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New Col-CC Operations Concept and New Challenges

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NEW COL-CC OPERATIONS CONCEPT AND NEW CHALLENGES

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ABSTRACT

On 15 January 2014 the Columbus Flight Control Team implemented the New Operations Concept after a short term preparation phase in the second half of 2013. The new setup consists of two 24/7 positions Col-FD and STRATOS support by several 8/5 positions like COSMO and COMET as well as the Eurocom. This new operations concept has been established in short timeframe in parallel to the ongoing cross-certification of the DMS and Systems team members to STRATOS.

Due to the short preparation phase the new setup has to be improved and fine-tuned will already in use together with updating the relevant ops products. It is planned to finalize the transition phase by mid of 2014 which will allow providing a first experience of the new setup.

In parallel to these big setup changes of the FCT a lot of challenges are waiting for the team. In January 2014 the next on-board software upgrade – Cycle 14 – has been successfully performed. The preparation for the next increment 39/40 is in full swing especially the preparation for the "Blue Dot" mission of the German ESA astronaut Alexander Gerst. During this mission many new payloads will be brought to the ISS and many experiments will be performed in Columbus.

Introduction

In the last 3 years Col-CC FCT implemented two big restructuring efforts leading to a completely new console setup. Shortly after the introduction of the new console setup in spring 2013 the second step has been introduced by taking the Col-OC off-console. 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]) this big effort has been successfully implemented. Nevertheless the new setup shows some limitation in operations stemming from the reduced resources on console. The new operations concept will allow operating Columbus until at least 2020 assuming that the boundary conditions won't change (see [10]).

In parallel to the restructuring of the Col-CC FCT the preparation of new exciting experiments like Airway Monitoring, EML or PK4 have been started. As an example for such experiments the PK4 preparation work will be described below.

European Astronaut Alexander Gerst on ISS

In May 2014 a one year period of nearly continuous presence of ESA astronauts in space starts. First ESA Astronaut Alexander Gerst left Earth in May 2014 for a stay on the ISS until November 2014 followed by next ESA astronaut Samantha Cristoforetti from December 2014 to May 2015. To prepare their mission both Alexander Gerst and Samantha Cristoforetti visited

Col-CC in 2013 and 2014, respectively. During this pre-launch tag-up the upcoming increment was discussed and the cooperation between Columbus control center and the astronaut during his stay at the ISS was agreed (see Fig. 1).

Fig. 1: Alexander Gerst and the Col-CC Team during his stay at Oberpfaffenhofen (Photo: DLR/Zoeschinger)

The launch of Soyuz on 28 May was picture-perfect and with the new transfer approach the crew reached ISS already 6 hours later (see Fig. 2). ATV-5 – the last ATV – launched two months later to ISS delivers a lot of new experiments providind a lot of work for Alexander Gerst and the Columbus Flight Control Team.

Fig. 2: Alexander Gerst, Maxim Suraev and Reid Wiseman prior to boarding the Soyuz TMA-13M (Photo: NASA)

New Operations Concept

In [10] the development of the Col-FCT and GCT has been described and an outlook to the future has been given. The new operations concept which has been started in January 2014 is still in the transition phase. Fig. 3 shows the main Col-CC control room with the two remaining 24/7 FCT position Col-FD and STRATOS. The transition period is planned to be finalized by the end of 2014 when all ops products are up to date again and the workarounds implemented in beginning of the year can be retired.

Fig. 3: Main Control room of the Col-CC during Increment 39 (Photo: DLR/Zoeschinger)

In the first half year 2014 the new setup shows that the reduced team on-console without OC is constantly at the rim of their operational capabilities and is partly overloaded in case several activities have to be performed in parallel. The flexibility of the Col-CC FCT is reduced especially during high activity periods while increasing the risk of operational errors.

As expected in previous analysis, [12] the performance of the on-console team and its flexibility has decreased over the last years. Therefore following consequences of the on-console team reduction and workarounds have been implemented in Columbus real time operations environment:

- Sequential working of Columbus payloads, i.e. activation of racks and payloads by the team on console
- Adding time buffer between activities by means of planning to allow clean-up work or to cope with delays if necessary
- Reduced re-planning capabilities, i.e. only one shift instead of three shifts

- Reduced knowledge in technical details on console
- Loss of flexible reaction to real-time changes including anomalies
- Loss of the four- eyes principle for technical decisions because of one technical position available, only
- Loss of Ground Segment flexibility and availability

In the next months the new setup will be consolidated and small adaptation will be introduced to make the new setup ready for the years to come. The updates and if applicable the ownership transfer of the OPS products from Flight Control Team (FCT) to USOCs including Flight Rules, Operations Data Files, Payload regulations, Operations Interface Procedures (OIP), Joint Operations Interface Procedures (ESA JOIP), Flight Control Operations Handbook (Col-CC FCOH). Finally, as explained in [10] further reduction in the FCT would increase the operational risks to an inacceptable level and has to be avoided in any case.

