ZR- ROBO-WP5-D5.2-User's Manual

Grant Agreement n°308313

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User's Manual

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List of abbreviations:

- DB = data base
- HVAC = Heating, Ventilation and Air-Conditioning

1. Executive summary

This deliverable define the user's Manual of the growth chamber beside its installation, calibration, maintenance and troubleshooting.

The deliverable is structured with the following sections:

- Installation of the system
- Operation
- Calibration
- Preventive maintenance
- Specifications
- Electrical schematics
- Troubleshooting
- Spare parts replacements
- •

Reference documents

This work has been carried out taking as reference the following documents:

- ✓ ZR-Cometart-WP2_D4.1 _Final-Mechanical-Design
- ✓ ZR-Valoya-WP2_D4.2 _Final-NewLEDLamp-Design
- ✓ ZR-IFAM-WP2_D4.3 _Final-NewSensors-Design
- ✓ ZR-ADV-WP2_D4.4 _Control-System
- ✓ ZR-ROBO-WP2_D4.5 _Robotic-Device
- ✓ ZR-Exergy-WP2_D4.6_Power-System
- ✓ ZR-ROBO-WP4_D4.7 _Complete system integrated

2. Section 1 – Equipment Overview



1	20 feet container
2	Solar panel
3	External power supply
4	Power system
5	Batteries pack
6	Control system
7	HVAC system
8	Growth chamber

Figure 1: Zephyr system Overview

3. Section 2 – Specification

Futures	Specification
Size	5898 x 2350 x 2390 mm
Total weight	7 tons
Growth chamber capacity	10 shelves, 2 tries each, 144 pots each
Growth chamber volume	6,36m3
Power needed	1900 watts max load with a daily average of 1450 watts
Autonomy under batteries	One day
power	

4. Section 3 – Installation

4.1 Choosing a Location

To ensure proper operation, the unit must be located on an outside firm level surface, capable of supporting approximately (machine weight: 600kg. The entire system, including container, batteries, HVAC, etc is

about 7 tons). The unit should be placed in a free space and positioned in order to have solar panels oriented to south for better exposition to the sun light.

The unit requires:

- Optionally a dedicated electrical connection. Power requirements is 1900 watts max load with a daily average of 1450 watts (300wattsonly rotating, translation and watering systems). <u>The unit must be always connected to the ground</u>
- Water connection: Manual filling of the 200 litters tank
- Water evacuation: Use the same pump for the filling of the irrigation tank deflecting the two valves (faucets) manually

4.2 Unpacking after transport

Place the container on a flat or levelled floor, with the PV side (window side) oriented to South

First operation: ground connection; do not do anything before the ground connection is established and tested by an electrician.

Connect the command of the PV panels hydraulic mover and place the PV panels in the right positions, according to the following picture; a movie of the operation is available at: <u>https://www.youtube.com/watch?v=1zdJh4jpHjQ</u>

Block the lower row of PV panels with the opposite bars



Figure 2: PV panels installation

Remove the steel bars blocking the shelves and check the system components against the drawings in this manual;

check the shelves are free to tilt on their longitudinal axis; be sure the transmission chain is free from any obstacle. store the bars outside the conditioned area

4.3 Packing before transport

Remove the bars blocking the lower row of PV panels, then connect the hydraulic command and move the roof until horizontal position. Put the lower panels inside the roof (please refer to the video mentioned above

4.4 Transportation

4.4.1 Handling

The zephyr container has a weight of 7 tons and should be handled by an adequate mover, like in the following picture (Milan, 2015)



Figure 3: Container handling

4.4.2 Precaution to consider during transport

The mover should place the container on an truck able to transport standard TEU containers, like in the following picture and adequately blocked before starting the transport



Figure 4: Container transportation

5. Section 4 – Operation

5.1 Description of the user's interface

A user interface is that portion of an interactive computer system that communicates with the user. Design of the user interface includes any aspect of the system that is visible to the user. The user interface is becoming a larger and larger portion of the software in a computer system. Design of a user interface begins with task analysis; an understanding of the user's underlying tasks and the problem domain. The user interface should be designed in terms of the user's terminology and conception of his job. A good understanding of the cognitive and behavioural characteristics of the particular user is thus important. Good user interface design works from the user's capabilities and limitations. Knowledge of the nature of the user's work and environment is also critical.

Zephyr system User Interface has been designed and developed to allow a user, in this particular case a biologist or a technician to decide the values of a set of predefined parameters (system inputs) that will drive the behaviour of the growth chamber, lighting irrigation, image capturing, etc.., to access the information collected by the system, sensor readings, status signals, notifications... considered as system outputs.

The system is intended to be operated using a graphical user Interface (GUI), as front end of a standalone software application running locally in a computer. The user interface main functions are to interact with the configuration module, to manage and set the subsystems individually -or grouped- (ie: lighting, watering, motion, ...), manually or defining automated routines, to monitor the parameters reported back by the subsystems and the wireless devices fitted with specific sensors.



Figure 5: Zephyr system UI

5.1.1 Zephyr Scheduler installation

The software developed and the libraries needed to integrate all the subsystem functionality is contained in an application file of less than 7MB. The installation is very straightforward, this application file can be copied to any location in a computer and the application can be launched using the **Zephyr Scheduler.exe** file-type

Figure 3 describes the content of the application file and the different libraries developed and integrated.

Nombre	Fecha de modifica	Тіро	Tamaño	
External_DLL	07/08/2015 10:15	Carpeta de archivos)	
鷆 img	05/10/2015 11:27	Carpeta de archivos	-	optical sensor libra
腸 init-data	05/10/2015 11:27	Carpeta de archivos		
ACREO uEve DLL.dll	13/05/2015 17:12	Extensión de la apl	109 KB	
🚳 Kinova.API.Jaco.DLL	28/03/2014 11:07	Extensión de la apl	132 KB	
Kinova.DLL.CommData.DLL	28/03/2014 11:01	Extensión de la apl	94 KB	
🚳 Kinova.DLL.Data.DLL	28/03/2014 11:07	Extensión de la apl	82 KB	- robotic arm librari
Kinova.DLL.SafeGate.DLL	28/03/2014 11:07	Extensión de la apl	9 KB	
Kinova.DLL.TcpConnector.DLL	28/03/2014 11:07	Extensión de la apl	8 KB	
Kinova.DLL.TestData.DLL	28/03/2014 11:07	Extensión de la apl	42 KB	
Kinova.DLL.Tools.DLL	28/03/2014 11:07	Extensión de la apl	56 KB	
Kinova.DLL.USBManager.DLL	28/03/2014 11:07	Extensión de la apl	47 KB	
🚳 MySql.Data.dll	07/11/2014 21:35	Extensión de la apl	434 (0	— system database
NModbus4.dll	19/02/2015 17:36	Extensión de la apl	77 KB	
NModbus4.pdb	19/02/2015 17:36	Archivo PDB	24	— motion system lib
I NModbus4.xml	19/02/2015 17:36	Hoja de cálculo O	110 KB	
🚳 tinyos-sdk.dll	26/11/2014 9:54	Extensión de la apl	20 KB	
tinyos-sdk.pdb	26/11/2014 9:54	Archivo PDB	62 KB	wireless devices
🚳 uEyeDotNet.dll	08/12/2014 12:12	Extensión de la apl	353 KB	
Zephyr Scheduler.exe	28/10/2015 11:44	Aplicación	4.118	— executable
Zephyr Scheduler.exe.config	28/05/2015 19:10	Archivo CONFIG	9 KB	
Zephyr Scheduler.pdb	28/10/2015 11:44	Archivo PDB	410 KB	

Figure 6:	Zephyr	application	file content
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The "**img**" folder is the location where all the images captured by the system are stored along with the processed information generated by the greenness calculation algorithm. The folder is organised in successive folders corresponding to the tray- and pot number where the image originated. The image files are labelled with the date, time, and camera ID.

