

## **CEREBRO: Central Control Room for On/Off-site AIT Test Campaigns Sets**

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### **ABSTRACT**

This is a proposal from AIT Bremen department in order to have a central control room for on-site and off-site AIT test campaigns. This control room, hereafter refereed as **CEREBRO**, would be capable to operate satellites during their AIT phases. The main advantages are to reduce the cost during AIT phases and increase the operational condition for the technical teams. The CEREBRO is fully capable to operate satellites during all AIT phases. This includes all satellites with their respective EGSE in all possible locations during their AIT lifetime. This means, CEREBRO, is not intended to operate flying satellites but only cover on-ground AIT activities.

The general design of CEREBRO is similar to the one we have during our test campaign. The enhancement would be to have the possibility to monitor & operate the satellite from a remote location, i.e. we consider the scenario of a satellite being physically located in IABG and the control room in Bremen.

In our current activities, a complete team is following the satellite, i.e. teams are re-located in the test facility (e.g. IABG) and launch sites. The bottom line: during AIT Test campaigns it is not necessary to have all the people all the time on site. Our target is to keep a minimum of people traveling without compromising the good development of the activities. The implementation of a Central Control Room would contribute to the reduction of people traveling and therefore save an immense cost associated to it. We present in the paper the benefits of this concept in terms of costs by considering a realistic scenario, i.e. an average traveling cost over 1 year for a telecom satellite project.

The CEREBRO shall enforce the AIT operations standardization process, e.g. standardization of procedures and user manuals. On the preparation aspect, the core part of the documentation shall be re-use from project to project. On the training side, the technical people will be trained to work on the same system. Therefore they will have almost no need of additional training from one project to the other. CEREBRO is part of a bigger picture that includes our central EGSE core infrastructure and our enhanced monitoring capabilities (e.g. MOST, RAPTOR). Therefore the test data will be stored in the same fashion on a central database and therefore can be used by end-user using a standardized format and display.

Operationally, CEREBRO, will contribute to have always an up and running system and will reduce the setup and de-setup activities. The reduction of traveling reduces also the tiredness and stress of the team. The infrastructure shall improve the communication with the core team in Bremen and facilitate the resolution of issues. The ultimate goal is to improve our cost competitiveness and to provide a better condition of work with less tiredness and less effort/stress which is well-known from experience. Last not least, CEREBRO will enable our EGSE core engineers to monitor in real time our EGSE landscape for multiple projects promoting fast and reliable corrective measures.

## DESIGN OF CEREBRO

CEREBRO in a nutshell an on-site infrastructure for enabling the remote capability for off-site test campaigns, e.g. Test Environment Campaign.

The main drives for CEREBRO:

- Increase productivity with respect to operational condition
- Reduce costs
- Improve competitiveness
- Technically viable
- Create a long-term standardized infrastructure
- Centralized AIT best practices, EGSE monitoring, CCS & IT core



Figure 1. An artistic representation of an off-site control room for the planet Earth

CEREBRO's headline is simple enough: an on-site infrastructure with everything we need to enable remote command & monitoring capability. An artistic representation of CEREBRO<sup>1</sup> is shown in Figure 1.

Traditionally AIT test setups constitute of a CCS setup, SCOEs, and the spacecraft under test. A typical configuration is depicted in Figure 2. It holds the following components/system:

- CCS & IT core with 2 subnets, one subnet is used for the CCS itself i.e. the server, the clients a storage system and optionally external devices e.g. printer. The second subnet is for the communication of the SCOEs. The CCS server and the Test Conductor Workstation (TCWS) are connected to both networks.
- SCOEs they model the EGSE landscape as entities for the EGSE system. Through a dedicated protocol (**EGSE Data Exchange Network EDEN**) mission independent type of messages can be exchanged between the CCS and SCOEs and between CCS and TM/TC front-end<sup>2</sup>.
- Spacecraft under test. Our OHB outstanding satellite fleet, worth to mention a few potential candidates for CEREBRO includes MTG S/Cs, Enmap S/C, SARah S/Cs, and Plato. Table 1 presents an overview of OHB current programs

<sup>1</sup> Marvel Universe and the portuguese word for brain

<sup>2</sup> TM/TC Front-end that provides up and down link data to/from the spacecraft under test

