MANNED SPACE-LABORATORIES CONTROL CENTER (MSCC) OPERATIONS CONCEPT

Dr. Joachim Kehr
Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR)
D-8031 Oberpfaffenhofen, Germany

ABSTRACT

The paper will recall the initiation of the (German-) nationally funded control center for manned spaceflight operations triggered by the invitation of President Reagan to ESA, Japan and Canada in 1984 to join the International Space Station Freedom Program.
The requirements for a Manned Space-Laboratories Control Center (MSCC) as defined at the beginning of the planning and construction process in 1987 and the resulting modifications during the various programmatic scenario changes on NASA and ESA side between 1987 and now will be presented.
The validity of the original requirements with respect to the current scenario, which asks for a logical evolution from the execution of the D-2 mission in January 1993 via the European Columbus Precursor flights (in particular the E-1 mission) towards Columbus Attached Laboratory (APM)-operations by the end of this century will be discussed.
The resulting tasks of the MSCC for the various missions, the current configuration and the ensuing operations concept leading from a more centralized concept for D-2 towards a decentralized payload operations concept for the APM and the implications with respect to European and International interfaces will be presented.
The planned Columbus MSCC facility architecture and its expected modifications introduced by the ESA Ministerial Conference in Munich (Nov. 1991) and follow-on discussions will be briefly addressed.
The last chapter will outline the planned services to be provided by the MSCC to the decentralized User (experimenter) community. Issues like decentralized mission planning on executional level, command validation, data flow coordination, archiving services and telescience capabilities will be highlighted from a MSCC point of view.

Key Words: Columbus Operations, Manned Space Laboratory Control Center, User Operations Support

1. MSCC FACILITY DESCRIPTION

The Columbus program originally consisted of three elements ("Den-Haag Scenario"):

- an Attached Pressurized Module (APM) to the Space Station Freedom to be launched in 1996 by the Shuttle
- an European Free Flying Laboratory (MTFF) in a similar orbit as the Space Station to be launched with an ARIANE-5 booster in 1998 and serviced by HERMES from 1999 onwards.
- a serviceable observation platform (PPF) in polar orbit to be launched by ARIANE-5 in 1997

During the ESA Ministerial Conference in November 1987 at Den-Haag, it was decided to develop a decentralized European ground infrastructure, Germany being entrusted with the built-up of the control center for the two manned Columbus elements.
Columbus Experimentation and MTFF Operations would be accommodated in the nationally funded and constructed Manned Space Laboratories Control Center (MSCC) with its arrangement of operations rooms and office space as required for the operations and support functions of the original Columbus scenario:

- Payload operations coordination for all the European experiments to be carried out onboard the Space Station Manned Base (SSMB), as well as safety and health ensurance of all European-provided payload facilities/instruments located in the APM or elsewhere in the SSMB,
- Mission control functions for the Columbus Free Flyer Laboratory and Resource Module subsystems, payload operations monitoring, control and/or coordination functions for all

on-board payload equipment and experiments,

- Ground operations functions for the implementation, preparation, operations and maintenance of MSCC subsystems and external space- and ground-network planning and execution coordination,
- Training (T) functions for MSCC ground personnel,
- Qualification & validation (Q & V)functions of the MSCC for supporting the above functions, and
- Related facility, administrative, financial and personnel managerial functions.

The MSCC, as completed in 1989 consists basically of two buildings, the Mission Control Building and the Operations Mission Sequence Simulator (OMSS) High Bay area, which are connected via a Foyer. A third building, the In-Orbit Operations Simulation Facility (IOSF), is also connected to the Foyer, but is dedicated to manned spaceflight technology developments including the European Proximity Operations Simulator (EPOS) and Servicing Test Facility (STF). The IOSF is independently managed and operated and is not addressed further.
The Mission Control Building accommodates the flight and ground operations control / coordination functions and facilities.
The OMSS High Bay area would accommodate the majority of the TQ & V tools and simulation capabilities for the two flight elements. The simulation tools are MSCC "in-house" tools which will be used to support independently from external sources both test and validation activities for the MSCC facilities, as well as training of MSCC Operations personnel.