The "**Init-data**" folder is where all the HSV configuration files are stored; it can contain a number of these user-defined configuration files. Any of these files can be selected during operation when defining the processing parameters.

5.1.2 Configuration Tab

After launching the Zephyr scheduler application, the user can access the configuration tab (Figure 7) and set up the connection parameters to enable the communication with the subsystems through different physical interfaces (LAN, Serial COMs,..) and initialize the system Database (DB) using the connect buttons.

figuration Soil Sensors	Ambient Sensors Optical Sensor Motion Cont	rol Irrigation Control	Lighting Control
Database : · Host : · Port :	localhost 3306	Connect	
802.15.4 COM N	Nanager :	Connect	
Modbus Gatewa	av :		
· Host : · Port :		Connect	
Motion Control	;		Arm Control :
• Host : • Port :	0	Connect	Connect
• Host : • Port :		Connect	Connect

Figure 7: Configuration tab

The subsystem connection status is updated and displayed at the bottom of the screen (Figure 8).

· Host :	192.168.1.54	Disconnect		
· Port :	502			
Motion Control :			Arm Control :	
· Host :	192.168.1.2	Disconnect	Connect	
· Port :	60000			

Figure 8: subsystems configuration and connection

A proper initialization requires the all the subsystems communication interface (DB, 802.15.4, MODBUS, MOTION, ARM) to be in a **CONNECTED** status (Figure 9).

· Port :	192.168.1.54 502	Disconnect		
Motion Control :			Arm Control :	
· Host :	192.168.1.2 60000	Disconnect	Disconnect	

Figure 9: all subsystems connected - ready to work

5.1.3 Soil sensor Tab

The soil sensor tab allows selection of a specific wireless sensor ID no. (11 to 20) and a specific parameter (water content, temperature, soil conductivity) from a predefined dropdown menu (Figure 10). The last reading available for the selected parameter is displayed on the screen with the correspondent time stamp.

Figure 10: soil sensor selection and last reading display

Other functionalities in this tab allow also to define a time interval (start/end date) and retrieve all the data stored in the system DB for that time interval clicking on the "**Get**" button. The data available will be displayed as a list and can be exported in CSV format using the "**Export**" button (Figure 11 and Figure 12).

em figuration Soil Sensors Ambient Sensors O	ptical Sensor Motion Control Iniga	tion Control Lighting Control	
Sensor : 18 - Water Content ▼ Extract Data : rom: 2015-10-01 00:00:00 ↓ October, 2015 ↓ Mon Tue Wed Thu Fri Sat Sun 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 _ Today: 2015-11-12	Signal Name : Last Valid Measurement : Value : To : 2015-09-01 00:00:00	18 - Water Content 2015-10-19 19:09:44 5.396287 m3/m3	Get Export

Figure 11: soil sensor data display - time interval definition

🗢 Zephyr Sche	duler v2.4.4.0			
Save data to CSV			×	
PMD -	data	✓ 4 Search PMD data	ر ا	
Organize 👻 New fo	older	8== •	• • •	
🔶 Favorites	Name	Date modified	Туре 📩 4	
📃 Desktop	soilsensor_PMD#13.csv	2015-04-16 09:58	CSV Fi	
🕕 Downloads	Solisensor_PiviD#15_5.csv	2013-04-21 10.54	COVPE	
Recent Places	soilsensor_PMD#14.csv	2015-04-16 09:58	CSV Fi	Cat. Event
	soilsensor_PMD#14_3.csv	2015-04-21 16:35	CSV Fi	Get Export
🧮 Desktop	soilsensor_PMD#15.csv	2015-04-16 09:58	CSV Fi	
🥽 Libraries	soilsensor_PMD#15_3.csv	2015-04-21 16:36	CSV Fi	
Documents	soilsensor_PMD#16.csv	2015-04-16 09:59	CSV Fi	
🁌 Music	soilsensor_PMD#16_3.csv	2015-04-21 16:36	CSV Fi	
E Pictures	soilsensor_PMD#17.csv	2015-04-16 10:00	CSV Fi	
😸 Videos	soilsensor_PMD#17_3.csv	2015-04-21 16:36	CSV Fi 🗸	
ZEPHYR	• • I	a a	•	
File name:			-	
Save as type: cs	/ files (*.csv)		-	
Hide Folders		Save	incel	
				.:

Figure 12: soil sensor data export

5.1.4 Ambient sensor Tab

The Ambient sensor tab has similar functionalities than the soil sensor tab, but in this particular case the ambient sensors provide readings of temperature, humidity and CO2 level from 2 wireless sensors, one located inside the growth chamber (controlled environment) and the other outside the growth chamber close to the operator (non-controlled environment)

Zephyr Scheduler v2.4.4.0		
System		
Configuration Soil Sensors Ambient Sensors	Optical Sensor Motion Control Irrigation Control Lighting Control	
Sensor :	Signal Name :	
	Last Valid Measurement :	
IAQM01 Temperature	Value :	
IAQM01 Humidity		
IAQM01 CO2	To :	Get
IAQM02 Humidity IAOM02 CO2	2016-01-01 00:00:00	

Figure 13: ambient sensor parameters

Zeph	yr Sched	uler v2.4.4.0								
sten	n									
onfig	uration	Soil Sensors Amb	pient Sensors Op	tical Sensor	Motion Cor	trol Irriga	tion Control	Lighting Control		
_										
5	Sensor	:		Signal Na	ame :		IAQM02	2 CO2		
ſ	AOM02 (°O2	•	Last Valio	d Measure	ment :	2015-1	1-12 15:31:00	- 	
Ľ	Aquitoz			Value :			377.000	mgg 0000		
	Extract	Data :								
F	rom :			To :						
2	015-11-0	01 00:00:00		2015-11	-12 00:00:	00			Get	Export
			9				3			,
	ld	Description	Timestamp	Value 👻	Unit					4
•	6	IAQM02 CO2	2015-11-03 1	828.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	791.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	791.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	768.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	768.000	ppm					
	6	IAQM02 CO2	2015-11-04 1	759.000	ppm					
	6	IAQM02 CO2	2015-11-04 1	755.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	751.000	ppm					
	6	IAQM02 CO2	2015-11-05 1	748.000	ppm					
	6	IAQM02 CO2	2015-11-05 1	748.000	ppm					
	6	IAQM02 CO2	2015-11-04 1	746.000	ppm					
	6	IAQM02 CO2	2015-11-05 1	742.000	ppm					
	6	IAQM02 CO2	2015-11-03 1	740.000	ppm					
	6	IAQM02 CO2	2015-11-05 1	740.000	ppm					

Figure 14: ambient sensor data display

5.1.5 Optical sensor Tab

The optical sensor tab allows for capturing and processing of images from 2 cameras integrated within the robotic arm. The image capturing requires coordination with the motion system, i.e. the robotic arm must point the cameras to a specific tray and pot (image position) and the motion system must ensure the selected tray is stopped at that specific image position. Assuming the robotic arm and the selected tray are properly positioned, image capturing and processing (greenness calculation) is done by clicking on the "**Start Analysis**" button (**Errore. L'origine riferimento non è stata trovata.**). The greenness calculation is done considering the HSV **configuration file** selected. This file must be previously stored in the "init-data" folder in order to be accessible (Figure 15 and Figure 16).