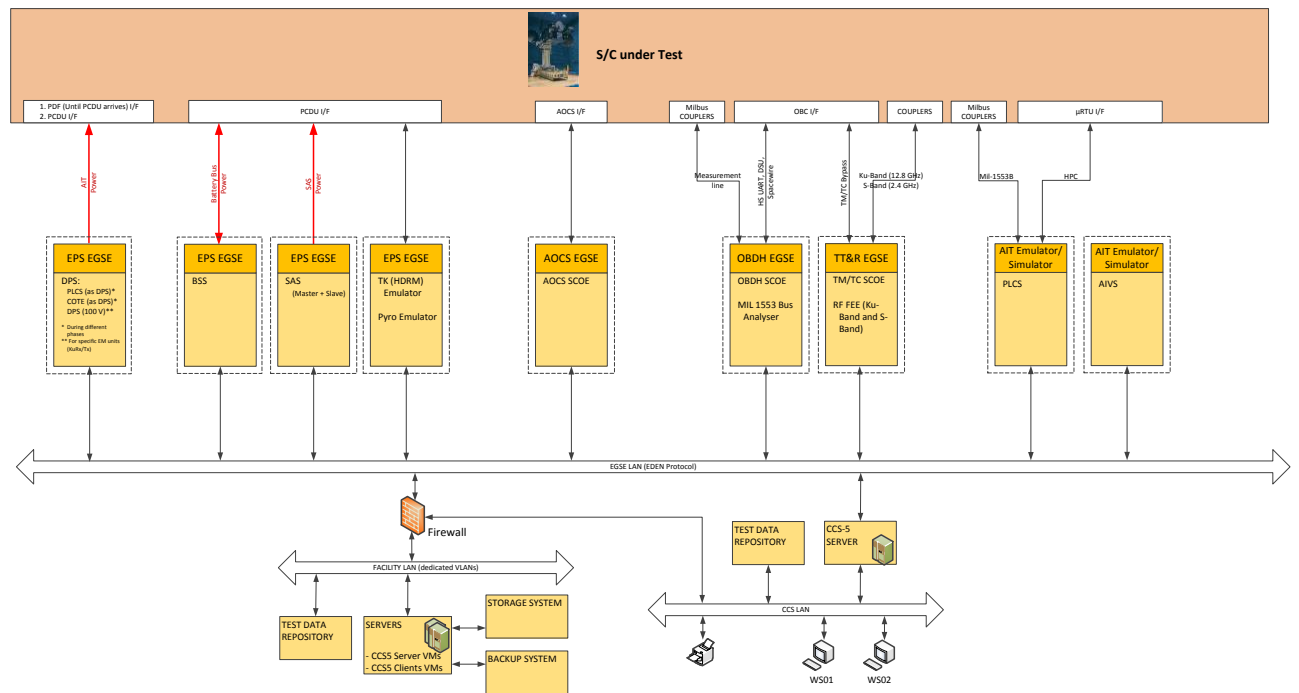


Figure 2 Traditional Spacecraft Test Setup

In order to enable a remote connection with the components, i.e. CCS, SCOE, and S/C under test, a facility LAN must be designated. The established connection will only be used for the CCS subnet/network.

The CEREBRO is inspired by a Holy Trinity of Science – reason, observation and experience. As quoted by Robert Green Ingersoll in *On the Gods and Other Essays*

*“Reason, Observation and Experience have taught us that happiness is the only good; that the time to be happy is now, and the way to be happy is to make others so. This is enough for us. In this belief we are content to live and die. If by any possibility the existence of a power superior to, and independent of, nature shall be demonstrated, there will then be time enough to kneel. Until then, let us stand firm”.*

CEREBRO encircle the acumen of all best initiatives & ideas of AIT EGSE team thus **reason**.

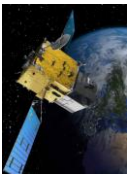
CEREBRO strives to capitalize our monitoring capability of EGSE and S/C systems thus **observation**.

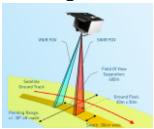


CEREBRO empowers our engineers to maximize experience by focusing on the system under test thus **experience**.

Last not least, CEREBRO aims to help our engineer to achieve *happiness*. We AIT EGSE team wants to establish a place of work where engineers can feel the joy of technological innovation, be aware of our mission to society and work to our heart’s content. CEREBRO was born with that in mind. On the other hand, cost reduction (high efficiency) is also a paramount.

CEREBRO is not only an idea but so far some established initiatives are already part of our reality. Some of them are presented in the next sections.

