaded in ATV-4 on short notice to shorten the time without redundancy for the Columbus TCS. ATV-4 was successfully launched on 5 June 2013 and brought the spare

water pump with many other experiments and logistics items, water and fuel to the ISS.



Fig. 4: Luca Parmitano installs the new WPA in Columbus (Credits: NASA)

Before the WPA activity could take place all the operational products had to be prepared, which was performed by the Increment Team together with EST. A description of the work of the increment team at Col-CC is given in [12]. On 5 July the exchange of the water pump was performed by Luca Parmitano. He replaced the failed pump by the spare part and set up again a small water circuit for the testing of pump (see Fig. 3 and Fig. 4) This time the test was successful and the new WPA 2 was finally integrated in the Columbus TCS re-establishing the full redundancy for the Columbus TCS. Some days later on 11 July the switch-over was successfully performed to run the Columbus TCS using WPA 2 and giving a relief to WPA 1 after nearly half a year of continuous service.

Payload Operations Support by Col-CC

The experiment with the longest run-time on Columbus is the Solar external payload, which has been installed during STS-122/1E and is active since then. Nevertheless it was not possible to measure a complete rotation of the sun because the ISS obscures the view for two weeks every month (not counting the shadow phases of the ISS). To allow the observation of the sun continuously over one full sun rotation it was necessary to rotate the ISS by some degrees for about 10 days to ensure a continuous sun observation. After a lot of preparation on working level supported by Col-CC and high level agreement the ISS was turned by about 7 degrees on 1 December for the necessary 10 days to allow a continuous measurement of the sun over a full rotation.

As already described in [10] the Biolab rack is undergoing several maintenance and refurbishment steps to be ready for the next payload planned for beginning of 2014. Fig. 5 shows Luca Parmitano during the Biolab maintenance activities in July 2013.



Fig. 5: Luca Parmitano during Biolab maintenance activities (Credits: NASA).

All these activities have to be well prepared on ground by a combined effort of the responsible USOC, EST and the Col-CC OC team which is responsible for the payload coordination. The work of the Increment Lead OC is described in [11]. Additionally to standard maintenance some parts of Biolab have to be replaced after 5 years in orbit. In Fig. 6 Luca Parmitano is shown during installation of the Life Support Modules of the Biolab rack in July 2013. The Life Support Modules contain the samples during an experiment runs with Biolab.



Fig. 6: Luca Parmitano installs the Life Support Modules in Biolab (Credits: NASA)

These are only a few examples of the payload support task of Col-CC. Many more payloads and experiments have been run by the USOCs

supported by Col-CC to ensure a high science return of the Columbus module.

Adaptation of Columbus FCT

The Columbus Flight Control Team is currently in the phase of a major restructuring to reduce the permanent on-console positions from 4 to 3. To achieve this, a new operations concept has been developed which is outlined in [10] showing that the two separate positions DMS/Comms and Systems are merged to a new position called STRATOS. Due to the combination of the already merged position DMS/Comms and the Systems positions responsible for 3 subsystems, the new position is responsible for the 5 major Columbus subsystems ECLSS, TCS, EPDS, DMS and Comms. This leads to very demanding tasks on console which could lead to overload of the console position in special situation. To avoid this some ops products have be rewritten or newly established to give the STRATOS and the Col-FD on console clear guidelines how to act in these situation.

The following ops products had to be adapted, changed or newly established before start of console work of the STRATOS position:

- Operations Data File (ODF)
- Flight rules
- Payload regulations
- Operations Interface Procedures (OIP)
- Joint Operations Interface Procedures (ESA JOIP)
- Flight Control Operations Handbook (Col-CC FCOH)

Additionally the following tools, displays and documents have to be updated

- Pass on information (POI)
- Handover sheets
- Position tools
- Ops Support Tools
- Manning Roster
- Col-CC T & Q Plan
- Subject Matter expertise (SME) training material

Based on the new concept and the updated ops products listed above a cross training has been developed. Due to the time constraints for the implementation of the new concept, the changes in the ops products and the cross training development were done in parallel which increases the necessity of good coordination of all tasks. To ensure this, a regular weekly internal meeting for STRATOS transition was established to follow the on-going work, to show problems in development and implementation, to trigger decisions and to steer the restructuring in the right direction and according to the predefined schedule.

