D3.13 – PCD and CDH Design Document

prepared for

WP 3.6 – Power Control and Distribution and Command and Data Handling

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Approved by:	Paul Zabel	DLR	Work Package Leader
Approved by:	Matthew Bamsey	DLR	Systems Engineer
Approved by:	Daniel Schubert	DLR	Project Manager

List of Authors:

Participant No.	Short name	Author name(s)
1	DLR	P. Zabel, C. Zeidler, M. Bamsey
4	UoG	M. Stasiak
13	TPZ	A. Ceriello, R. Fortezza

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Executive summary

This document presents an overview of the Mobile Test Facility Power Control and Distribution System. Additionally, this document describes the Command and Data Handling System (CDHS) of the EDEN ISS project. In particular, it describes the CDHS of the Mobile Test Facility including the Argus control system, general network infrastructure, mobile platform and camera control and management hardware, the wireless link between the MTF and Neumayer Station III as well as Neumayer Station III EDEN ISS data and communication hardware. The document also details the overall Antarctica-Europe control and data transfer link and the EDEN ISS User Home Bases. Finally, Mobile Test Facility safety hardware is also described.

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Acronyms

Acronym	Explanation	Acronym	Explanation
ADO	Argus system digital output	NDD	NDS Drawer
AMS	Air management system	NDS	Nutrient delivery system
AWI	Alfred Wegener Institute	NM-III	Neumayer Station III
CDHS	Command and Data Handling System	PC	Personal computer
CNR	Consiglio Nazionale delle Ricerche	PCDU	Power Control and Distribution Unit
CPO	Cold Porch	PDS	Power Distribution System
DLO	University of Wageningen	PHM	Plant Health Monitoring
DLR	German Aerospace Center	PMP	Pump
EXT	Exterior	PMS	Plant Monitoring System
FEG	Future Exploration Greenhouse	PoE	Power over Ethernet
GEL	General External Lighting	S/S	Subsystem
HD	High Definition	SES	Service Section
HDCP	High-bandwidth Digital Content Protection	SW	Software
I/F	Interface	TAS-I	Thales Alenia Space Italy
I/O	Input/output	TBD	To be determined
ILS	Illumination System	TC	Thermal Control System
IR	Infrared	TCS	Thermal Control System
ISPR	International Standard Payload Rack	TM/TC	Telemetry/telecommand
ISR	International Standard Payload Rack	TPZ	Telespazio
ISS	International Space Station	UHB	User Home Base
LDO	LabVIEW system digital output	UPS	Uninterruptible Power Supply
LED	Light-emitting diode	VOIP	Voice over IP
MID	Middle position	WET	West
MTF	Mobile Test Facility		

1 Power Control and Distribution System Baseline Design

1.1 Overall design

The power control and distribution system consists of the main power box, cable channels for power and data cables, the power cables, and the internal and external lighting (excluding the plant illumination system). The main power box is located on the north side of the service section adjacent to the wall to the FEG. The box holds all fuses, relays, wattmeter and DC converter and splits the power line incoming from Neumayer III into lines for each subsystem, which are then split into lines to the different components.

The primary cable channels are attached to the ceiling of the MTF and run along the walls of the service section and in the corridor of the FEG. The red lines in Figure 1-1 illustrate the positioning of the primary cable channels. In addition to the primary channels under the ceiling there are also secondary channels which run vertically at strategic points to direct cables to equipment located e.g. within the different level of the FEG.

Most of the power cables are for 230 VAC. For the distribution of the electricity, three-wire NYM-J installation cable certified for wet rooms will be used. There are also a number of components running at 24 VDC, which will be supplied by two-wire cables also certified for wet rooms.

The power control system for the plant LED fixtures is part of WP3.4 and the described in the according deliverable. The 230 VAC supply lines from the main power box to the LED fixtures are part of the general power control and distribution system.

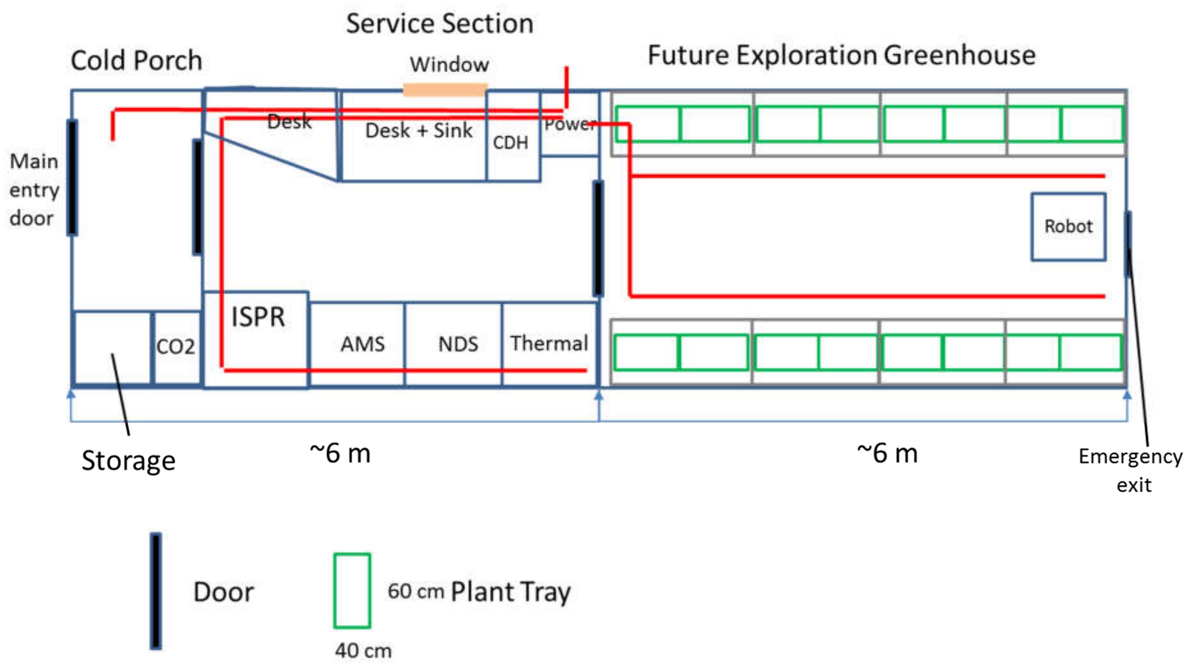


Figure 1-1: Overview power distribution.

1.2 Main power box

The main power box is the heart of the MTF. It splits the incoming three-phase line from Neumayer into separate lines for the different subsystems and components. The baseline layout of the power box can be seen in Figure 1-2. The used cabinet has a glazed door. The main power line coming from Neumayer enters the cabinet through the bottom of the cabinet, is split up into separate lines for each subsystem, which are in turn split into lines for each component or group of component. The power distribution cables leave the cabinet through special openings in the top part of the cabinet.

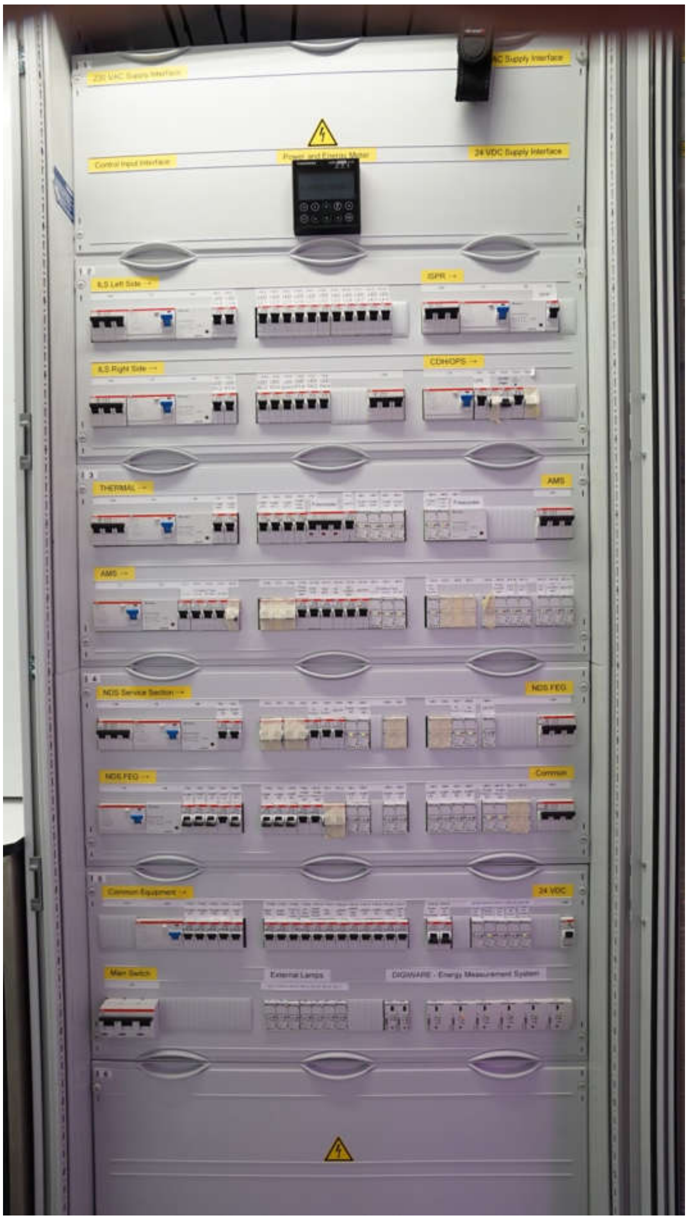


Figure 1-2: Main power box, as built.

1.3 Cable channels

The cable channels within the FEG are made out of the modular installation channel system of the company ITEM. The channels are made out of aluminium. Their modular system allows the construction of a wide variety of cable channels with different cross section dimensions. The cable channels in the Service Section and Cold Porch are made of white plastic in order to fit into the clean design of both rooms.

1.4 Energy measurement

The overall energy consumption of the MTF as well as the consumption of each subsystem and selected components is measured. The goal of the energy measurement system is to get a better insight in the total electrical energy required to produce food in a closed environment. Furthermore, the measurement of each subsystem and selected components allows the identification of optimization potential with respect to energy efficiency.

The Diris Digiware modular system by the company SOCOMEC is used as measurement system. The system used within the MTF consists of a three-phase voltage measurement module and a three phase current measurement module for the main supply line, six six-port current measurement modules, a display module inside the power box and a gateway module to communicate to the local network. The display and the gateway module are built into the top part of the power box, while the measurement modules are located in the bottom part.

The gateway module can be accessed by an internet browser. The so called Hyperview software is then used to show the measured parameters. An export to an FTP server can be activated.

1.5 Backup power supply

Potential power shortages and voltage fluctuations have to be buffered to avoid the uncontrolled shut-down of the command and data handling system and the communication between the MTF and Neumayer III. Therefore, a backup power supply (or uninterruptable power supply (UPS)) will be installed within the MTF. Table 1-1 shows the equipment which is connected to the UPS.

Table 1-1: List of equipment which needs to be buffered by the UPS.

Equipment
Argus server
Camera server
Argus System
24 VDC power supply (includes HTK safety system, relays, etc.)
Service Section switch
FEG entrance switch
FEG exit switch
Server screens in Service Section

An APC SMART-UPS 1500VA with three battery extension modules has been built into the MTF in the top compartment of the NDS rack. The UPS (including the extension batteries) has the following characteristics:

- Max. power: 1000W / 1500 VA
- Dimensions per module: 440 x 509 x 86.2 (2U) mm

The UPS should be able to run the connected equipment for around 80 minutes.

2 Estimated power and energy budget

The installed power of a facility is an important key value to lay out the interface (e.g. fuses or cables) between the power supply and the facility. The installed power represents the sum of all consumers of electrical energy when they are running at 100 % power all together. The MTF has a total installed power of around 26.7 kW. Table 2-1 shows the installed power per subsystem. The AMS with 7.0 kW and the ILS with 7.5 kW have the highest power demand.

Table 2-1: Installed power per subsystem and the according phase of the main power line.

	Installed power
CDH	1.0 kW
General	4.0 kW
Ops and Coms	1.8 kW
AMS	7.0 kW
NDS	1.5 kW
Thermal	3.0 kW
ILS	7.5 kW
ISPR	0.9 kW
TOTAL	**26.7 kW**

While the installed power is important to lay out the interface between Neumayer and MTF, the average power demand (and therefore the energy consumption) is important to estimate the additional fuel consumption of the diesel generators. The average power demand is also important to integrate the MTF in the Neumayer power control system.

The average power demand of the MTF calculated over one year is around 11.5 kW. However, the plants require a certain photoperiod-darkperiod cycle. Where photoperiod means the plants are illuminated and darkperiod means, that the plants are not illuminated. The cycle results in a different power demand during photoperiod and darkperiod, because some subsystems are not or only running at a low level during the latter. During day the average power demand is around 14 kW and during the darkperiod around 6.7 kW, as seen in Figure 2-1.

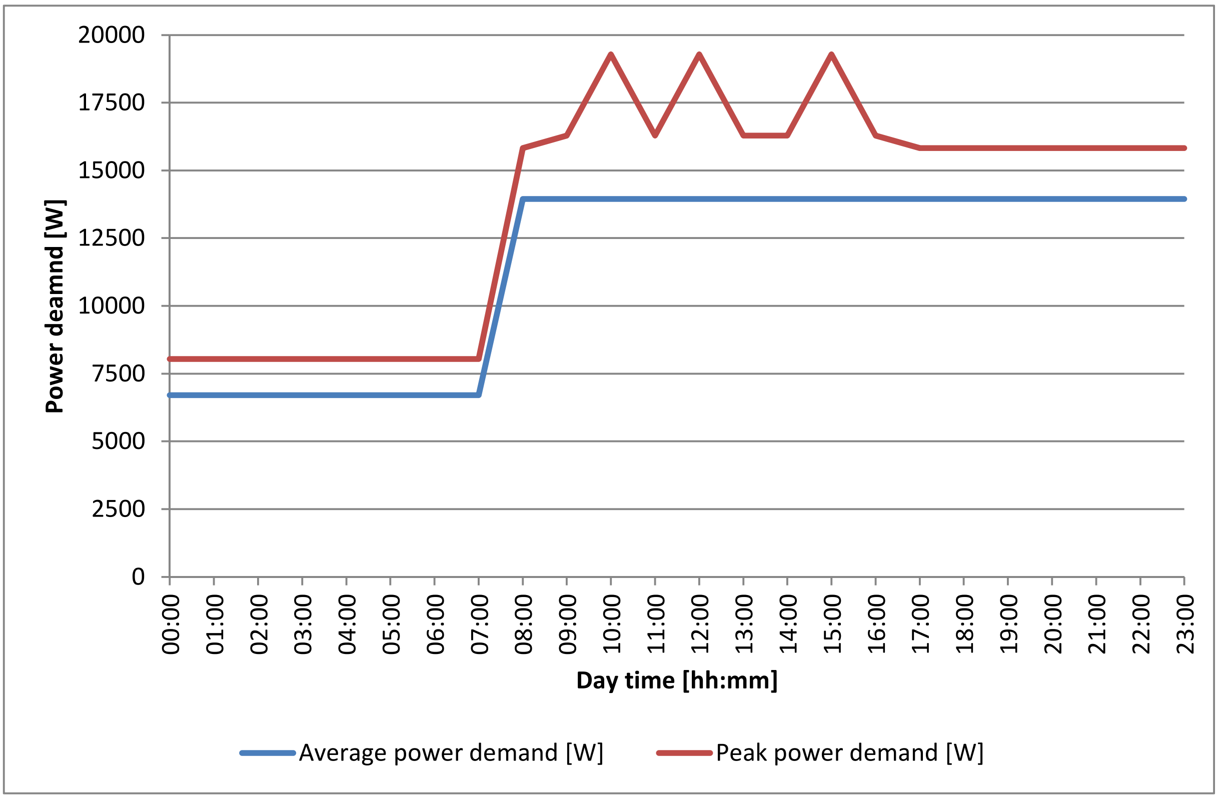


Figure 2-1: Average and peak power demand during a typical operation day.