Table 1 Some of OHB outstanding satellite fleet

Project	Program	Number of S/C	Time line / comments
<b>MTG</b> 	Earth Observation, Weather prediction and nowcasting, high resolution observation data, new sounding.	6	First Launch MTG-I 2021 First Launch MTG-S 2023

<b>EnMap</b> 	Earth observation, Environmental Mapping	1	On-going System Test
<b>SARah</b> 	Satellite-based Radar reconnaissance	3	On-going integration phase
<b>Plato</b> 	ESA's cosmic Vision program, Observation of planets in other solar system (exoplanets)	1	Phase C

## Infrastructure

CEREBRO infrastructure is part of an existing OHB infrastructure, e.g. firmware and hardware. A representation of our available **core EGSE IT-infrastructure** is depicted in Figure 3. It shows the physical and logical view of our core EGSE & IT infrastructure.

Currently, the infrastructure is available for some of our Telecom projects and shall be available for all new projects. The centralization of the server-infrastructure guarantees the better utilization of resources. Server-infrastructure means servers, storage and backup devices. The central infrastructure provides the ability for running virtual machines that means that the CCS servers run on central physical servers and can be accessed from project side. Data is stored on central storage subsystems in accordance with our internal security policies e.g. security aspects. Some features of our core EGSE IT-infrastructure:

- Centralization of storage and therefore access (restrictions are accounted for different projects and security levels)
- Automatically backup
- Centralized virtual infrastructure, i.e. project is provided with additional resources as overhead, thus no need of project maintenance of server hardware
- Continuity of support and services e.g. access to files as reports, control version, time services (domain name service DNS)
- Highly connectivity, nonetheless project view access is restricted to only needed connections and services are available
- Standardization of operations, i.e. procedures and process

The current implementation/design of our EGSE IT-infrastructure presents additional features gained through heritage and experience as such better utilisation of hardware, more flexibility, hardware independency, redundancy and reduced hardware costs. The communication network between CEREBRO and the test site shall be established via ISDN or VPN (encrypted), connecting CEREBRO to the TM/TC Front End SCOE within the test centre or test facility e.g. IABG.

Part of the infrastructure for the CEREBRO also include our firmware.

- SPOC<sup>3</sup> a central point of administration and monitoring, the system is our foundation for a central and cross-mission EGSE support.
- Raptor an enhanced monitoring system through three steps: extraction, transformation and loading.



<sup>3</sup> Spacecraft Operation Center or SPOC is presented at the SESP2019 conference

