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Heinrich Hertz Lights Out Geostationary Operations

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Abstract

The Heinrich Hertz mission is a German geostationary satellite mission procured by DLR which aims to explore and test new communications technologies in space at a technical and scientific level in order to determine how broadband communications, for example, can result in high data rates for mobile final users.
As well as this, the mission will offer universities, research institutes and industry a platform for conducting numerous scientific/technical experiments with the Payload. In addition, the mission deploys a communications payload for the German Ministry of Defence.
OHB Digital Connect is prime for operations of the mission. Together with CGI the Ground Segment was developed and is currently operated by a mixed team. OHB System provides manufacturer support. The mission was launched 07/2023.
The Space segment is based on the OHB-System SGEO platform and deploys a hybrid chemical and electrical propulsion system also for Station Keeping.
This paper will describe the chosen implementation and Operations Concept. The mission is characterised by a dedicated Control Center located in Bonn for the overall mission, a strict separation of the mission in Scientific (experiments) and Military (communications service) parts both in Space and on ground. The presence of a Military Payload further necessitates a classified environment. The following main features of the routine Operations will be explained.
Lights Out: 24/7 operations without 24/7 staffing (outside of working hours no staff are in the control center). This is driven by the need to reduce operations costs, but also technology driven as ground algorithms and ground automation capabilities and the design of the satellite allow this.
High Level of Automation: Driven by high availability requirements which also enable the Lights out Operations
Two missions: One Platform, One Control Center. Independent Operations of two types of missions, experiments and Military communication channels.
Mission Operations Team: A small multidisciplinary mission Operations team will manage routine operations tasks, encompassing Flight Dynamics, Ground Stations management for Telemetry/Telecommanding and the scientific experiments, Platform, both Payloads and users. This team is also responsible for first line maintenance of the Ground Segment HW & SW.
Keywords: Automation,Operations, Geostationary Satellite, OHB, CGI, DLR

Acronyms/Abbreviations

DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V.)
H2Sat	Heinrich-Hertz Satellite
FDIR	Fault detection, isolation, and recovery
W/T	Scientific part of payload and operations
FMEA	Failure mode and effects analysis
TM	Telemetry

1. Introduction

Geostationary satellites are usually reachable in orbit 24/7. Therefore, the satellite and the corresponding ground stations are typically designed in a way that requires personnel to be on shift 24/7. However, this design has high costs for routine operations and requires a large number of highly trained personnel to be available.
To reduce costs for routine operations and be less depended on the availability of highly trained personnel, the H2Sat has an advanced FDIR-design which ensures that an anomaly is solved on board at the lowest level possible.
In case of an event that cannot be solved by on board measures (space TM or ground TM) the PLENITER system can be configured to execute an automated procedure via the mission planning system (PLAN). This is used for additional ground based FDIR, for an immediate response (within 60 seconds, configurable by the operator).
In case of an event that requires an operator, PLENITER can be configured to notify an on-call operator.
The operator is able to access the telemetry (including all displays visible in the control center) remotely (except for restricted/MIL TM), allowing for the operator to assess the space and ground health. Based on the assessment an appropriate action for the anomaly can be chosen by the operator.
Since this paper shows the operations perspective, the following chapters cover the different sections and features allowing a non-24/7 operations concept of the ground segment.

2. Ground Segment

The H2sat Ground Segment is realised by a distributed system of various hardware and software components. The User Interface is a web-based application providing access from a single operator workstation to all PLENITER modules within the (SCS, W/T, MIL) segment. Each PLENITER module groups together functionality for a large aspect of the Ground Segment operations.