Zephyr Scheduler v2.4.4.0		
System		
Configuration Soil Sensors Ambient Se	ensors Optical Sensor Motion Control Imgation Control Lighting Control	
Optical Sensor Control : - Camera Light Status : ON OFF	ON	
Optical Sensor Analysis :		Clear
· Select Tray :	1	Console
· Select Pot :	1	Start Analysis
· Select Config File :	plant_type_9999.hsv 👻	Minu Image
· Select Image :	plant_type_0001.hsv plant_type_9999.hsv	View image
		*
		Ŧ

Figure 15: Image capturing settings

There is a LED lamp integrated with the camera support to guarantee repeatable lighting conditions when taking the pictures. This LED lamp (camera light) can be switched ON-OFF using the optical sensor Control buttons and the light status is always displayed.

		Clear
 Select Tray : 	1	Console
· Select Pot :	2	Start Analysis
· Select Config File :	plant_type_0001.hsv	View Imag
Select Image :	20151112 160825 410261816(-	
arting Analysis on tra 015-11-12 16:08:15 Inc 015-11-12 16:08:15 DI	y 1 using hsv file plant_type_0001 uding a DLL: Pre-/De-allocation of revision:	.hsv data structs by extern API functions

			plant_type_0001 - Notepad	
/stem			File Edit Format View Help	Close
Configuration Soil Sensors	Ambient Sensors Optical S	Sensor Motion Contr	Hmax=0.4274	
			Hmin=0.1373 Smax=1.00	
Optical Sensor			Smin=0.1451	
			Vmax=1.00 Vmin=0.3922	
· Camera Light s	Ca v Proje	cts ▶ Zephvr ▶ i		ch pot P
ON OFF				
	Organize 🔻 🧾 O	pen 🔻 New fo		
		 Name 		
Ontical Sensor	Nesktop			
Optical Sensor	libraries	<pre>plant_ty</pre>		File
· Select Tray :	Documents	plant_ty		File
· Select Pot :	J Music		1	· · · · · · · · · · · · · · · · · · ·
	Pictures			
 Select Config F 	Videos			
· Select Image :	ZEPHYR			
	Computer			
	S Network			
	Control Panel	=		<u>^</u>
	Recycle Bin			
	hackun Insubria			
	first growth trial			
	Greenness x visite			
	ima			
	init-data			
	init-data - Insubr			
	Modbus			-
) old			
	Jan Old			·

Figure 16: Image HSV analysis (Greenness)

Figure 17: Image HSV configuration file

The "**View Image**" button allows to load and display the images captured/stored from a specific tray/pot (Figure 18).



Figure 18: View Image

5.1.6 Motion control Tab

The motion control tab allow the user to manage 2 motion systems, the robotic arm positioning and the tray rotation system. The robotic arm can be positioned at 3 predefined positions: PICTURE, INTRERMEDIATE, HOME and sent to any position manually introducing X,Y,Z and Theta coordinates in CUSTOM mode.

Zephyr Scheduler v2.4.4.0			
System			
Configuration Soil Sensors Ambient Sensors	Optical Sensor Motion Control Irrig	ation Control Lighting Control	
Robotic Arm Position : · Status : CONNECTED			
· X Coordinate : 0.2127717	0.0000 · Theta X :	0.0000 0.0000	
· Y Coordinate : -0.2730831	0.0000 🚔 · Theta Y :	0.0000	
· Z Coordinate : 0.4875473	0.0000 💌 · Theta Z :	0.0000	
	· Default Arm Position :	CUSTOM PICTURE INTERMEDIATE HOME CUSTOM	Move Arm
Drive Movement :			
Status : CONNECTED Move Tray :	• Arm Translation :	4.882813E-07 · Abs. Angle :	5.410485
To Position : IMAGE To Angle : 0.00	• Default Trans. Position	0.0000 · Current Speed : : CUSTOM •	-1.457282E-05
	3 y	Current Rotation : Translate Arm	Stopped
1			

Figure 19: Motion control – Robotic arm

Drive movement menu is used to set the rotation speed and the rotation direction (anti/clockwise) and to send any tray (1 to 10) to a predefined position (IMAGE, IRRIGATION) or to a specific location using the angle positioning option. This menu display continuously the positioning values (abs. angle) and system status (stopped, clockwise, anticlockwise)

Drive Movement : · Status : CON	NECTED				
· Move Tray :	1	· Arm Translation :	4.882813E-07	· Abs. Angle :	5.410485
To Position :	IMAGE -		0.0000	· Current Speed :	-1.457282E-05
💿 To Angle :	0.0000	· Default Trans. Position :	CUSTOM -		0.017400 🚔
2	Move Tray		Translate Arm	· Current Rotation :	Stopped

Figure 20: Motion control – Rotation system

5.1.7 Irrigation control Tab

The irrigation control tab provides information on the status of the tub an tank level, the filling pump and the drain valve and supports 2 types of control, manual and automatic. The manual control allows to fill/drain the tub at any time, **Auto fill** option can be used to fill the tub up to a predefined level (pot tray). The automatic mode include options like: time scheduling (date/time), (tray) immersion time, cycle repeatability (hours) or SWC trigger, using water content last reading from a specific soil sensor to decide whether to start the cycle or not.

tem						
figuration Soil Sensors	Ambient Sensors Optical Se	ensor Mo	tion Control Irrig	ation Control Lighting Control		
Status :						
Tank Level :	LOW					ATA
Tub Level :	FULL	/				
Filling Pump Status :	OFF					
Drain Valve Status :	OFF					
						,
Automatic Contro				Current cycle status :	IDLE	
Program Start Date :	2015-09-23 00:00					
Repeat cycle every :	1		hours	Started :		
Current date-time :	2015-11-12 16:24:56			Current Tray / Status :	1	IDLE
	2015 11 12 10.24.50			Irrigation Started		
Next cycle start :	2015-11-12 17:00:00					
Inmersion Time :	1		minutes			
—			. U	Manual Control		
Use SWC Sensor :		-		ON OFF Filling Pur	np	
Start cycle if value <	1.000		m3/m3	ON OFF Drain Valv	e	
last value :	0			V AUTO FIII		

Figure 21: Irrigation control

The irrigation cycle is coordinated with the rotation system (IRRIGATION) and the robotic arm position (HOME) before starting.

