SpaceOps-2023, ID # 535

OHB Flexible Mission Control: Multi mission control center

Author: Dr. Alan Moorhouse[2], Eike Halbroth[2], Giuseppina Salemme[3], Michalis Charlampakis[2] , Markus Banholzer[2], Guido Broker[2], Oliver Karger[2]

[1] OHB Digital Connect, eike.halbroth@ohb.de +49-421-2020-6079
[2] OHB Digital Connect, Lise-Meitner-Str. 2, 28359 Bremen, Germany
[3] OHB System AG, Universitaetsalle 27-29, 28359 Bremen, Germany

Abstract

Context

The growing space industry drives the need for flexible services around satellite operations.

The OHB group in Bremen is setting up a new modern Multi-Mission Control Center, led by OHB-Digital Connect, specialized in up and downstream Ground segments and Operations.

OHB group development and flight experience from system integration of LEO, GEO and MEO satellite based solutions, and the operations thereof are incorporated in the design of this center intended to provide services from a multi-mission perspective.

This requires to analyse the requirements of different mission concepts also as potential future missions and consolidate them into a Multi-Mission Control Center. This has to cover flexibility, scalability, modularity and wide connectivity, in order to provide operational services for multiple missions.

Flexibility Concept

Besides interfacing to individual external services like ground stations, space weather information provider, collision avoidance services, payload control, data processing etc., the Multi-Mission Control Center will have the capability to align to the satellite manufacturers test systems. Using a modular approach, the interfaces and the M&C core can be exchanged on system needs and requirements. The current baseline for the Multi-Mission Control Center foresees OHB Ramses or Terma CCS 5 provided as standard.

The modularity implies a trade-off to check system integration implementation effort and re-use of test scripts/procedures from the satellite manufacturer versus Operational product rewrite and validation within an existing system.

The capability to integrate Monitoring & Control Cores enables to implement "test how it flies and fly how it's tested" minimising development efforts, and increasing quality, of Procedures at mission level (Satellite Manufacturer, Ground, and Operations provider)

The approach can be realized by taking as much input as possible from the satellite system integrator

Different mission concepts and their varying demands with respect to ground segment availability and performance, security aspects and control center infrastructure needs are covered by a set of flexibility requirements.

Flexible Datacenter

The Multi-Mission Control Center Datacenter is driven by a scalable and software defined Hyper Converged Infrastructure (HCI) and can be distributed over two or more physical locations.

It provides very advanced data protection with real-time replication on the different hypervisors, even in multiple locations. Build-in support of very advanced high availability architecture with two or more datacenters in active/active mode.

Upscaling can be handled efficiently by adding new hypervisor/s on the existing cluster or hardware resources (disk space, memory etc.) to the existing hosts.

The approach delivers flexible, available and scalable IT Infrastructure to deal with future missions easily, quickly and effectively. Within this environment the Mission Software's are running on an "internal cloud", and are deployed via code.

Flexible Front-End Infrastructure

The Mission Control Room and its side offices are designed in a modular way. This is needed to include offices to the Multi-Mission Control Center dependent on current needs on the one hand and to be able to use floor spaces in an efficient way on the other hand.

The Front-End provides the workspaces for monitoring and control and access to various operation tools to accomplish a mission besides the Monitoring & Control Cores.

The mission center further provides remote operations capabilities to ease performing actions in certain mission phases.

Mission Activities

The OHB internal invest for the Multi-Mission Control Center is currently being deployed in a step by step manner and its use has been explored within the concepts for several potential missions like a telecommunication constellation (Spacelink), Low-Earth Orbit Environment Monitoring Systems, e.g. Arctic Weather System, or GEO-based telecommunication systems, such as OHB's Electra platform.

It supports single satellite missions up to small constellations. The main weight for the Mission Center is based on unclassified missions like commercial telecom missions, scientific missions (i.e. hyper spectral satellites) and others. But it can also be configured for classified missions for governmental purposes.

Different phases will be supported. Starting from LEOP and In-Orbit-Testing up to routine operations implementing automation layers where required.

Further the multi mission center is planned to provide backup for external satellite operator in case of ground segment contingency, or to support activities from other mission centers remotely.