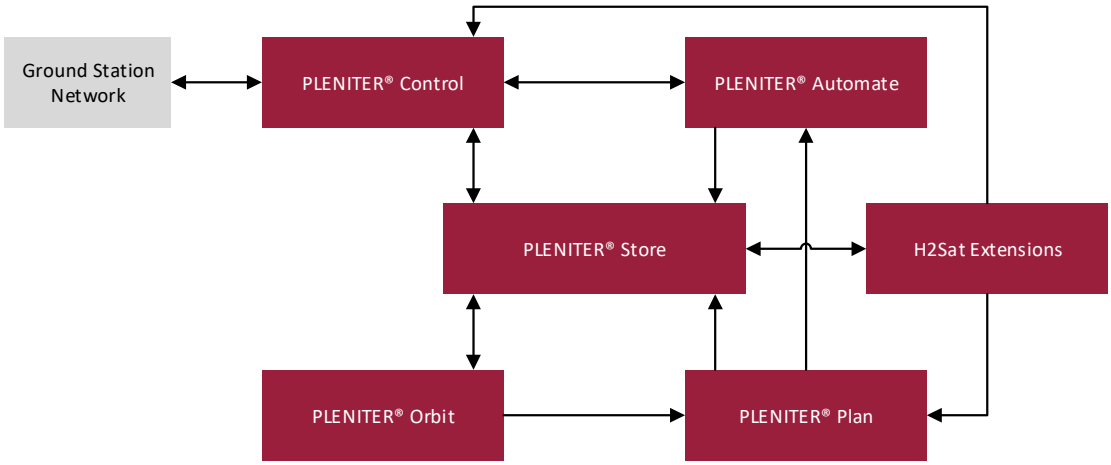


Figure 1: PLENITER modules and major interaction flows

Main access point of an Operator to interact with the segments is the PLENITER Web HMI. The HMI can be accessed from the control centre via workstations or remotely (only non-critical data) via VPN. Within the entire Ground Segment different roles have been defined, giving access to different sets of data.

Among other modules, each with a distinct set of features, it includes a mission planning system (PLAN). Any activities outside of normal office hours can be planned via PLAN, triggering an automated procedure which will execute via AUTOMATE.

SCS Operator

The SCS Operator is operating the Satellite Control Segment (SCS) and has all privileges to access all data, including W/T and MIL data. The SCS Operator may be considered as being On-site during agreed office hours or On-call outside of the agreed office hours.

W/T Operator

The W/T Operator is the main interface for all W/T payload activities. The Operator has access to all unrestricted space and ground telemetry.

W/T User

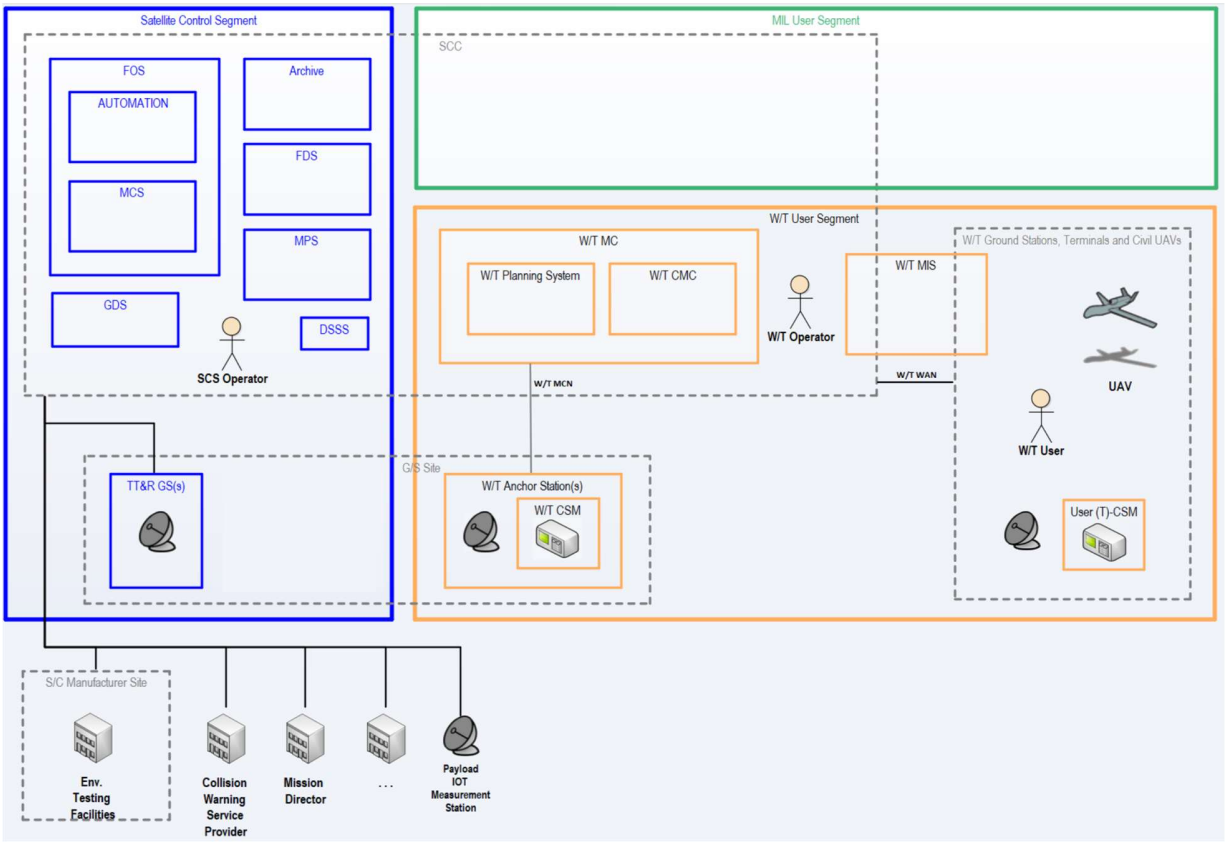
The W/T User is the role given to the experimenter, and is the main user of the W/T mission. The W/T User may be located at his own premises, in contact with the W/T Operator by phone and connected to the W/T User Portal via internet.