tem								
nfiguration Soil S	Sensors Ambie	nt Sensors (Optical Sensor	Motion Control	Irrigation Control	Lighting Control		
Robotic Arm	Position :							
Status :	CONNECTED)						
X Coordinate :	0.2123559	0.	.2121	· Theta X :	0.0000	1.53	21	
Y Coordinate :	-0.2751766	-0.	.2766	· Theta Y :	0.0000	1.05	18	
Z Coordinate :	0.4773858	0.	.4876	· Theta Z :	0.0000	0.07	08	
			· Defa	ult Arm Positio	n : HOME		•	Move Arm
Drive Mover	nent :							
Drive Mover	nent : CONNECTED)						
Drive Mover Status : Move Tray :	nent : CONNECTED)	• Arm	Translation :	0	- Ab	s. Angle :	5.144656
Drive Mover Status : Move Tray : To Position :	nent : CONNECTED	RIGATION	• Arm	Translation :	0	- Ab 0000 + Cu	s. Angle : rrent Speed :	5.144656 -0.01743408
Drive Mover · Status : · Move Tray : ③ To Position : ⑦ To Angle :	nent : CONNECTED	RRIGATION	4 ▲ · Arm • Defa	Translation : ult Trans. Posit	0 0.1 ion : P01	- Ab 0000 + - Cu	s. Angle : rrent Speed :	5.144656 -0.01743408 0.017400 (m)
Drive Mover Status : Move Tray : To Position : To Angle :	nent : CONNECTED	RRIGATION	· Arm	Translation : ult Trans. Posit	0 0.1	- Ab 0000 4 - Cu - Cu	s. Angle : rrent Speed : rrent Rotation :	5.144656 -0.01743408 0.017400 (m) Stopped
Drive Mover Status : Move Tray : To Position : To Angle : To Angle :	nent : CONNECTED	RRIGATION 0.0000 Move Tray	· Arm	Translation : ult Trans. Posit	0 0.1 ion : P01 Translat	- Ab 0000 - Cu • Cu • Cu	s. Angle : rrent Speed : rrent Rotation :	5.1446556 -0.01743408 0.017400 (***********************************

Figure 22: Motion control system – irrigation positioning

5.1.8 Lighting control Tab

The lighting control tab is designed to allow the user to define the LED luminaire status (**ON-OFF**) and the PAR level, **Dimmer level** (0-100%). The PAR level (μ moles/m2.s) is measured by a PAR sensor installed in the growth chamber at the tray distance from the luminaire. An automated mode is also possible for the lighting system, the user can define an combine different time slots (scheduling) with specific configuration for the luminaire status (on/off) and the PAR level (dimmer percentage) to be applied daily.

Zephyr Scheduler v2.4.4.0					
ystem			Liebting Control		
Configuration Soil Sensors Ambie	ent Sensors Optical Sensor	Motion Control Irrigation C			
	Luminaire St PAR Level : Dimmer Leve - Set Dimmer	r Value : ON	ON OFF 904 μmol/(m^2 · s) 0 0 Σ		
Daily Schedule :	Automatic Control On Active Sta	rt Program At	Auto Mod Luminaire Status	e Enabled - Program P(Dimmer Percentag	02 Active
Daily Schedule :	Automatic Control On Active State Image: Control On	rt Program At	Auto Mod Luminaire Status DFF	e Enabled - Program P(Dimmer Percentag 100	02 Active (%)
Daily Schedule :	Automatic Control On Active Image: Control On Image: Contro	rt Program At	Auto Mod Luminaire Status DFF	e Enabled - Program Po Dimmer Percentag 100 100	02 Active
Daily Schedule :	Automatic Control On Active State Image: Control On 00:00 Image: Control On 01:30 Image: Control On Image: Control On	rt Program At	Auto Mod Luminaire Status DFF	e Enabled - Program P(Dimmer Percentag 100 100 100	02 Active
Program 01 02 03 04	Automatic Control On Active State Image: Control On 00:00 Image: Control On 01:30 Image: Control On 17:30 Image: Control On 00:00	rt Program At	Auto Mod Luminaire Status DFF DFF	e Enabled - Program PC Dimmer Percentag 100 100 100 50	02 Active
Program 01 02 03 04 05	Automatic Control On Active State Image: Control On 00:00 Image: Control On 01:30 Image: Control On 17:30 Image: Control On 00:00 Image: Control On 00:00	rt Program At	Auto Mod	e Enabled - Program PC Dimmer Percentage 100 100 50 50	02 Active
Program Image: Constraint of the second	Automatic Control On Active Stell Image: One of the other of the other oth	rt Program At	Auto Mod	e Enabled - Program P(Dimmer Percentag 100 100 50 50 50 50	02 Active

Figure 23: Lighting system

5.1.9 System Data output

The system stores all the data collected periodically from the wireless devices in the database, these data can be accessed at any time from the soil and ambient sensor tab menus and exported in csv format for further analysis.

🗢 Zephyr Sch	eduler v2.4.4.0					◆ Z	phyr Sched	uler v2.4.4.0						
 Save data to CSV Save data to CSV PMD 	data		حد م	trol		Sys	nfiguration	Soil Sensors Am	bient Sensors 0	tical Sensor M	tion Control Inig	ation Control Lighting Control		
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E Desktop	soilsensor_PMD#13.csv soilsensor_PMD#13.3.csv soilsensor_PMD#14.csv soilsensor_PMD#14.3.csv soilsensor_PMD#14.3.csv	2015-04-16 09:58 2015-04-21 16:34 2015-04-16 09:58 2015-04-21 16:35 2015-04-21 16:35	CSV Fi CSV Fi CSV Fi CSV Fi CSV Fi	Get	Export		Extract From : 2015-11-	Data : 01 00:00:00		Value : To : 2015-11-12	00:00:00	377.000000 ppm	Get	Export
C Libraries Documents Music Pictures Videos E Videos ZEPHYR	soilsensor_PMD#15.3.csv soilsensor_PMD#16.csv soilsensor_PMD#16.csv soilsensor_PMD#17.csv soilsensor_PMD#17.3.csv	2015-04-21 16:36 2015-04-16 09:59 2015-04-21 16:36 2015-04-16 10:00 2015-04-21 16:36	CSV Fi CSV Fi CSV Fi CSV Fi CSV Fi			F	6 6 6 6 6	Description IAQM02 CO2 IAQM02 CO2	Timestamp 2015-11-03 1 2015-11-03 1 2015-11-03 1 2015-11-03 1 2015-11-03 1	Value v Uk 828.000 pp 791.000 pp 768.000 pp 768.000 pp	nt n			â
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Figure 24: wireless devices output data

The images captures by the optical system (2 cameras), are stored in the image file under the correspondent tray and pot, i.e \img\tray_08\pot_02. The .hsv config file is stored under init-data\tray_08\pot_02; this file can be edited or new ones added (Figure 25).

 Zephyr Scheduler v2.4.4 	1.0		Relation and American			83								
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Configuration Sol Sensor	Ambient Sensors Optical Ser	Notion Contr	Hmax=0.4274	- Cite	×									
			Hm1n=0.1573 Smax=1.00											
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- Camera Light		A Zealar A i	vm1n=0.3922		sh ant O		Nombre			Fecha de modifica	. Tipo	Tamaño		
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	🕌 init-data - Insubr							tray 10	🌒 po	t_01		05/10/2015 11:27	Carpeta de archivos	
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Figure 25: optical sensor output data

The results of the image processing is displayed during the operation and stored in the same folder than the images captured (Figure 26).

 Zephyr Scheduler v2.4.4.0 		♥ 20151106 161701 4102701613 ppg	
System			
Configuration Soil Sensors Ambient Sensors Optical Sensor Motion Control Imgation Control Lighting Control			
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- Select Image :		and the second	
	~		
Starting Analysis on tray 1 using hsv file plant_type_0001.hsv 2015-11-12 16:08:15 Tacluding a DLL: Pre-/De-allocation of data structs by extern APT functions			and the state of the
2015-11-12 16:08:15 DLL revision:			
2015-11-12 16:08:16 330 2015-11-12 16:08:16 pCam1 = 7007236 (address of dummy)		and the set of the	
2015-11-12 16:08:22 Cam1 init returned: 0		The second s	
2015-11-12 16:08:25 Cam2 init returned: 0 2015-11-12 16:08:33 Plant-content: pCam1=0.4% pCam2=1.05%			
2015-11-12 16:08:34 pCam1 value: 135786192			and the second se
2015-11-12 15:08:54 pcam2 value: 141950540			
	~		

Figure 26: optical sensor output data

6. Section 5 – Calibration

6.1 Calibration of the chamber temperature

The HVAC system is a self-standing system inside the Zephyr Unit: the attached manual of the PLUS 100 THR seasoning controller should be carefully (sections 3,4 and 5) before starting with the operations.

