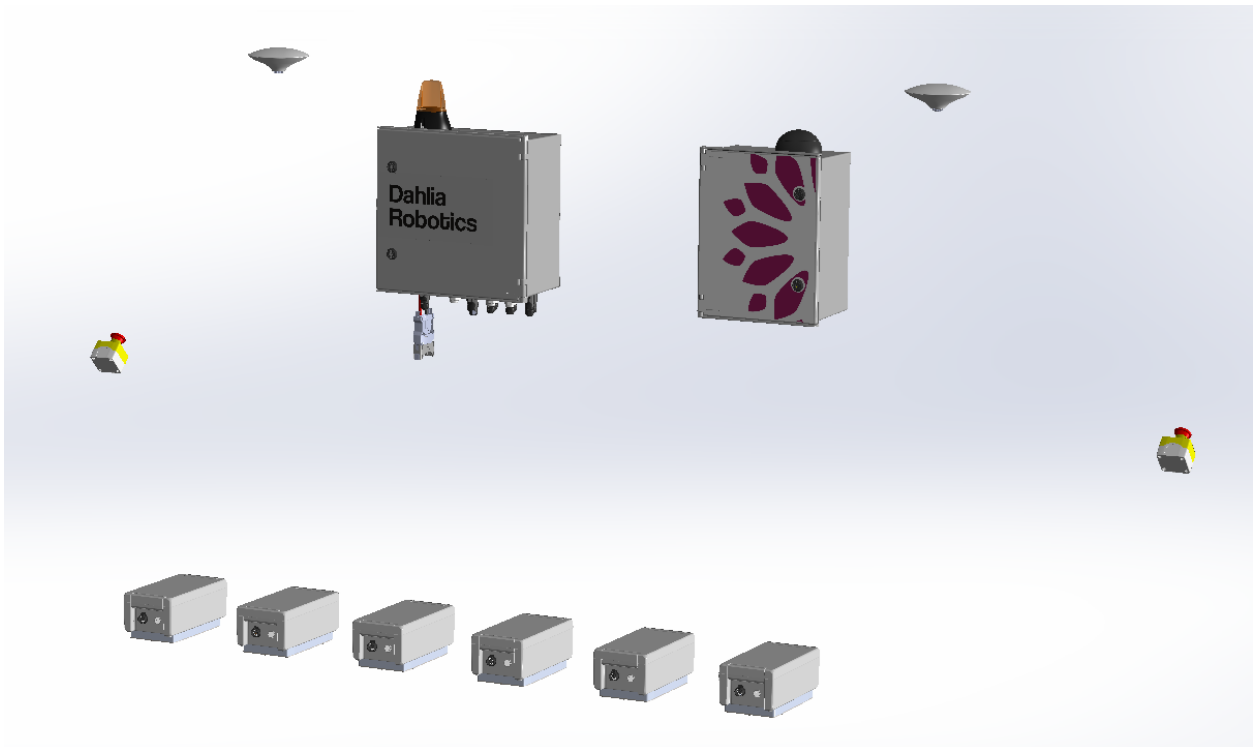




AgAI Vision v4

Operator's Manual



Revision 2
5 February 2026

Contents

1	Introduction	1
1.1	Preface	1
1.1.1	General Indications	1
1.1.2	Key Text Passages	2
1.2	General Information	2
1.2.1	Validity of this Manual	2
1.2.2	General Instructions	2
1.2.3	Qualified Specialist Workshop	3
1.2.4	Warranty Information	3
1.2.5	Maintenance Notes	3
1.2.6	Service and Warranty Handling	3
1.3	Definition and Purpose of the AgAI Vision System	3
2	Safety	5
2.1	Limitation of the End User	5
2.1.1	Requirements for the End User	5
2.1.2	Restrictions for the End User	5
2.2	Hazard Areas	5
2.3	Safe State of the System	6
2.4	Modifications to the System	7
2.5	Spare Parts	7
2.6	Maintenance and Repair	7
2.7	Operating the User Interface	7
2.8	Driving on Public Roads	7
2.9	Operating the AgAI Vision System	8
3	Product Description	9
3.1	Description of the AgAI Vision System	9
3.1.1	System Description	9
3.1.2	System Functions	9
3.1.3	Product Variants	10
3.2	The Components of the AgAI Vision System	10
3.2.1	Central Module (CM)	11
3.2.2	Distribution Module (DM)	12
3.2.3	Weeding Module (WM)	13
3.2.4	Peripherals	14
3.2.5	User Interface	16
3.2.6	Connecting Wires	17
3.2.7	Schematic View of the Complete Implement	18
3.3	Safety Devices	19
3.3.1	Safety Features	19
3.3.2	Implement Position Sensor (IPS)	19
3.3.3	GNSS Antennae	20
3.3.4	Expected Behaviour	20
3.4	Spare Parts and Tools	20
3.4.1	Electronic Protection Elements	20

3.4.2	CM and DM Enclosure Key	20
3.4.3	SIM Tools	20
3.4.4	WM Power Plugs Caps	20
3.5	Identification Plates and Identification Numbers	21
3.5.1	Typeshield	21
3.5.2	Marking of Modules	21
4	Specifications and Performances	22
4.1	System Specifications	22
4.1.1	Position of CM and GNSS Antennae	22
4.1.2	WM Position Specification	22
4.1.3	Crop Plant Specifications	23
4.1.4	Field Specifications	24
4.2	System Accuracy	24
4.2.1	Accuracy of the Crop Plant Detection	24
4.2.2	Accuracy of the Crop Row Detection	25
4.2.3	GPS Signal Accuracy	25
4.2.4	Accuracy at Different Operating Speeds	26
4.2.5	User Defined Parameters for WMs	26
4.2.6	Hilly Terrain	26
4.2.7	Curves	26
5	User Interface and Dahlia Mobile Application	27
5.1	User Interface (UI)	27
5.1.1	The UI Control Tablet	27
5.1.2	UI Accessories	27
5.2	Dahlia Mobile Application	27
5.2.1	Use of the Control Application	28
6	Technical Specifications	42
6.1	Central Module (CM)	42
6.2	Distribution Module (DM)	43
6.3	Weeding Module (WM)	44
6.4	User Interface (UI)	45
7	Preparing the Product	46
7.1	Fundamental Prerequisites for the Commissioning	46
7.1.1	End User Supplied SIM	46
7.1.2	Registration to a Local NTRIP Provider	46
7.2	Sequence of Preparations	46
7.2.1	Occasional Preparations	46
7.2.2	Regular Preparations	47
7.3	Switching the System On and Off	47
7.3.1	Switching the System On	47
7.3.2	Switching Off and Securing the System	47
7.4	Leaving the Cabin	48
7.5	Prior to Weeding Operations	48
7.5.1	Regulation of the Implement Position Sensor (IPS)	48
7.5.2	Connection to the DC Power Source	49
7.5.3	Insert the SIM in the Router	50
7.5.4	Installation of the User Interface (UI)	51
7.5.5	Configuration of the NTRIP Client	52
7.5.6	Mechanical Adjustments	52
7.5.7	System Software Settings Update	54
7.5.8	Transport to and from Field on Public Roads	55
7.5.9	Software Updates	55
8	Operation	56
8.1	Status Light Coding	56
8.2	Standard Operating Modes	56

8.2.1	Software Modes	56
8.2.2	Other Influencing Factors	56
8.2.3	Expected System Behaviour	57
8.2.4	Mode Transitions	57
8.2.5	Self Test Function	58
8.3	Fieldwork	58
8.3.1	Switching On	58
8.3.2	Selecting the Correct Crop	59
8.3.3	Centering on the Crop Rows	59
8.3.4	Automatic Weeding	59
8.3.5	Setting up for the Next Pass	60
8.3.6	Switching Off	60
8.3.7	Night Time Operations	61
9	Troubleshooting	62
9.1	In Case of Damages	62
9.2	Faults Overview	62
10	Maintenance	67
10.1	Maintenance Intervals Overview	67
10.1.1	Every 10 Operating Hours or Daily	67
10.1.2	Every 100 Operating Hours or Monthly	67
10.2	Management of the Electrical Safety Elements	67
10.2.1	Electrical Safety Elements in the DM	67
10.2.2	Electrical Safety Elements in the WM	69
10.3	Cleaning	69
10.3.1	Cleaning the User Interface	69
10.3.2	Cleaning the Protective Windows of WMs	69
10.3.3	Cleaning the CM and DM	70
10.3.4	Cleaning the Electronic Connectors	70
11	Putting out of Operation and Disposal	71
11.1	Disposal Procedure	71
12	Technical Terms and Abbreviations	72
12.1	Units	72
12.2	Common Terms	72
12.3	Abbreviations	72
13	Limitations of Liability	73
13.1	Liability Statement	73

1. Introduction

1.1 Preface

This is the Operator's Manual for the AgAI Vision system sold by Dahlia Robotics GmbH ("Dahlia Robotics") to the complete implement manufacturer and contains the original instructions for its use. This Operator's Manual contains important instructions that should be complied with for the operation and maintenance of the AgAI Vision system only.