3 Command and Data Handling System Baseline Design

The command and data handling system (CDHS) is responsible for in-situ data acquisition and control within the Mobile Test Facility (MTF), for managing all MTF data (sensor, imaging) and for ensuring storage and remote access/control of the MTF from the Neumayer Station III (NM-III) and from User Home Bases (UHBs) located at EDEN ISS project partner premises. CDHS hardware located in the MTF, NM-III and UHBs are each described as are the operationally relevant aspects of each. Relevant safety system hardware is also detailed.

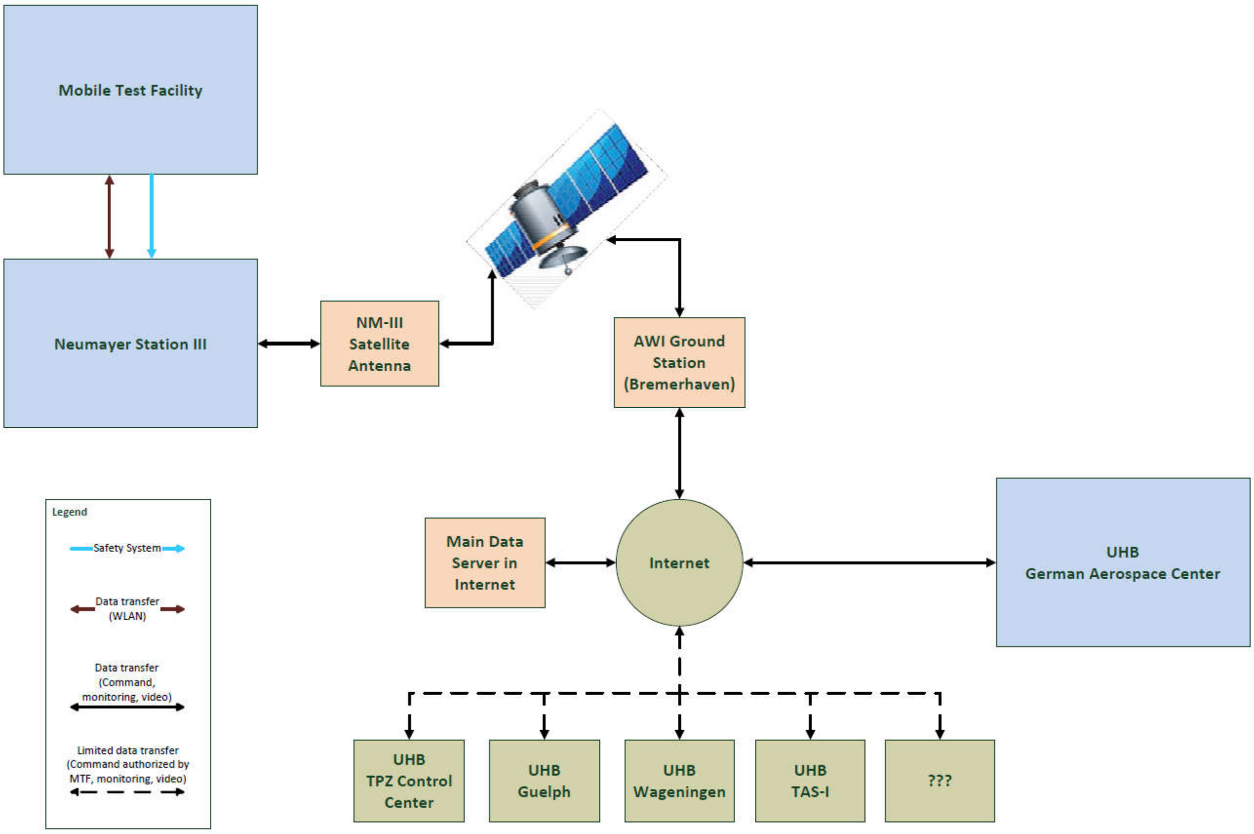


Figure 3-1: Simplified graphical representation of the main EDEN ISS CDHS elements.

3.1 Mobile Test Facility

The command and data handling system of the MTF (see block diagram Figure 3-2) is subdivided into:

- Control and monitoring system,
- Camera system,
- Mobile Platform and
- Safety system.

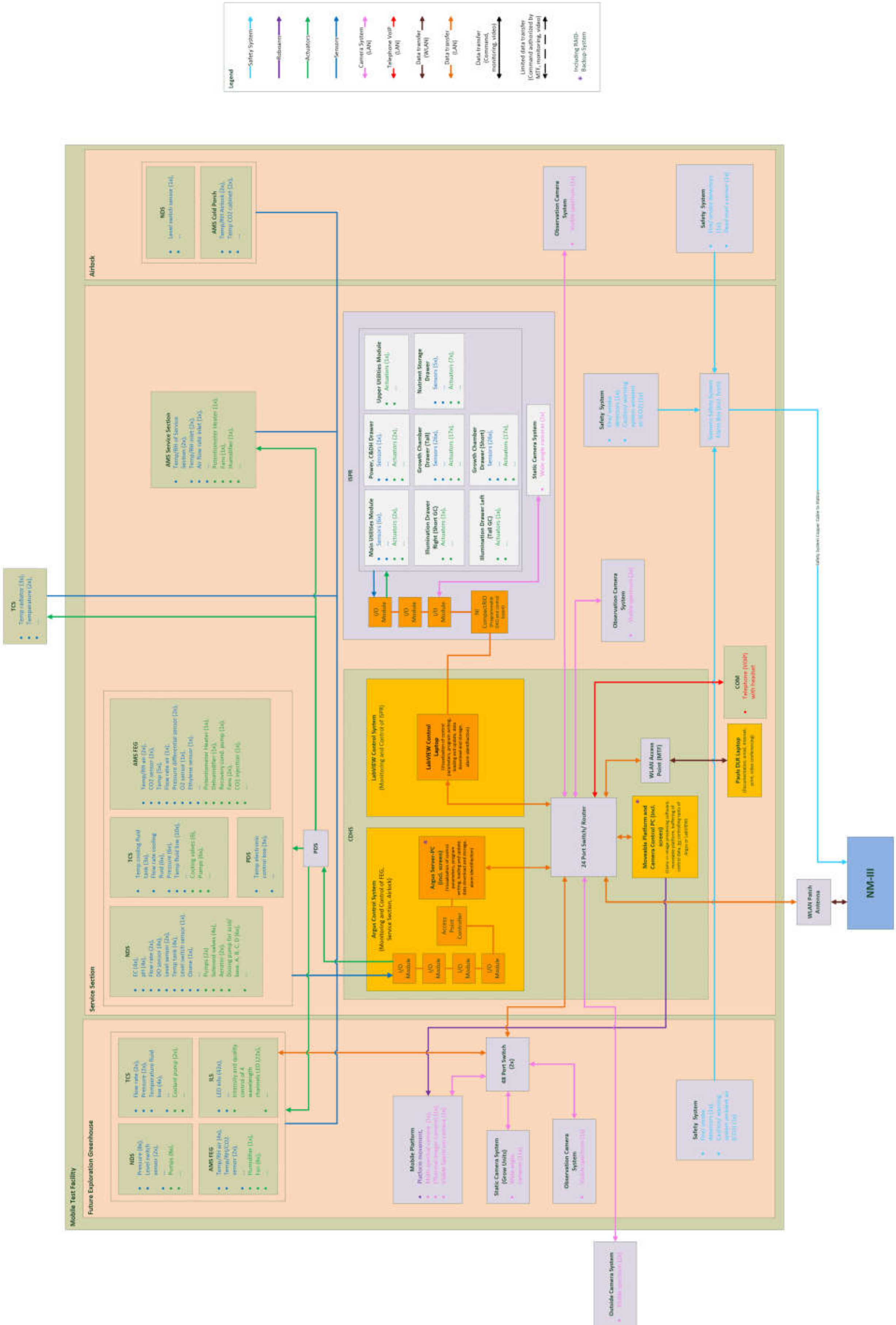


Figure 3-2: Block diagram from the CDHS baseline design of the MTF.

3.1.1 Control and Monitoring System

The control and monitoring system of the MTF consists of two PCs connected over an Ethernet switch to the MTF network. This local network is connected to the Neumayer III Ethernet network via two patch antennas, one installed outside the MTF facing NM-III and one installed outside NM-III facing the MTF. The total number of sensors connected to the command and data handling system is 215, the total number of actuators is 145 and the total number of cameras is 41 (see also Chapter 4.1.1). The distribution of some of the CDHS hardware located within the Service Section of the MTF is shown in Figure 3-3.

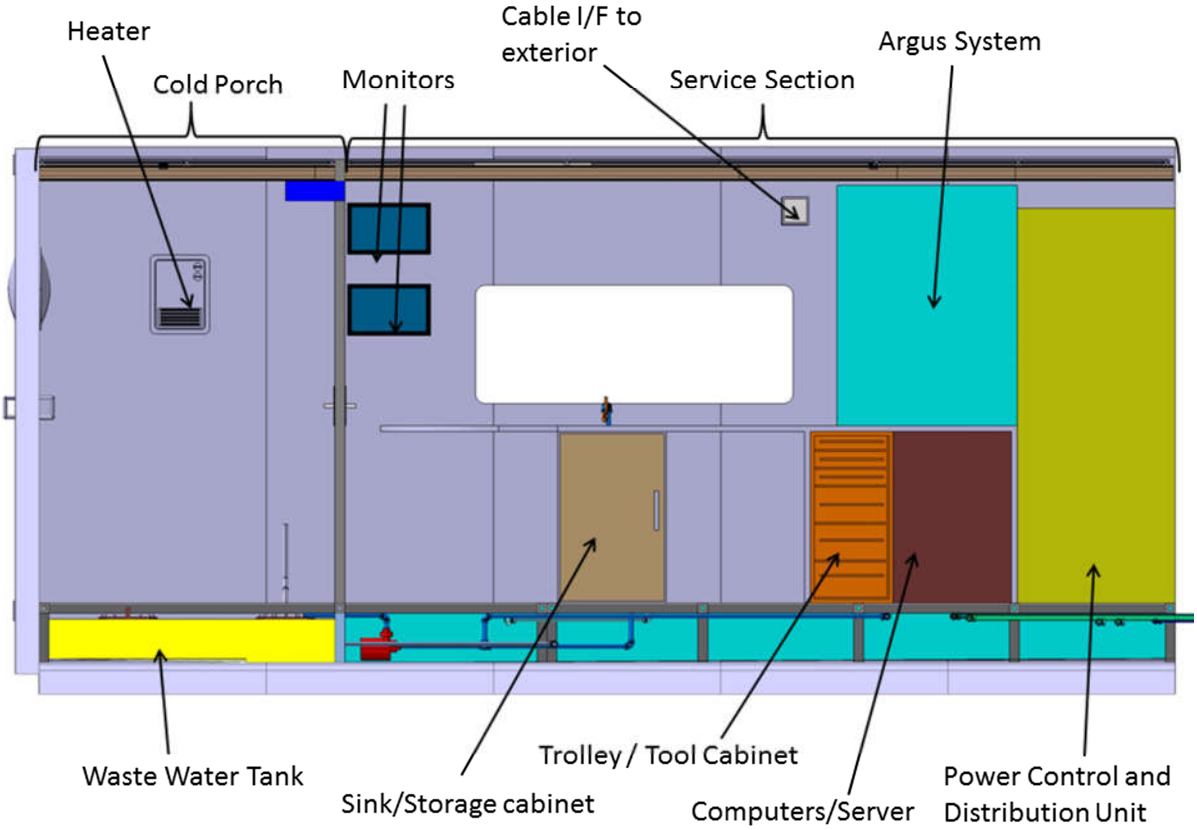


Figure 3-3: Command and data handling system in the Service Section.

Computers

The two CDHS PCs located within the Service Section include the **Argus Server PC** and the **Mobile Platform and Camera Control PC**. The Service Section also houses the **LabVIEW Control Laptop** for ISPR control. A personal laptop may also be used on an as desired basis within the Service Section by the MTF operator (i.e., for non-critical purposes such as accessing MTF procedures, reporting, outreach activities, etc.).

The **Argus Server PC**, including RAID system, is used to control and monitor all systems inside and outside the MTF except the ISPR, the safety system, the camera system and the mobile platform (see Figure 3-2) using Argus Titan control software. It can also be used to visualize the control parameters on the connected screen located on one wall of the Service Section (Figure 3-3), to write or upload new program code to the Argus control system and to download and store Argus control data.

The **Mobile Platform and Camera Control PC**, including RAID system, has various tasks including:

- Processing of images from camera system using dedicated software,
- Control the mobile platform (further information is provided in D3.11 – PHM Design Doc.) and
- Buffering of control data (but no controlling task by Argus or LabVIEW).

The command and data handling PCs (see Figure 3-4) are installed in a 19’’ rack system box with the dimensions of 600 x 600 x 900 mm (see Figure 3-4) located in the Service Section (see Figure 3-3). A 24 port network switch and the UPS of the Power Control System are also installed in this box.

Figure 3-4: 19"-rack system from RITTAL - 18 HE (left). Possible CELSIUS M740 command and data handling PC from FUJITSU (right).

Argus System

Argus provides a complete hardware and software solution for monitoring and equipment automation purposes (see Figure 3-5). The Argus System is developed by Argus Controls (Surrey, BC, Canada), a greenhouse control and environment management standard since 1984. The designed hardware is an essential component for handling the wide range of applications that the Argus system is capable of. It is exceptionally serviceable, scalable, and flexible.

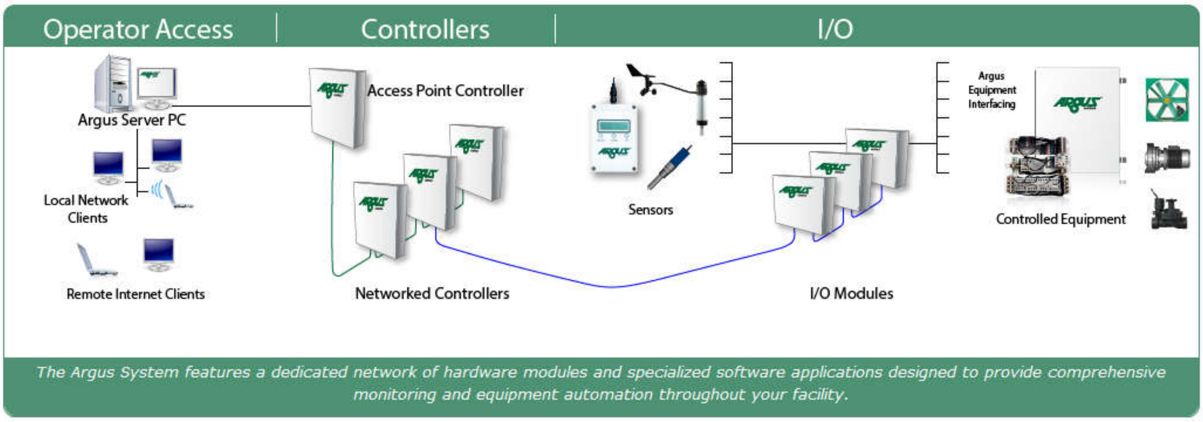


Figure 3-5: Overview of exemplary Argus control system.

As part of the Argus services, they select and preconfigure all of the control components required to meet the user's specifications. The user only needs to supply information about the equipment they need to control and the processes they need to manage. Argus supplies the user with a complete end-to-end control system tailored to their facility.

The **Argus Server PC** provides **password-protected access** to the Argus control system enabling authorized users on other PCs (like user home bases) to connect to the system via wired or wireless Ethernet networks and the Internet. The multi-user option lets multiple users connect for simultaneous access to the control system. Remote clients have access to all of the features authorized by their password level no matter where they access the system from.

As can be seen in Figure 3-5, the Argus control system to which the Argus Server PC is connected, consists of:

- Access point controller,
- I/O modules,

- Relay modules and
- Sensors and actuators.