Access to specific telemetry data is given by the W/T Operator based on the needs of the experimenter, with the experimenter being given access to either persistent, or time-constrained data (typically for the duration of the experiment, created by the operators in the control centre).

Custom displays, provided by the W/T Operator to the experimenter, enable the experimenter to monitor the experiment execution at a glance with all relevant data. In addition, files can be uploaded and downloaded via the W/T Product Store for archiving purposes or to provide files for experiment execution. The experiment execution can be planned and monitored using predefined activity requests, which are tailored to the individual experiment by the W/T Operator. All of these features are accessible via the W/T User Pleniter Web HMI.

MIL Operator

The MIL Operator is the main interface for all MIL payload activities. The Operator has access to all space and ground telemetry, including restricted, MIL data.



3. Operations Team

For routine operations there is a small team covering the full space and ground operations. This includes monitoring and control of both, space and ground segment, routine flight dynamics and L1 support for software and infrastructure support. If there is need for system or payload.

Flight Director

The Flight Director leads and manages the operations team during LEOP, IOT, routine mission and disposal phase. The OTM is, as well, involved in operational tasks, supporting the Mission Operators on shift, but also cares about organisational, logistic and personnel concerns, e.g. the implementation of the shift plan and coordination of prime operational measures.

Operations Team Manager

The OTM is the technical leader of the mission operations team and as such gets reports from the other members and is able to take decisions on the technical level. The OTM is at the SCC during standard office hours, on console, and reachable via phone outside office hours.

Operations Team Lead

The OTL is responsible for a subset of satellite and ground subsystems with regards to the preparation of operations procedures and training. They are considered experts in their subsystems, although have knowledge of all space and ground subsystems.

- Flight Dynamics group (routine Station Keeping)
- Control group (AOCS, CPPS, EPPS)
- PPT group (EPS, Payload, TCS)

- Data group (FDIR, OBDH, SCSW)
- Comms group (Crypto, TTR and ground stations)
- Software group (control centre software, infrastructure)

Mission Operators

The Mission Operators (MOs) constitute the core of the Heinrich Hertz operations team. Although each member of the team is trained on all aspects of satellite and ground control, and therefore is able to monitor and execute procedures on any part of the system, some of the MOs have additional knowledge within their group, and so are considered experts within the team.