This Operator's Manual does not cover any aspect that the end-user should follow in respect to the weeding implement or the tractor; as a result, the end-user must ensure that all instructions provided by the weeding implement manufacturer and the tractor manufacturer are in addition strictly adhered to at all times. Please contact the weeding implement manufacturer and the tractor manufacturer for a copy of the respective user guide/manual.

This Operator's Manual may be updated and integrated as necessary in the future. Any comments or questions can be sent to info@dahliarobotics.com, including the request of a free-of-charge electronic copy of the most up-to-date Operator's Manual. Please note that Dahlia Robotics does not automatically provide updated versions of this Operator's Manual.




1.1.1 General Indications

- Only authorized and qualified individuals should operate the system, i.e. people who:
 - have read and understood this Operator's Manual,
 - possess a valid driving licence for tractors and
 - are physically and mentally fit for operation.
- All indications in the Operator's Manual, as well as all operating, maintenance and servicing conditions should be strictly observed.
- Follow all safety instructions provided in the manuals of the tractor and of the weeding implement at all times.
- All applicable safety, accident prevention, occupational risk and road traffic regulation must be observed by the end-users or owners of the AgAI Vision system.
- Outside of Dahlia Robotics, only the implement manufacturer and the authorised specialised workshops can carry out maintenance and repair activities.
- Using the AgAI Vision system on public roads is strictly prohibited.
- Never leave the tractor unattended while the AgAI Vision system is active: the driver is always responsible for steering and navigation.
- Always turn off the tractor and the AgAI Vision system before installing or repairing electrical components of the AgAI Vision system or performing any maintenance or adjustment operation on it.
- Always wear personal protective equipment when outside the tractor cabin operating, adjusting, or repairing the system.
- In case of system failure or breakdown, switch off the AgAI Vision system and disconnect it from its power source (disconnect the DM power cord). For repair instructions, contact:

- the machine manufacturer for failures of mechanics, hydraulics or any part that is not listed in Product Description;
 - Dahlia Robotics for software, electronics or problems to any part that is listed in Product Description.
- To prevent injury or fire, replace defective or blown fuses and circuit-breakers only with elements of the same type and size (amperage).
 - The AgAI Vision system cannot detect or avoid obstacles: the driver must ensure a clear driving path.
 - Always start the tractor’s motor before activating the AgAI Vision steering system to prevent voltage spikes.
 - Use only your finger or a designated touchscreen pen to operate the UI. Sharp objects may cause permanent damage to the screen.
 - If the UI will not be used for an extended period, remove it from the tractor and store it in a warm environment: this will prolong its battery life.
 - To prevent theft, do not leave the terminal unattended in the tractor while on the field.

1.1.2 Key Text Passages

Key concepts are highlighted in the text by the use of the following indicators:

Indicator	Meaning
	Critical concept: failure to comply with its requirements is going to result in hazards for the end-user.
	Important concept: failure to comply with its requirements is going to result in deterioration of the system performances.
	Practical concept: failure to follow it will make the interaction with the system more time consuming.

1.2 General Information

1.2.1 Validity of this Manual

The Operator’s Manual relates to the following products:

Product	No. of crop rows	Part No.
AgAI Vision System v4	2	10.02.00.04
	3	10.03.00.04
	4	10.04.00.04
	5	10.05.00.04
	6	10.06.00.04
	7	10.07.00.04
	8	10.08.00.04

1.2.2 General Instructions

The Operator’s Manual can be used for preparing the documentation for end-users without Dahlia Robotics’ branding. The manufacturer of the complete implement is responsible for the preparation of the user guide/manual of the complete implement for the end-user, including language versions. This Operator’s Manual can be handed to distributors and service personnel.

1.2.3 Qualified Specialist Workshop

Apart from Dahlia Robotics and the manufacturer of the weeding implement, only a qualified specialist workshop can perform maintenance work not described in this Operator's Manual. As a precondition for any warranty claims, a qualified specialist workshop needs to be able to document if any installation, conversion, repair or maintenance work has been performed according to the manufacturer's specifications.

1.2.4 Warranty Information

The conditions of sale of the AgAI Vision system determine the applicability of any warranty claim. As soon as fault is discovered, the owner or the end-user of the AgAI Vision system should follow the steps outlined under Service and Warranty Handling.

Failure to comply with this Operator's Manual could invalidate any warranty claim.

The warranty automatically lapses if the AgAI Vision system has been repaired, modified, or has undergone alterations or replacements not explicitly detailed in this Operator's Manual or performed by personnel not authorised by Dahlia Robotics.

This warranty does not cover:

- defects caused by the owner or the end-user of the AgAI Vision system or by third parties as a result of negligence or misuse or non-compliant use of the AgAI Vision system, or
- the inadequate storage by the owner or by the end-user of the AgAI Vision system, or
- normal wear and tear of components, or
- external factors (such as fire, lightning, human error or force majeure events).

1.2.5 Maintenance Notes

The maintenance of the product according to the specifications of the Maintenance Section is required to ensure the proper functioning of the product. It is recommended that a qualified specialised workshop or Dahlia Robotics inspects the product on a yearly basis.

1.2.6 Service and Warranty Handling

Dahlia Robotics is responsible, either directly or through a qualified specialised workshop, for servicing and providing assistance in respect to a fault or malfunction of the AgAI Vision system.

For any assistance, please contact: +49 8801 3109895

Any documentation or returns should be sent to the following address:

- Dahlia Robotics GmbH
- Lichtenbergstrasse 8
- 85748 Garching bei München
- Germany

All emails should be sent to: info@dahliarobotics.com

In all communications always please include the AgAI Vision serial number.

1.3 Definition and Purpose of the AgAI Vision System

The AgAI Vision system is a control device which can only be installed on tractor-mounted hydraulic implements for in-the-row weeding (hereafter simply "weeding implements" or "implements") approved by Dahlia Robotics. The AgAI Vision system can only be assembled, installed and commissioned on the weeding implement by the manufacturer of the complete implement.

The combination of a said weeding implement with an incorporated AgAI Vision system (from here on referred to as "complete implement") can only be used for its intended specialist purpose, i.e. mechanical removal of in-the-row weeds on open agricultural fields.

Any use of the AgAI Vision system outside of its intended use is an improper use and Dahlia Robotics cannot be held liable for any resulting losses.

Upon request, Dahlia Robotics can provide details on whether an activity falls within the scope of the intended use.

2. Safety

2.1 Limitation of the End User

2.1.1 Requirements for the End User

The following minimum indications must be followed by a person working with the AgAI Vision system:

- The person must have understood the information contained in the Operator's Manual.
 - The person must understand how the AgAI Vision system works.
 - The person must be able to understand the hazards associated with the AgAI Vision system, the tractor implement and the tractor, as well as the task they are about to perform.
 - The person must be able to control the AgAI Vision system and perform the tasks described in the Operator's Manual.
- The person must be in good health and condition and not be tired.
- The person must not be under the influence of alcohol, drugs or medicaments which may impair their attention or their ability to promptly react if necessary.
- The person must hold a valid driving licence.
- The person must be aware of anybody who is in the hazard area or could potentially enter into the hazard area.

2.1.2 Restrictions for the End User

The AgAI Vision system is not suitable for:

- People with visual impairment;
- People with photosensitive epilepsy.

2.2 Hazard Areas

The image below shows examples of reasonably-expectable hazard areas for a complete implement and should not be construed as an indication by the machine manufacturer. Please refer to the Operator's Manual of the complete implement for accurate information about the actual hazard areas.

In case a person enters the hazard area without authorisation, the operator must:

1. Turn the hydraulics supply to the complete implement off (in case activated); more details in the tractor's and weeding implement's manuals;
2. Deactivate the automatic mode (in case activated); more details in Operation;
3. Turn the AgAI Vision system off; more details in Operation;
4. Secure the tractor and leave the cabin to clear the area from people; more details in the tractor's manual;
5. Before operations can be resumed, the hazard area must be clear from people.