2. D-2 / E-1 OPERATIONS

The MSCC is presently configured to execute the second German Spacelab mission (D-2) in spring of 93. For D-2 the MSCC will act as Payload Operations Control Center (POCC) which is different from its Columbus role as European Payload Operations Coordination Center (E-POCC).
The difference being that for D-2 all Experimenters are assembled at the MSCC for the duration of the 9-day mission to perform all experimentation activities while in the Columbus era the experiment operations will be conducted from the Experimenters' home bases.
Besides the experimenters' participating remotely in Columbus operations, the significant difference to D-2 is, that Europe will only utilize part of the total Space Station capabilities, i. e. the European utilization planning has to be integrated with that of the other partners. This overall integration is performed by the "Payload Operations and Integration Center" (POIC) at Marshall Space Flight Center (MSFC).
While D-2 planning could optimize the resources with "custom tailored" timelines, Columbus will have to utilize "resource envelopes" in order to allow decentralized utilization planning in Europe and all the other partner countries. An evolutionary process from the centralized D-2 concept towards the decentralized Columbus operations scenario has to take place. The interconnecting link will be an Europeanized Spacelab flight with international participation, called Columbus Precursor Mission E-1, in 1997. Since no experience exists on planning and operations schemes like that envisaged for Columbus, the goal of the E-1 mission will be to gain knowledge and exercise operational management arrangements and procedures for:

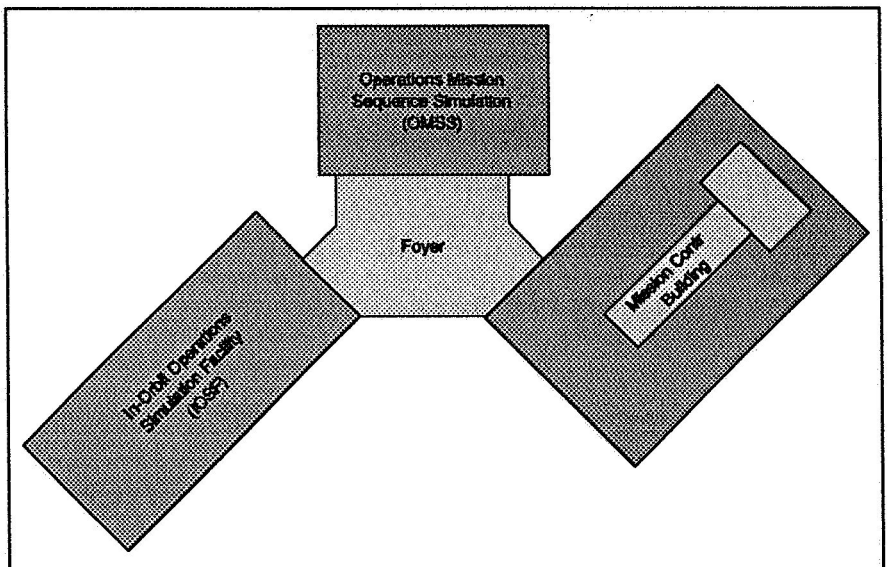

Figure 1. Manned Space-Laboratories Control Center (MSCC)

- payload operations planning on executional level in Europe by employing resource margins
- decentralized payload operations with enhanced telescience capabilities by minimizing interactive time delays
- direct high-speed data services to the user home bases with intermediate data storage capability at the MSCC.

This will change the focus of the MSCC from a "CONTROL" Center to a European resource- and command-"COORDINATION" Center.
So far no major impact of this change in focus on the functionality or the physical structure of the MSCC as described in Chapter 1 have been identified.

3. COLUMBUS OPERATIONS

Due to various de-scoping- and rescheduling exercises of the SSMB by NASA and due to the dramatic political developments in Europe during the recent years, in particular the German unification, the disintegration of the USSR and the ensuing opening of Europe towards the east, the European (ESA-) Long-term plan had to be readdressed. In the aftermath of the ESA Council Meeting on Ministerial Level in Munich 1991, also the Columbus program was considerably descoped:

3.1 Space Segment Baseline

The current MSCC Operations Concept takes the "Munich Conference" and follow -up decisions into account which are with respect to the MSCC:

- No Columbus Free Flyer has to be considered any longer
- No Hermes back-up functions have to be provided by the MSCC or vice versa
- APM launch in 1999

The following main space segment baseline items are currently considered in the MSCC design:

European Payload on board the SSMB

• Launch	Nov. 99 (NSTS)
APM integrated	4 t P/L mass
• Utiliz. Flights	3 UF (t.b.c.)
• Nr. of increments	4....5 / year
• APM length	4 x 8 double rack
• External	separate launch
Viewing platform	1.3 t P/L mass
	retrieve by NSTS