Figure 3-6: Argus access point controller.

The Access point (see Figure 3-6) is equipped with a Titan controller and components to facilitate Ethernet connection to the Operator PC, external alarm output relays, a battery for emergency backup power, and power supply circuitry for operating the controller and the first segment of the connected I/O Communications Network. The system is then expanded as needed by simply adding additional controllers connected together by a highly flexible communications network. Wired and wireless controller connection options are available. For maximum safety and reliability, each controller operates autonomously and all controllers are continuously monitored.

Titan controllers are industrial computers designed by Argus. All control programs are executed from the controllers. When an Argus system is accessed from a PC the communication is directly established with the controllers. When the user is not on-line, the Titan controllers automatically operate all of the controlled equipment in accordance with the dedicated settings and control targets.

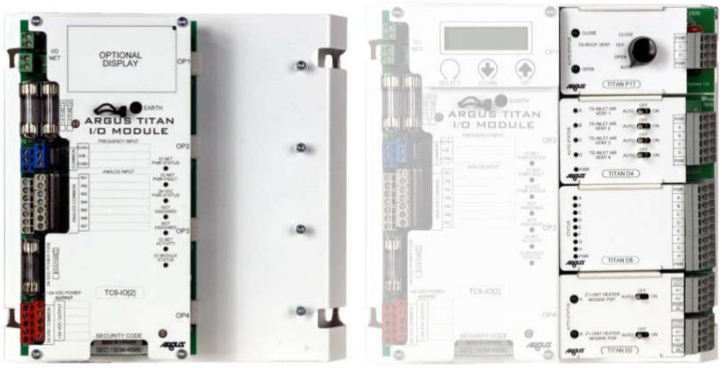


Figure 3-7: Argus I/O module (left). Argus relay module (right).

Argus I/O modules (see Figure 3-7) function as seamless extensions of each Argus controller, acquiring data from connected sensors and executing all equipment control operations. Large numbers of I/O modules can be linked together to match the applications under control and physical locations of the controlled equipment and sensors. They can be ganged together in panels or distributed individually throughout your operation as required.

Argus I/O modules have addressable connectors for automated equipment control signals. Any combination of Argus output relay boards (see Figure 3-7) can be connected to provide control signals that are precisely matched to the controlled equipment. Depending on the application, each I/O module can operate between 4 and 32 discreet outputs.

As mentioned, the above the whole Argus control system is customized to the needs of the user by Argus. Argus puts the control system in a customized Argus box including e.g. the controllers and I/O modules (see Figure 3-8).

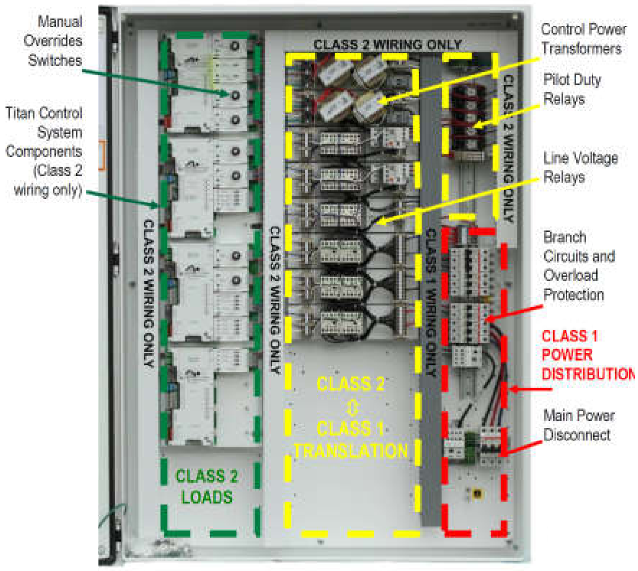


Figure 3-8: Example Argus box.

The following table shows the sensors and actuators that will be connected to and controlled by the Argus control system.

Table 3-1: Sensors and actuators connected to the Argus control system.

Argus			
Subsystem	**Location**	**Amount**	**Sum**
NDS	FEG.NDS	10	33
	SES.NDS	22	
	CPO.NDS	1	
	FEG.NDS	8	23
	SES.NDS	15	
ILS	FEG.ILS	42	42
	FEG.ILS	42	42
TCS	EXT.TCS	5	38
	SES.TCS	25	
	FEG.TCS	8	
	SES.TCS	12	14
	FEG.TCS	2	
PDS	SES.PDS	3	3
AMS Cold Porch	CPO.AMS	4	4
AMS FEG	FEG.AMS	6	20
	SES.AMS	14	
	FEG.AMS	9	15
	SES.AMS	6	
AMS Service Section	SES.AMS	5	5
	SES.AMS	3	3
		Sensors:	**145**
		Actuators:	**97**

For more detailed information regarding the type of sensors and actuators see Table 4-2 of chapter 4.

Taking all the sensors and actuators of Table 3-1 into account the Argus box will have the dimensions of 1220 x 915 x 204 mm. A number of the Argus standard I/O modules are replaced with Modbus I/O units to reduce the dimensions. These new modules are presently under development by Argus and are expected to be available by early to mid-2016.

The Argus main system components will consist of a TCX main access point coupled to a TCX-IOPS power supply and six TCX-IO relay boards. Also included are nine Modbus-RTU A/D modules used to simplify the overall design and reduce the control system footprint. A 24 VAC (75 VA) transformer fed by mains power (220 VAC/50Hz) is located in the Argus panel and provides all the power to the Argus system components within the panel. Argus relays will actuate high power devices through contactors located in the power distribution module.

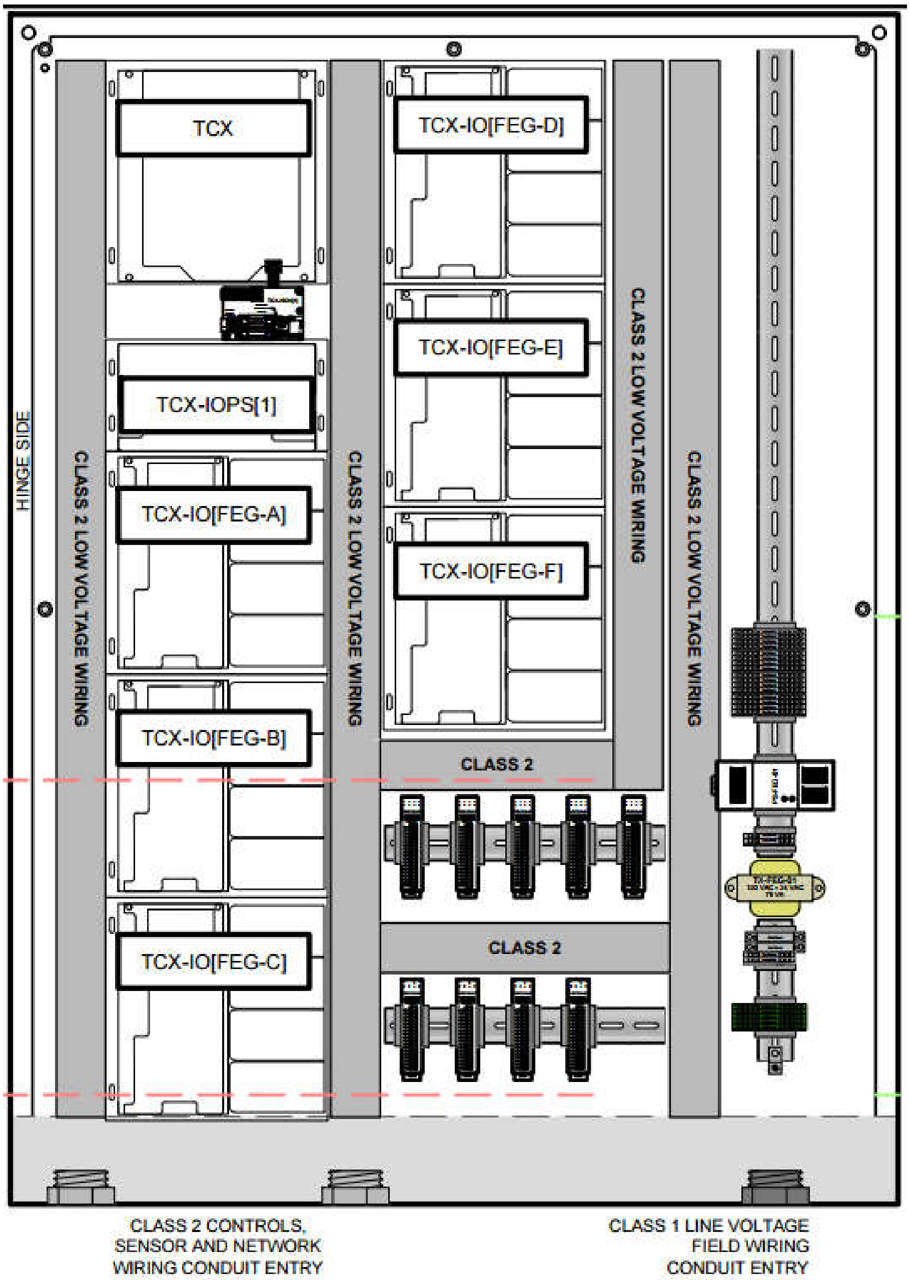


Figure 3-9: Argus control panel layout.

ISPR Interface

The **LabVIEW Control Laptop** can be used to visualize the control parameters of the ISPR, to write or upload new program code for the ISPR and to download and store ISPR data. It is only connected to the ISPR system in the described situations. Normally the whole ISPR system is controlled by the programmable data acquisition and control board NI-CompactDAQ integrated into the ISPR system using LabVIEW software. These items are described in more detailed in the ISPR design report.

The following table shows the amount of sensors, actuators and cameras connected to the LabVIEW control system.

Table 3-2: Sensors and actuators connected to the LabVIEW control system.

LabVIEW		
Subsystem	**Location**	**Sum**
Main Utilities Module	SES.ISR.MUM	6
	SES.ISR.MUM	2
Upper Utilities Module	SES.ISR.UUM	1
Power, C&DH Drawer	SES.ISR.PCD	1
	SES.ISR.PCD	2
Nutrient Storage Drawer	SES.ISR.NDD	5
	SES.ISR.NDD	7
Growth Chamber Drawer (Tall)	SES.ISR.GCT	26
	SES.ISR.GCT	17
Growth Chamber Drawer (Short)	SES.ISR.GCS	26
	SES.ISR.GCS	17
Illumination Drawer Left (Tall GC)	SES.ISR.ILL	1
	SES.ISR.ILL	1
Illumination Drawer Right (Short GC)	SES.ISR.ILR	1
	SES.ISR.ILR	1
	Sensors:	**64**
	Actuators:	**48**
	Cameras:	**2**

For more detailed information regarding the type of sensors and actuators see Table 4-2 of chapter 4.

Other network infrastructure

The CDHS contains a number of network and miscellaneous components that are described in the sections to follow.

Data transfer between the MTF and the NM-III is baselined to be conducted in a wireless manner (a cable connection was also considered but not implemented due to reasons of cost and the fact that the MTF is considered a 'crewed' facility, in that operators can visit the facility should communication issues arise). The MTF will include a patch antenna installed on the roof of the facility which communicates through line of sight to a matching antenna installed on NM-III. This follows a similar configuration to that presently utilized on the NM-III Air Chemistry Laboratory. The considered antenna is shown in Figure 3-10.

Figure 3-10: Patch antenna: PowerBridge M5 - Carrier Class 5GHz MIMO Bridging Solution (Ubiquiti Networks).

The CDHS also will contain a WLAN access point (see Figure 3-11), which is also connected to the MTF network switch and provides WLAN access to the network/Internet in the whole MTF.

Figure 3-11: PoE WLAN Access-Point 300 MBit/s 2.4 GHz Intellinet 525251.

The Service Section will house a 24 port switch from Cisco (model: SLM2024T-EU 200 Series SG200-26), which is installed, as mentioned above, in the 19'' rack system of the Service Section.

Figure 3-12: Cisco-SLM2024-Gigabit-Smart-Switch with 24 ports.

The 24 port switch will be connected to the MTF camera system, two computers and laptop of the Service Section, WLAN access point, patch antenna, VOIP telephone and over two 48 port switches to the LED system of the FEG.

The two 48 port switches (model: CISCO SG500-52P with 48 POE-ports) are located on the right and left side at the ceiling of the FEG. The dimensions of 48 port switches are 440 x 44 x 350 mm (W x H x D) and they are fully backwards compatible with IEEE 802.11af *PoE, which is needed for the camera system of the FEG. In total there are 42 LED lamps and 35 cameras connected to the 48 port switches.*

Figure 3-13: CISCO SG500-52P with 48 POE-ports.

Two screens are baselined to be mounted to the wall of the Service Section and positioned as shown in Figure 3-14. The proposed monitors are Fujitsu Display P23T-6 IPS with a 58.4 cm (23-inch) widescreen. The dimensions are 551 x 198 x 358 cm. They have an ultra-wide viewing angle of 178° and have a unique energy saving solutions with 0 watt power consumption in standby mode. They provide highly flexible connectivity through different interfaces - 4x USB, DisplayPort, HDCP (via DVI-D), DVI and analog.

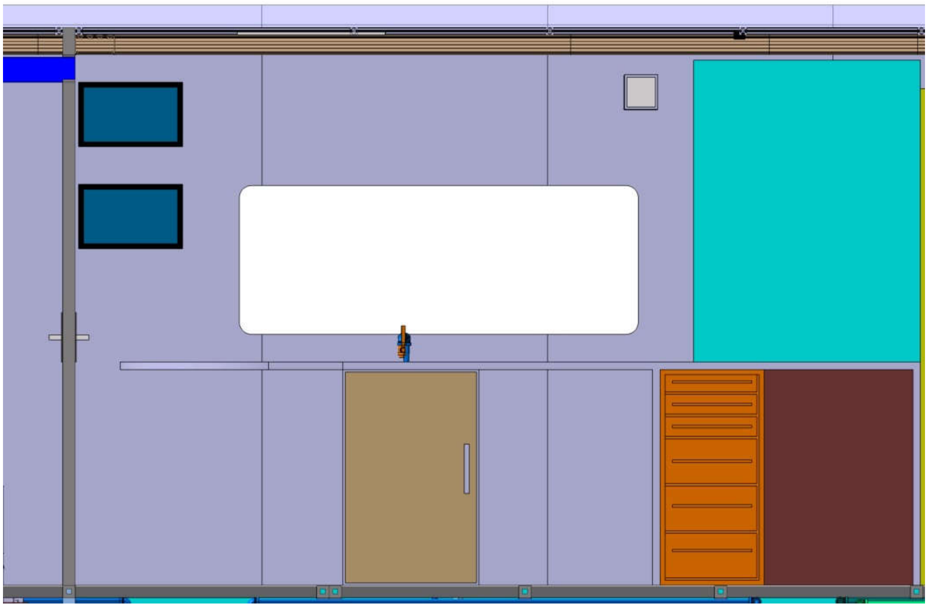


Figure 3-14: Proposed CDHS computer monitors on the left side of the window.

Another item used in the CDHS is the VOIP telephone including headset (see Figure 3-15).

Figure 3-15: Cisco IP-Telefon 7970G.

In addition to the above mentioned items, a mobile workstation laptop will be used in the MTF for documentation purposes, using the Internet, sending as well as receiving emails and video conferencing.

3.1.2 Camera System

The cameras listed in the following table are connected to the MTF network via Ethernet switches located in the FEG and the Service Section. As mentioned above, they are controlled by the **Mobile Platform and Camera Control PC** due to dedicated image processing software. For detailed information concerning the specific cameras employed in the MTF camera system (visual and multi-spectral) the Plant Health Monitoring design document should be referenced. The CDHS document describes the connections and management of the camera data (in some instances information is repeated for completeness).