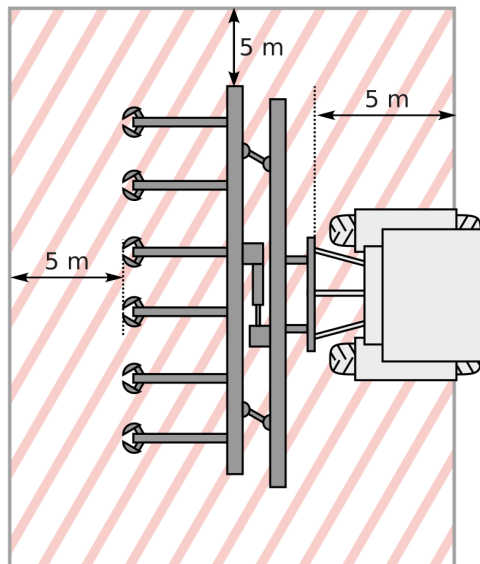


Figure 2.1: Hazard areas

By way of examples, the following hazards may occur in the hazard areas because of the AgAI Vision system:

- Risk of being crushed or hit by movements of the Side Shift Frame (more details in Product Description);
- Risk of being hit or cut by movements of the Active Weeding Tools (more details in Product Description);
- Risk of a seizure because of the strobe illumination LEDs for people with photosensitive epilepsy (more present in lack of ambient light).

Serious physical injury may result in the hazard area. As a result:

- The hazard area shall at all times be free of people when the AgAI Vision system is active.
- Do not switch on the AgAI Vision system if there are people in the hazard area.
- Do not lift or lower the tractor implement if there are people in the hazard area.
- Ensure that the tractor and the AgAI Vision system are switched off and secured prior to performing any work around the tractor, around the tractor implement, or between the tractor and the tractor implement, including any calibration, set-up, inspection, maintenance or repair work.
- Follow the indications of the Operator's Manual of each component that you use, including the tractor, the tractor implement, their peripherals, their transport and storage devices, as well as any connected component.

2.3 Safe State of the System

The AgAI Vision system is in its safe state when there is no supply of hydraulic fluid to the complete implement. This is the state to which the machinery must be brought every time somebody enters the hazard area.

Dahlia Robotics further suggest that the following additional measures are taken if the system is to be driven into its safe state:

- Automatic mode (in case active) is deactivated: more details in User Interface and Dahlia Mobile Application and Troubleshooting;
- LEDs are stopped;
- The implement is raised using the 3-point hitch of the tractor.

2.4 Modifications to the System

The correct functioning of the AgAI Vision system can be jeopardised by structural changes or modifications either to the AgAI Vision system itself or to the machine that incorporates it, potentially causing serious injuries.

Only the implement manufacturer, Dahlia Robotics or a qualified specialist workshop can carry out structural changes or modifications.

2.5 Spare Parts

The correct functioning of the AgAI Vision system can be jeopardised by the use of parts or components which do not meet certain specifications, potentially causing serious injuries. Therefore:

- Only use parts or components which are original or which meet the correct specifications.
- Ask Dahlia Robotics for any missing specification about a part or component.

2.6 Maintenance and Repair

The correct functioning of the AgAI Vision system can be jeopardised if a person carries out incorrectly the required maintenance or repair work, potentially causing serious injuries.

- Prior to carrying out any maintenance and repair work, switch off and secure the tractor, switch off the AgAI Vision system as explained in Switching the System On and Off.
- Only carry out maintenance and repair work according to what is reported in Maintenance.
- Only let a qualified specialist workshop carry out maintenance and repair work which is not specified in the Operator's Manual.

2.7 Operating the User Interface

The User Interface controls the AgAI Vision system. Switching off the User Interface during weeding operations could potentially cause injuries. These guidelines shall be followed at all times by the user:

- Switch the UI on and start the Dahlia Mobile Application before the AgAI Vision system is started.
- Do not switch the UI off or exit the Dahlia Mobile Application whilst operating the AgAI Vision system.
- Keep the UI under charge with the provided cable any time it is possible (when in the tractor cabin); monitor its battery state and avoid weeding when it is critically low.
- Do not lock the screen of the UI while weeding with the AgAI Vision system and keep the volume of the device always at a reasonable level to be able to clearly hear its audio signals without discomfort.
- When the AgAI Vision system is powered the UI must at all times be:
 - carried on you or
 - left in a safe place with its screen locked.
- If the User Interface loses power or gets disconnected from the AgAI Vision system, stop the tractor and turn off the hydraulics supply to the implement.

More details about the Dahlia Mobile Application can be found in Dahlia Mobile Application.

2.8 Driving on Public Roads

Leaving the AgAI Vision system switched on when driving on farm roads or public roads is strictly prohibited as it could potentially cause injuries. Prior to driving on farm roads or public roads:

- Stop the automatic weeding operations (if any) via the User Interface.
- Center the Side Shift Frame using the same User Interface (more on that in Dahlia Mobile Application).

- Turn the machine off as explained in Switching the System On and Off.
- Follow the road transport instructions of the manuals of the tractor and weeding implement.
- Secure the tractor implement for road transport.

2.9 Operating the AgAI Vision System

Operating the AgAI Vision system in the proximity of people could cause potential serious injuries. As a result:

- Only use the AgAI Vision system on open agricultural fields.
- Before switching on the Main Switch of the AgAI Vision system, ensure that nobody is within the hazard area.
- Whilst using the AgAI Vision system, always ensure that nobody is within the hazard area.
- If someone enters the hazard area, stop and secure the tractor as prescribed in its manual and switch off the hydraulic supply to the implement.

3. Product Description

3.1 Description of the AgAI Vision System

3.1.1 System Description

The AgAI Vision system is a steering system for the mechanical removal of in-the-row weeds in agricultural weeding open field applications. The system in itself is not capable of any work and can only be utilised once incorporated in a compatible weeding implement. The system utilises advanced Artificial Intelligence techniques for the detection of crop plants; its detection is robust to the presence of weed pressure and can be utilised for different crops.

The positions of the detected crop plants are used to automatically control hydraulics actuators and perform an accurate weed-removal up to the immediate vicinity of each plant. In fact, the weeds that are closer to the plant are those that can most impact its growth and health, as they compete with it for sun, water and soil nutrients. The AgAI Vision system can be used in combination or substitution of other weeding techniques for high-performance results in weed control.

3.1.2 System Functions

The AgAI Vision system fulfills three main functions, namely:

1. the recognition of crop plants in the row thanks to machine vision and a suite of AI recognition algorithms;
2. their localisation in global coordinates thanks to RTK-GPS;
3. the generation of the control signals for solenoid hydraulic valves.

These hydraulic actuators in turn are not part of the system itself but rather of the weeding implement it needs to be incorporated into. These are controlled by the AgAI Vision system to perform two functions:

1. The shifting of the soil-engaging part of the implement in the direction perpendicular to travel direction to keep it aligned with the recognised crop rows. This function will be referred to as "side-shifting"; the unit that performs this function is called "Side Shift Frame", in short "SSF"; the section of the implement that is side-shifted is called "side-shifted part".
2. The opening and closing of blades that run some centimeters under the ground with the aim to accurately cut and/or uproot weeds all around the crop plants. This function will be referred to as "active weeding"; the units that perform it are called "Active Weeding Tools", in short "AWTs"; the AWTs are solid to the side-shifted part of the implement.

The actuation signals that make these functions possible are generated by various components of the AgAI Vision system on the basis of:


1. camera images,
2. GPS signal,
3. settings provided by the user through the User Interface,
4. the signals provided by additional sensors:
 - a. The implement position sensor (IPS): a limit switch that determines whether the implement is raised or lowered. This sensor is part of the AgAI Vision system.

- b. The side shift frame position sensor: a linear transducer that determines the position of the SSF. This sensor itself is *not* part of the AgAI Vision system.

The general behaviour to be expected from the AgAI Vision system is that:

- AWTs are never moved when the implement is raised;
- SSF can be moved:
 - Manually by the operator when the implement is raised;
 - Automatically when the implement is lowered.

More details are available in the “Operation” Section.



The system does not:

- Follow the GPS tracks recorded by other machineries;
- Use the data generated by GPS seeders to perform its weeding.

3.1.3 Product Variants

The product has two main variability factors:

- Number of WMs:
 - can go from 2 to 8;
 - Determine the product code as reported in General Information;
- Type of power connection:
 - Battery connection: if the implement is powered by direct connection to the tractor battery;
 - ISOBUS connection: if the implement is powered by an ISOBUS socket on the tractor.

This manual is valid for both.