3.2 Current European In-Orbit Infrastructure Ground Segment

The original decentralized European In-Orbit-Infrastructure (IOI) Ground Segment (GS) set-up included a variety of existing and planned ground facilities in the ESA Member States under the overall control of a central ESA tactical planning and monitoring authority:

- the Central Mission Control Centre (CMCC) at ESOC in Darmstadt for APM and MTFF tactical planning tasks, coordination and control of mission activities involving more than one European element, central navigation support and management of communication resources management
- the MSCC for APM Payload and MTFF Payload / System Operations
- the HERMES Flight Control Centre in Toulouse
- the Polar Platform Control Center
- Engineering Support Centres for payload integration, engineering support and logistics services for the APM, MTFF and Hermes, located in Italy, Germany and France
- an European Astronaut Centre with associated Astronaut Training Facilities in various member states
- DRS Operations Control Centre in Italy
- AR-5 launch and landing facilities

In addition a range of User Support and Operations Centres (USOC's) and User Home Bases (UHB's) for APM and MTFF payload operations in many ESA member states were planned.
With the described descoping measures the above infrastructure had to be simplified and is depicted in Fig. 2.

The MSCC role for the "Munich"-Scenario is described in the remainder of this paper.

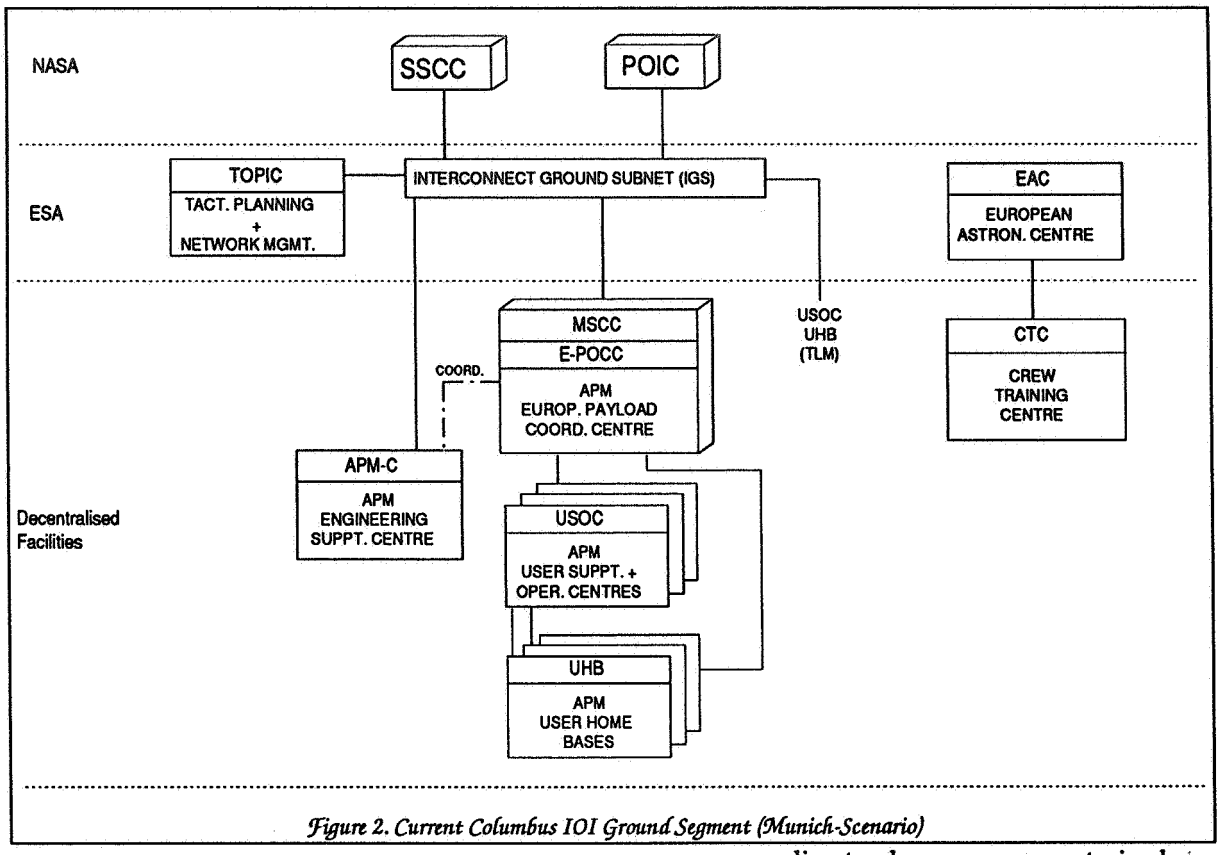

Figure 2. Current Columbus IOI Ground Segment (Munich-Scenario)