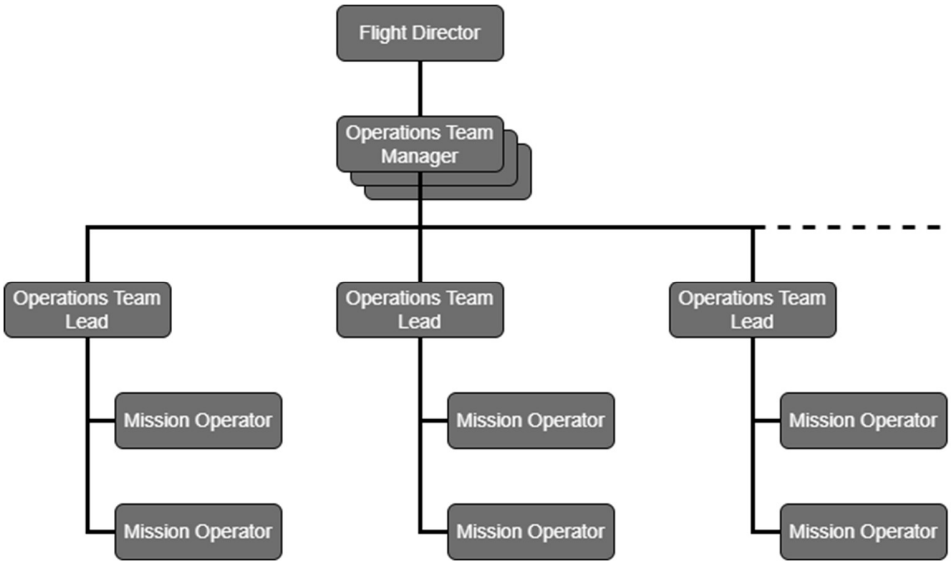


Figure 2: Operations Team Overview

Due to the small size of the team each person may have more than one role, for example:

	Flight Director	Operations Team Manager	Operations Team Lead	Mission Operator
ROLES	Flight Director OTM OTL (Software group) MO (PPT group)	OTM MO (Comms group) MO (Software group)	OTL (Control group) MO (FD group)	MO (Data group)

In case of non-routine and contingency operations there is a specialist team available upon request. The experts cover Flight Dynamics-, Software- and Infrastructure-support. Since their expertise is only required in rare cases they do not have to assigned exclusively to a single mission.

4. Operator Configured Automation (OCA)

In order to enable the operations team to not have to be in office 24/7 the satellite and PLENITER feature Lights out Operations. To be able to identify potentially dangerous anomalies while the operators are not on console Pleniter constantly analysis space TM an ground TM in order to identify out-of-limits or specific packets (eg individual Service 5 Event Packets).

With the OCA, PLENITER listens for events and if they match one of the configured filters, a reaction is triggered, either an notification to the on-call operators, the execution of individual commands to either the space or ground segment, or the execution of an automated procedure via the mission planning system, or a combination thereof.

These filters are applied to all events that pass through the PLENITER system. This includes all events generated by the various ground software components as well as spacecraft events. Some examples are received S/C PUS 5 events or any ground events like TM parameter OOL events. The filters can check different attributes of the events, like event source, generation time or, most general, the content of the event message. By combining these filters with AND- or OR-Combinators, arbitrarily complex conditions about what events are to be reacted on can be defined by the operators.

Figure 3:Technical overview over Operator Controlled Automation

To handle anomalies this way it is crucial to have an FMEA for the spacecraft and ground system to identify an appropriate response for each possible event. The resulting look up table can be incrementally adjusted to take latest information and development of the mission into consideration.

5. Operator Remote Access (ORA)

The cornerstone of the lights-out concept is the ability for the on-call OTM and MO to be able to access live telemetry from the space and ground segments at any time. This functionality is provided by the WT User segment, whereby the Operator has specific super-user access to all unrestricted telemetry, as well as all HMI displays. This allows for the operator to have a similar UI to that from the control centre.

Once Pleniter has identified an issue with the space or ground segment, a notification is sent to the on-call OTM/MO. This message can be configured to provide details on the problem, such as the identifier of an OOL parameter. Due to the nature of H2Sat, only a generic message is given containing the criticality of the event.

The OTM/MO can then access the User segment remotely, and view the current and historical data to identify the event, and to plan further actions. For security, no restricted TM is visible remotely to the operators, and no direct commanding is possible through the remote access. However, the operator is able to request pre-defined tasks through the mission planning system (PLAN). Only a pre-selected/pre-defined subset of activities are visible and can be selected remotely.

6. Summary

With the spacecraft and the ground segment being designed to be robust in case of failures while simultaneously monitoring all TM to identify any anomaly the system is able to work without an operator present in the control room. Users can access their payload via a remote access thus allowing users to operate their payload with the need of an operator to configure the payload (this access however has to prepared by an operator).

If outside office hours there is an anomaly detected the on-call operator is notified. With the remote access to non-restricted data the on-call operator can analyse the anomaly without having to be present in the control room and can decide on the way forward.

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