The cross training started in summer 2012 with 2 trainees as forerunners going into simulations in November 2012. Using the feedback for the first training experience some fine-tuning in the cross-training approach was introduced to offer the next trainees an improved roadmap. After performing the necessary simulation in winter 2012/13 the first STRATOS flight controller were finally certified in March 2013.

In parallel to the training information exchanges were done in several occasions to introduce the new setup at Col-CC to the ESA team and the internal partners and the changes, e.g. in call signs, which they should expect at the start of the new position on console. The feedback from these discussions were also included in the concept before starting the first shift on console.

After all these preparation being performed over more than a year the first STRATOS shift was performed on 3 April 2013. Since then the STRATOS take over part of the shift work from the DMS and Systems team. Due to the small number of 4 certified STRATOS up to now the STRATOS team is not able to take over the whole shift work. Hence, more than 50% of the shift work is still performed by DMS and Systems team members. This leads to the necessity for continuous handover from 2 positions (DMS/Comms and Systems) to the STRATOS positions and back. Thanks to the good preparation work and supported by early feedbacks during the first shifts a good handover concept has been found ensuring the flow of information from shift to shift independent of the manning of the console.

To ensure a suitable working environment for the new position the control rooms at Col-CC had to be refurbished. The necessary rework and change of the console setup has been performed in 3 Steps:

In a first step the B/U control room K11 was refurbished because of the layout of the consoles (DMS and Systems double-console were already directly connected) the new setup was easy to realize. To ensure a good overview on the extended number of monitors, they were stacked in two rows. After implementing this new setup, simulations were performed in the backup control room allowing a check of the new setup in close-to-real-ops situations.

Using the experience from the first simulations in K11 a design for K3 was developed. The double consoles of DMS and Systems are combined in one "triple console" with two rows of monitors to offer a good overview for the flight controller. The change from one row of monitors to 2 rows of monitors reduces the view on the big screens for the other team members. Hence the new console was put to the back to avoid disturbances in viewing for the other positions.

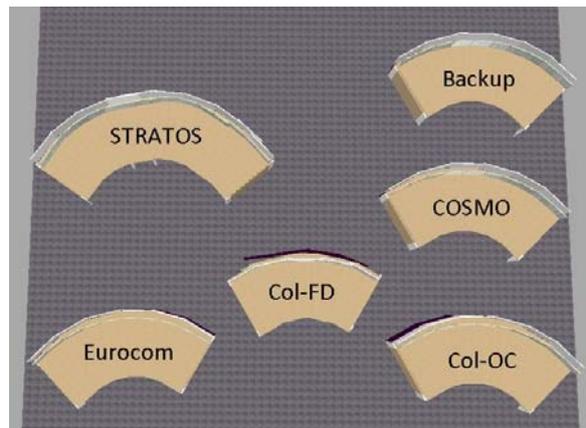


Fig. 7: Layout of K4 after STRATOS upgrade

The final step was the upgrade of the main control room K4. Due to the larger control room and the gained experience in K11 and K3, the setup of K4 was slightly modified as seen in Fig. 7. After some months of operation in K3 it was evident, that the line of sight between the flight controllers was more important than the line of sight to the big screens. Hence, the STRATOS console in K4 was placed in the front row to allow good communication and viewing lines between all positions. Re-arrangement of information on the big screens guarantees the view on all necessary data for all participants. This setup is used in K4 since April 2013 providing a suitable environment for the Col-CC flight controllers.

Outlook to long-term operations phase

In the next years a number of European astronauts will live and work on the ISS. At the moment Luca Parmitano is on board ISS during the increments 36&37. He will be followed in May 2014 by Alexander Gerst for the Increment 40&41 and Samantha Cristoforetti in December 2014 for the increments 42&43. Meanwhile already the ESA astronauts for Increments 46&47 Timothy Peake starting in December 2015 and for Soyuz flight in September/October 2015, Andreas Mogensen have been announced. 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 5.5 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 there are always new challenges for the Flight Control Team, like the WPA exchanges described here and the preparation and coordination of a number of new payloads offering new research opportunities to the scientists. Additionally the flight control team has to focus new challenges in the operational setup, i.e. to restructure the team, the setup and the processes which will continue next year. This still ongoing process will allow adapting the FCT to the new boundary conditions to ensure a long-term operations phase until 2020 and maybe beyond.

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