The cameras described in the following table are connected to the MTF network (it should also be noted that although presently not considered in the baseline design, accommodation for a thermal imaging camera is also being included to permit it to be installed should it later be deemed worthwhile):

Co-funded by the Horizon 2020
Framework Programme of the European Union

Table 3-3: Cameras connected to the MTF network.

Element/Component	Qty	Selected camera	Power Supply	Maximum Power per element (W)	Communication Interface	Network Protocols
Interior Monitoring (Serv. Section, Cold Porch, FEG)						
Videocamera for interior monitoring	4	ZAVIO B6210 2MP	12VDC +/- 10% or PoE (802.3af)	4,0	RJ-45 10/100M ethernet port	TCP/IP, HTTP, HTTPS, FTP, others
Exterior Monitoring						
Videocamera for exterior monitoring*	2	ZAVIO B8210 2MP	12VDC +/- 10% or PoE (802.3af)	13,0	RJ-45 10/100M ethernet port	TCP/IP, HTTP, HTTPS, FTP, others
FEG Plant Monitoring System						
Fixed High Resolution Cameras (top view)	31	HIKVISION DS-2CD2532F-I	12VDC +/- 10% or PoE (802.3af)	5,0	RJ-45 10/100M ethernet port	TCP/IP, HTTP, HTTPS, FTP, others
High Resolution Camera (on the mobile platform)	1	HIKVISION DS-2CD2032F-I	12VDC +/- 10% or PoE (802.3af)	5,0	RJ-45 10/100M ethernet port	TCP/IP, HTTP, HTTPS, FTP, others
Multi-spectral Camera (on the mobile platform)	1	GOPRO Camera	Battery powered via USB	5,0	HDMI	t.b.d.
ISPR Plant Monitoring System						
Visible Spectrum Camera	2	DFM 25GP031-ML	GigE 11 - 13 VDC	10,0	RJ-45 10/100M ethernet port	t.b.d.
Total Cameras:	**41**					

* Outside cameras are connected to the internal MTF network via Ethernet cable => using e.g. 7931A Multi-Conductor – Category 6 DataTwist; Twisted Pair Cable from Belden (installation temperature range -55°C to +150°C and operating temperature range -70°C to +150°C).

3.1.2.1 Videomonitoring requirements

Cameras for general interior/exterior monitoring shall be active all the time (TBC). Video shall be received at NM-III, as live streaming. Video shall be generated at the minimum bit rate possible, and shall be recorded at NM-III. Some images shall be forwarded to DLR for remote access as described below:

- 8:00 – 20:00 UTC: 3 images/hour
- 20:00 – 8:00 UTC: 1 image/hour

When the on-site operator is in the MTF and is being actively monitored by a remote user, the bit rate will be adapted to the maximum possible value to be permit effective monitoring and interaction with the on-site operator.

The system shall be able to activated/deactivated and operable from several locations:

- The Service Section
- From NM-III
- From the DLR Control Centre (Mission Control Centre)

The other EDEN ISS entities will have access to the images, but without any possibility to interact with the cameras. In addition, selected EDEN ISS images will be made available on the EDEN ISS project website and as part of special project outreach activities.

3.1.2.2 Camera control software

Science images are required for plant health monitoring. The image acquisition strategy will strongly depend on the operations scenario (not yet completely defined). Some preliminary requirements for the SW selection and/or development have already been carried out from the ongoing discussion on this topic. In principle it has been agreed that:

- The system shall automatically acquire one top HD image per tray and per day.
- The system shall automatically acquire one lateral HD image per tray and per day.
- The acquired images shall be recorded on site (at NM-III station) and sent to DLR every day.
- Multi-spectral camera images shall be acquired on demand.
- The system shall be controlled by remote users.
- The SW shall provide the capability to override the automatic control in favour of manual activities and vice versa.

The SW for camera management shall fulfil the above described requirements, but of course in addition it has to provide several functionalities as described below:

1. Basic Configuration:
    a. Camera ID and IP address definition,

   b. Port assignment
   c. Camera name assignment
   d. Access via User ID and password
2. Camera Health and Status monitoring
   a. ON/OFF
   b. Recording (Yes/No)
3. Video Streaming configuration:
   a. Image resolution
   b. Bit rate
   c. Video compression
   d. Frame fate
4. Video Management
   a. Camera activation/deactivation
   a. Camera information visualization
      i. Camera name
      ii. Date and time
   b. Camera visualization option definition
      iii. One camera at time (camera selection)
      iv. All the camera's at the same time
      v. Loop definition (for example 4 cameras a time with automatic change to next 4 cameras)
   c. Pan, tilt and zoom function
   d. Recording function
5. Recorder Configuration
   a. Recording activation/deactivation
   b. Path definition on the PC HDD
   c. Folder definition
      i. For the single camera
      ii. For recording session
   d. Time window definition
   e. Snapshot acquisition
      i. Manual (from the operator)
      ii. Automatic (predefined)
6. Playback Management
   a. Camera definition
   b. Timeslot definition
7. Remote Control

As seen for EDEN ISS project two different companies have been selected for the interior/exterior monitoring and science images acquisition (External: Zavio, Internal: HIKVISION) and both provided cameras with their own control SW. For multi-spectral imaging another one is under analysis (GoPro Hero 4). Of course it is not expected that the SW provided by one company is compatible with the cameras of the other companies, and that of course represents a problem that can be overcome in two ways:

- Try to use camera's from one single company
- Use a commercial SW package able to manage different camera's at the same time

Both solutions will be taken into account in the next iteration. As far as the second point is concerned, a preliminary analysis shows that some SW packages exist for the camera management. Some possibilities are listed in Chapter 4.3, but it is worth to report in this chapter the features of one of them. The **Security Monitor Pro** of Deskshare (www.deskshare.com) represents a good example of what this kind of SW can do:

Live Previewing

- Control up to 32 camera feeds, simultaneously
- Support for 2,000 camera models and counting (including those of HIKVISION and Zavio)
- View JPEG, MJPEG, MPEG-4 and H.264 stream from IP cameras
- Pan, tilt and zoom cameras to adjust coverage areas
- Supports High Res cameras, with multi-resolution recording
- Export and Import cameras with individual settings
- Operate in hidden mode

Recording

- Capture live events and save as video files
- Add timestamp and watermarks to your footage
- Schedule your camera to automatically start recording
- Upload videos to your website or any FTP server

Motion Detection

- Set motion-triggered actions individually for each camera
- Get notified by email when an alert is triggered
- Detect, highlight and record the motion event
- Mask an area to exclude from motion detection
- Prevent false alarm by adjusting the motion trigger level

Camera Schedule

- Create schedules for each camera individually or in a group
- Cameras can be scheduled to monitor for motion daily, weekly or any custom timetable
- Customize the schedule to include 6 different action types. Video recording, take photo, email notification, upload media files, audio alarm and launch a program.

Review

- Built-in Media analyser for quick review of all captured events
- Filter recordings by camera and time
- Play videos with 4x speed and view only keyframes
- Maintain a complete event log for all cameras
- Auto-deletion of old recordings to free disk space
- Broadcast video feeds live on the internet.

3.1.3 Mobile Platform

The cameras for lateral view and multi-spectral image (accommodation to also be provided for a thermal camera even if not presently considered into the current baseline design) acquisition are mounted on a mobile platform that is controlled by the **Mobile Platform and Camera Control PC**. According the defined requirements and preliminary interaction with robot companies, the mobile platform should be connected to this PC via a RJ-45 10/100M Ethernet port, and should have a power interface of 230 VAC (15 kW). Three systems are under evaluation from two different companies (described in the plant health monitoring design document), nevertheless no detailed description of the power and data interfaces of these systems has yet been provided.

As far as the mobile platform control SW is concerned, also in this case the requirements have been defined as below:

- The system shall be able to perform operations in autonomy as per predefined sequences, to predefined locations (at least 40), and/or to be manually commanded.
- The max sequence time in automatic mode shall be 2 hours.
- The system shall be remotely controllable by any authorized user using Human Computer Interfaces.
- The system shall automatically stop the operations and come back to the home position when a human operator is entering in the FEG.
- The system shall prevent any movement remotely commanded when the operator is inside the FEG.

3.1.4 Safety System

The following table lists the various subsystems of the MTF safety system and their locations in the MTF with their dedicated amount:

Table 3-4: Safety System of the MTF.

Safety System			
Subsystem	**Location**	**Amount**	**Sum**
Fire/ smoke detectors	FEG	1	3
	SES	1	
	CPO	1	
Caution/ warning system ambient air (CO2)	FEG	1	2
	SES	1	
Dead man's sensor	CPO	1	1
		Sensors:	**6**

All those sensors will be incorporated in the overall Siemens alarm system of NM-III. For that purpose all the sensors of the MTF safety system have to be connected to a central fire alarm system (430 x 398 x 160 mm) of Siemens (see Figure 3-16) via potential free contacts or opto-couplers.

Figure 3-16: Central fire alarm system of Siemens (FC2020-AZ).

The central fire alarm system is connected to a horn in the MTF, which sets of the alarm, when there is a fire or a threshold of the other sensors of the safety system is surpassed.

Figure 3-17: Horn of the central fire alarm system of Siemens (FDS221-R).

Due to the fact that the central fire alarm system is also linked with the NM-III fire/alarm system via a 350 m copper cable, three beacons (one for fire sensor, one for CO_2 sensor and one for the dead men sensor) in the NM-III observation room or in the radio room will inform the crew about hazards in the MTF.

The various safety system components are described in detail in the following sections.

Fire/ smoke detectors

There are three fire/ smoke detectors in the MTF (see Figure 3-18). One will be located in the Cold Porch, one in the Service Section and one in the Future Exploration Greenhouse.

Figure 3-18: Fire/ smoke sensor of the central fire alarm system of Siemens (FDOOT241-9).

Caution/ warning system ambient air (CO_2)

The CO_2 safety system from LogiCO2 is designed to measure CO_2 concentration in confined environments. It provides an alarm in the event of a CO_2 level considered unhealthy or dangerous in accordance with existing safety codes.

The basic CO_2 safety system is a precision instrument comprising of one central unit (with a digital display), one (up to eight) sensor unit, one horn/strobe. A separate electronic transformer supplies power to the system. The sensor unit uses infrared analysis for detecting CO_2. The system monitors STEL as well as TWA levels of CO_2. The system also provides visible indication of CO_2 levels and temperature in the area where the remote sensor is located. It is displayed on a screen of the Central Unit in most languages. The CO_2 Safety System performs a self-calibration at regular intervals ensuring calibration under normal circumstances.

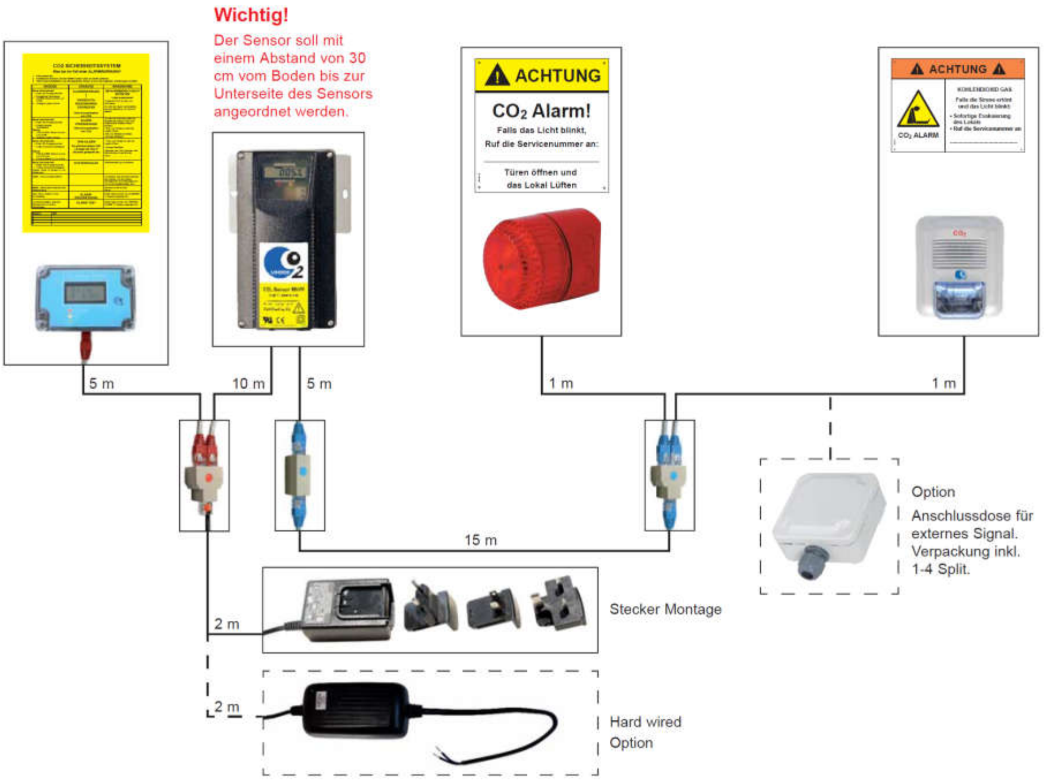


Figure 3-19: Connection diagram for the CO_2 Safety System from LogiCO2.

When installed properly, the CO_2 Safety System will continuously monitor the CO_2 concentration and temperature wherever a sensor unit is located. A green LED on the central unit indicates normal safe conditions. If ambient conditions at the sensor unit reach a CO_2 concentration level of 1,5% (pre-set low alarm), the central unit will emit an intermittent audible tone and the « low alarm » red LED will blink. A remote horn/strobe will be activated. This will also happen if the TWA for 8 hours also surpasses 5000 ppm. The difference can be acknowledged on the display.

Dead man's sensor

The human greenhouse operator will use a "dead man's" sensor, when he enters the MTF. The sensor will automatically monitor if the greenhouse operator becomes incapacitated, such as through death or loss of consciousness. In such cases it will then send an alarm via radio link to the Neumayer Station III.

Figure 3-20: Dead man's sensor: Left: Loner® 900 employee-worn safety monitoring device (left). Loner® Bridge portable satellite & cellular base station (right).

Co-funded by the Horizon 2020
Framework Programme of the European Union

The Loner Bridge System is the world's most comprehensive employee safety monitoring system for remote operations and is comprised of two parts: the Loner® Bridge portable satellite and cellular base station and the Loner® 900 employee-worn safety monitoring device.

The Loner Bridge System works anywhere, especially on the road and in the field where cellular coverage is often spotty or doesn't even exist. Using an industrial-quality 900 MHz radio link, the Loner Bridge base station communicates with up to 10 Loner 900 devices up to 2 km away at once. Self-powered and portable, Loner Bridge allows users to quickly move it from one place to another in seconds.

The employee-worn Loner 900 safety monitoring device features a combination of automatic incident detection and manual triggers that enable employees to call for help at any moment. It automatically detects falls, and, if one of your crew members is unable to request help manually, it automatically alerts when the employee is motionless or fails to respond to a check-in request. If the employee is in need of help and can trigger an alert manually, it's as simple as pulling a fire alarm—even if his or her vision is compromised. In case of an emergency, low battery or power off the system will send an alert text messages (SMS) to configurable numbers.

The system is also capable to deal with the harsh environment in Antarctica:

- Storage temperature: -50 to 75°C
- Operating temperature: -40 to 55°C
- Charging temperature: -20 to 45°C

Many industries encounter environments with the potential for an explosive atmosphere of gases or dusts. Loner 900 is also certified UL913 Class I, Division 1 and Class II, Division 1 intrinsically safe for use in such hazardous environments.

Traditional Safety Equipment

Figure 3-21 presents the general layout of traditional safety equipment within the three sections of the MTF. As is evident, the safety system is composed of several CO_2 and smoke detectors which are not connected to the aforementioned to the MTF data acquisition system nor the NM-III wired safety line. An ABC class fire extinguisher is installed in the cold porch, Service Section and FEG. In each instances there are located near the internal separation doors. Battery powered, emergency lighting as well as flashlights are also distributed throughout the facility. In addition to the emergency lighting, phosphorescent emergency labels are planned to be installed within the facility to help lead operators to exit doors. The Service Section contains a chemical spill kit as well as an eye wash station (disposable bottle version). A basic first aid kit is planned to be co-located with these items. To aid in compliance with the Madrid protocol and suggested Antarctic hydroponic guidelines, a facility sign-in list as well as the MTF safety manual are installed in the cold porch by the access door to the Service Section. Very basic external clothing will also be installed in a readily accessible location by the emergency exit door in the FEG.