3.2 The Components of the AgAI Vision System

#	Designator
1	Central Module (CM)
2	Distribution Module (DM)
3	Weeding Module (WM): 1–8x
4	Peripherals — partially shown in the image below
-	User Interface (UI) — not shown in the image below
-	Connecting wires — not shown in the image below

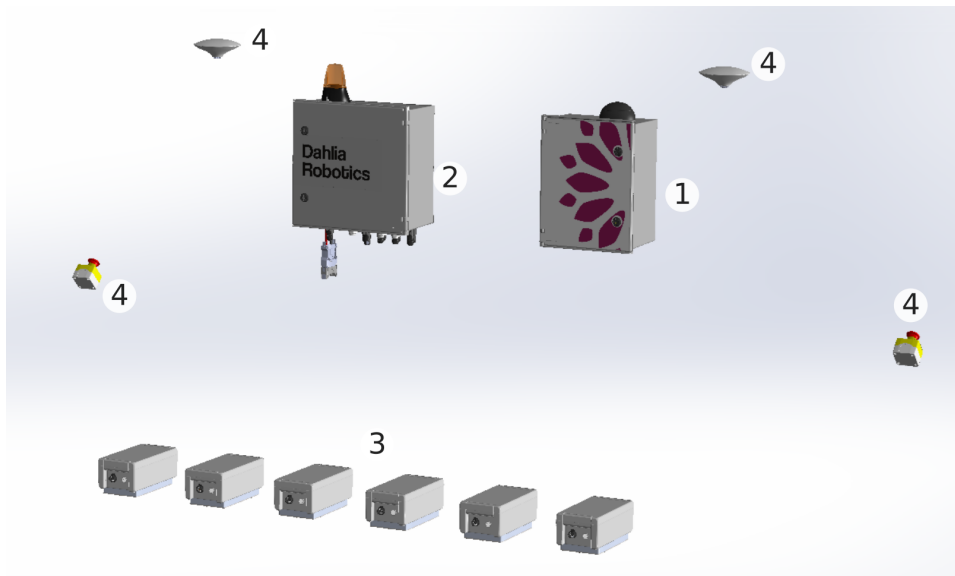


Figure 3.1: AgAI Vision System — components overview

3.2.1 Central Module (CM)

This module is responsible for the side-shifting function and coordination of the measurements provided by all sensors.

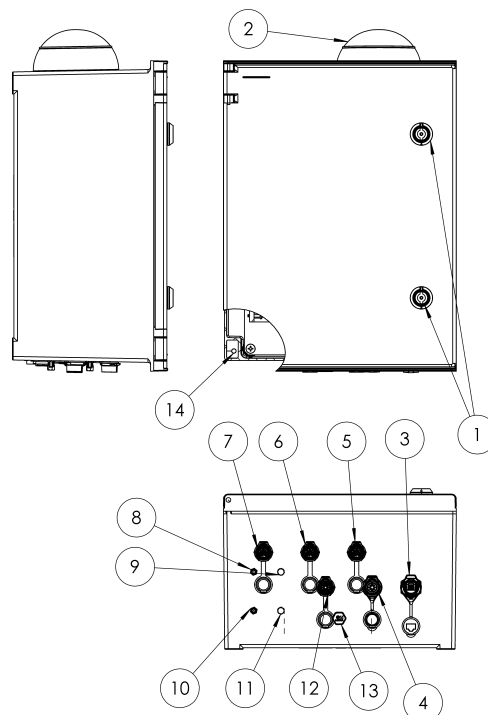


Figure 3.2: Central Module (CM)

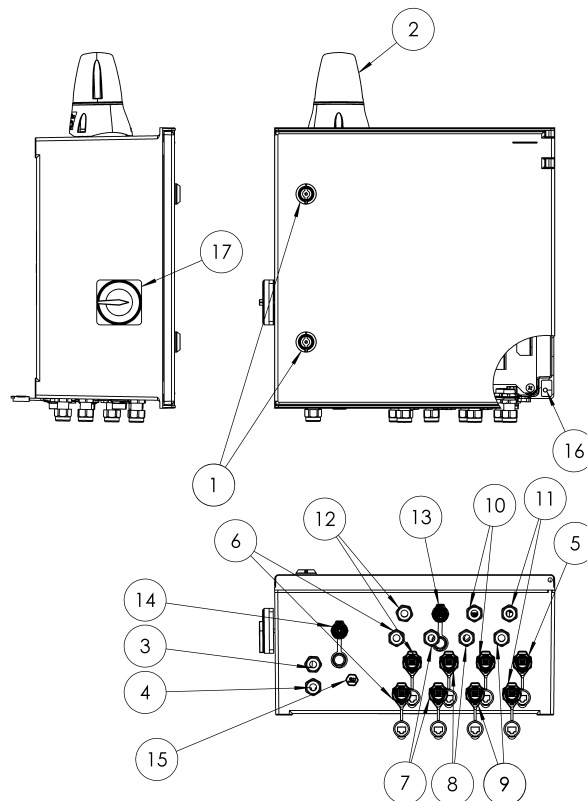
#	Designator
1	Box door keyway (x2)

#	Designator
2	WiFi / Mobile antenna
3	Connection — Data cable from Distribution Module
	Connection — Data cable to Module 8 (not shown)
4	Connection — Power cable from Distribution Module
5	Connection — SSF position sensor
6	Connection — SSF right coil
7	Connection — SSF left coil
8	Connection — GPS left antenna
9	Connection — LoRA left antenna
10	Connection — GPS right antenna
11	Connection — LoRA right antenna
12	Connection — IPS
13	Pressure compensation element
14	Mounting Holes (x4)
	CAN socket (not shown)

The key to open CM and DM is provided as part of the AgAI Vision system delivery and is described in Spare Parts and Tools.

3.2.2 Distribution Module (DM)

This module is responsible for the stabilisation and fusing of electrical power from the tractor and the distribution of power and data to all WMs and CM. It also hosts the safety components.



#	Designator
1	Box door keyway (x2)
2	Status light
3	Connection — DM Extension Cord (12V)

#	Designator
4	Connection — DM Extension Cord (GND)
5	Connection — Diagnostics Ethernet
6–11	Connection — Module 1–6 power and data Wires
-	Connection — Module 7 power and data Wires (not shown)
-	Connection — Module 8 power Wire (not shown)
12	Connection — Central module Wires (power and data)
13	Connection — Hydraulic cutoff solenoid
14	Connection — Safety stop wire
15	Pressure compensation element
16	Mounting Holes (4x)
17	Main On/Off switch

The key to open CM and DM is provided as part of the AgAI Vision system delivery and is described in Spare Parts and Tools.

The status light has three states:

- OFF when the system is turned OFF or the emergency stops are pressed;
- Solid ON when the system is powered and the implement is raised;
- Flashing ON when the system is powered and the implement is lowered.

3.2.3 Weeding Module (WM)

This module is responsible for the detection of plants with cameras and LEDs. This information, together with the information received from the Central Module, is used for the automatic control of the Side Shift Frame (SSF) and the Active Weeding Tools (AWTs). The WMs are also responsible for the actuation of the AWTs.

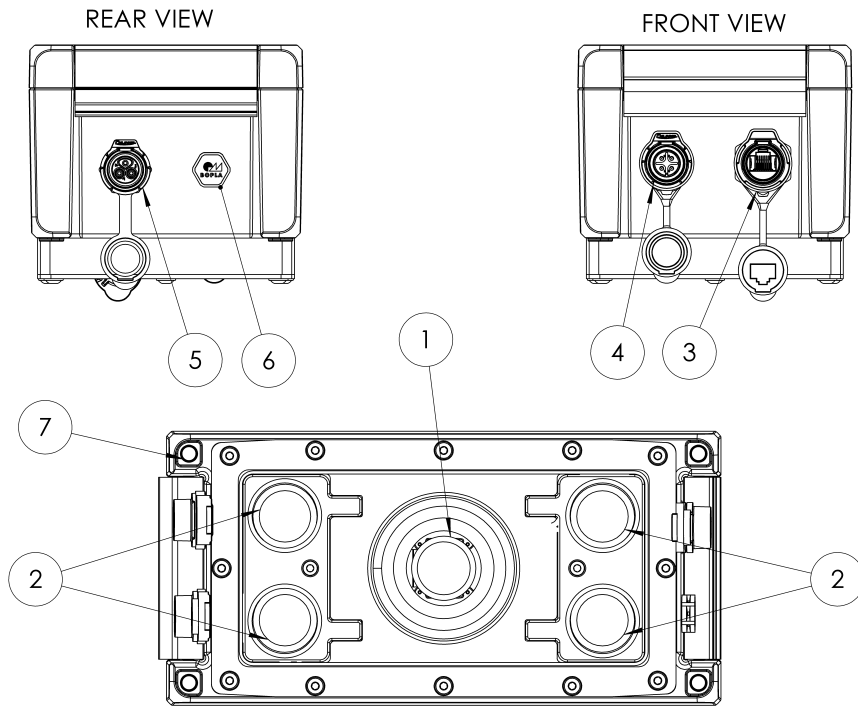


Figure 3.3: Weeding Module (WM)

#	Designator
1	Optical lens
2	LED's
3	Connector for data cable
4	Connector for power cable
5	Connector for hydraulic cable
6	Pressure compensation element
7	Fastening holes

3.2.4 Peripherals

These peripheral components of the AgAI Vision system are all necessary for its working.