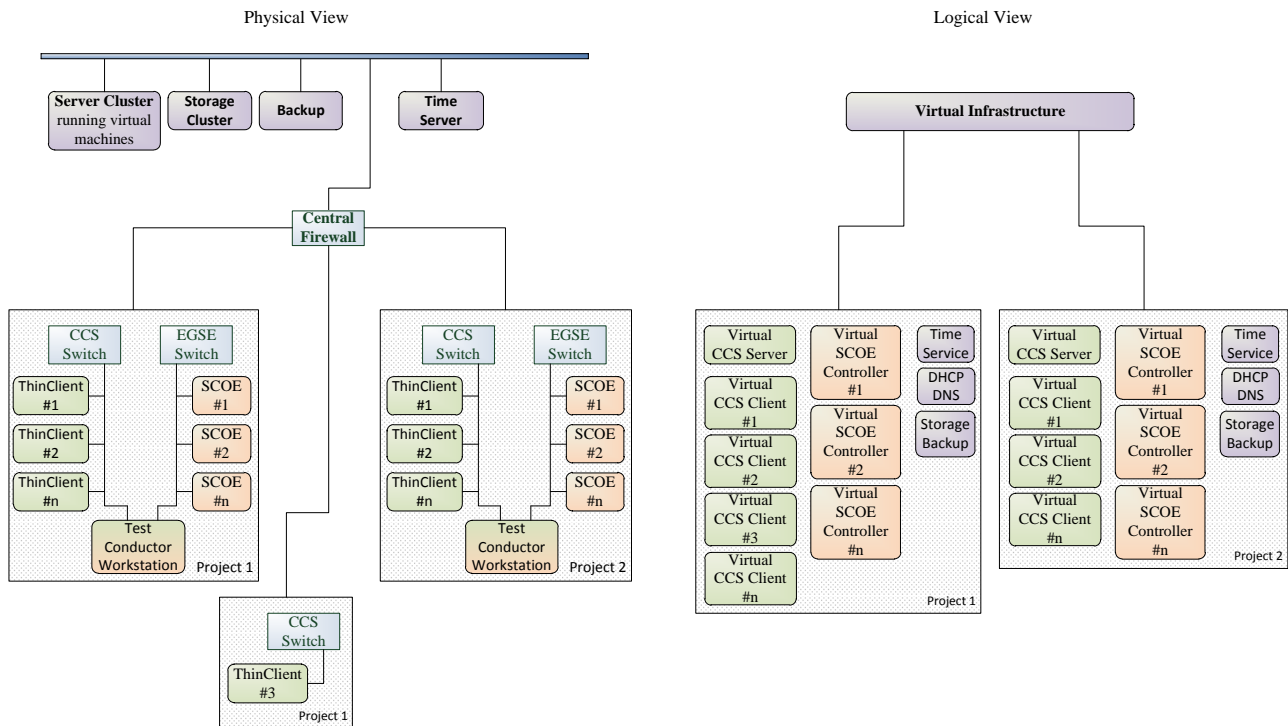


Figure 3 Central IT-Infrastructure for CEREBRO

## AIT OPERATIONS

Some of AIT off-site operations envisaged with CEREBRO:

- TVAC campaigns including preparation e.g. open doors and delta tests
- Healthy checks (Short functional test)
- CATR with combined Autocomp Test
- Short Functional and Performance Test
- EMC Tests
- E2E polarity

## CEREBRO Requirements

CEREBRO's gold requirement is the capability of remotely monitoring, analysis and conducting rehearsal operation of our satellites. Remotely, means the S/C is located off-site. CEREBRO is located at OHB headquarters empowering all essential people (system engineers, s/s engineers) to perform analysis, system support, and if needed, to conduct remote corrective operations.

Moreover, security and S/C safety shall be guaranteed throughout any off-site operations. In one sentence – safe and secure remote S/C monitoring & control.

Secure requirement shall be met by configured firewalls and encrypted VPN. Safety policies shall be covered by specific test procedures. Additionally, multimedia services shall constitute part of CEREBRO i.e. voice links between the off-site location (e.g. IABG) and CEREBRO shall be available.

## Product and Technology

The product is a control room fully capable to operate satellites during their AIT phases. This includes all satellites with their respective EGSE in all possible location during their AIT lifetime. This means that this control room is not intending to operate flying satellites. This option could be consider for the future.

The general design (see Chapter Design of CEREBRO) of the room is similar to the one we have during our test campaign. The improvement would be to have the possibility to operate the satellite from a remote location. If we consider the scenario of a satellite being physically location in IABG and the control room in Bremen. The control room in Bremen shall have the capability to connect to the EGSE in IABG and then operate the satellite with TM and TC capabilities. The TM/TC Front End incorporates a CORTEX BB that provides the baseband signals to the satellite under test and all Telecommand encoding and Telemetry decoding. In addition an SLE gateway shall be available for CEREBRO in order to extend its capabilities/flexibility (in case we need to employ the SLE protocol).

This capability is already existing in our current EGSEs. We are using it for our SVT ant MST test campaigns. Those tests involve the participation of the ground segment of our customers or LEOP operator (e.g: GSOC). Those tests are there to prove the capability to operate the satellite using their ground segment (control room, communication system) and perform rehearsals.

CEREBRO top-level function architecture is shown in Figure 4.