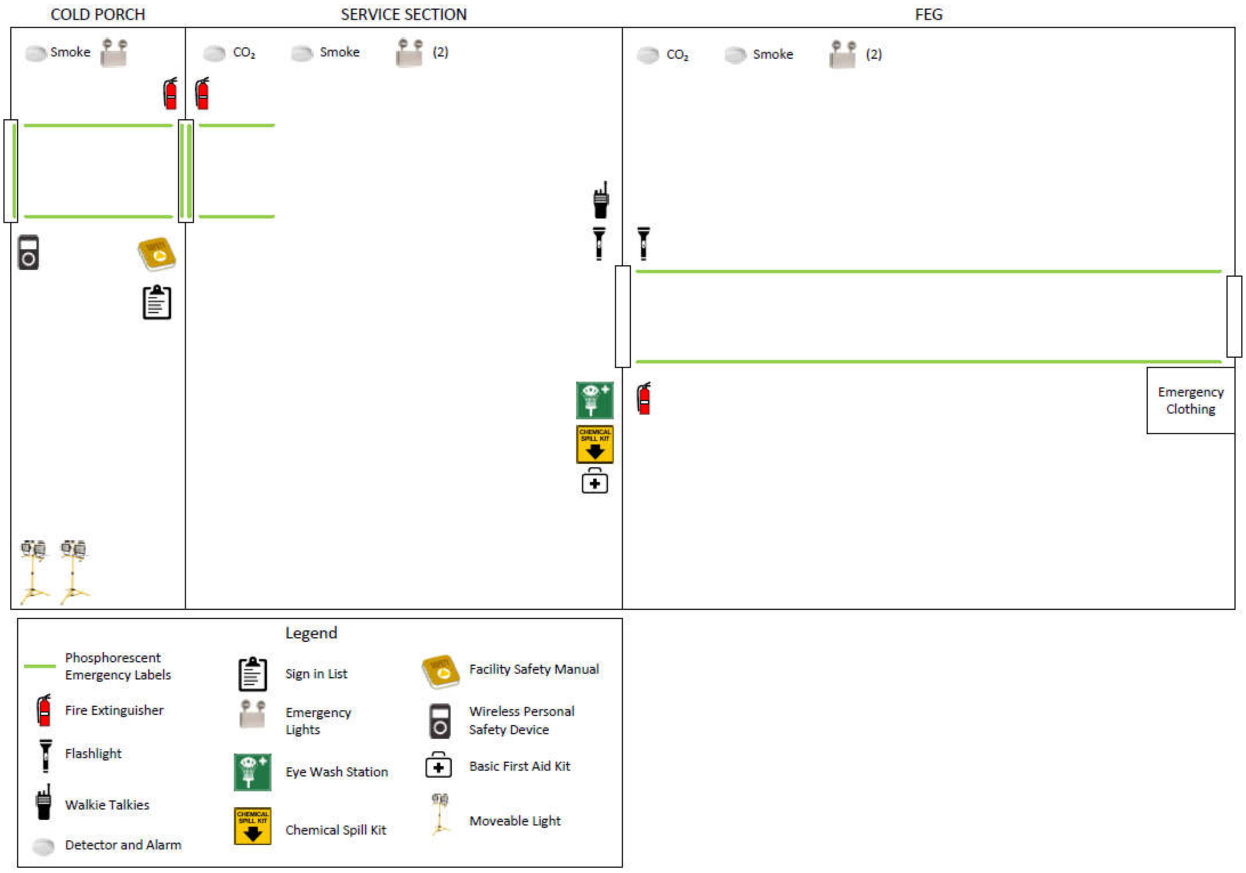


Figure 3-21: General MTF safety equipment layout.

3.2 Neumayer Station III

The CDHS in NM-III (see Figure 3-22) is connected as mentioned above via the two patch antennas and switches with the local MTF network. The NM-III Control Centre will be located within one corner of the NM-III multipurpose laboratory (room is approximately 25 m^2) and will consist of the following computer elements:

- One PC, **Mobile Platform and Camera Remote Control PC**, which serves as the EDEN ISS NM-III main server PC in which all MTF data is stored but is also used to control cameras and the mobile platform in the MTF remotely from the station (including screen) and
- One PC, the **LabVIEW and Argus Remote Control PC,** which is used to send commands and receive data from the Argus and the LabVIEW system (including screen).

These PCs are configured in such as to also serve as redundant PCs for the two PCs operating in the MTF. Should a failure of an MTF PC occur, one of these machines can be relocated into the MTF (with minimal to no modification required) and replace the non-functional machine. The remaining single computer in NM-III would subsequently be modified (if required) so that it can serve the functions of EDEN ISS NM-III main server PC, Argus/ LabVIEW control and monitoring as well as controlling and monitoring of the cameras and mobile platform. Like the MTF computers the two NM-III computers have a RAID system to guarantee reliable function throughout the mission.

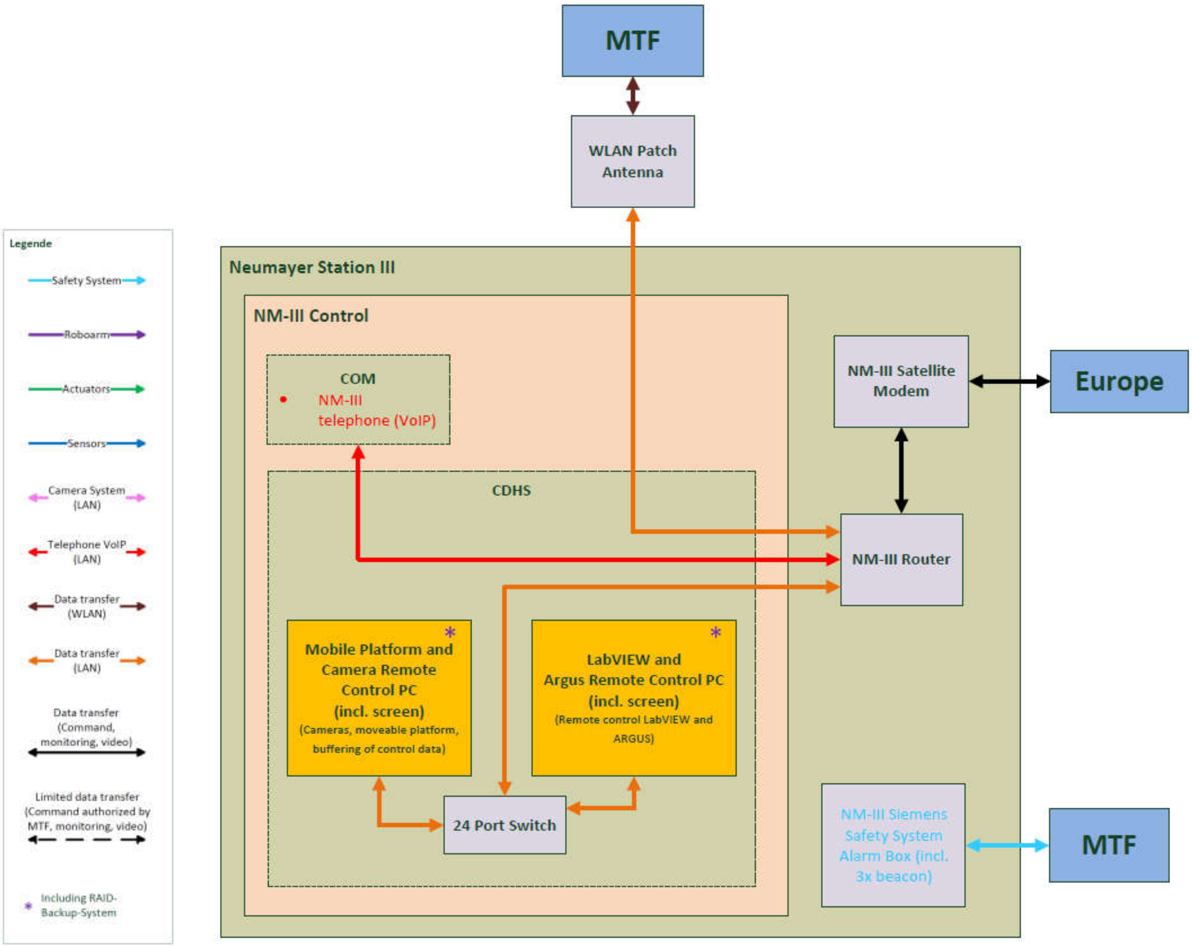


Figure 3-22: Block diagram for CDHS baseline design of NM-III.

In addition to the computers, a personal laptop may be used by the NM-III MTF operator within the NM-III Control Centre. This personal laptop will be used for documentation purposes, printing, using the Internet, sending as well as receiving emails and video conferencing. Another item used in the CDHS of the NM-III Control Centre is a NM-III VOIP telephone including headset, which is in property of the AWI.

All network items of the NM-III Control Centre are connected to a 24 port smart-switch from Cisco (440 × 43,2 × 257 mm). For commonality the same as utilized in the Service Section (Figure 3-12).

Over this switch the connection is established via the NM-III router to the NM-III satellite modem, which is connected to a NM-III satellite antenna, to the DLR Control Centre in Bremen and the other user home bases. The network at NM-III as well as the AWI Ground Station in Bremerhaven is protected by a firewall. But it is no problem to get access to those networks (in case of sending/ receiving commands/data to/from Antarctica) after discussion with AWI.

3.3 Operations entities

EDEN ISS Control Network and Ground Segment

As already explained, EDEN ISS has among others goals, the objective to introduce the distributed control in the greenhouse control field. That could appear similar to the remote control of a greenhouse, but on the other hand there are some differences that make EDEN ISS similar to a space program. For example:

- The distance between the remote user and the greenhouse and the distance between the remote users themselves is preventing the intervention on site of the experts
- The different monitoring and control requirements of the different remote users, leads to the need of different tools or displays (for example the plants experts need data that are different of those necessary for S/S monitoring and control)

- The bandwidth limitation. The EDEN ISS communication to/from Europe is done via satellite link that has physical/economical limitations. A bandwidth of 100 kbps is available for EDEN ISS. This limit can be exceeded upon agreement with satellite service provider with an increase of costs.
- The need to define control processes with the clear identification of control hierarchy, responsibilities and tasks.

The top-level architecture of the EDEN ISS control network including its UHBs are illustrated in Figure 3-23.

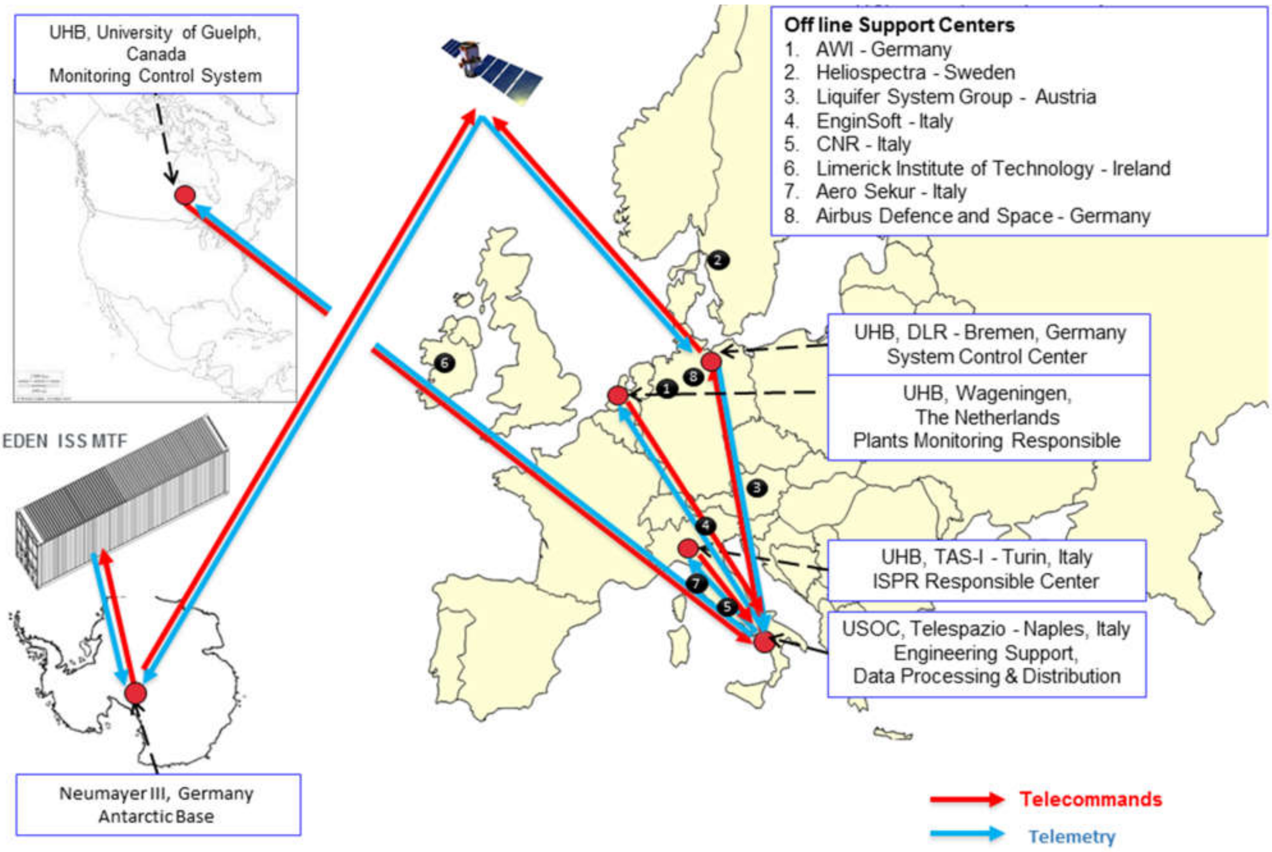


Figure 3-23: EDEN ISS Control Network.

EDEN ISS will be installed at the German Antarctica station NM-III and is designed to be operated by one single on site operator. Five locations will be configured as User Home Bases, i.e., will be provided with systems and tools to receive the EDEN ISS images and data for real time support.

The **On-site operator** will be mainly responsible of the nominal operations as for example sowing/harvesting, plants growth monitoring, sample preparation for off line analysis, S/S management, periodic inspection and maintenance of critical items (like filters), etc. In case of anomalies, it is expected that the on-site operator will manage them as according predefined procedures if any, otherwise he is only requested to take saving actions and rely on the remote experts indication on how to proceed.

It is worth to noting that the Service Section and NM-III will be equipped with workstations for MTF and FEG control. In particular, NM-III will be configured as the DLR control room to provide the on-site operator with the same capabilities of provided at the DLR Control Centre, i.e. the capability to interact with the FEG, with the ISPR and with all the related subsystems.

AWI as responsible for NM-III, will receive the EDEN ISS data as part of the NM-III data stream over satellite and will make them available to DLR over Internet. AWI is directly involved in the EDEN ISS MTF operations, but will provide any support for all NM-III matters, as concerned

DLR is the EDEN ISS Responsible Center and will accommodate the Mission Control Centre. DLR is responsible for the all the EDEN ISS operations. For that reason it will coordinate the entire EDEN ISS team operations, will be responsible for planning activities and the primary responsible for all the commanding activities. Moreover, DLR will be the prime in communication with the on-site operator. It will coordinate all the remote operations as necessary, enabling/disabling the other remote site for commanding. DLR will also coordinate all the troubleshooting activities and recovery actions. DLR is also responsible for managing the development of the thermal control system.