3.2.4.1 GNSS Antennae

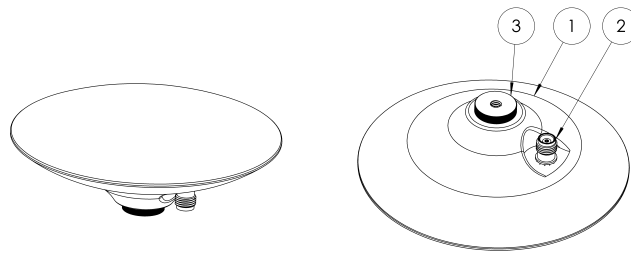


Figure 3.4: GNSS Antenna

#	Designator
1	GNSS Antenna body
2	Connection — TNC Female connector
3	Mounting Hole (originally compatible with 912 UNC 5/8"; adapter to UNC 1/4" is included)

3.2.4.2 Implement Position Sensor (IPS)

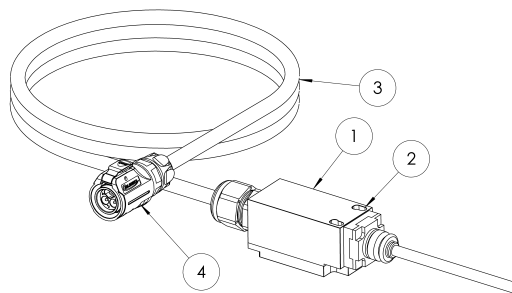


Figure 3.5: Implement Position Sensor (IPS)

#	Designator
1	Position switch body
2	Mounting Holes
3	Wire
4	Waterproof plug — To Central Module

3.2.4.3 Emergency Stops

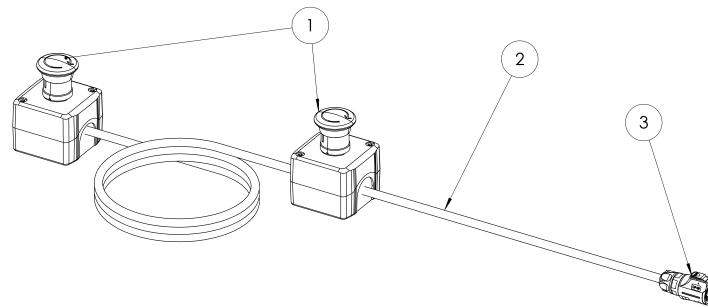


Figure 3.6: Emergency Stop

#	Designator
1	Emergency stop button
2	Wire
3	Waterproof plug — To Distribution Module

3.2.5 User Interface

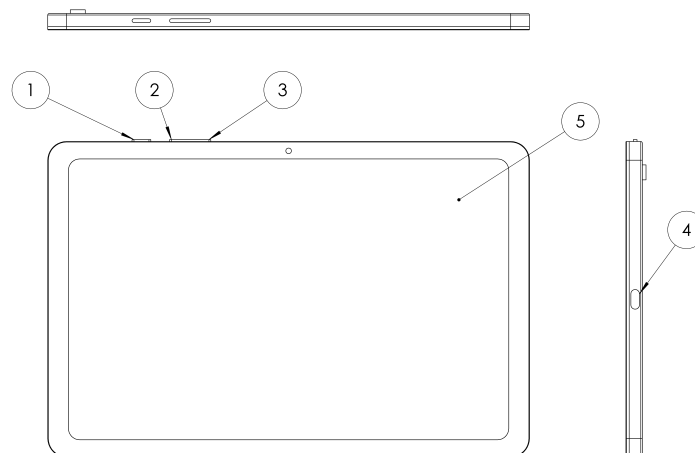


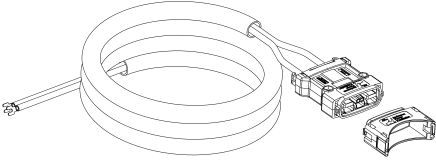
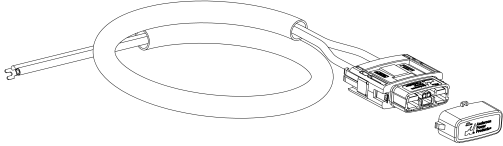
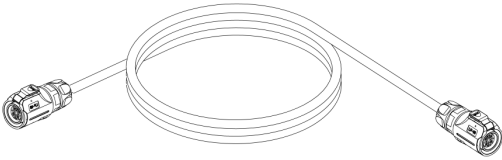

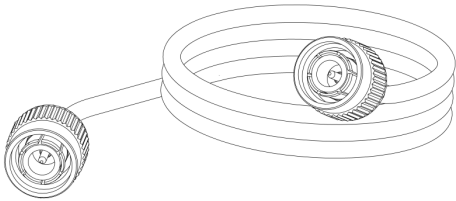
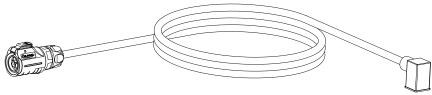
Figure 3.7: User Interface (UI)

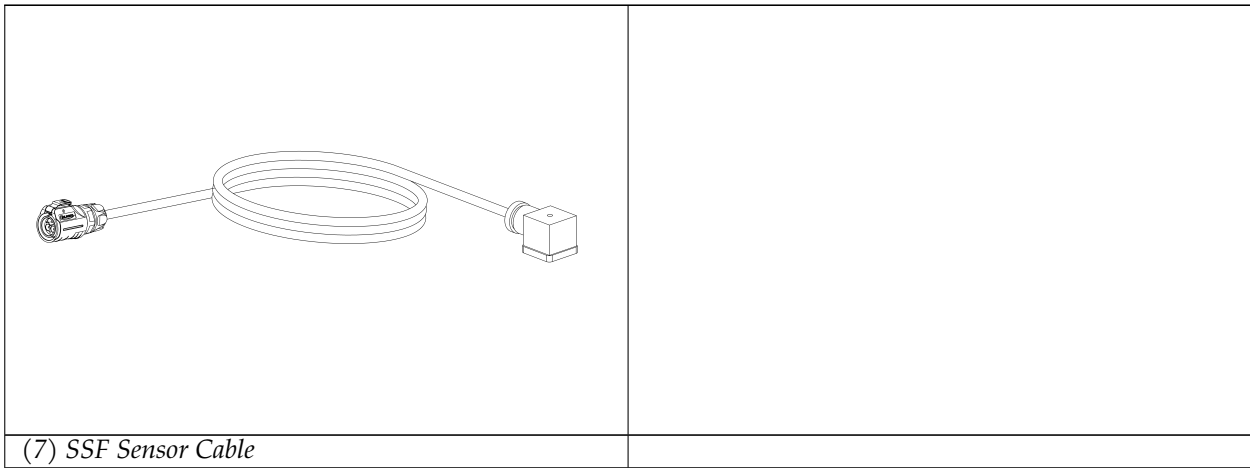
#	Designator
1	Power button
2, 3	Raise, lower volume
4	USB C socket

#	Designator
5	Touch screen


More details on its accessories are available in UI Accessories.

3.2.6 Connecting Wires

	
<p>(1) <i>Battery Extension Cord</i></p>	<p>(2) <i>DM Extension Cord</i></p>
	
<p>(3) <i>CM / WM Power Cable</i></p>	<p>(4) <i>CM / WM Data Cable</i></p>
	
<p>(5) <i>GNSS Antenna Cable</i></p>	<p>(6) <i>Solenoid Valve Cable</i></p>



#	Designator	Length (m)	Product variant	Origin Element	Origin Connector	Destination Element	Destination Connector
1	Battery Extension Cord (with cap)	7	Battery-powered	Tractor battery	M8 fork lugs	Plug of the DM extension cord	Heavy duty receptacle
2	DM Extension Cord (with cap)	2	Battery-powered	Prewired inside of the DM	-	Receptacle of battery extension cord	Heavy duty plug
2a	DM ISOBUS cord	3	ISOBUS-powered	Prewired inside of the DM	9-pin IBIC-ISOBUS	Tractor ISOBUS socket	Heavy duty plug
3	CM / WM power cable	Multiple	-	Prewired inside of the DM	-	CM or WM	Waterproof 4-way plug
4	CM / WM data cable	Multiple	-	DM's wall-mount socket	Waterproof Ethernet plug	CM's or WM's wall-mount socket	Waterproof Ethernet plug
5	GNSS antenna cable	Multiple	-	CM wall-mount TNC socket	TNC male	GNSS Antenna's TNC socket	TNC male
6	Solenoid valve cable	Multiple	-	CM / WM / DM wall-mount socket	Waterproof 3-way plug	CM / WM / DM solenoid valve socket	DIN 43650 Type A
7	SSF sensor cable	3	-	CM wall-mount socket	Waterproof 4-way plug	SSF position sensor	DIN 43650 Type C

 Cable 2 and 2a come prewired into the DM.