In the future the integration of downstream services within the center, such as Payload Data processing, enables end to end mission solutions.

This paper will describe the concept, design, interface abstraction approach, as well as implementation and Test status of the new OHB Control Center described above

Acronyms/Abbreviations

CCS Central Checkout System

Ramses Control system Software from OHB-Sweden

1. Introduction

The growing space industry drives the need for flexible services around satellite operations.

- Satellite constellations are getting more and more popular
- New technologies are developing fast, also because of New Space
- Dedicated control centres are operational and in use since many years, however not always re-usable due to sensitivity

Requests from customers (commercial and institutional) for operations increasing from system primes, either In-Orbit-Delivery or full routine operations

This has led OHB group in Bremen to set up a new modern centre led by OHB-Digital Connect, specialized in up and downstream ground segments and operations

- This required to analyse the requirements of different mission concepts also as potential future missions and consolidate them into a Multi-Mission Control Centre
- OHB group development and flight experience from system integration of LEO, GEO and MEO satellite based solutions, and the operations thereof are incorporated in the design of this centre intended to provide services from a multi-mission perspective

2. Concept

Needs identified driven from RFI's and RFP's and early phase work for several different types of missions. These are mainly unclassified missions such as commercial telecom missions, scientific missions (i.e. hyper spectral satellites) and others but also considerations for classified missions (for governmental purposes) have flown into the concept

Scalable sizing of system to allow for single satellite missions up to small constellations

- The requirements and design cover:
  - Flexibility
  - Modularity
  - Scalability
  - Wide Connectivity

2.1 *Functional Architecture*

The Functional Architecture breakdown of the MMCC follows a rather classical structure as depicted in Figure 1

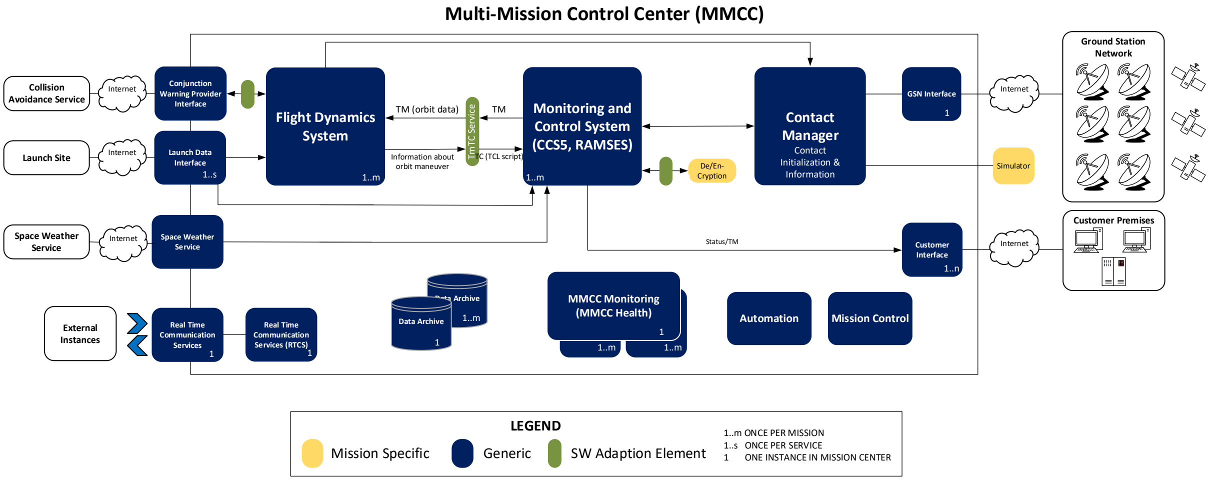

Figure 1 Functional Architecture

The main functional elements are classical in Nature;

Monitoring and Control System: The MCS is the central Telemetry decoder and Telecommand Encoder, as well as providing the HMI of the space/ground systems and procedure/scripting tools. This is designed to be an exchangeable module depending on the supported mission and equivalent used for AIT by the Satellite manufacturer. The first deployments envisage Terma CCS-5 (used by OHB-System for AIT) and Ramses (used by OHB-Sweden), other systems will be considered at need following a trade-off of Operations products rewrite or adaptation from Satellite AIT.