TAS-I is responsible for the ISPR operations and will be configured as UHB. It will be equipped with a console for the ISPR rack monitoring and with the dedicated displays for TM/TC management. In this role and upon coordination with DLR it will be responsible for all the remote operations of the ISPR, including the commanding of the facility. It is the prime in anomaly handling, troubleshooting activities and recovery actions.

University of Wageningen (DLO) is responsible for plant health monitoring. It is configured as UHB, with a workstation for scientific data visualization and image processing tool for plant status monitoring and early detection of plant disease. In case of anomaly detection, DLO will coordinate with DLR all the necessary actions to solve the issue, from the change in system settings (for example light intensity) to the definition of plants medical treatments. If new procedures for anomaly management are required, DLO will provide inputs for procedures development.

In addition, being DLO responsible of the crops selection, it is also responsible for the definition of the best conditions for crops cultivation in terms of ambient parameters settings (temperature, humidity, light) and composition of the nutrient solution. On that regards, during the operations preparation phase DLO task is to provide inputs for the definition of the procedures and the cultivation plan.

University of Guelph is responsible for the EDEN ISS control system (Argus). It is configured as UHB with the workstation and displays to monitor and manage control system performance and to provide additional programming and commands if necessary.

TPZ is responsible for user segment monitoring and control. It will be equipped with all the consoles and displays as distributed to the other entities to be able to solve issue and/or to updated the SW applications, including displays as required. TPZ, as procedures development will participate to all the anomaly resolution team, to collect inputs and recommendations for anomaly procedures management.

All the other entities will provide off-line support as required.

Heliospectra for the lighting system

Aero Sekur for the Air Management System

CNR and Limerick Institute of Technology for food quality and safety analysis and related evaluation procedures

Airbus for the E-Nose and TransMADDS activities

Liquifer for Systems Engineering

All the UHBs will be connected to DLR for data reception. On the other hand, whenever required, all the commands will pass through DLR to reach EDEN ISS in Antarctica site. A graphical representation of the EDEN ISS User Segment is displayed in Figure 3-24.

It is worth to spend some words on the tasks and responsibilities of the **remote operators**. Of course it is not expected to have people in control rooms looking at the EDEN ISS telemetry all the time, i.e. working on 24/7 shift scheme, but rather people that, during scheduled events or on demand, are capable to interact with the MTF looking at telemetry and sending commands via dedicated displays and using available procedures. As part of the routine job, the remote operators should monitor daily the EDEN ISS telemetry (especially that coming from diagnostic sensors) for a limited time (could be one or two events of few minutes during office hours) and take logs of the status. Off nominal situations, i.e. troubleshooting activities and malfunctions resolution will be handled as required.

DLR operators have one additional task to accomplish, i.e. the management of the interaction (via videoconference) with the on-site operator. That should be done twice per day (at the beginning and at the end of the working day) nevertheless this scenario has not been baselined.

It is obvious that all the entities configured as UHB shall identify some persons to be trained on the tools and procedures to be used to efficiently cover the console positions.

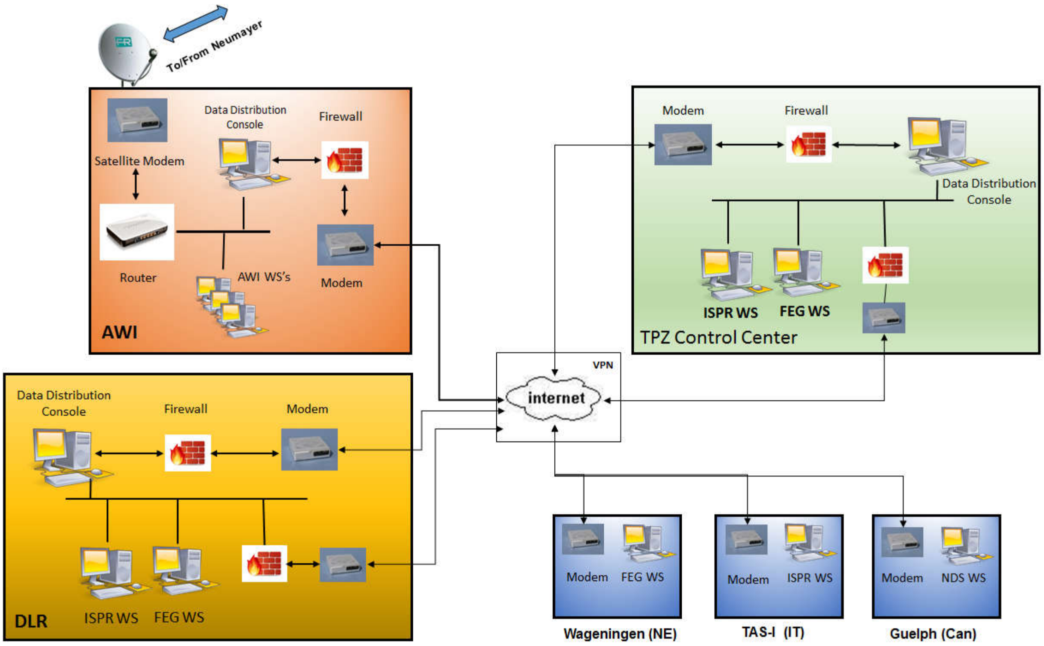


Figure 3-24: Layout of the EDEN ISS User Segment.

The following hardware is envisioned for the specific UHBs:

DLR is equipped with (see Figure 3-25):

- 1 x Workstation to monitor and control the mobile platform and camera system remotely,
- 1 x Workstation to monitor and control the Argus and LabVIEW system and
- 1 x Workstation for data distribution to the UHB and data archiving.

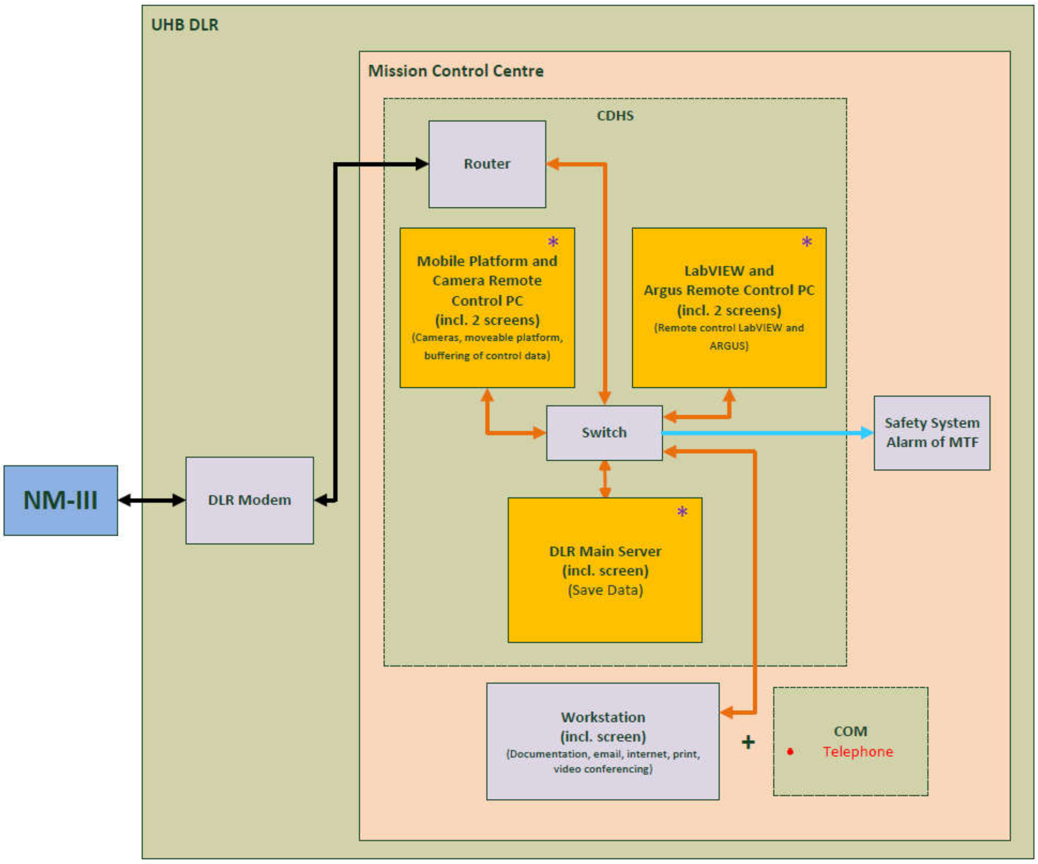


Figure 3-25: Block diagram for CDHS baseline design of EDEN ISS Mission Control Centre in Bremen.

The safety system alarm block in Figure 3-25 could stand for an alarm horn, beacon or automatic email to the team at DLR in Bremen in case of an emergency in the MTF.

In addition to the system for data routing and safe access to the Internet for data distribution (modem, router, switch, firewall).

TAS-I is equipped with:

- 1 x Workstation for ISPR rack control (LabVIEW system)

In addition to the system for safe access to the Internet.

DLO is equipped with:

- 1 x Workstation for FEG scientific telemetry monitoring
- 1 x Workstation for plants images acquisition and processing

University of Guelph is equipped with:

- 1 x Workstation for control system monitoring

TPZ is equipped with:

- 1 x Workstation to monitor and control the mobile platform and camera system remotely,
- 1 x Workstation to monitor and control the Argus and LabVIEW system and
- 1 x Workstation for ground systems control

4 Detailed design

The specific breakdown of the sensors and actuators connected to the Argus control system are illustrated in Table 4-1.

Table 4-1: Detailed description of sensors and actuators connected to the Argus control system.

ARG								
Subsystem	**Sensor/Actuator**	**Location**	**Amount**	**Sum**	**Controlled by**	**Control Type**	**Argus Input**	**Argus Output**
NDS FEG	Pressure	FEG.NDS.???.???.???.???	8	33	ARGUS	Analog	4 to 20 mA	none
	Level switch sensor (sump tank)	FEG.NDS.???.???.???.???	2		ARGUS	Digital	Contact	none
	EC	SES.NDS.???.???.???.???	4		ARGUS	Analog	4 to 20 mA	none
	pH	SES.NDS.???.???.???.???	4		ARGUS	Analog	4 to 20 mA	none
	Flow rate	SES.NDS.???.???.???.???	2		ARGUS	Analog	Frequency	none
	DO sensor	SES.NDS.???.???.???.???	4		ARGUS	Analog	4 to 20 mA	none
	NDS Tank continuous level sensor	SES.NDS.???.???.???.???	2		ARGUS	Analog	Potentiometer	none
	Temp tank	SES.NDS.???.???.???.???	4		ARGUS	Analog	Thermistor	none
	Level switch sensor (fresh water tank)	SES.NDS.???.???.???.???	1		ARGUS	Digital	Contact	none
	Ozone sensor	CPO.NDS.???.???.???.???	1		ARGUS	Analog	4 to 20 mA	none
	Level switch sensor (waste water tank)	SES.NDS.???.???.???.???	1		ARGUS	Analog	Potentiometer	none
	Pump (high pressure - aeroponic)	FEG.NDS.???.???.???.???	8	23	ARGUS	Relay	none	24V
	Sump pump (4x)	FEG.NDS.???.???.???.???	0		autonomous	-	-	-
	Solenoids (3-way for acid/base feed)	SES.NDS.???.???.???.???	2		ARGUS	Relay	none	24V
	Pumps	SES.NDS.???.???.???.???	3		ARGUS	Relay	none	24V
	Solenoids (fresh water feed)	SES.NDS.???.???.???.???	2		ARGUS	Relay	none	24V
	Aerator	SES.NDS.???.???.???.???	2		ARGUS	Relay	none	24V
	Dosing pump for acid/base, A, B, C, D	SES.NDS.???.???.???.???	6		ARGUS	Relay	none	24V
	Pump	CPO.NDS.???.???.???.???	0		manual	-	-	-
	Ozone generator	SES.NDS.???.???.???.???	0		autonomous	-	-	-
ILS FEG	Temp per bar LED Current per bar LED Set points per panel LED Status per panel LED HW configuration LED FW version LED	FEG.ILS.???.???.???.???	42	42	ARGUS	Heliospectra Ethernet	Heliospectra Ethernet	none
	Intensity and quality control of 4 wavelength channels LED	FEG.ILS.???.???.???.???	42	42	ARGUS (same like above)	Heliospectra Ethernet (same like above)	Heliospectra Ethernet (same like above)	none
TCS FEG	Temp radiator	EXT.TCS.???.???.???.???	3	38	ARGUS	Analog	Thermistor	none
	Temperature	EXT.TCS.???.???.???.???	2		ARGUS	Analog	Thermistor	none
	Temp cooling fluid tank	SES.TCS.???.???.???.???	3		ARGUS	Analog	Thermistor	none
	Flow rate cooling fluid	SES.TCS.???.???.???.???	6		ARGUS	Analog	4 to 20 mA	none
	Pressure	SES.TCS.???.???.???.???	6		ARGUS	Analog	4 to 20 mA	none
	Temp fluid line	SES.TCS.???.???.???.???	10		ARGUS	Analog	Thermistor	none
	Flow rate sensor LED	FEG.TCS.???.???.???.???	2		ARGUS	Analog	4 to 20 mA	none
	Pressure sensor LED	FEG.TCS.???.???.???.???	2		ARGUS	Analog	4 to 20 mA	none
	Temperature fluid line sensors LED	FEG.TCS.???.???.???.???	4		ARGUS	Analog	Thermistor	none
	Tischkühler	EXT.TCS.???.???.???.???	0	14	autonomous	-	-	-
	Pumps	SES.TCS.???.???.???.???	6		ARGUS	Relay	none	24V
	Cooling valves	SES.TCS.???.???.???.???	6		ARGUS	Relay	none	24V
	Coolant pump LED	FEG.TCS.???.???.???.???	2		ARGUS	Relay	none	24V
PDS MTF	Power demand	SES.PDS.???.???.???.???	0	3	ARGUS	-	-	-
	Power supply status	SES.PDS.???.???.???.???	0		ARGUS	-	-	-
	Temp electronic control box	SES.PDS.???.???.???.???	3		ARGUS	Analog	Argus sensor	none
	Patch Antenna	EXT.PDS.???.???.???.???	0	0	always on	-	-	-
	Platform lighting	EXT.PDS.???.???.???.???	0		autonomous	-	-	-
	Door lighting	EXT.PDS.???.???.???.???	0		autonomous	-	-	-
	230 VAC sockets outside	EXT.PDS.???.???.???.???	0		autonomous	-	-	-
	230 VAC sockets cold porch	CPO.PDS.???.???.???.???	0		autonomous	-	-	-
	Lighting cold porch	CPO.PDS.???.???.???.???	0		autonomous	-	-	-
	230 VAC sockets FEG	FEG.PDS.???.???.???.???	0		autonomous	-	-	-
	Lighting FEG	FEG.PDS.???.???.???.???	0		autonomous	-	-	-
	230 VAC sockets service section	SES.PDS.???.???.???.???	0		autonomous	-	-	-
	Lighting service section	SES.PDS.???.???.???.???	0		autonomous	-	-	-
	Back-up power supply	SES.PDS.???.???.???.???	0		always on	-	-	-
	Screens, WLAN access point	SES.PDS.???.???.???.???	0		autonomous	-	-	-
	Argus Server PC (Computer 1)	SES.PDS.???.???.???.???	0		autonomous	-	-	-
	Moveable Platform and Camera Control PC (Computer 2)	SES.PDS.???.???.???.???	0		autonomous	-	-	-
	24 VDC supply	SES.PDS.???.???.???.???	0		always on	-	-	-
AMS Airlock	Temp/RH Airlock	CPO.AMS.???.???.???.???	2	4	ARGUS	Analog	Argus sensor	none
	Temp CO2 cabinet	CPO.AMS.???.???.???.???	2		ARGUS	Analog	Thermistor	none
	Heater	CPO.AMS.???.???.???.???	0	0	autonomous	-	-	-
AMS FEG	Temp/RH (PHM)	FEG.AMS.???.???.???.???	4	20	ARGUS	Analog	Argus sensor	none
	Temp/RH/CO2 sensor (PHM)	FEG.AMS.???.???.???.???	2		ARGUS	Analog	4 to 20 mA	none
	Temp/RH	SES.AMS.???.???.???.???	2		ARGUS	Analog	Argus sensor	none
	CO2 sensor	SES.AMS.???.???.???.???	2		ARGUS	Analog	4 to 20 mA	none
	Temp	SES.AMS.???.???.???.???	5		ARGUS	Analog	Thermistor	none
	Air flow sensor	SES.AMS.???.???.???.???	1		ARGUS	Analog	4 to 20 mA	none
	Pressure differential sensor	SES.AMS.???.???.???.???	2		ARGUS	Analog	4 to 20 mA	none
	O2 sensor	SES.AMS.???.???.???.???	1		ARGUS	Analog	4 to 20 mA	none
	Ethylene sensor	SES.AMS.???.???.???.???	1		ARGUS	Analog	0...5 V	none
	Humidifier 3kg/h	FEG.AMS.???.???.???.???	1	15	ARGUS	Relay	none	24V
	Fan, return air	FEG.AMS.???.???.???.???	8		ARGUS	Relay	none	24V
	Dehumidifier	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
	Recovery cond. water: pump	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
	Potentiometer Heater	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
	Fans	SES.AMS.???.???.???.???	2		ARGUS	Relay	none	24V
	CO2 injection valve	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
	UV lamp (1x)	SES.AMS.???.???.???.???	0		allways on	-	-	-
AMS Service Section	Temp/RH of Service Section	SES.AMS.???.???.???.???	2	5	ARGUS	Analog	Argus sensor	none
	Temp/RH inlet	SES.AMS.???.???.???.???	2		ARGUS	Analog	Argus sensor	none
	Air flow rate inlet	SES.AMS.???.???.???.???	1		ARGUS	Analog	4 to 20 mA	none
	Fan, fresh air	SES.AMS.???.???.???.???	1	3	ARGUS	Relay	none	24V
	Potentiometer Heater, inlet air	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
	Humidifier	SES.AMS.???.???.???.???	1		ARGUS	Relay	none	24V
			Total Argus Sensors:	145				
			Total Argus Actuators:	97				

Table 4-2: Detailed description of sensors and actuators connected to the LabVIEW control system.