3.2.7 Schematic View of the Complete Implement

The image below shows an example of a reasonably-expectable combined machine and should not be construed as an indication by the machine manufacturer itself. Please refer to the documentation provided by the machine manufacturer for accurate information about the complete implement.

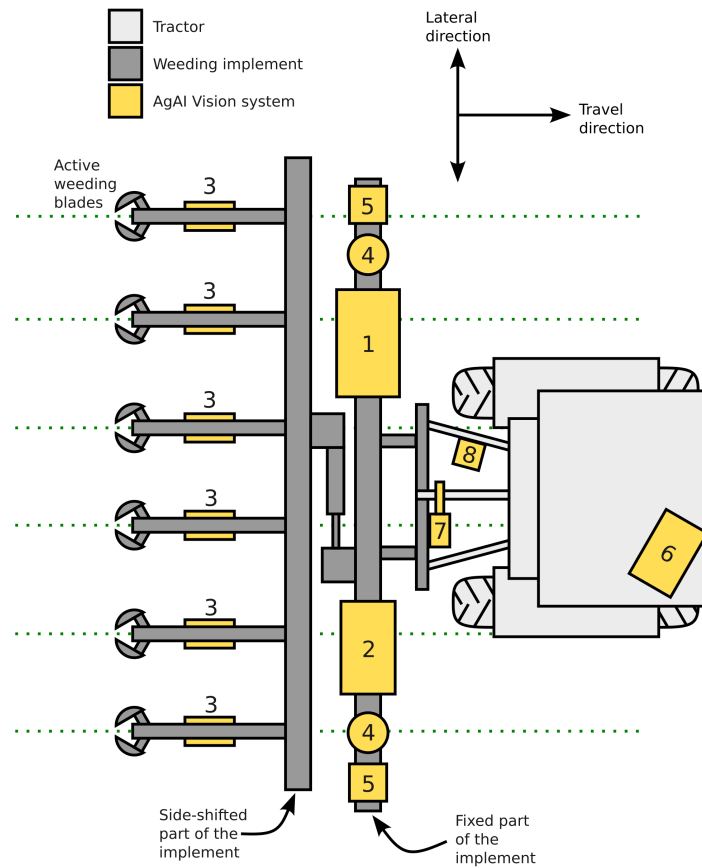


Figure 3.8: Schematic view of the complete implement

#	Designator
1	DM
2	CM
3	WMs (6 displayed)
4	GNSS antennae x2
5	Emergency stops x2
6	UI
7	Implement Position Sensor (IPS)
8	Receptacle of the battery extension cord

3.3 Safety Devices

3.3.1 Safety Features

The AgAI Vision system's safety concept ensures user protection per industry standards. Replacing or removing any safety-critical component voids this concept. The party modifying the system assumes full responsibility for any resulting risks.

The safe state of the system is defined in Safety.

3.3.2 Implement Position Sensor (IPS)

The IPS detects the position of the implement — lowered or raised. It is a limit switch equipped with a steel spring as an end effector. It has a normally-opened and a normally-closed contact.

It shall not be bridged or modified in any other way. It shall be installed as explained in Preparing the Product.

The status light on the DM gives information about the position of the implement:

- Solid yellow light when raised;
- Flashing yellow light when lowered.

3.3.3 GNSS Antennae

The two GNSS antennae detect the position of the implement together with its speed. They shall not be modified or substituted with similar devices without the prior authorisation of Dahlia Robotics.

3.3.4 Expected Behaviour

The two hazardous functions of the AgAI Vision system are:

1. Movement of the SSF;
2. Movement of the AWTs.

Their behaviour is explained in detail in Operation.

3.4 Spare Parts and Tools

3.4.1 Electronic Protection Elements

The AgAI Vision system makes use of fuses and circuit breakers as protection elements for its electronics. These components are preassembled in the system; additionally some spare parts are provided at the purchase and are listed in the following table together with their respective quantities.

#	Element	Quantity of spares
1	ISO 8820-3 Mini Blade Fuse 2 A	5
2	ISO 8820-3 Mini Blade Fuse 3 A	10
3	Littelfuse MINI® Blade Diode 1 A	2
4	Littelfuse MINI® Blade Circuit Breaker 5 A	5

3.4.2 CM and DM Enclosure Key

Two keys used to open DM and CM are provided as part of the AgAI Vision system.

3.4.3 SIM Tools

These components are provided as part of the AgAI Vision system:

- A SIM tray opener key;
- A SIM tray adapter, from smaller sizes to required 2FF (also known as "mini").

3.4.4 WM Power Plugs Caps

6x watertight caps are provided as part of the AgAI Vision system and can be used to seal off the power cables of unutilised WMs.



The lids for the plugs on the WM and CM power cables.

CM and DM enclosure key — Image courtesy of Bopla.

3.5 Identification Plates and Identification Numbers

3.5.1 Typeshield

The identification plate (typeshield) is located on the bottom surface of the DM. An example is shown in the following image. The serial number for the AgAI Vision system is AVnnnnnn, where “nnnnnn” is the 6-digit, 0-padded unique identified number for that system, e.g. 000023 for n. 23.

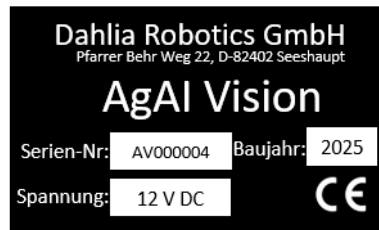


Figure 3.9: Typeshield

3.5.2 Marking of Modules

Each module (CM, DM, WM) is marked with a unique serial number using the format XXnnnnnn, where:

- “XX” is the 2-letter code for the module type, i.e. either CM, DM or WM;
- “nnnnnn” is the 6-digit, 0-padded, unique identifier-number for that module, e.g. 000023 for n. 23.

Serial numbers of each module are always visible in two locations, one inside and one outside of the enclosure. Details about them are in the following table.

Module	External Label	Internal Label
CM	Bottom surface, right side	On the swing door, close to its hinges
DM	Bottom surface, left side	On the swing door, close to its hinges
WM	Next to the lid screws, under the snap hinge	On the swing door, on the opposite side to the hinges

4. Specifications and Performances

4.1 System Specifications

4.1.1 Position of CM and GNSS Antennae

The position of CM and GNSS antennae cannot be modified by the user at any time.



Changes to the positions of CM and GNSS antennae can be applied by technicians of the machine manufacturer or by Dahlia Robotics only.

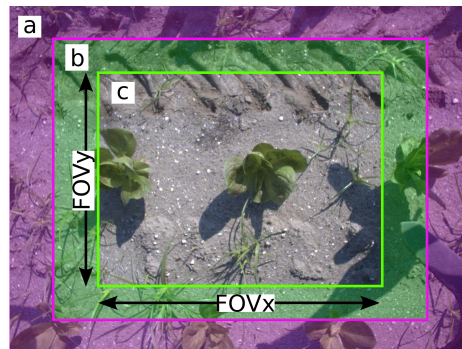
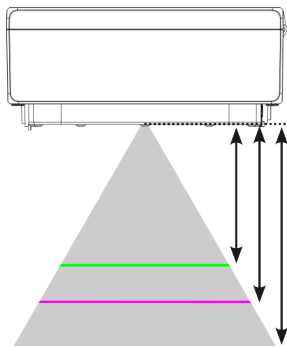
4.1.2 WM Position Specification

4.1.2.1 Height Adjustment of the WM

The pictures imaged by the WM vary in dimensions depending on the height above the ground the WM is mounted at. The distance is measured from the lower surface of the WM, as shown in the image below.

Different heights might be needed for plants of different sizes, considering that performances are best when:

- Plants have a height smaller than 50% of WM height;
- Plants have a width smaller than 80% of the field of view width (FOV_y in picture below);
- Plants from the next rows are not seen in the images of one WM;
- Plants that are offset from the crop line still fall within the field of view (FOV) of the camera in the WM.



WM height regulation	Used for	Distance to ground h (cm)	FOV _x (cm)	FOV _y (cm)
Low (c)	Very small plants	35	54	41
Standard (b)	Most plants	42	65	49
High (a)	Big plants	50	78	58



Each change in the height over the ground of any WM must be reflected in the Dahlia Mobile App (with an accuracy of 5 cm), otherwise the system might behave erratically. For details, refer to Settings Page.