3.3 MSCC Role

The MSCC will be responsible for European experimentation activities coordination on board the SSMB i.e. for all European Payloads and Experimentation onboard the Columbus Attached Laboratory or elsewhere on the Space Station the MSCC Payload Operations Coordination function will be:

- Act as the Single Point of Contact between the European User Community and the POIC
- Coordinate and Integrate formalized User Requirements
- Provide Planning Inputs to the POIC in form of an European Increment Operation Plan (IOP) for the overall IOP Generation, and as Activity Models for the Short Term Plan (STP) Generation
- Provide coordinated European Replanning Inputs to the PIOC for the IOP and STP
- Ensure the Resource Availability for European Experimentation during the planning phase
- Enable/disable command capability for European users, and validate commands, according to plans or on requests, in close cooperation with the POIC
- Monitor and control Experiment Resource Envelopes during operations
- Ensure Health and Safety of European Payloads and take appropriate steps of coordination
- Coordinate and Ensure End-To-End Data Handling for all European Experimentation
  - Coordinate Voice Communication between Crew and authorized User
  - Coordinate RT and Offline Data Dissemination
  - Provide Data Storage for Low Data, Vioce and Video and High Rate Data in Backup Case
  - Distribute recorded data offline
- Provide Post Increment Reports
- Accommodate users which are not supported by an USOC

3.4 MSCC Operations Team Structure

The shown MSCC Team Structure is derived from the role as described in the previous chapter for the APM Payload Operations Function.

The structure is based on the agreements as defined in ESA/C(87)84 "Ground Facilities for Operations" and the Den Haag Resolution ESA7C/LXXXIX/Ref.1 "Resolution on the ground segment associated with the European in-orbit infrastructure operations", i.e. for each increment:

- the "delegated" operational tasks on executional level will be executed by a DLR Flight Director (approved by ESA)
- tactical level representation will be performed by an ESA appointed Representative possibly with staff on site.

Overall MSCC executional management will be performed by the DLR MSCC-Project Manager. The staffing profile for the operations teams will be optimized to allow the execution of the current increment and preparation of the next ones simultaneously.