To calibrate the chamber temperature please refer to the section 6.1 in the PLUS 100 THR manual

6.2 Calibration of the chamber humidity

HVAC control panel To calibrate the chamber humidity please refer to the sections from 6.2 to 6.5 in the PLUS 100 THR manual

6.3 Calibration of the soil sensor stick

The soil sensor stick is design to measure between about 30% to 60% volumetric bulk water (m^3/m^3) and soil conductivity between about 0.1 dS/m to 2 dS/m in Jiffy substrate.

The following procedure has been done to obtain a conversion formula between the raw signals from the soil sensor (R, C) and the volumetric bulk water and electrical conductivity of the soil. This procedure is not needed to be done by the User again. However, for critical and/or more accurate measurements, the User can supplemented / modified the water volume calibration procedure with measuring the water content by relative weighing of the soil versus measured PM-D permittivity.

In the PM-D soil sensor system, the resistance R and capacitance C is determined for a specific wet state of the soil. The soil conductivity, σ , and volume water content, θ , is related to R and C according to:

$$R = \frac{A}{\sigma} \tag{1}$$

$$C = \varepsilon_r C_0 \tag{2}$$

$$\sqrt{\varepsilon_r} = b_0 + b_1 \theta \tag{3}$$

where A is a calibration parameter, ε_r is the relative permittivity of the soil, C₀ the capacitance between sensor electrodes in air (ε_r =1), and b₀ and b₁ are calibration parameters.

The translation of PM-D resistance readings (R) into soil bulk conductivity (EC_p [S/m]) is done by measuring R in a number of samples of known conductivity, covering an appropriate conductivity interval.

The PM-D sensor stick was calibrated with respect to the conductivity and resistance between the electrodes by using liquid substances with different conductivities (in the same range as for the soil). The conductivity was measured independently with a commercial conductivity meter (CDM210, Radiometer Copenhagen). The result from the conductivity calibration can be seen in Figure 27.



Figure 27. Conductivity versus measured PM-D conductance (1/R).

The sensor stick was also calibrated with respect to the permittivity of the soil and the measured PM-D capacitance between the electrodes, by using substances with different permittivity (Table 1). The result of this calibration can be seen in Figure 28 below.

Table 1. Sample utilized for calibration of capacitance to water content in soil

Sample	Dielectric constant (literature)			
PEG (liq)	12.4			
Ethanol (liq)	24.3			
Methanol	33			
Glycerol (liq)	42.5			
Tap water (liq)	80			



Figure 28. Permittivity (dielectric constant) versus measured PM-D capacitance.

The PM-D readings from measured soil permittivity can be translated into soil volume water content $[m^3/m^3]$. To do this, the water content measured with the commercial WET-2 soil sensor (Delta-T Devices) was plotted versus the permittivity and the calibration constants b_0 and b_1 (see eq. 2, 3) were determined. The result of this calibration can be seen in Figure 29.



Figure 29. Volume water content (measured with the WET-2 sensor) as a function of permittivity measured with the PM-C sensor stick.

The temperature sensor situated on the microprocessor has been also calibrated by measuring at a constant temperature and correcting the values in the calibration equation.

The conversion equations for the sensors are listed below:

Conversion formulas for the temperature readout (A-value)

#11 ECp [ms/m] = (64.5*(0.631/(9.104395e-6*A+0.0079175))-150.3)

- #12 ECp [ms/m] = (64.5*(1.419/(9.104395 e-6*A+0.0079175))-150.3)
- #13 ECp [ms/m] = (64.5*(0.595/(9.104395 e-6*A+0.0079175))-150.3)
- #16 ECp [ms/m] = (64.5*(0.618/(9.104395 e-6*A+0.0079175))-150.3)
- #18 ECp [ms/m] = (64.5*(0.579/(9.104395 e-6*A+0.0079175))-150.3)

#20 ECp [ms/m] = (64.5*(0.647/(9.104395 e-6*A+0.0079175))-150.3)

Conversion formulas for the temperature readout (B-value)

#11 Theta [m3/m3] =	((176.14*(0.463/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	
#12 Theta [m3/m3] =	((176.14*(0.475/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	
#13 Theta [m3/m3] =	((176.14*(0.430/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	
#16 Theta [m3/m3] =	((176.14*(0.431/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	
#18 Theta [m3/m3] =	((176.14*(0.435/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	
#20 Theta [m3/m3] =	((176.14*(0.490/(0.8085-(0.5954-1.4103*9.104395*B)^(0.5))-1)-
109.87)^(0.5)-1.3)/7.603	

Conversion formulas for the temperature readout (C-value) #11 T [°C]=((600/1.32)*((C -32768)/32768))-264.94 #12 T [°C]=((600/1.32)*((C -32768)/32768))-267.34 #13T [°C]=((600/1.32)*((C -32768)/32768))-263.07 #16T [°C]=((600/1.32)*((C -32768)/32768))-271.52 #18 T [°C]=((600/1.32)*((C -32768)/32768))-272.34 #20 T [°C]=((600/1.32)*((C -32768)/32768))-266.00

6.4 Calibration of optical sensors

The optical sensor is calibrated for colour of the leaves and ambient light intensity & contrast & colour via software. Images are taken and the various parameters of the image quality are modified manually inside software. The software is calibrated for a certain focusing distance between the photo camera to plant and also distance from between the cameras. The focusing distance is dependent on the lens on the camera and its number is written on the lens.

The following must not change during measurements:

- The amount of light and position of the light source;
- The position of the camera, the aspect and the focus of the lens;
- The exposition (the duration of the camera shutter);
- The aperture of the lens;

This ambient light intensity & contrast have to be kept constant during all the measurements. If some of the parameters change (e.g. leave colour from green to red) then new calibration has to be made.

The utilization of the software in manual mode is as following:

Keyboard shortcuts for uEyeDualCam.exe

ctrl-N Open a new camera.

- ctrl-TAB Switch frame makes the other frame active.
- alt-W S Swap frames vertically.
- alt-W P Load preset parameters for the active frame.
- alt-W V Tile the open frames side by side.
- alt-W G Extract the green content for the active frame.
- alt-W C Stacks all frames in the center;

use ctrl-TAB to switch between the frames.

Preferred sequence for camera operation using uEyeDualCam.exe

- 1) Open the first camera (ctrl-N).
- 2) Open the second camera (ctrl-N).
- 3) When both have opened an image, press the "Freeze Video" button.
- 4) Press button "Preset Size and Color".
- 5) Tile images (window-frames) side-by-side (alt-W V).
- 6) If camera 4002890992 is on the left-hand side, swap images (alt-W S).

7) Resume - press the "Live Video" button. Images should update real-time now.

- 8) Position the scene as desired.
- 9) Take a snapshot (freeze) using the button "Manual Trigger Freeze Video".
- 10) Repeat step 9) until the time-stamps become identical on both images.
- 11) The images are now simultaneous; use button "Save Pictures".

12) For each new scene, repeat from step 7).