4.1.2.2 Other Specifications

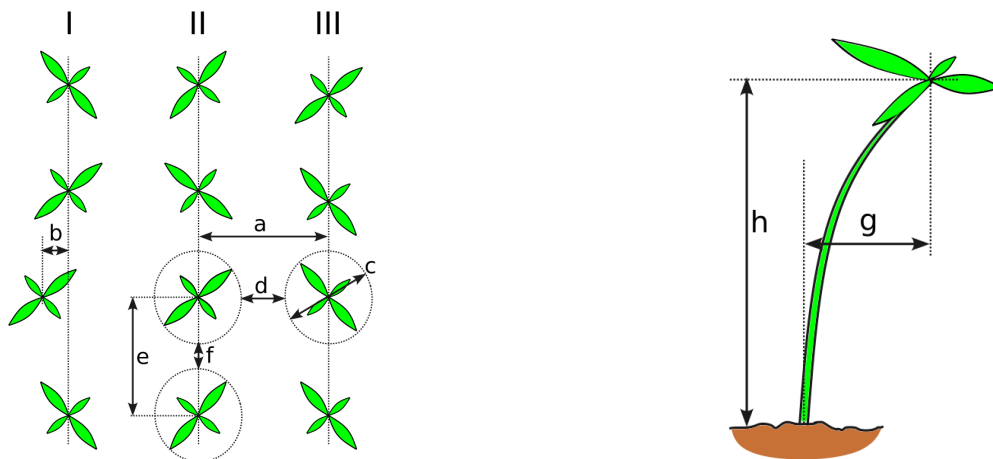
Additional specifications regarding WM position for optimal performances are reported in the next table. For details on the meaning of lateral and travel direction, refer to Schematic View of the Complete Implementation.

Dimension	Direction	Minimum value	Optimal value	Maximum value	Requires software adjustment
Lateral offset of WM from crop row	Lateral	-3 cm	0 cm	+3 cm	By user (on the app)
In-operation variations of WM height over ground	Vertical	-5 cm	0 cm	+5 cm	By user (on the app)
Distance between WM centre and tip of blades	Travel	-	Factory value	-	Contact Dahlia Robotics before modifications
Distance between CM and WM	Travel	-	Factory value	-	Contact Dahlia Robotics before modifications

4.1.3 Crop Plant Specifications

4.1.3.1 Geometrical Specifications

The figure below shows the salient geometrical dimensions for crop plants. The following table lists the specifications for a correct functioning of the AgAI Vision system.



Symbol	Description	Min	Max
a	Crop row distance	60% of FOVy	-
b	Crop plant offset	-	30% of FOVy or as long as the plant is visible in FOV
c	Crop plant diameter	See next section	80% FOVy

Symbol	Description	Min	Max
d	Crop plant distance across rows	0 cm	-
e	Crop plant centre distance along rows	See point f	-
f	Crop plant distance along rows	0 cm	-
g	Stem offset	-	30% of FOVy or as long as the plant is visible in FOV
h	Plant height	3 cm	50% of camera height
I, II, III	Crop rows	-	-

4.1.3.2 Supported Crops

The supported crops are shown in the following table together with their minimum dimension. The list might vary with time: for more information, contact Dahlia Robotics.

Plant	Variety	Minimum dimension (diameter if not specified)
Sugar beets	-	3 cm (2-leave stage)
Salad	Multiple	10 cm (early stage after transplant)
Cabbage	Green, red	10 cm (early stage after transplant)

4.1.4 Field Specifications

The field should have good internet coverage and be free of obstacles that might interfere with GPS communication, such as big trees or high buildings. The specifications for mobile data and GPS coverage are reported in the next Table.

Property	Min value	Rated / optimal value	Max value
Internet uplink network	1G	4G	N.a.
GPS RTK signal quality	N.a.	RTK Fix	N.a.

4.2 System Accuracy

4.2.1 Accuracy of the Crop Plant Detection

The accuracy in detecting crop plants is influenced by a set of parameters, which are listed and explained in the following subsections.

4.2.1.1 Algorithm Mismatch

The crop plants can be only detected if the correct algorithm is utilised. Differently, the detection and the resulting system behaviour could be erratic.

4.2.1.2 Unusual or Unknown Plant Morphology

Some circumstances might cause significant modifications to the morphology of plants from known and supported crops. This might happen because of:

- The choice of peculiar varieties or
- The use of peculiar cultivation techniques or
- An unusual choice for the time of intervention, i.e. when plants are too small or too big.

Stable algorithms are developed for standard cultivation conditions and varieties, according to widespread state of the art. Always verify the availability of a fitting, stable algorithm with Dahlia Robotics.



Refer to the suggested routine reported in Operation to maximise performance and reduce downtimes because of undesired events.

4.2.1.3 Weed Pressure

The AI detection algorithm can robustly distinguish crop plants from weeds even in presence of a significant weed pressure. This holds true only if the following conditions are respected:

- Crop plants can still be seen by the overhead camera. Overgrown plants will not be recognisable; the "rule-of-thumb" check is that the algorithm can detect those plants that can still be seen by a human observer walking along the crop row and looking down onto it.
- Weeds look different from the crop plant or have been included in the training database of the AI detection algorithm, i.e. observed in the past.

It is encouraged to share with Dahlia Robotics details like pictures or videos of the fields the machine should operate on to tackle issues.

4.2.1.4 Dust and Moisture on the Camera

Dust buildup on the external side of camera protective windows of the WM might lead to erratic detection. The same holds for water drops which can distort the visual of the camera on the plants.

4.2.2 Accuracy of the Crop Row Detection

By detecting crop plants, the AgAI Vision system can also determine the pose of crop rows. All limitations listed for the detection of crop plants therefore apply to crop row detection. Additional sources of inaccuracies are listed in the following subsections.

4.2.2.1 Overlapping Crop Rows

In case the field has been seeded/planted with overlapping crop rows, the AgAI Vision system will not be able to determine which crop rows should be followed, with potentially erratic behaviour for both the SSF and the AWTs. As a result, the AgAI Vision system is to be used only on sections of fields that have not been seeded with overlapping crop rows.

4.2.2.2 Low Crop Plant Emergence

In case of partial or no crop plants emergence along one or more rows, if the AgAI Vision system is equipped with multiple WMs, the position of interrupted crop rows can be inferred thanks to the data generated from other rows that have a more evident track. However, in case of no emergence of crop plants in all of the crop rows or if the crop plants are too small to be detected, the AgAI Vision system will still fail to determine the position of the crop rows and correctly track it.

4.2.3 GPS Signal Accuracy

The AgAI Vision system includes two GNSS antennae and requires mobile internet uplink through which the GPS base station signal can be received. Physical obstacles which restrict or obstruct the ability of the GNSS antennae to timely receive the GPS signal will deteriorate the accuracy of the GPS signal, with detrimental effects on the accuracy of the AgAI Vision system itself. Operating the AgAI Vision system in an area with low mobile internet signal strength or speed will produce the same results.



The accuracy of the GPS signal is displayed at all times on the User Interface and can be directly monitored during operations.

4.2.4 Accuracy at Different Operating Speeds

The speed at which the tractor implement is used will have an impact on the accuracy of the system. The performances of the detection and control by the AgAI Vision system may vary from crop to crop but a reasonable reference maximum speed value is 5 km/h. Higher speeds can make the detection of crop plants less stable. The issue can be improved by recording additional data from the field. Contact Dahlia Robotics for more details.

As a rule of thumb, lower speeds will yield more accurate results. Moreover, a tight spacing of plants along the row will require a slower speed to allow the time for the blades to open and close around them. Similarly, the SSF movements are limited in speed and a curvy row profile might prove difficult to track at too high speeds. Finally, too high speeds might cause problems because of the shovelling of soil by the AWTs on the plants.

4.2.5 User Defined Parameters for WMs

The height above ground of the WMs can change depending on the needs of weeding operations (see Accuracy of the Crop Plant Detection). The failure to reflect changes to this value in the Dahlia Mobile App might reduce the accuracy of the system. For more details about setting software parameters, refer to Dahlia Mobile Application.

4.2.6 Hilly Terrain

Whilst working on hilly terrain, slippage of the tractor and/or the tractor implement may reduce the accuracy of the system.

4.2.7 Curves

In the presence of crop rows with small curvature radii, the accuracy of the system will be reduced. When possible, keep to the common values of curvature radii for similar weeding implements.

5. User Interface and Dahlia Mobile Application

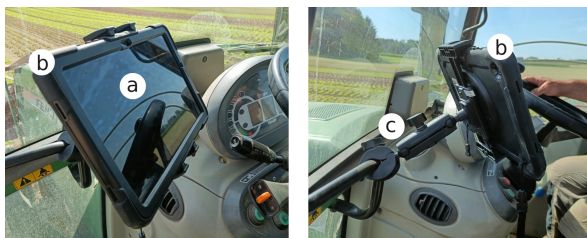
5.1 User Interface (UI)

5.1.1 The UI Control Tablet

The AgAI Vision system cannot be operated without a UI. It is a tablet and is provided together with the rest of the hardware of the AgAI Vision system. The UI is used to control the behaviour of the system via a dedicated software application, called Dahlia Mobile Application. A misuse could lead to hazardous situations. The operator shall follow the indications contained in this manual, and in the User Manual and Safety Indications of the UI. The operator is responsible for keeping the UI safe at all times during use, i.e. to keep it with himself or locking its screen otherwise. The user is responsible for storing the UI in a safe place when not used.