Contact Manager: For Handling Ground Station Contacts (either a global Network, i.e. for a LEOP, or dedicated stations for routine) via a GSN Interface module which can also connect to a mission specific simulator for Test and Training purposes.

Flight Dynamic System: The target for the Flight Dynamics System (FDS) within the MMCC is to have a mission independent Flight Dynamic System which will be used for every mission (with Mission configuration and possibly adaptations). The core system will be based on an OHB FDS Library which is Flight ready. The Interface to the MCS is configured via a TMTC service adapter.

MMCC monitoring: The MMCC Monitoring application supervises all applications, virtual machines, containers and hardware running in the MMCC. It therefore provides a health status for the MMCC to support the operator. Based on the MMCC health status decisions can be made. Further the MMCC Monitoring shall provide the status of automated processes also as trouble shooting functionalities.

In addition are support functional elements for automation, overall Mission Control, and Data archiving.

Several Interfaces are considered in the core design including;

- Customer Interface, for relay of Data (TM, TC, auxiliary) to customer sites
- External services, for remote secure access
- Collision warning Avoidance services
- Space Weather
- Launch site

In addition further automation layers and mission/payload management are considered to be first however implemented within realisation missions, utilising in-house experience.

Support Tools

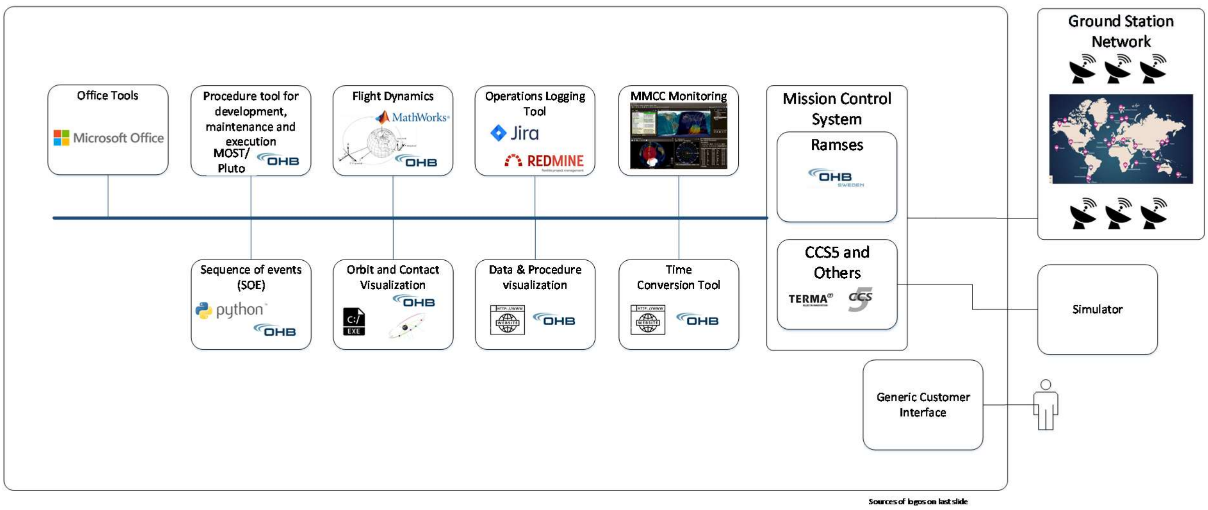

Figure 2 Operational Support Tools

As well as the sub-system modules explained within the functional Architecture there are a number of support tools required for Operations, these are depicted in context in Figure 2, refer to [1] in references for source of Logos

- Office Tool set, excel, word, etc.
- Procedure, scripting, environment.