Extracting the green colour content

- 21) Select / activate one of the color cameras.
- 22) Take a snapshot (freeze) using the button "Manual Trigger Freeze Video".
- 23) Press button "Extract Green Color" (works only on the active frame).
- 24) Note the green content message in the status bar.
- 25) Optionally, use button "Save Pictures" (works on all open frames).

MAINTENANCE

Camera colour-adjustment/equalization using uEyeDualCam.exe:

A. Ensure steps 1)-4) are completed.

- B. Place the two frames stacked in the centre (alt-W C).
- C. The "Properties" button opens a tab-menu for the active camera.
- D. Adjust the parameters in the "Image" tab and accept with "OK".
- E. Compare the images in "Live Video" mode, by switching between them (ctrl-TAB).

Usage of the `HeightMap.exe` standalone application {#HeightMap_exe_HOWTO}

General information

Each image `<filename>.png` should be accompanied by an `<filename>.info file. The respective <filename>` consists of the Date, Time, and CameraSerialNumber.

The `<filename>.info` file contains text with information needed in the processing:

- the current revision of the software that generated the image

- the chosen Area-of-Interest (AOI) within the camera field of view

- the pixel-offset between the cameras in a given pair

- the selected HSV parameters for extraction of the foliage content, named Hmax, Hmin, Smax, Smin, Vmax, Vmin, and can be edited manually.

HeightMap normal processing sequence {#HeightMap_normal_sequence}

1. After starting up the `HeightMap.exe`, choose the folder/directory containing the images with the *File->Select Directory* menu item. The chosen folder should appear in the field *Working directory* at the bottom of the window.

2. Select one of the desired images with the *File->Open* menu item.

The application automatically computes the plant/green content in each image, based on the data in the `<filename>.info` files.

The foliage-only images are displayed side by side, and the percentage is shown in the *Plant content* fields.

NB: A pair of images must exist, tagged with the same time-stamp.

3. Select the item *Display plant-pixels only...* from the pull-down menu and press the *Display* button. A new window called *Figure 1* shows the data contained in memory.

4. Select the item *Display height-map...* from the pull-down menu and press the *Display* button. The mapping process can be seen in Figure 1. Wait until the counter *Remaining levels* reaches 0.

5. Select the item *Display height-histogram for chosen region...* from the pull-down menu and press the *Display* button. The histogram is then shown in a new window named *Figure 2*.

In the absence of a calibration file named `init-data\conversion_formula.m`, only the *Mean unnormalized height* is shown, measured in pixels.

In the presence of `init-data\conversion_formula.m`, also the computed *Mean normalized height* is shown accordingly.

NB: `conversion_formula.m` contains text in the form of a function: $y = a + b^*x + c^*x^2 + ...$ `, which should be derived by the user by analyzing the growth of a typical plant over time.

6. The procedure can be repeated from Step 2) for all image pairs in the chosen *Working directory*.

The item *Check image alignment...* from the pull-down menu is useful for

demonstration purposes. The process of plant-pixel correlation can be visualized in a separate window called *Figure 3*.

HeightMap processing with changed HSV parameters

Occasionally, the `Zephyr Scheduler` user may accidentally choose the wrong `.hsv` file for a given plant type.

While the `Zephyr Scheduler` will save the complete image information in `<filename>.png`, the `<filename>.info` files will contain the wrong HSV color parameterization.

At a later time, the user may edit the `<filename>.info` files with the proper values for Hmax, Hmin, Smax, Smin, Vmax, and Vmin. At that point, the sequence above can be repeated with the new HSV colour parameters:

1. Steps 1)-2) allow recomputation of the plant/green content for a given image pair.

2. Steps 1)-6) allow also for complete re-computation of the height-map for a given image pair. Note that both `<filename>.info` files should be edited in that case.

6.5 Calibration of radiation sensor

The SQ-225 is an amplified quantum sensor that measures photosynthetically active radiation and is calibrated for use with electric lights. The sensor housing design features a fully potted, domed-shaped head making the sensor fully weatherproof and self-cleaning. Photosynthetically active radiation (PAR), or photosynthetic photon flux (PPF), is the wavelength range from 400 to 700 nanometers and is strongly correlated with plant growth. Gardeners, greenhouse managers, growth chamber users and salt-water aquarists measure PAR to insure optimal specimen health.



Figure 30: radiation sensor

Sensitivity: 2.0 mV per μ mol m⁻² s⁻¹ Calibration Factor: 0.5 μ mol m⁻² s⁻¹ per mV (reciprocal of sensitivity) Calibration Uncertainty: \pm 5% Measurement Repeatability: < 1% Non-stability (Long-term Drift): < 2 % per year Non-linearity: < 1 % (up to 2500 μ mol m⁻² s⁻¹; maximum PPF measurement is 2500 μ mol m⁻² s⁻¹) Response Time: < 1 ms Field of View: 180° Spectral Range: 410 nm to 655 nm Directional (Cosine) Response: \pm 5 % at 75° zenith angle Temperature Response: 0.06 \pm 0.06 % per C Operating Environment: -40 to 70 C, 0 to 100 % relative humidity, Can be submerged in water up to depths of 30 m

7. Section 6 – Preventive Maintenance

7.1 The rotation system

Oil periodically the chain

7.2 Watering system

Refer to the following figure to clean the circulation pump and the immersion tank periodically (preferably after each growth cycle; clean the bottom grids of the shelves after each growth cycle.



Figure 31: illustration of the watering sensor

7.3 Translation system

Clean with compressed air the track once a month;

7.4 Robotic arm

The only maintenance that must be done on a regular basis is the finger lubrication according to the following information.

Designation	Periodicity	Time needed	Procedure	
Finger lubrication	Fingers should be	30 minutes for total	Refer to the Jaco	
ensures optimal	lubricated every 6	procedure	maintenance guide	
performance of the	months	(lubrication of the 3	in the appendix A	
gripper and noise		fingers).		
reduction.				

7.5 HVAC system

Check sections 2 and 3 sections in the PLUS 100 THR manual in Appendix B

7.6 Electrical system

Preventive maintenance for the electrical system

Solar systems require little maintenance as compared to other electrical systems such as diesel generators; however they are not maintenance free. Proper maintenance ensures the solar system life is preserved for as long as possible and the original conditions.

The system does not have any moving parts and therefore requires only minimal maintenance. The system owner should periodically (e.g. monthly) check that the system is still operating, this can be most easily done by either:

- Checking that the inverter and charge controller are operating (the green light is on in good weather conditions)
- Visual display shows an increased value over a period of a day

Note: At all times an authorised personnel should be available for general pattern and maintenance of the solar PV electrical system.

Solar Panel Maintenance:

The solar array (a number of solar panels connected together) is often thought to be maintenance free. However, occasional maintenance and inspection of the solar array must be performed to ensure the optimal use of the solar panels. This can be done by keeping the surface (glass) area of the module clean from any excess dirt.

- To remove a layer of dust and dirt from the modules, simply wash the panel with water. If the module has thick dirt or grime and bird droppings, which are harder to remove, wash with cold water and rub the panel surface with a sponge.

Battery maintenance:

The Zephyr unit comes with a well-structured and safely positioned batteries as shown in Figure below:



Figure 32: Batteries location

In the Zephyr unit the battery system is designed to keep the battery charged at all time for emergency backup requirement, the inverter and charge controller are set to offer longest backup time in the event of a grid failure, and the longest life for the batteries.

Additionally, the batteries should be regularly and carefully maintained to extend their useful life, by inspecting the state of charge on the display and cleaning periodically taking safety precautions.