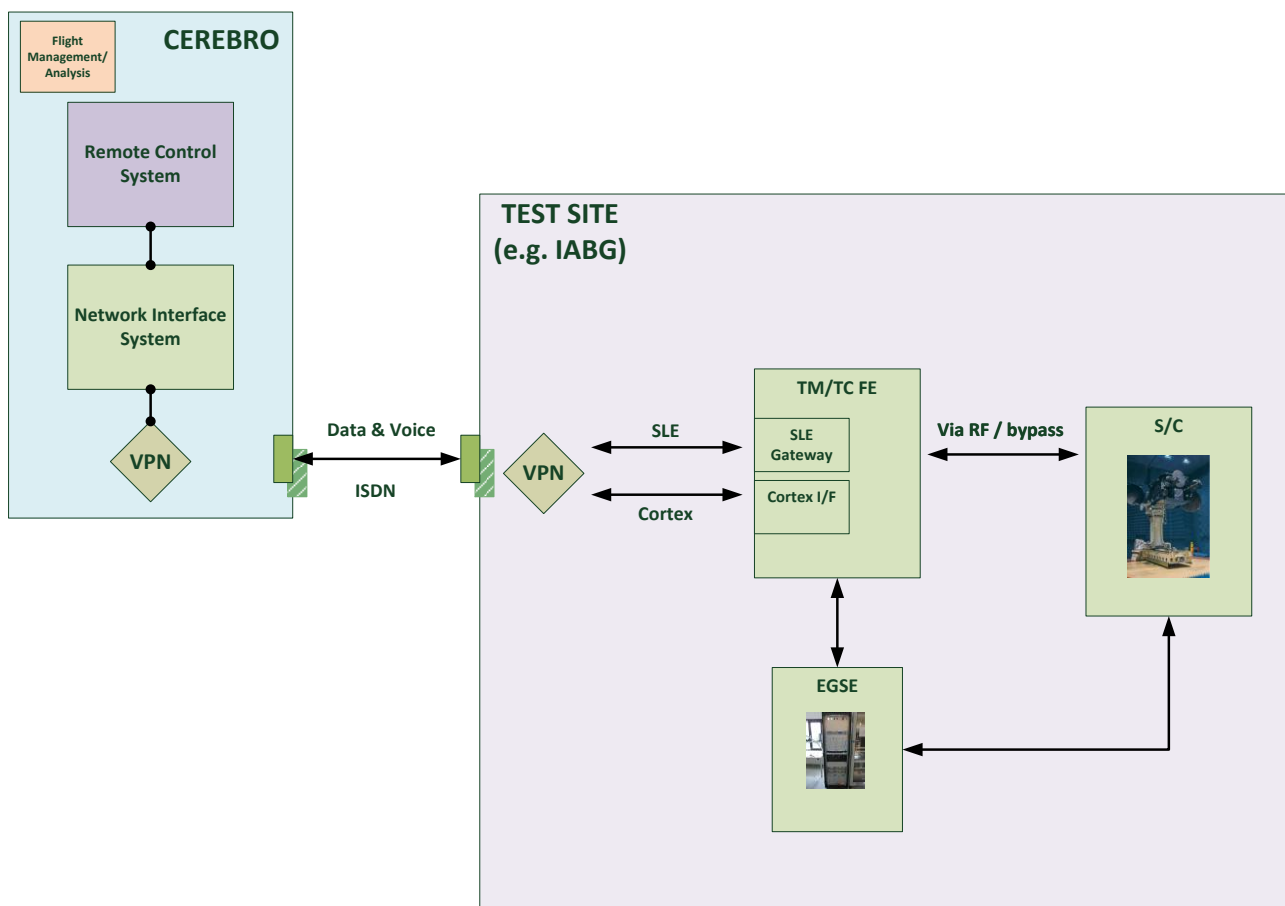


Figure 4 - CEREBRO and Test Site Functional Architecture

## Return of Investment

The return of investment ROI shall be used to measure or evaluate CEREBRO efficiency. The ROI from CEREBRO is based on the number of projects and operation costs. The improvement of the work conditions (happiness) created by CEREBRO cannot be measured as a cost but as a value for our engineers.

OHB System should invest in the necessary facility and equipment and will get a ROI after the first satellite. All satellites after that will be a plus. The system shall be operation for H2Sat Environmental Test campaign. The project team is experienced with the Hispasat 36w-1 environmental test campaign and would most probably welcome this initiative. Also the customer would have the mind-set to agree with this solution.

## CEREBRO AT WORK

### Scenario – Test Case: Test Environment Campaign @IABG - Ottobrunn

One of CEREBRO's target is to keep a minimum of engineers traveling without compromising the good development of the activities. Our test-case illustrates an average traveling cost over 1 year on a telecom satellite project.

The following scenario is reflecting today our current work approach i.e. a complete team following the S/C, located in the test facility (IABG) or launch site. At OHB System, AIT & Logistics division is divided into 4 departments. Among them we have the Test Operation Ottobrunn (TOO) Department and the AIT Department in Bremen (BRE) are responsible for the S/C AIT test campaigns. The roles assigned from the teams are presented in Table 2. The following assumption is considering a) time line as a full year, and b) the minimalist assumption of the presence of engineers within their roles as provided in Table 2. In our current way-of-work the estimated average cost for travel (transport & accommodation), only, would be about 400k€.

CEREBRO structure would **zero** that cost. Most importantly, the colleagues will have better condition of work with less tiredness and less stress.