- Flight Dynamics HMI.
- Logging and Ticketing Tool, MMCC selection ongoing. OHB have deployed and used Redmine and Jira based confguration's.
- Sequence Of Event Tool: OHB Python development used on other dedicated missions.
- Contact and Orbit visualisation

3. Backend Infrastructure

The Back End Infrastructure hosting servers for Virtual machines, Network, Data Storage, Firewalls, security gateways is built as a Datacentre as depicted in Figure 3 below

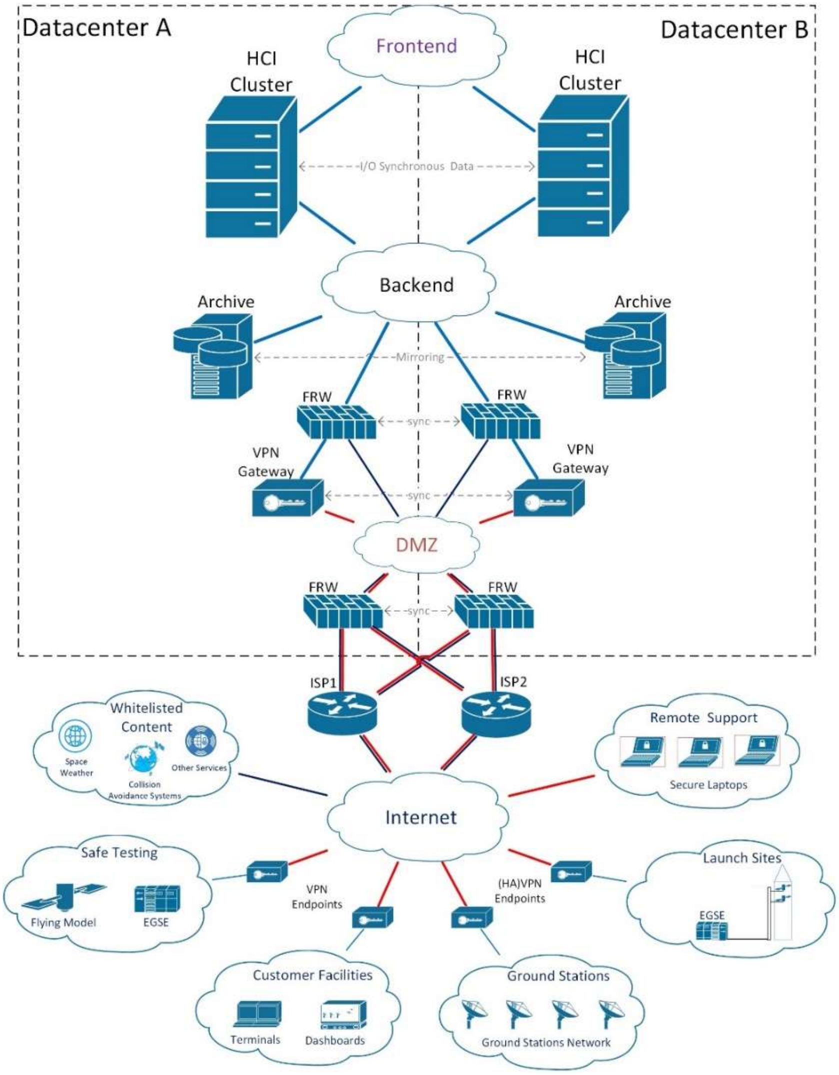

Figure 3 Backend Architecture

This is composed of the following major elements and features

- High Availability architecture with redundant components and paths (≥2N form of resilience)

- Hyper-Converged Infrastructure (HCI) with Virtual Machine (VM) and container-based applications support
- Active/Active (HCI) Clusters with synchronous I/O of data between in two datacenters
- Dedicated and scalable resources pool (compute, storage and network) for each mission
- Infrastructure as Code (IaC) processes for rapid deployment and improved infrastructure consistency (via automation tools)
- Available templates for common services such as directory, monitoring, auditing, file-shares and several others services
- Flexible interconnectivity options (IPSec, MPLS,eVPN etc.) to remote sites
- Design takes restricted mission requirements into account

4. Front End

The Front End comprises a Main control room, extendable Floor and office space for support staff and customer adjacent to the Main control room, as well as mission extensions

Figure 4 Working Consoles in Main Control room

- 15 operator terminals in the Main Control Room, see Figure 4
  - Configurable to be thin or fat clients
  - Able and flexible to realise several projects in parallel
- Able to reach full virtual capabilities
- Uniform hardware/software (console) installations
  - Flexible roles
- Dedicated network
- Side offices – also connected to dedicated network
  - Room scalability and flexibility for mission needs
  - More console working positions simply by installing more terminals or utilizing the remote access.
- Fully flexible data dashboards on the video wall
- Remote secure satellite monitoring

