Microgravity User Support

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The Microgravity User Support Center (MUSC) at the DLR site Cologne is in charge of payload and experiment operations on orbital and sub-orbital platforms. It provides large-scale scientific and technical ground infrastructures including scientific laboratories and payload control rooms. MUSC is contracted by ESA since 1995 to take the main role in European User Support in the fields of Material Science, Biology and Radiation Research, including experiment planning, verification and operation on the International Space Station to support European principle investigators. In this framework MUSC is entrusted by ESA with the experiment preparation, verification and payload operation in dedicated science fields in coordination with the scientific user community. The European payloads Materials Science Laboratory (MSL), Biolab, Dosis, the Electromagnetic Levitator (EML) and the European Drawer Rack (EDR) are operated from the MUSC control rooms.

The MUSC is cooperatively operated by the Institute of Space Operations and Astronaut Training, the DLR Institute of Materials Physics in Space and the Institute of Aerospace Medicine. It benefits from the long-term scientific experience and the extensive knowledge in payload operation of the contributing DLR Institutes from the beginning of research under microgravity conditions with the first TEXUS flights and the German Spacelab missions in the 1980s.

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Photos

2. Microgravity Research Services

Fig. 2-1 Alexander Gerst during Biolab operations

In the present decade microgravity research is dominated by the utilization of the International Space Station. Experiment preparation and payload operation is nowadays performed by four European User Support Centers on behalf of ESA. The Centers are outfitted with Agency Furnished Equipment to interface the European ISS Ground Operations network and to accommodate ground models of the ESA developed payload facilities. The Centers are supported in their work by an offsite industrial engineering team providing sustaining payload engineering tasks. MUSC is instrumental for payload operation preparation, real-time data distribution and payload commanding. During in-orbit operations MUSC receives payload and experiment telemetry and performs, in coordination with the Columbus Control Center in Oberpaffenhofen and the US Huntsville Payload Operation Center, the respective payload and science operations it is responsible for. Furthermore MUSC is performing payload ground model operations, payload and experiment procedure development, as well as experiment verification and validation.

In the framework of data archiving and valorisation in the EU project CIRCE (Cooperative International Space Station Research Data Conservation and Exploitation) a concept and a roadmap for the Long Term Data Preservation (LTDP) of ISS experiments data were developed by MUSC together with partners from Telespazio (It) and CADMOS (F). In coordination with ESA a new data policy for experiments performed during human spaceflight was developed and a strategy for a data infrastructure for ISS defined. Based on these recommendations, in 2018 the ESA Human Spaceflight Program Board approved a new data policy for experiment data received from experiments under microgravity conditions including precursor missions on parabolic flights, sub-orbital missions and the ISS. Medium term data archiving is continued at MUSC and long term data archiving is now implemented within ESAs LTDP program at ESAC in Madrid.

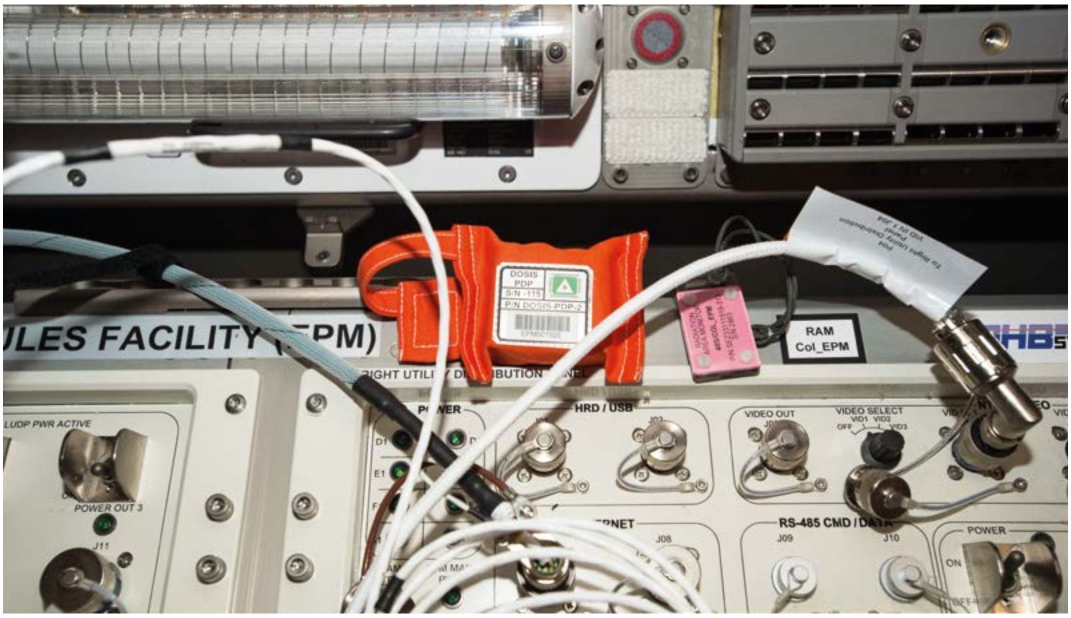

Fig. 2-2 Dosis_Dosimeter in ISS Columbus module

Presently, data archiving at MUSC is realized using the platform ‘Hypertest’, which was developed together with the medium enterprise WERUM. The platform provides data and information by navigating through logical metadata structures. A full text search function is implemented without knowing the exact physical storage. Metadata can be generated fully in line with the newly established ESA Human and Robotic Exploration Data Policy. It provides information on science goals, experiment records, experiment times, crew activities, and applied experiment procedures and protocols. Raw and calibrated experiment data are stored as well as physically derived data, together with the derivation formula applied. The system is web-based and authorized customers can easily connect for quick look data review and full data retrieval. The data archive will be maintained in the future and a new interface is established to ESAC for long term data archiving (10 years+) at ESA.