Table 2 - Test Case Scenario for an off-site test campaign (@IABG)

Team	Division	Role	Required presence for typical test week	Traveling per week without proposal	Traveling per week with proposal
TOO	AIT	ETC Manager	1	0	0
TOO	AIT	AIT System Engineer	1	0	0
TOO	AIT	Mechanical AIT Lead	1	0	0
TOO	AIT	Mechanical Operator	1	0	0
BRE	AIT	Electrical AIT Lead	1	1	0
BRE	AIT	Test conductor	1	1	0
TOO	AIT	Test operator	1	0	0
BRE	AIT	Test operator	1	1	0
BRE	AIT	Engineering Support (e.g. EGSE)	1	1	0
BRE	SE	System Engineering	1	1	0
BRE	PA	Product Assurance	1	1	0
TOO	PA	QA	1	0	0
			hotel for 4 nights 70€ * 4	280 €	
			one week compensation (24€ * 5)	120 €	
			return flight to Munich with flex condition	400 €	
			cars + gas = 200 (rental) * 2 (car) + 50 (gas)	450 €	

Team	Division	Role	Required presence for typical test week	Traveling per week without proposal	Traveling per week with proposal
			Total traveling cost for 1 week of test	7,500 €	
			1 year of test at IABG	<b>382,500 €</b>	0 €

### On Site Activities (Ottobrunn, Korou)

It includes all activities that must be performed on site with the S/C. The on-site team are all essential staff for performing all necessary operations. In case of Ottobrunn at IABG a team is already established, i.e. no need of relocation for the AIT or System teams in Bremen.

### Remote Activities (from Bremen)

CEREBRO shall be located in Bremen. On site activities includes:

- Monitoring of S/C and EGSE
- Coordination & training
- Operations and analysis

Having one central control room will force the standardization of procedures and user manuals. On the preparation aspect, the import part of the documentation will be re-use from project to project. On the training side, the technical people will be trained to work on the same system. Therefore they will have almost no need of additional training from one project to the other. The test data will be stored in the same fashion on a central database and therefore can be used by end-user using a standard format. Up to a certain extend linked to the knowledge of the satellite, the operators could be exchangeable on short notice. The central control room will contribute to have always an up and running system and will reduce the setup and de-setup activities. The reduction of traveling will reduce the tiredness and stress of the team. On the other hand, it will improve the communication with the core team in Bremen and facilitate the resolution of issues.

### Risks

Implementing CEREBRO creates a limitation of the need of having a big department in remote location like Ottobrunn and Kourou. This could create a conflict with some colleagues personal / professional interests. From the cost point of view the additional infrastructure (e.g. room) has a relative low cost. Technologically, due to our heritage (e.g. Hispasat 36w-1) OHB has all the knowledge to implement CEREBRO.

### LONG TERM VISION

The design, procurement and installation can take up to one year. The system shall be operation for H2Sat environmental Test campaign.

The development includes:

- Identification of the location of a central control room.
- The room shall be able to accommodate 5 satellites (regardless of the model, EM, ATB, FM etc.) with their respective team at the time.
  - 2 workstation per satellites (2 screens, 1 keyboard, 1 mouse)
  - Projectors or Big size displays for satellite visualization on the wall. Switchable input to be able to display any satellite data
  - Secured and controlled access of the room with OHB Badges
- The central control system shall have a central database to store the test data.



- The central control system shall be compatible with all satellites projects.
- The central control system shall be on an UPS to avoid power outage.

The performance target is to have maximum 1 AIT tester from Bremen traveling to Ottobrunn or Nordwijk during the test campaign.

## **OHB On-site Infrastructure and EGSE Core**

### **IT-Infrastructure**

For the IT-infrastructure the monitoring will cover “standard” parameters that will show how healthy the IT-infrastructure is:

- utilization of CPUs
- level of filesystems
- accessibility of servers, storage systems, switches
- accuracy of time-services

The capacity using the Cortex SLE is already present in our current EGSEs on the satellite side. The development of server room is known by EGSE system team and by OHB DS. The purchases of IT goods can be done by OHB DS (Central IT).

## **CONCLUSION**

CEREBRO is a proposal from AIT Bremen department in order to have a central control room for on-site and off-site AIT test campaigns. A test case based on test environment campaign is presented taking into account a year operation. The critical infrastructure as EGSE & IT and core technologies (control & monitoring) are already in place / existing at OHB. CEREBRO is a viable solution that could improve efficiency and also the operational conditions for our engineers.

## **ACKNOWLEDGEMENT**

The authors would like to thank OHB system for founding this work. We also would like to express our deepest appreciation to all those passionate colleagues who provided the motivation and inspiration to embrace this initiative.

## **REFERENCES**