LabVIEW								
Subsystem	**Sensor/Actuator**	**Location**	**Amount**	**Sum**	**Controlled by**	**Control Type**	**Labview Input**	**Labview Output**
Main Utilities Module	Thermocouple	SES.ISR.MUM.TPS.???.???	2		LABVIEW	Analog	2 wire TC	-
	Smoke sensor with potential free contacts	SES.ISR.MUM.FSW.???.???	1		ARGUS	Analog	9-pin SUB-D	24 VDC
	CO2 Line Pressure Sensor - gauge	SES.ISR.MUM.PSS.???.???	1	6	LABVIEW	Analog	0 to 10 V 4-wire	7 - 32 VDC
	Cooling loop delta pressure sensor - differential	SES.ISR.MUM.PDS.???.???	2		LABVIEW	Analog	0 to 10 V 4-wire	7 - 32 VDC
	CO2 1/8" Electrovalve	SES.ISR.MUM.SOL.???.???	2	2	LABVIEW	relay	none	24 VDC
Upper Utilities Module	LCD Screen	SES.ISR.UUM.LCD.???.???	1	1	LABVIEW	RS232	RS232	5 VDC
Power, C&DH Drawer	Thermocouple	SES.ISR.PCD.TPS.???.???	1	1	LABVIEW	Analog	2 wire TC	-
	TEC Controller PR-59	SES.ISR.PCD.CTR.???.???	2	2	LABVIEW	TBD	TBD	24 VDC
Nutrient Storage Drawer	pH sensor (in line)	SES.ISR.NDD.PHS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	EC sensor (in line)	SES.ISR.NDD.ECS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	Thermocouple (in line)	SES.ISR.NDD.TPS.???.???	1	5	LABVIEW	Analog	2 wire TC	-
	Pressure sensor (in line) - gauge	SES.ISR.NDD.PSS.???.???	2		LABVIEW	Analog	0 to 10 V 4-wire	7 - 32 VDC
	Conc. Nutrient solution piston pump	SES.ISR.NDD.PMP.???.???	2		LABVIEW	relay	none	24 VDC
	Nutrient solution delivery piston pump	SES.ISR.NDD.PMP.???.???	1		LABVIEW	relay	none	24 VDC
	Water to nutrient piston pump	SES.ISR.NDD.PMP.???.???	1		LABVIEW	relay	none	24 VDC
	Water delivery piston pump	SES.ISR.NDD.PMP.???.???	1	7	LABVIEW	relay	none	24 VDC
	Condensate recovery piston pump	SES.ISR.NDD.PMP.???.???	1		LABVIEW	relay	none	24 VDC
	UVC sterilizer	SES.ISR.NDD.UVL.???.???	1		LABVIEW	relay	none	24 VDC
Growth Chamber Drawer (Tall)	Substrate Moisture sensor	SES.ISR.GCT.SMS.???.???	8		LABVIEW	Analog	3 wire AI	5 VDC
	Substrate Moisture/EC/T sensor	SES.ISR.GCT.SMS.???.???	4		LABVIEW	Digital	3 wire (GND, Pow, Dat) - serial	3 - 15 VDC
	EC sensor (in line)	SES.ISR.GCT.ECS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	pH sensor (in line)	SES.ISR.GCT.PHS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	T+RH air sensor	SES.ISR.GCT.THS.???.???	3		LABVIEW	Digital	I2C Digital 4 PIN	5 VDC
	GC Air Pressure sensor - absolute/barometric	SES.ISR.GCT.PSS.???.???	1	26	LABVIEW	Analog	0 to 10 V 4-wire	7 - 32 VDC
	O_2 air concentration sensor	SES.ISR.GCT.O2S.???.???	1		LABVIEW	Analog	0 to 10 V 4-wire	24 VDC
	CO_2 air concentration sensor	SES.ISR.GCT.COS.???.???	1		LABVIEW	Digital	I2C Digital 5 PIN	4.5 - 5.5 VDC
	Thermocouple	SES.ISR.GCT.TPS.???.???	6		LABVIEW	Analog	2 wire TC	-
	Electrovalve (for 4-Electrovalve manifold)	SES.ISR.GCT.SOL.???.???	4		LABVIEW	relay	none	24 VDC
	Piston Pump	SES.ISR.GCT.PMP.???.???	1		LABVIEW	relay	none	24 VDC
	Micronel D-series Fan	SES.ISR.GCT.FAN.???.???	1		LABVIEW	relay	none	24 VDC
	Direct liquid TEC (cooling/dehumidification)	SES.ISR.GCT.DHU.???.???	1		LABVIEW	relay	none	24 VDC
	PTC Heater (heating)	SES.ISR.GCT.HTR.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCT.SOL.???.???	2		LABVIEW	relay	none	24 VDC
	Micronel D-series Fan	SES.ISR.GCT.FAN.???.???	1	17	LABVIEW	relay	none	24 VDC
	Direct liquid TEC (cooling/dehumidification)	SES.ISR.GCT.DHU.???.???	1		LABVIEW	relay	none	24 VDC
	PTC Heater (heating)	SES.ISR.GCT.HTR.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCT.SOL.???.???	2		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCT.SOL.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCT.SOL.???.???	1		LABVIEW	relay	none	24 VDC
Growth Chamber Drawer (Short)	Substrate Moisture sensor	SES.ISR.GCS.SMS.???.???	8		LABVIEW	Analog	3 wire AI	5 VDC
	Substrate Moisture/EC/T sensor	SES.ISR.GCS.SMS.???.???	4		LABVIEW	Digital	3 wire (GND, Pow, Dat) - serial	3 - 15 VDC
	EC sensor (in line)	SES.ISR.GCS.ECS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	pH sensor (in line)	SES.ISR.GCS.PHS.???.???	1		LABVIEW	Analog	4-20 mA AI	14 - 30 VDC
	T+RH air sensor	SES.ISR.GCS.THS.???.???	3		LABVIEW	Digital	I2C Digital 4 PIN	5 VDC
	GC Air Pressure sensor - absolute/barometric	SES.ISR.GCS.PSS.???.???	1	26	LABVIEW	Analog	0 to 10 V 4-wire	7 - 32 VDC
	O_2 air concentration sensor	SES.ISR.GCS.O2S.???.???	1		LABVIEW	Analog	0 to 10 V 4-wire	24 VDC
	CO_2 air concentration sensor	SES.ISR.GCS.COS.???.???	1		LABVIEW	Digital	I2C Digital 5 PIN	4.5 - 5.5 VDC
	Thermocouple	SES.ISR.GCS.TPS.???.???	6		LABVIEW	Analog	2 wire TC	-
	Electrovalve (for 4-Electrovalve manifold)	SES.ISR.GCS.SOL.???.???	4		LABVIEW	relay	none	24 VDC
	Piston Pump	SES.ISR.GCS.PMP.???.???	1		LABVIEW	relay	none	24 VDC
	Micronel D-series Fan	SES.ISR.GCS.FAN.???.???	1		LABVIEW	relay	none	24 VDC
	Direct liquid TEC (cooling/dehumidification)	SES.ISR.GCS.DHU.???.???	1		LABVIEW	relay	none	24 VDC
	PTC Heater (heating)	SES.ISR.GCS.HTR.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCS.SOL.???.???	2		LABVIEW	relay	none	24 VDC
	Micronel D-series Fan	SES.ISR.GCS.FAN.???.???	1	17	LABVIEW	relay	none	24 VDC
	Direct liquid TEC (cooling/dehumidification)	SES.ISR.GCS.DHU.???.???	1		LABVIEW	relay	none	24 VDC
	PTC Heater (heating)	SES.ISR.GCS.HTR.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCS.SOL.???.???	2		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCS.SOL.???.???	1		LABVIEW	relay	none	24 VDC
	Electrovalve (air exchange with cabin)	SES.ISR.GCS.SOL.???.???	1		LABVIEW	relay	none	24 VDC
Illumination Drawer Left (Tall GC)	Visible Spectrum Camera	SES.ISR.ILL.VCS.???.???	1	1	LABVIEW	Ethernet	Ethernet	GigE 11 - 13 VDC
	LED Lamp (incl. Ballast)	SES.ISR.ILL.LED.???.???	1	1	LABVIEW	Ethernet	Ethernet	230 VAC
Illumination Drawer Right (Short GC)	Visible Spectrum Camera	SES.ISR.ILR.VCS.???.???	1	1	LABVIEW	Ethernet	Ethernet	GigE 11 - 13 VDC
	LED Lamp (incl. Ballast)	SES.ISR.ILR.LED.???.???	1	1	LABVIEW	Ethernet	Ethernet	230 VAC
	Total LabVIEW Sensors:			64				
	Total LabVIEW Actuators:			48				
	Total LabVIEW Cameras:			2				

The third column of Table 4-2 shows the location of the various sensors and actuators of the LabVIEW system. In order to facilitate integration, operations, assembly and maintenance of the EDEN ISS facility, all major parts are named and labelled according to a standard stated in the Operations Nomenclature and Labelling document. This document is relevant to all subsystems and personnel involved in EDEN ISS development. The leads on each subsystem have the main role in applying this document.

Major parts and spares connected to the Argus or LabVIEW system will be labelled according to the following general labelling scheme:

zone.subsystem.position.part type.DAQ location.DAQ channel

For example, a controlled pump located in the middle of the air management system rack in the Service Section that is controlled by Argus on digital output pin #3 would be given the designation:

SES.AMS.MID.PMP.ADO.003

Another example, a controlled pump located in the NDS Drawer of the ISPR in the Service Section that is controlled by LabVIEW on digital output pin #4 would be given the designation:

SES.ISR.NDD.PMP.LDO.004

Major parts and spares of the PCDU that are not connected to the Argus or LabVIEW system will be labelled according to the following general labeling scheme:

zone.subsystem.position.part type.???.???

For example, the general external lighting of the power distribution system located outside of the container on the west side that would be manually controlled would be given the designation:

EXT.PDS.WET.GEL.???.???

The meaning of last two abbreviations above is still open and depends on the final PCDU system.

In the above mentioned document major identifiers are outlined. Additional identifiers can be added to this document as required.

4.1 System sizing/analyses

4.1.1 Data traffic analysis

Several entities are supposed to receive data from the EDEN ISS MTF and to interact with it via commands. That approach is of course only effective if the allocated bandwidth is compatible with the amount of data generated during the MTF operations.

The NM-III recently upgraded (2015/2016 field season) their communication system from a 300 kbps to a 1 Mbps satellite connection. That said, the EDEN ISS data traffic analysis results presented here are consider a 100 kbps NM-III satellite link bandwidth that can be devoted explicitly to the MTF data stream. The following analysis will show that, considering all the sensors and the video cameras used in the MTF, remote control is possible at this data rate provided that some limitations in image transmission are adopted. In particular, it is assumed that whatever the image generation rate will be, only one image per day and per tray will be transferred to Europe. Moreover, the transmission will occur overnight. In this way the remote experts (in principle DLO experts) can process the images and provide feedback during office hours.

The following items have been considered for the data traffic analysis:

- In total ca. 215 sensors will be installed in the MTF (including those for exterior monitoring). These include (approximate numbers provided):
    - Argus system (145)
    - ISPR (64)
    - Safety system (6)

- In total ca. 145 actuators will be installed in the MTF. These include (approximate numbers provided):
  - Argus system (97)
  - ISPR (48)
- In total ca. 41 cameras will be installed in the MTF. These include (approximate numbers provided):
  - 34 cameras for FEG Plant health monitoring
    - 31 fixed cameras for top view
    - 3 cameras for side view installed on the mobile platform (incl. 1 IR camera),
  - 4 general interior MTF observation cameras,
  - 2 observation cameras installed outside and
  - 2 cameras in the ISPR rack for plant health monitoring.
- E-Nose data
- 1 audioconferencing system
- 1 videoconferencing system

It is worth emphasising that for data traffic analysis the worst case has been considered:

- All the data transferred during a single day and
- 3 (instead of 2) camera's considered for lateral image acquisition, to take into account that an IR camera could be used as further tool for plant health monitoring.

The following tables provide an indication on what could be generated during the EDEN ISS operations:

Table 4-3: EDEN ISS data generation: Worst case, with IR camera.

System	Controller	Items/Sensors #	Frequency	Data (MB/day)
FEG NDS	Argus	33	1 Hz	5,70
FEG ILS	Argus	42	1 Hz	7,26
FEG TCS	Argus	36	1 Hz	6,22
FEG PDS	Argus	3	1 Hz	0,52
FEG AMS	Argus	20	1 Hz	3,45
AMS SERVICE SECTION	Argus	5	1 Hz	0,86
AMS AIRLOCK	Argus	4	1 Hz	0,69
EXTERIOR	Argus	2	1 Hz	0,34
Safety Sensors	Dedicated HW/SW	6	1 Hz	1,03
E-Nose Sensor	Dedicated HW/SW	1		30 (but 1 day/month)
FEG PMS – Fixed Camera	Dedicated HW/SW	31 Visual Camera	1 image (2MB)/camera/day	62
FEG PMS – Cameras on Mobile Platform	Dedicated HW/SW	1 High Resolution Camera 1 Infrared Camera 1 Multi-Spectral Camera*	1 image (2MB)/camera/tray/day * Only 5 images per day	80/camera 10
MTF Observation Camera	Dedicated HW/SW	6 Visual Camera	3 images (2MB)/camera/hour (during the day) 1 image (2MB) /camera/hour (during the night)	432 (day) 144 (night)
ISPR (Sensors)	National Rio+Labview	64	1 Hz	11,05
ISPR (Camera)	National Rio+Labview	2 Visual Cameras	5 images (2MB)/camera/day	40
Audio conference	Dedicated HW/SW	N/A	2 hours/day@64Kbps	0,4
Video Conference	Dedicated HW/SW	1 dedicated Camera	2 hours/day@192kbps	1,38

Table 4-4: EDEN ISS data transfer over 24 hours: Worst case, with IR camera.