3. Infrastructures

3.1 Control rooms at MUSC

The control rooms of MUSC are located at the DLR campus in Cologne. Two control rooms were established, which are used for the scientific operations of space flight instruments and experiments. Both control rooms are outfitted with standardized infrastructures and could be configured according to the individual mission requirements. The infrastructure consists of communication interfaces including secure web interfaces with dedicated firewall technology, separated mission and office networks, videoconference systems, multimedia wall, temperature controlled server rooms, conference rooms and uninterrupted power systems.

From the large control room the instruments and experiments onboard the International Space Station are operated since 2004 under an ESA contract. In the control room up to 20 positions can be established for monitoring and commanding of dedicated instruments on the Station. Presently five different payloads are operated: Biolab, Material Science Lab, European Drawer Rack including the Electromagnetic Levitator and the radiation measurement system DOSIS.

The standard DLR provided infrastructure is extended with agency furnished equipment and software from ESA and NASA for instrument telemetry monitoring and payload commanding. This includes the ESA system CD-MCS and the NASA TreK system, the temporary data archive system HRDP, the mission information and

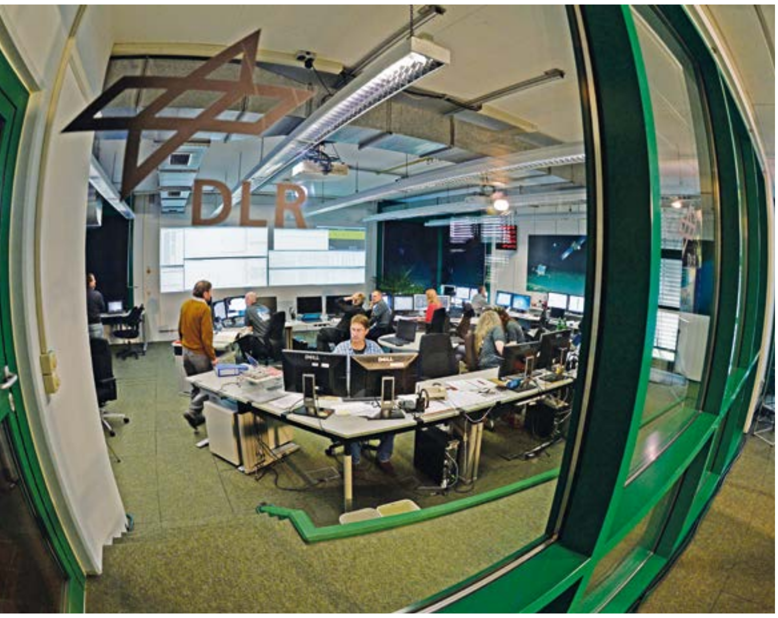

Fig. 3-1 MUSC Control Room

Fig. 3-2 Rosetta-MUSC-LCC_02

planning software OSTPV, on-going migration and testing to Yamcs for different ISS and space science mission payloads, and the ESA and NASA audio system for the voice interface of the ground segment and the ground to space segment.

The smaller control room is dedicated to space science mission operations, its capacity is up to ten positions. This control room was and is connected to different mission control centers, which are ESOC in Darmstadt, JPL in Pasadena and JAXAs control center in Sagamihara. The interfaces are configured according to international standards, which are defined by the respective mission hosting Space Agencies. It was specifically designated to the cometary mission Rosetta and the operation of the Lander Philae, which was launched in 2004. The mission was operational until 2016 with the goal, to land for the first time a small probe on the surface of a comet and perform in-situ investigations. In recent years the room was used for the operation of the asteroid lander MASCOT onboard the JAXA mission Hayabusa2. MASCOT (Mobile Asteroid Surface Scout) is a hopping probe, which performed measurements on the asteroid surface at different locations. The mission was successfully completed in October 2018.

Currently, preparation and operations of small satellites and rocket experiments with the projects Eu:CROPIS and APEX are part of the activities besides support to further developments of a ground facility building named LUNA which is forseen to support future Lunar activities. The exobiology payload integrated on the Bartolomeo platform outside the Columbus module is under preparation.

Presently the room is dedicated to the Mars mission INSIGHT, performed in cooperation with JPL and the French Space Agency CNES. The DLR part of the mission is consisting of a mole penetrometer, which is designed to determine the heat flow from the planet to its surface and released to the atmosphere. The mission was launched in 2018 and landed on MARS in November the same year. The penetrometer started operations in February 2019. In the near future, the control room will be additionally used for the Mars Moon Exploration (MMX) mission, a landing and sample return mission to the Mars moon Phobos, planned to be launched in 2024.