Inverter/Battery Charger and Charger controller:

This component can be maintained by minimizing dust accumulation. A dry cloth should be used to wipe away any accumulated dirt/dust. A visual inspection should be done to ensure that all the indicators such as LED lights are working and that the wires leading to and from this device are not loose. Note that the charge controller should indicate that the system is charging when the sun is up. If not, contact the installer immediately.

Wiring and Connections:

Wiring installations should be checked for any cracks, breaks or deterioration in the insulation/conduits. Inspect panel boxes to ensure that they have not become a home for rodents and insects. Also inspect connections for any corrosion and/or burning. Switches should not spark when turned on or off. The following sections of conduit and wiring should be checked for any signs of damage:

- Solar panels to the charge controller
- Charge controller to the battery bank
- Inverter/charger to the battery bank
- Generator/Grid connection to Inverter/charger
- Inverter/charger and Generator to the AC outlets/load
- Battery bank to the DC outlets/load.

If damage is found, consult with the installer as soon as possible. All ground wires should be checked to ensure they are not broken. PV performance is increased with a long-term commitment to a preventative and predictive maintenance program.

7.7 LED Lamp

Designation	Periodicity	Time needed	Procedure
Cleaning of the	Plexi should be	2 minutes	Wipe the plexi with a
luminaire plexi cover	cleaned every 2		clean cloth. Do not
	months		use any strong
			detergents!

7.8 Sensors

7.8.1 Optical sensor

Lenses should not be touched by hand or other sharp objects. Oil and debris from hands or from used lens tissue can stain or damage optical coatings. If it is not dirty, don't clean it. Handling optics increases their chances of getting dirty or damaged, so one should clean optics only when necessary.

Dusting is always the first step in cleaning optics. Wiping a dusty optic is like cleaning it with sandpaper. So always dust with a canned air duster, compressed and filtered air, or nitrogen before wiping any optic. If the dusted optic has no visible stains after one dust it, then it is done. If it is still not clean, use reagent- or spectrophotometric-grade solvent and special tissue for optical lens. The grade solvent should be a mix of 60% acetone and 40% methanol. Always use acetone-impenetrable gloves when using acetone.

7.8.2 Soil sensor

The electrodes from the soil sensors can be cleaned gently with a soft cloth without liquids when beginning a new series of measurements to remove the remaining soil particles.

8. Section 7 – Electrical Schematics

8.1 Electrical system

Electrical system schematic for the PV system is shown in the figure below:



Figure 33: Wiring of Electrical system

8.2 Main controller



Figure 34: Wiring of the main controller

Main components:

- Radio transceivers 868MZ /2.4Ghz
- MPC controller
- Embedded PC
- Ethernet switch

8.3 Growth Chamber

8.3.1 Watering system

Tank level monitoring - Manual filling





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Figure 35: Watering system wiring

Details in the appendix B

8.3.2 Rotation, translation and robotic arm









8.3.3 Inspection sensors





8.4 HVAC



- 1 General power on/off
- 2 Led indicating power on
- 3 Cooling system on/off
- 4 heating system on/off
- 5 Temperature/Humidity controller (see the

See section A2 of the PLUS 100 THR manual

9. Section 8 – Troubleshooting

The following table summarise the list of possible problem, possible cause and possible solutions for each problem

Problem	Possible causes	Solutions	
Rotation stops to	Emergency stop activated, Motor	Check the emergency stop status,	
turn	overheated, connector(s) removed,	the status of the motion controller	
		(refer to Motion controller manual in the appendix A)	
Bad initialisation	Problem with reference switch	Check the reference switch	
of the rotation			
during start-up			
Translation stops	Emergency stop activated, Motor	Check the emergency stop status,	
to move	overheated, connector(s) removed,	the status of the motion controller	
		(refer to Motion controller manual in	
Robotic arm	Power or control connector removed	Check both connectors	
stops to move		Use Jaco soft to proceed with arm	
		diagnosis (refer to Jaco arm User's	
		Manual in the appendix A	
HVAC System	See chapter 7 of the PLUS 100 THR		
N			
Negative or	(a) Not good contact between sensor	(a) Properly inserting of electrodes	
from soil sensor	(b) Measurements outside the	(b) Wait until the defined	
	designed interval of functioning.	measurement interval.	
Not correct	Not correct settings for optical /	Follow the instructions for installation	
values for	camera sensor	and don't modify parameters during	
greenness and/or		measurements	
plant neight	Connectoro are not connected	Charly the connections	
not operate after	properly		
installation			

Luminaire does LED light source malfunction not light up or lights up partially		Check power connections. If it does not help, please contact distributor for customer service.	
The power to the electrical unit stops	No enough charge left in the battery/no enough power from sun	Check the RCC display for battery level and State of Charge (SOC), if less than 30% connect the external generator to the Zephyr unit (as per the Inverter manual in Appendix C)	
PV array performance decrease	Wiring problems/shading or soiling effects	Check all wiring, switches, fuses and circuit breakers. On the PV array look for shadding from nearby trees or leaves and dirt deposited on the panels (shading on the panel array can reduce the overall performance by 5%) Note: All the checks should be performed by authorised personnel at all times.	
The inverter is not producing the correct output	 if the inverter is not producing the right amount of power there may be a number of problems: blown fuse tripped breaker broken wires 	First use the voltmeter and dc ammeter to check and record the inverter's operating dc input voltage and current level. On the ac side, use the AC multimeter to check the inverter's output voltage and current levels. Once confirmed consult the installation company for repair or replacement of default fuses and or broken wires inside the inverter.	

10. Section 9 – Spare Parts Replacement

10.1 Legend

X	Operation time needed.			
	Difficulty level :			
Y	Y	Easy.		
	ΥY	Average level, care must be taken.		
	YYY	Difficult, take special care in this operation.		
İ	Number of person needed.			
*	Needed tools.			

10.2 Electrical system

The electrical system comes with products on warranty from individual components which are transferred to the owner.

10.2.1 Installation and Wiring

- 5 year electrical system full covered parts and labour warranty on the installed system, inspection.

10.2.2 Solar PV Modules

- 2 year PV modules product warranty,

10.2.3 Inverter/Charge Controller

- 5 year Inverter/Charge controller product warranty

10.2.4 Battery

- 2 year product warranty

*All the electrical equipment comes with a warranty and should be replaced by the experienced and qualified installer/technician. 10.3 Growth chamber

10.3.1 Mechanical frame

The following picture shows the list of the mechanical parts with their reference respect to the whole frame; with the exception of the shelves only, that can be easily removed and replaced, all the other parts should be requested to the producer and replaced by an authorized technician. The drawings in the appendix B show the detail of each mechanical