Plasma Kristall 4 (PK-4) Payload

In parallel to the new constrains driven by the FCT reduction, the upcoming European Astronaut missions and ISS expeditions contain several new complex European experiments. One of the payloads which will be deployed on board ISS in December 2014 is Plasma Kristall 4 (PK-4). The PK-4 will be launched on the Progress resupply vehicle flight 57P by the European Space Agency (ESA) in cooperation with the Russian Space Agency. PK-4 payload is designed to investigate Direct Current (DC) controlled plasma under microgravity conditions.

It is the 4th generation payload, which is build based on the three successful on-board campaigns performed on-board the ISS on the Russian Segment. Once deployed and installed in Columbus in December 2014, PK-4 will be operated in the "European Physiology Module (EPM)" during the next years. Figure 4 is showing PK-4 installed into EPM rack in COL1 A3 location.

PK-4 experiment preparation and execution is a consolidated effort with support provided by MCC-H, MCC-M, POIC, COL-CC and CADMOS OPS.

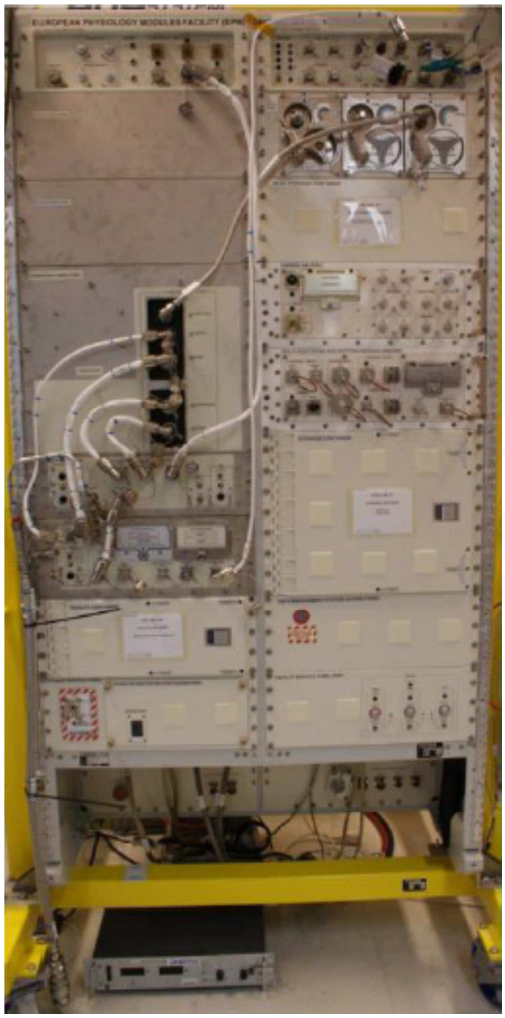

Fig. 4: COL EPM rack configuration V 2.0 with PK-4 integrated

In particular, the ESA being owner of the payload has the overall coordination for PK-4 integration on-board ISS. Moreover, ESA is providing the PK-4 hardware and payload control capabilities via COL-CC and CADMOS. While on-board Crew time is mostly provided by the RSA as part of the bilateral agreements. MCC-H is supporting the experiment mechanical integration by means of providing temporary stowage location on USOS segment and power resources during the PK-4 experiment execution. Furthermore, US Crew member involvement and the overall activity flow execution are coordinated with MCC-H.

POIC centre in Huntsville is providing support during PK-4 mechanical integration by means of reconfiguring COL external payloads as part of the safing requirements.

Due to complexity of the PK-4 payload integration choreography a dedicated team was nominated within the COL FCT in order to support payload preparation, integration and execution during the real time OPS by concentraining on operational aspects. In particular, PK-4 flight control team points of contacts have been nominated in the COL Flight, EPIC, COMSO and EUROCOM team.

Obviously, PK-4 preparation has plenty of aspects starting from lessons learned coming from the previous science runs, throughout hardware development, testing, certification and integration into real time OPS. Science script development, experiment run preparation and on-board execution is extremely wide area, which is not going to be toughed within the scope of this paper. Here I'm concentrating on real time operations aspects and on-board activity preparation performed by the FCT.