Time	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00
Sensors/cameras	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00
Top images (31 images x 2MB)	13,778	13,78	13,78	13,78	13,78	13,78	13,78	13,78															13,778	13,778
Side Images (40 images x 2MB)	17,778	17,78	17,78	17,78	17,78	17,78	17,78	17,78															17,778	17,778
Multi Spectral Camera (5 images x 2MB as example)		4,444	4,444	4,444	4,444	4,444																		
IR camera (40 images x 2MB)	17,78	17,78	17,78	17,78	17,78	17,78	17,78	17,78															17,778	17,778
ISPR (5 images x 2MBx 2 view x 2 chambers)	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70	3,70
ISPR	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02	1,02
FEG NDS	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53	0,53
FEG ILS	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
FEG TC	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58	0,58
FEG PCDU	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05
FEG AMS	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32
Service Section AMS	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
Airlock AMS	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06
MTF Exterior	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
Safety Sensors	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10
External day (2 camera x 2 MB x 3 images/hour)									26,67	26,67	26,67	26,67	26,67	26,67		26,67	26,67	26,67	26,67	26,67				
Internal day (4 camera x 2 MB x 3 images/hour)									53,33		53,33	53,33	53,33	53,33		53,33	53,33	53,33		53,33				
External night (2 camera x 2 MB x1 images/hour)	8,889	8,89	8,89	8,89	8,89	8,89	8,89	8,89													8,89	8,89	8,89	8,89
Internal night (4 camera x 2 MB x 1 images/hours)	17,78	17,78	17,78	17,78	17,78	17,78	17,78	17,78													17,78	17,78	17,78	17,78
FEG Camera for audio conf. (1MB each 5 sec.)										200,00									200,00					
Audio Teleconference 64 Kbps										64,00					64,00				64,00					
Video Teleconference 192 Kbps															192,00									
E-NOSE (30MB x 1 day/month)	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78	2,78
	85,92	90,37	90,37	90,37	90,37	90,37	85,92	85,92	89,92	300,59	89,92	89,92	89,92	89,92	265,92	89,92	89,92	89,92	300,59	89,92	36,59	36,59	85,92	85,92

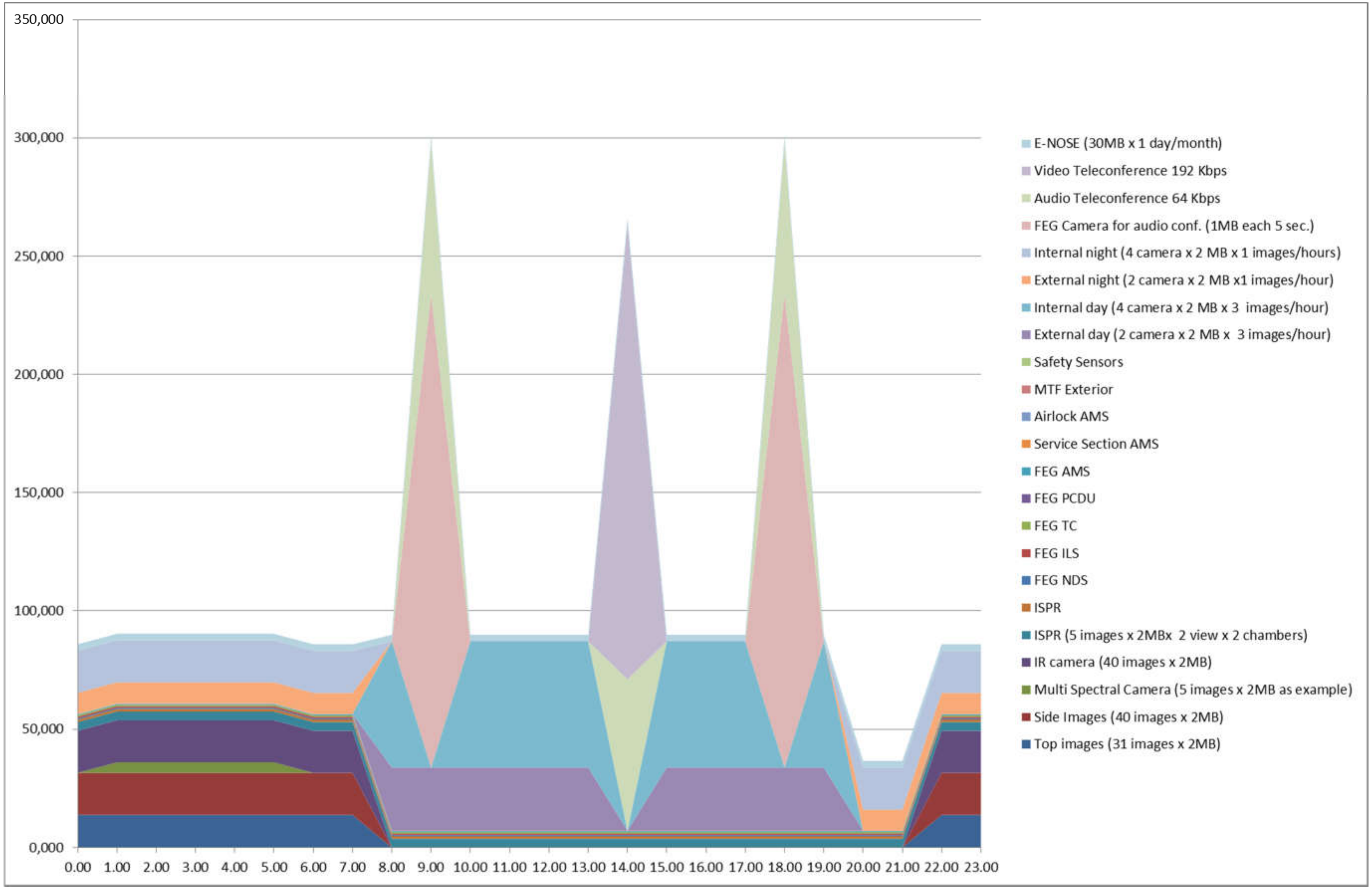


Figure 4-1: EDEN ISS telemetric data volume – Worst case, with IR camera. Y-axis reports data transmission rate (kbps), x-axis reports time of day.

The analysis clearly shows that the nominal EDEN ISS data/image transmission never exceeds the 100 kbps assumed available. Video/audioconferencing requires more bandwidth and thus negotiation with the Neumayer Station III operators.

4.2 Spares, consumables and tools

To run the CDHS during the whole mission the following spares, consumables and tools are needed:

Table 4-5: Spares, consumables and tools of the CDHS.

SPARES, CONSUMABLES TOOLS		
Element/Component	**Qty**	**Ordering Company**
Spares		
Controller Board	1	UoG
Controller Master Backplane Board (w/USB + AP)	1	
I/O Module Board (ATTiny Processor)	1	
I/O Module Backplane Board [ROHS]	1	
I/O Network Power Supply Board	1	
Termination Board - 100 Ohm	2	
Digital Output Module	1	
Modbus interfaces	1	
Patch antenna	1	DLR
Beacon	1	DLR
Horn	1	DLR
Cables	1	DLR
Switch (48 POE ports)	1	UoG
Switch (24 ports)	1	DLR
Fire/ smoke detector	1	DLR
CO2 warning system	1	DLR

4.3 Options and trades

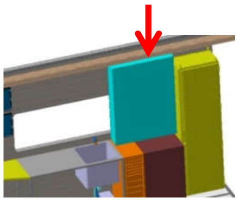
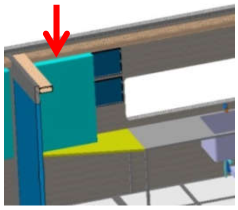
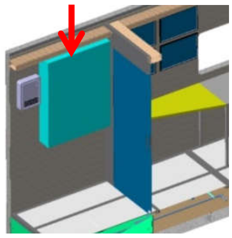
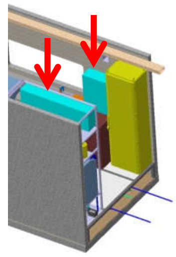
4.3.1 Argus system location

The finalized location of the Argus System box was decided based upon the results of a trade-off comparing a number of different locations as described in

Table 4-6. Option 1 (located between the window and the power box on the north side of the Service Section) was selected.

Table 4-6: Argus System location trade-off results.

	OPTION 1	**OPTION 2**	**OPTION 3**	**OPTION 4**
Location	Left of Power Unit (right side of window)	At entrance to SS (left side of window)	In Airlock/ Cold Porch	Two boxes (smaller box as option 1 and rest in CEA Wall above NDS)

	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Picture				
Needed cables & Cable channel	Good connection to power unit (minimal distance)	A bit more cables required; Longer distance power unit then back	Longer way. Power unit –> cold porch and back	Box one directly next to power unit (=optimal); Box two within CEA Board (=neutral)
Work table & Sink & window	400 mm depth left for work table; Window needs to be shifted to the left.	Work table (right side of sink) is fully accessible => depth (600 mm). Cancelation of foldable table	Work table (right side of sink) is fully accessible => depth (600 mm). Foldable table stays	400 mm depth left for work table; or full accessibility, but not over the full height
Observa-tion Moni-tors	Remain at location (left of window) Monitors need to be sized down.	Need to be switched. Now on the left side of window Reduction to max. 2 Monitors	Remain at location (left of window)	Remain at location (left of window)

The following additional variables were also considered in the trade:

- Margin for expansion
- Ease of work access
    - Restriction of activities during install/wiring
    - Power and C&DH troubleshooting – nice when beside one another so don't have to walk too far back and forth (e.g. if one were to be in the cold porch) – especially if we have a hygiene protocol between SS and cold porch
    - See computer screens when troubleshooting may also be important
- Proximity to water / safety
- Condensation in cold porch?

4.3.2 Types of cameras

At the moment different cameras models have been selected depending on the requirements and on the final goal. That can pose some trouble in cameras management, in terms of interface to the CDH (Zavio and HIKVISION cameras interface the CDH via Ethernet connection, GoPro via HDMI) and in terms of SW interfaces. Also in this case it is worth understanding if it is possible to have a complete system coming from one single company provided with its control SW.

4.3.3 Camera control SW

In case the cameras already selected will be used, it is necessary to use a commercial SW designed to manage cameras coming from different companies. A survey led to a preliminary list:

- The already mentioned **Security Monitor Pro** of Deskshare (www.deskshare.com) can support more than 2000 different IP camera models (including those of HIKVISION and Zavio) and manage up to 32 cameras at the same time (could be used in case the number of camera's for plant monitoring is decreasing from 31 to 20).
- The **WebcamXP / webcam 7 PRO (**www.webcamxp.com**) that as above can support more than 1500 different IP camera models and manage an unlimited number of cameras.**
- The **Netcam Studio 1.2.8** (www.netcamstudio.com) is another SW for camera management (up to 1500 different IP camera's models). The top version of this SW can connect up to 64 cameras.
- The ultimate version of the **go1984** (www.go1984.com) also support up to 1500 different IP camera and can manage an unlimited number of cameras.

4.3.4 Mobile Platform

As per requirements a 230 VAC power interface has been defined, but with the possibility to exploit a different interface, as for example the 28 VDC. Also the data connection is not yet baselined. The consolidation of these interfaces will be done in the next phase.

4.4 Subsystem key values

The mass, cost and power needed in the various modes for the MTF, NM-III and the required spares, consumables and tools are listed in the following table:

Table 4-7: Overview of mass, cost and power for the MTF, NM-III and the spares, consumables and tools.

MOBILE TEST FACILITY					Nominal Operations Mode			Day Nominal Mode			Night Nominal Mode		
	Mass (MTF)		*Cost (MTF)*		Total Power	Avg. Power		Total Power	Avg. Power		Total Power	Avg. Power	
Subtotal	288	kg	32.048	€	1512	1345	W	1512	1467	W	1262	1262	W
Margin	10	%	10	%	10	10	%	10	10	%	10	10	%
Grand total:	**316**	**kg**	**35.253**	**€**	**1664**	**1479**	**W**	**1664**	**1614**	**W**	**1389**	**1389**	**W**

NEUMAYER STATION III					Nominal Operations Mode			Day Nominal Mode			Night Nominal Mode		
	Mass (NM-III)		*Cost (NM-III)*		Total Power	Avg. Power		Total Power	Avg. Power		Total Power	Avg. Power	
Subtotal	61	kg	4.496	€	905	798	W	905	860	W	745	745	W
Margin	10	%	10	%	10	10	%	10	10	%	10	10	%
Grand total:	**67**	**kg**	**4.945**	**€**	**996**	**878**	**W**	**996**	**946**	**W**	**820**	**820**	**W**

Spares, Consum., Tools	*Mass (NM-III)*		*Cost (NM-III)*	
Subtotal	21	kg	3.076	€
Margin	10	%	10	%
TOTAL:	**24**	**kg**	**3.384**	**€**

As can be seen in Table 4-8, the total mass of the CDHS is 407 kg, the total costs amounts to approximately 43,6 k€ and the needed total power in nominal day mode is approximately 2,7 kW and approximately 2,2 kW during nominal night mode (note that these values include both MTF and NM-III hardware).

Table 4-8: Overview of total mass, cost and power for the whole CDHS in Antarctica.

Antarctica					Nominal Operations Mode			Day Nominal Mode			Night Nominal Mode		
	Mass		*Cost*		Total Power	Avg. Power		Total Power	Avg. Power		Total Power	Avg. Power	
Subtotal	370	kg	39.620	€	2.417	2.143	W	2.417	2.327	W	2.007	2.007	W
Margin	10	%	10	%	10	10	%	10	10	%	10	10	%
TOTAL:	**407**	**kg**	**43.582**	**€**	**2.659**	**2.357**	**W**	**2.659**	**2.560**	**W**	**2.208**	**2.208**	**W**

5 Outstanding design issues

The open points requiring further investigation include:

- Finishing of general labeling scheme for PCDU system,
- Final layout of the whole safety system (maybe add O_2 sensors),
- Sensor and actuator layout of TCS,
- Decision on type and amount of cameras (depending on that size of switches),
- The cabling for the whole CDHS,
- Software and hardware interface to the multi-spectral imager,
- Software/interfaces to user home bases and
- Firewall => will be discussed in detail with AWI.

6 Schedule

Argus System

As first attempt we could assume the following dates for the acquisition of the Argus System:

- Argus system will be ordered on April 01, 2016 and will arrive at University of Guelph at June 01, 2016.
- Main milestones in testing at University of Guelph:
  - Argus system integration and wiring (2 weeks - 1 month) – June, 2016.
  - Sensor validation (2 weeks) – July, 2016.
  - System validation with plants (4 weeks) – August, 2016.
- Oct 17, 2016 – Delivery of Argus system (and other Guelph components to DLR Bremen)

Images Acquisition System and Mobile Platform

As first attempt we could assume the following dates for the acquisition of the Plant Health Monitoring System components associated with the CDHS:

- September 2016: Cameras, switches and workstations delivery to TPZ
- September 2016: Mobile Platform delivery to DLR
- September – December 2016: Images Acquisition System Stand Alone test at TPZ premises
- September – December 2016: Mobile Platform Stand Alone Test at DLR premises (with TPZ personnel support)
- January 2017: Delivery of Image Acquisition System to DLR, followed by the integration of cameras for lateral view into the mobile platform and integrated test.

Nominal CDHS H/W

As first attempt we could assume the following dates for the acquisition of the nominal CDHS H/W:

- July 2016: Complete acquisition of patch antenna, switches, WLAN access points, safety system hardware, MTF and NM-III computers.
- August 2016: Computer SW configuration complete.
- October 2016: Integration and testing of CDHS.
- January 2017: Installation of Siemens safety system cable at NM-III.
- February 2017: Integration and testing of Image Acquisition System and the mobile platform.

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