		ELENCO PARTI		
ELEMENTO	QTÀ	NUMERO PARTE	DESCRIZIONE	
1	3	VALOYA	LAMPADA LED	
2	1	ZPHR-107-7000	ASSIEME RID. ASSE X	
3	1	ZPHR-106-6000	ASSIEME POMPA	
4	1	ZPHR-102-2000	ASSIEME SERBATOIO	
5	1	CWMI-4075-A13-63B14-214	MOTORIDUTTORE VF/VF	
6	1	ZPHR-101-1000	ASSIEME STRUTTURA	
7	1	ZPHR-105-5000	ASSIEME TAMBURO	
8	1	ZPHR-104-4000	ASSIEME ASSE PRINCIPALE	
9	2	Catena a rulli	CATENA A RULLI	
10	2	Ruota dentata catena a rulli2	CORONA 100Z	
11	2	Ruota dentata catena a rulli3	PIGNONE 15Z	
12	2	Ruota dentata catena a rulli1	PIGNONE 15Z	
13	2	RCT-T1	TENDICATENA	
14	2	ISO 2982-2 - 60 x 73	Dadi di fissaggio e dispositivi di fissaggio - Quote - Rondelle di fissaggio di sicurezza con	
			linguetta di fermo diritta	
15	2	ISO 2982 - M60 x 2 x 73	Dadi di fissaggio e dispositivi di fissaggio - Quote - Dadi di fissaggio (4 intagli)	
16	8	ISO 7092 - ST 6 - 140 HV	Rondelle platte - Serie piccola - Grado prodotto A	
17	8	ISO 4017 - M6 x 16	Viti a testa esagonale	
18	28	150 7092 - ST 8 - 140 HV	Rondelle platte - Serie piccola - Grado prodotto A	
19	4	ISO 4017 - M8 x 25	Viti a testa esagonale	
20	4	ISO 4032 - M8	Dadi esagonali, stile 1 - Gradi prodotto A e B	
21	2	ISO 4017 - M10 x 30	Viti a testa esagonale	
22	20	ISO 4017 - M8 x 20	Viti a testa esagonale	
23	9	ISO 7092 - ST 4 - 140 HV	Rondelle platte - Serie piccola - Grado prodotto A	
24	2	DIN 625 SKF - SKF 6201-RS1	Cuscinetti a sfere con scanalatura profonda a fila singola con guarnizione RS1 SKF	
25	1	NL106RC	GUIDA A RICIRCOLO	
26	1	MAVILOR-BLS-072	MOTORE MAVILOR	
27	1	ZPHR-103-3000	BRACCIO ROBOTICO	
28	4	ISO 4762 - M8 x 16	Vite con esagono incassato	
29	1	ZPHR-108-8000	ASSIEME FERMA SERBATOIO	
30	1	ZPHR-001-0002	STAFFA SENSORE VASCA	
31	1	SensVASCA	SENSORE VASCA	5 (35) (30) (3) (31) (29) (2) (19) (20) (18)
32	1	ZPHR-001-0001	VASCA IMMERSIONE	
33	1	ZPHR-108-8001	FERMA SERBATOIO	
34	2	ZPHR-109-9000	ASSIEME SUPPORTO VASCA	NAME DATE Ó
35	2	ZPHR-110-1000	ASSIEME SUPPORTO VASCA	
36	9	ZPHR-111-1100	ASSIEME STAFFA LAMPADA	
37	1	ZPHR-001-0003	SUPPORTO POMPA	
38	1	ZPHR-001-0004	OMEGA POMPA	
39	1	ISO 4762 - M5 x 35	Vite con esagono incassato	
40	1	ISO 7090 - 5 - 140 HV	Rondelle platte, smussate - Serie normale - Grado prodotto A	
				ANGLES & X.X" 2 PL & X.XX 3 PL

part in d

10.3.1.1 Rotation motor replacement

ROTAZIONE Motore "rotazione" Bruschless a: c. Mavilor Ty. BLS 072A.00.10N.00 Da ELCAM spa It.

10.3.1.2 Translation motor replacement

ROTAZIONE Motore "rotazione" Bruschless a: c. Mavilor Ty. BLS 072A.00.10N.00 Da ELCAM spa It.

10.3.1.3 Watering pump replacement

Pompa riempimento vasca irrigazione e svuotamento serbatoio per trasporto. Mod. 5843-2P02_8101; 230V; 60W da TECHMAGPM It.

10.3.1.4 Index switch replacement

10.3.2 LED Lamp replacement

10.3.2.1 Unpacking



Figure 38: The LED lamp parts

- a) luminaire
- b) power supply unit
- c) hanging device

10.3.2.2 Installation

Caution! Inappropriate installation may cause injury to persons and damage to the lamp. Deviation from the instructions may result in electric shock or an electrical hazard. If the external cable or cord of this luminaire is damaged, it must only be replaced by the manufacturer or a service agent or similar qualified person, in order to avoid a hazard. If you notice that any part of this luminaire is damaged, please contact Valoya.



In North America luminaire is fixed type and is equipped with open tail cable. Do not attach plug to mains cable! En Amérique du Nord, led luminaires sont de type standard et sont équipés d'un cables de transmission ouvert. Ne pas attacher de prise électrique aux câbles principaux !

Figure 39: LED lamp equipment

- 1) hanging options
- 2) grounded power connection only
- 3) if the luminaire is provided with an open tail cable, the connection to the branch circuit must be equipped with proper strain relief

10.3.3 Robotic arm





Finger parts identification:



Figure 40: Arm finger parts

PROCEDURE



JACO must be powered and connected to a joystick to complete procedure.

- Remove obsolete finger as following:
 - Remove pin #1 of finger by pushing it out with the 2mm Allen Key
 - Remove the 4 corners cap screws holding phalanx #1 with 2mm Allen key
 - Unscrew the finger from the lead screw
- Using dry tissue, remove old grease from finger motor's lead screw and remaining grease on the limit switch located at the bottom of the finger motor as shown in the following Figure;



Figure 41: Arm finger attachment base

Do not use thinner

- With 2mm Allen key, gently push out pin #1 of the new finger;
- Add new grease (about grain of rice) in phalanx #1 of the new finger (brass threads, plastic insert);
- Add new grease (about a grain of rice) on the bottom of the lead screw on a 7mm height;
- Install new finger as following:
 - Lubricate the finger
 - Place the finger's insert on the finger motor's lead screw and, using joystick, open the fingers until the insert is fully engaged and the lead screw is visible outside the insert;
 - o Add a light amount of Loctite 242 on 3 mm at end of each cap screw;
 - Screw finger in place
 - Realign all holes of pin #1 and gently push it back in
 - Make 5 open/close cycles to make sure the finger opens and closes properly

10.3.3.2 Motor replacement

Refer to the Appendix A

11. Appendix A – Arm and motors controllers guides

🔁 Jaco Arm Maintenance Guide.pdf

- 🔁 jaco-arm-user-guide.pdf
- 🔁 Motion controller manual.pdf

12. Appendix B – Growth chamber drawing and HVAC user guide

- 🔁 Float switch 1 lower tank.pdf
- 🔁 Float switch 2 immersion tank.pdf
- 🔁 Manuale Regolatore Plus 100 THR.pdf
- 🔁 Pump 1 immersion tank filling.pdf
- 🔁 SensoriMePompe.pdf
- 🔁 ZE04PDF.pdf
- T ZPHR-001-0000A.pdf
- T ZPHR-001-0000B.pdf
- 🔁 ZPHR-001-0000C.pdf
- 🔁 ZPHR-001-0001.pdf
- 🔁 ZPHR-101-1000.pdf
- 🔁 ZPHR-102-2000.pdf
- 🔁 ZPHR-103-3000.pdf
- 🔁 ZPHR-104-4000.pdf
- 🔁 ZPHR-106-6000-1.pdf
- 🔁 ZPHR-107-7000.pdf
- 🔁 ZPHR-108-8000.pdf
- 🔁 ZPHR-111-1100.pdf

13. Appendix C – Power system guides

- 🔁 Exergy Safety Manual ZEPHYR (IT).pdf
- 🔁 Manuel RCC V4.4.0_EN.pdf
- 🔁 Xtender & Charge Controller User manual.pdf