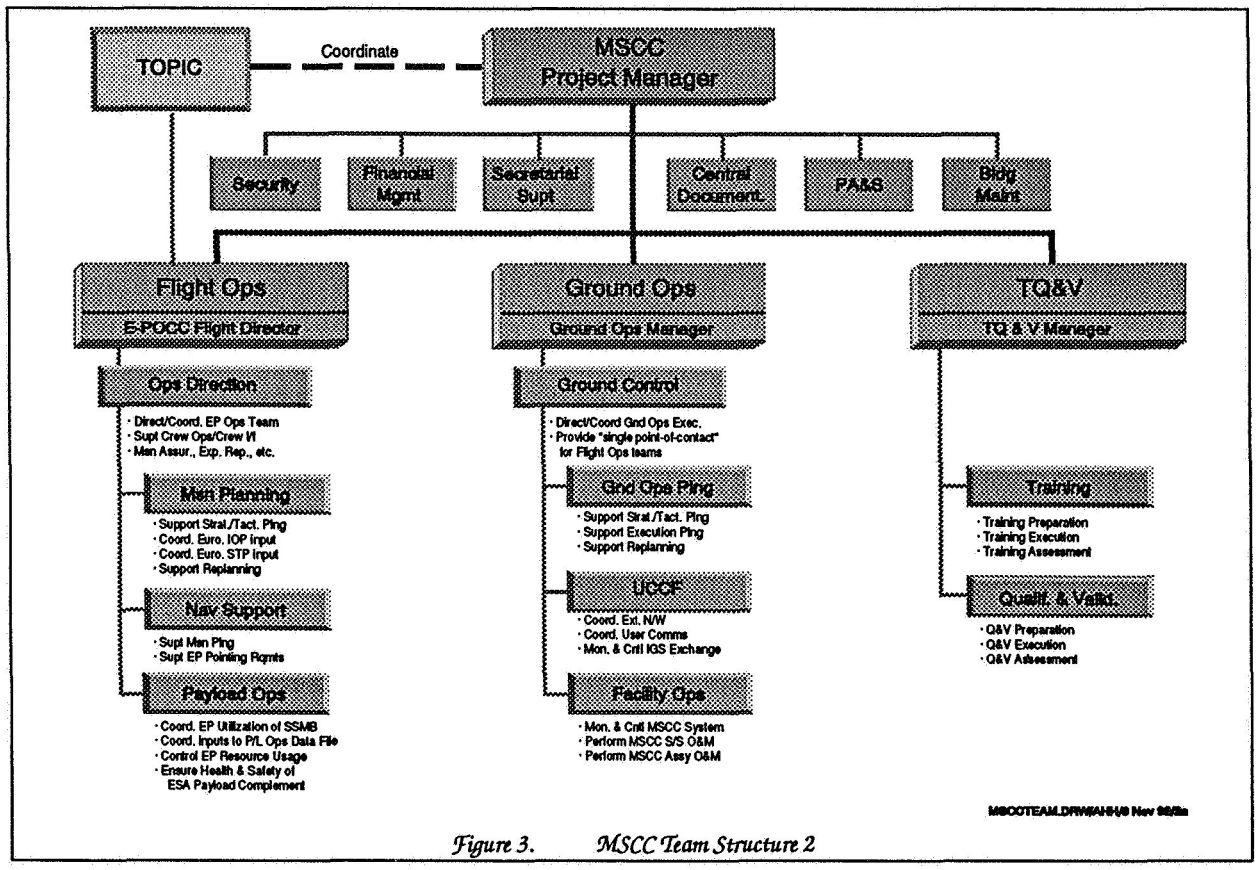

Figure 3. MSCC Team Structure 2

3.5 MSCC External Interfaces

An overview of the MSCC external interfaces is provided in Figure 4.

3.5.1 US Interfaces

A preliminary definition of the interfaces to International partner facilities has been developed. These interfaces are the subject of the Functional Control Documents (FCDs), which document the agreements between the US and the international partners. Although these documents are still in the process of being developed and negotiated, general description of the US interfaces is provided.

POIC Interfaces

The major POIC functions with respect to European Payload Operations are:

- coordination of NASCOM data services
- command validation
- generation of hazardous P/L commands
- integration of mission planning / replanning inputs (IOP, STP)

- coordination of Air-to-ground voice communications
- SSMB resource coordination for all payloads
- assurance of safety and health for all payloads
- overall responsibility for servicing and trouble shooting activities (with MSCC support)