During the PK-4 preparation, among other documents a dedicated Operations Interface Procedure has been developed in coordination with CADMOS OPS, Columbus Flight Control team and International Partners. Based on contractual agreements, this OIP specifies the operational roles and responsibilities during different phases of the Plasma Kristall-4 (PK-4) experiment preparation and science campaigns execution on board the ISS including:

- Responsibility for OPS product preparation
- Responsibilities for coordination and allocation of payload resources
- Specification of the responsibilities for on-board operations
- Planning coordination choreography from offline until the execution in real time OPS
- Stowage coordination choreography
- Communication path between ISS Crew, COL-CC, CADMOS, MCC-H, MCC-M and POIC
- Response to on-board anomalies and unscheduled events
- Point of contacts for PK-4 in all involved control centres.

Fehler! Verweisquelle konnte nicht gefunden werden.: Team of Scientists and Flight Controllers supporting PK-4 experiment preparation at CADMOS OPS in February 2014.

In addition to the nominal OIP pre-coordination, some of the interface descriptions could be tested during the simulations. The coordination between COL-CC and CADMOS and the interface to MCC-H have been tested. Moreover, the simulation environment was used for evaluation of the PK-4 Operations Data file procedures for the experiment mechanical integration. Comments from the simulations and training have been incorporated into OPS products and OIP before starting the formal review.

In Fig. 5 a typical view of the plasma Kristall experiment science video is showed.

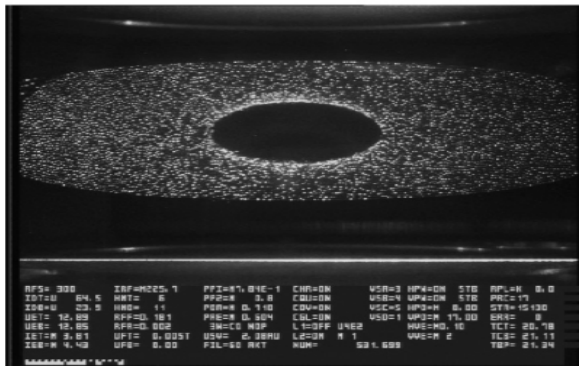

Fig. 5: Example of Plasma Kristall experiment video and telemetry downlinked from ISS to the ground

Final step before OIP formal review was coordination with MCC-H, POIC and MCC-M during the Increment 41/42 preparation. OIP pre-coordination has made unresolved questions transparent in a timely manner. For example, based on the OIP draft the coordination of the additional temporary stowage allocation in USOS segment was started between COL-CC COSMO and MCC-H ISO team. Furthermore, an update of

the COL-CC voice subsystem matrix was started for being able to provide talk and listen capabilities to the science and CADMSO OPS team during PK-4 mechanical integration and science campaigns. Awareness about PK-4 specifics and constraints was triggered at Increment, planning and flight control team levels.

As a consequence the open questions identified during OIP coordination could be transferred into concrete action items and mostly solved in a timely manner.

In addition to the process description document COL-CC FCT has developed an integrated flow chart of the PK-4 on-board activities. While payload developer community is concentrating on payload itself and interface to the Columbus module, the purpose of the integrated flow chart is reflecting:

- Dependencies with other COL payloads (external payloads)
- On-board and on-ground recourse allocation constraints (power high rate data, space and working volume allocation in the COL module)
- COL subsystem reconfiguration activities required as part of the preparation and clean-up for the PK-4 (venting system leak check)
- Other control centre activities, which are prerequisites or Flight Rule requirements for a dedicated PK-4 activity to happen
- Transfer of the PK-4 containers into COL module for the mechanical integration and empty bag trash activities
- Coordination and prerequisite requirements between different positions of the COL flight control team and/or IPs
- Crew time allocation (RS/USOS Crew time)

In addition, the integrated PK-4 is used as a reference by the Flight control team allowing keeping track on the overall flow of the PK-4 experiment on-board preparation.

Conclusion

Summarizing first lessons learned concerning PK-4 experiment operational aspect preparation following conclusions are made:

- COL FCT reduction has impacts on the real time OPS environment as well as offline work including increment preparation and execution tasks
- In case by case basis a dedicated team shall be nominated for a curtain experiment to support the increment team
- Dedicated team is acting as a point of contact for a curtain complex experiment preparation and execution
- New processes shall be defined, pre-coordinated and tested as part of experiment preparation
- Agreements achieved at agency and flight control team level shall be transferred into operational documentation, meaning a dedicated OIP/JOIP

Summarizing the current status of the new COL-CC operational concept, following conclusion can be made: the reduction in resources which were implemented during the last 3 years is much larger than the gained efficiency increase. Hence, the performance, the flexibility and the availability of the teams at Col-CC have to be reduced to adapt to the new boundary conditions while increasing the risk of operational errors. Any further reduction in on-console or off-console work force would increase the risks to an inacceptable level with potential impacts on the long-term operations of the Columbus module. For the sake of successful and smooth Columbus operations in the upcoming years the size of the Col-CC team should not be further reduced or restructured.

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