5. Missions Activities

The MMCC has been designed, procured (step wise) and under realisation to support up to five missions in parallel with one in a critical phase (i.e. LEOP)

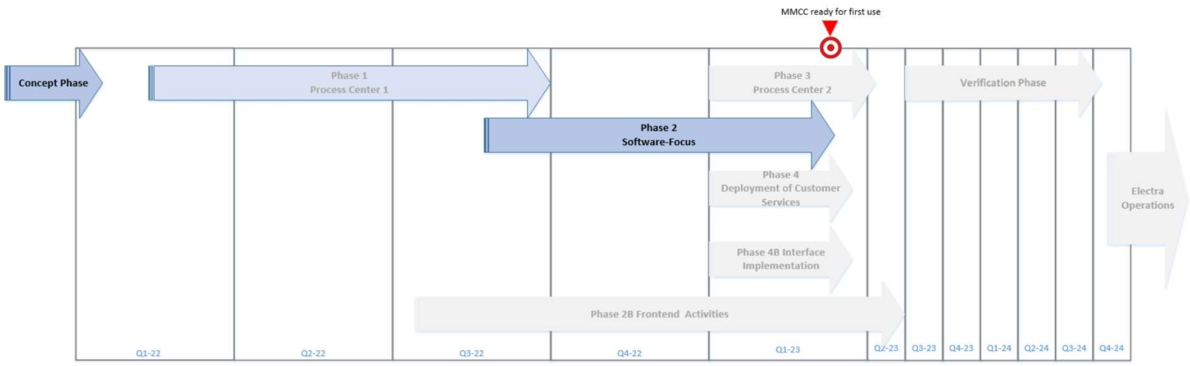

Figure 5 Development Planning

At the time of writing this paper the first build of the Backend Infrastructure is implemented, rooms and Networks for the control center established. Consoles and Front end equipment is being procured such that in Q2 of 2023 the first simulations can take place.

Usage for a Telecommunications mission reached CDR status reviewed by ESA.

Lessons learned from current OHB-DC control centers have flown into the design and Technology selection.

Considered projects: GEO OHB-System Electra based Telecommunication, MEO/LEO Telecom constellation's, LEO Earth Observation;

- SGEO Electra based Mission with CCS as core Mission Control
- OHB-Sweden Innosat platform with Ramses as core Mission Control

Encouraging a "Test how Fly" and "Fly as you Test" approach

Realisation is done independent of any future missions:

- To allow generic implementation
- To be able to quickly prepare Operations
- Trade Off re-use/adapt AIT products to OPS products or re-write

Pilot and realization Projects are under planning for 2024

EGS-CC and other core processing systems are possible extensions for the future, but not the core focus is in integrating a suite of flight proven sub-systems at the present time.

6. Conclusions

This paper has provided an overview of the concept, design and realisation of an OHB Multi Misison Control Center characterised by a flexible and modular design, scalable Hardware and network Infrastructre to allow the Operations and Ground Teams to adapt to a particular project by utilising components and products most suited for the mission, minimising and localising adaptation to interface layers.

Acknowledgements

References

[1] Source of Logos used in Figure 2

- ESA'S ANNUAL SPACE ENVIRONMENT REPORT, ESA Space Debris Office, April 2022, Issue 6.0
- Python logo, https://www.python.org/
- Terma and CCS5 logo, https://www.terma.com/products/space/satellite-control-systems/
- OHB Sweden logo, https://www.ohb-sweden.se/
- Jira logo, https://www.atlassian.com/de/software/jira

- Redmine logo, https://www.redmine.org/projects/redmine/wiki/Logo
- Microsoft Office logo, https://learn.microsoft.com/en-us/microsoft-365/cloud-storage-partner-program/online/branding
- Satellite monitoring, https://www.gano.name/shawn/JSatTrak/
- C exe icon, https://www.onlinewebfonts.com/icon/442876
- MathWorks logo, https://www.mathworks.com/products/matlab.html