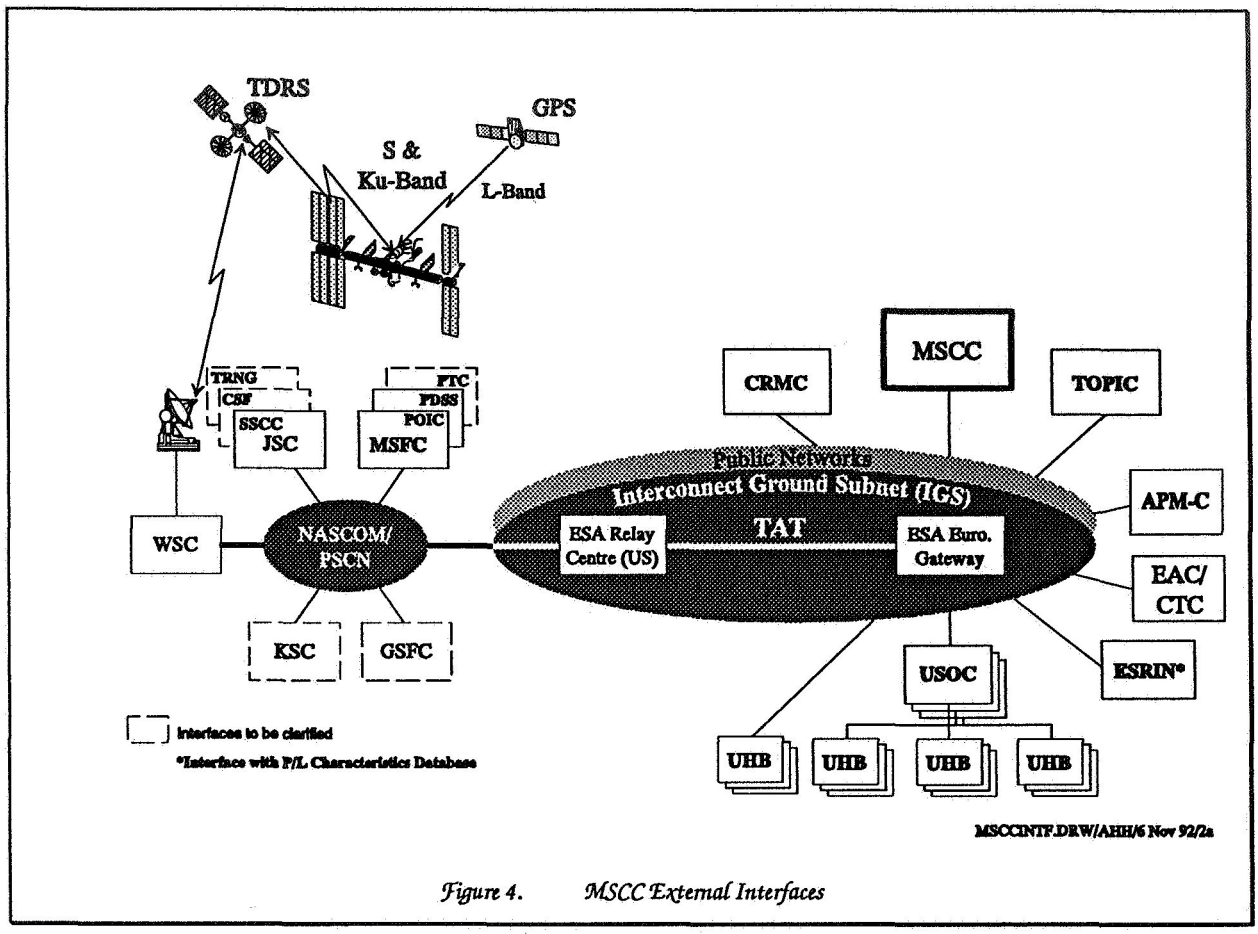

Figure 4. MSCC External Interfaces

SSCC Interfaces

Although the POIC is the point-of-contact for coordination with SSMB system operations, the MSCC will establish interfaces to the SSCC for the delivery of selected planning and preparation data, and for the reception of broadcast video and systems data. The coordination of these data transfers will be performed over coordination voice loops with POIC, which extend to selected areas in the SSCC. In addition, access to the NASA electronic information System TMIS will allow the MSCC to access information and services support at Johnson Space Center.

3.5.2 European Interfaces

The MSCC will establish interfaces to user facilities and other IOI GS facilities. The majority of these interfaces will be provided by a ESA Interconnection Ground Subnetwork (IGS), however non-operational interfaces and-non-real time interfaces to users will be established through public communications networks (local PTTs). Unlike the NASA interfaces, which require negotiation and agreement between ESA and NASA and are documented in the FCD's, MSCC interfaces to facilities in Europe will be developed during the design phase, agreed upon by the facilities involved, and documented in separate Interface Requirement Documents (IRD's). Such interfaces have to be established to Tactical Operations and Integration (TOPIC) Function, APM Engineering Support Center (APM-C) and to the European Astronaut Train-

ing Center (EAC) with associated Crew Training Center (CTC).

4. MSCC SERVICES FOR USERS

The decentralized Columbus payload operations concept provides opportunities for the users to operate and control their experiments from their home institutes / home countries (USOC's and UHB's) with less stringent conditions than during Spacelab Operations by employing planning margins and enhanced use of telescience capabilities. The operational concept is based on the following responsibility distribution:

- Experiment Operations: Prime Investigator, UHB
- Payload Facility coordination: USOC
- European Payload operations coordination vis-à-vis POIC: MSCC

Generally, the MSCC will be able to interface with up to 9 User Support and Operations Centers (USOC) and 15 to 20 User Home Bases (UHB).
Interfaces to user sites will ultimately be tailored to each user needs and the total extent of user communications services will probably vary from one increment to the next. Therefore, interfaces between the MSCC and users must rely upon a generalization of user communication needs until that time when actual users are available.

Services provided by the MSCC to the Users are:

- Operations Preparation
  - European Execution level planning and replanning by integration of harmonized Requests from USOCs
- Operations Execution
  - European Payload resource monitoring and control
  - European Payload health and safety control
  - Payload command coordination/validation incl. telescience throughput coordination
  - End-to-end communication coordination
- User Data Services
  - User Data Service Coordination
  - Data Quality Monitoring
  - Data Accountability
  - Intermediate Data Recording and Data Product Generation / Distribution

In selected cases, users may also be accommodated in MSCC internal user rooms during their operations "campaigns". In such cases, the user interfaces will be treated identically to those located externally.