5.1.2 UI Accessories

The UI is provided together with a protective cask, a universal fixture and a charging adapter with USB cable.



#	Designator
a	User Interface (UI)
b	Protective cask
c	Universal clamp fixture
d	DIN 9680 to USB adapter
-	USB male C to USB male A cable

5.2 Dahlia Mobile Application

The Dahlia Mobile App is a proprietary application of Dahlia Robotics and is distributed via Google Play Store. It is run on the UI and allows the end-user to interact with the AgAI Vision system, use it and configure it. To know more about how to install the application, refer to Installation of the User Interface.

5.2.1 Use of the Control Application

5.2.1.1 Launch the Application from the UI

The application is called Dahlia Mobile and, once installed, can be found by searching for it amongst the installed applications or by clicking on its icon.



Figure 5.1: Dahlia Mobile application icon

5.2.1.2 Login Page

This is the landing page when the Dahlia Mobile app is started. It allows the user to log in with the credentials that have been given by Dahlia Robotics and prevent unauthorised personnel to gain access to an AgAI Vision system.

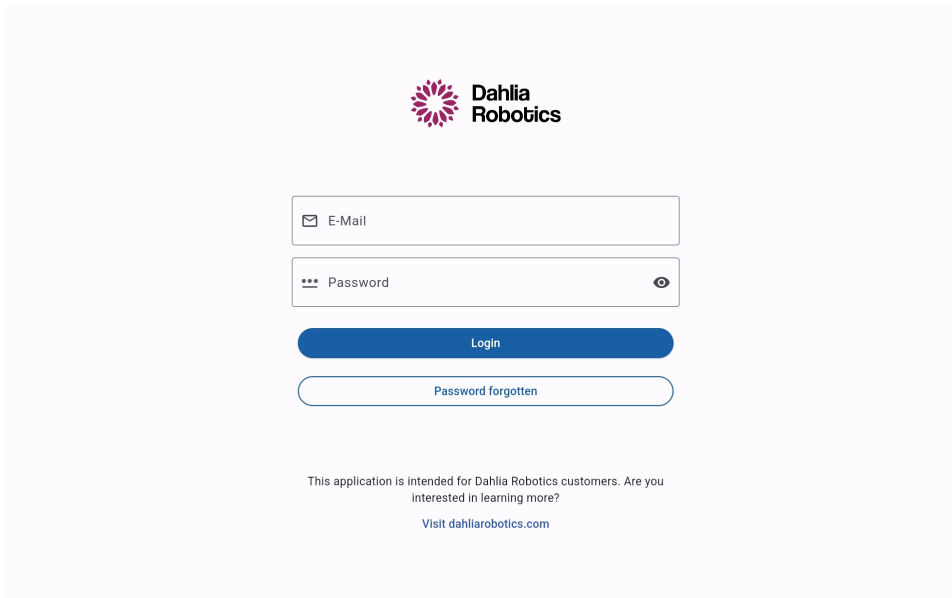
The image is a screenshot of the Dahlia Robotics login page. At the top center, there is the Dahlia Robotics logo, which consists of a purple flower icon followed by the text "Dahlia Robotics". Below the logo, there are two input fields: the first is labeled "E-Mail" and has an envelope icon on the left; the second is labeled "Password" and has a password icon (three dots) on the left and an eye icon on the right. Below these fields is a blue "Login" button. Underneath the button is a link that says "Password forgotten". At the bottom of the page, there is a small text block that reads: "This application is intended for Dahlia Robotics customers. Are you interested in learning more? Visit dahliarobotics.com".

Figure 5.2: Login page

Once logged in, the user will be sent to the "System Selection page" or "Connection page".

5.2.1.3 System Selection and Connection Pages

The "System selection page" allows the user to first select the AgAI Vision system to connect to. The same user with the same UI can connect to all systems he has been given access to by Dahlia Robotics.

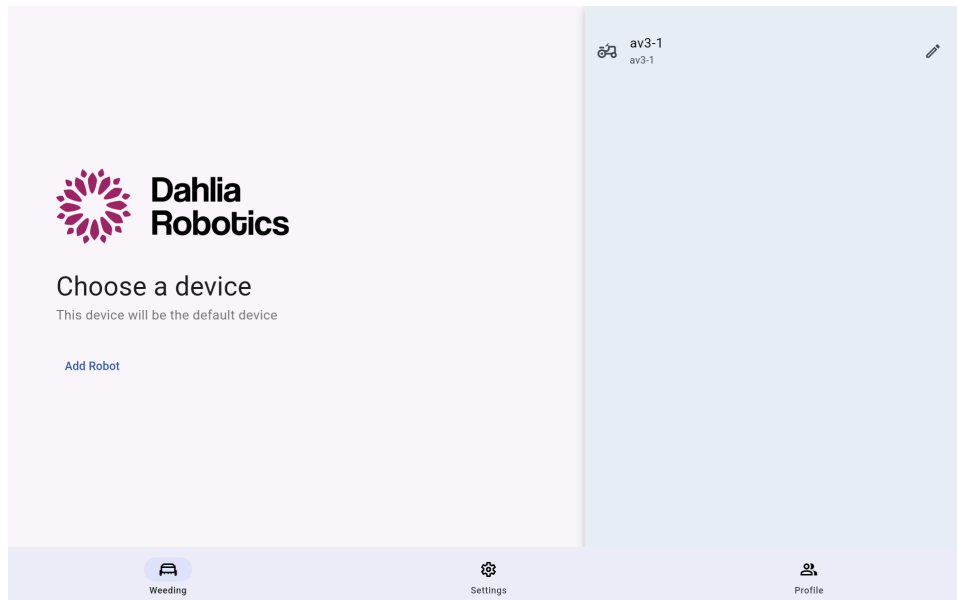


Figure 5.3: System selection page

System selection page: it shows a list of the systems that the user can connect to.

Once a selection has been made, the status of the connection procedure will be shown in the "Connection Page".

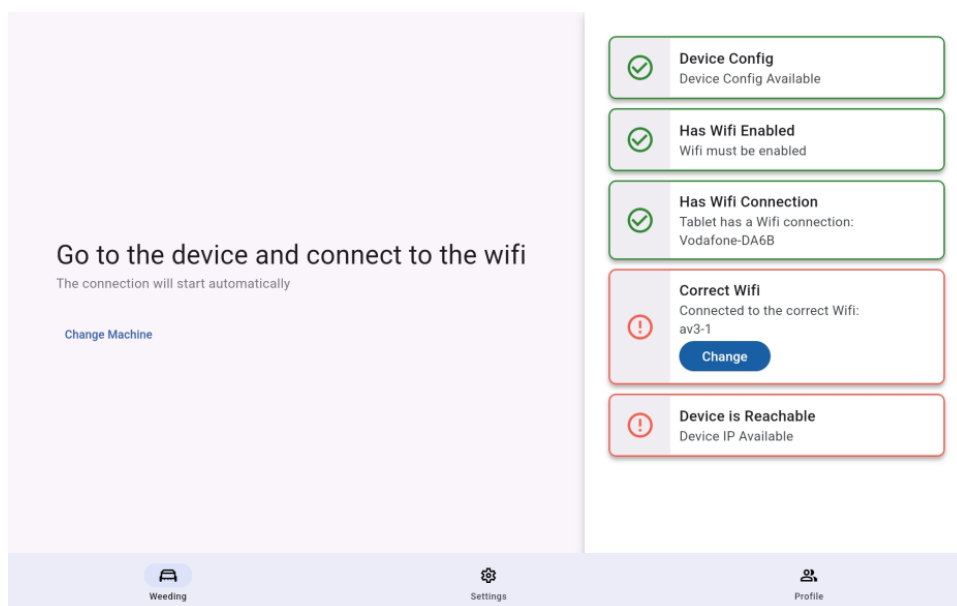


Figure 5.4: Connection page

The connection page shows the state of the current connection: in case some conditions for connection are not satisfied, they will be shown in red boxes on the right. The device to connect to can be changed by clicking on "Change Machine".

After a first successful connection, the app will always try to automatically connect to the same system and the page shown in the first image of this section will be skipped. To change the selection, use the button "Change Machine". More details are to be found in Installation of the User Interface.

Once a connection is correctly established, the app will move onto the "weeding page".

5.2.1.4 Weeding Page

This is the main page for interacting with the AgAI Vision system, i.e. starting and stopping automatic mode (weeding operations), operating the sideshifter and having the overview of the system performances and its diagnostics.

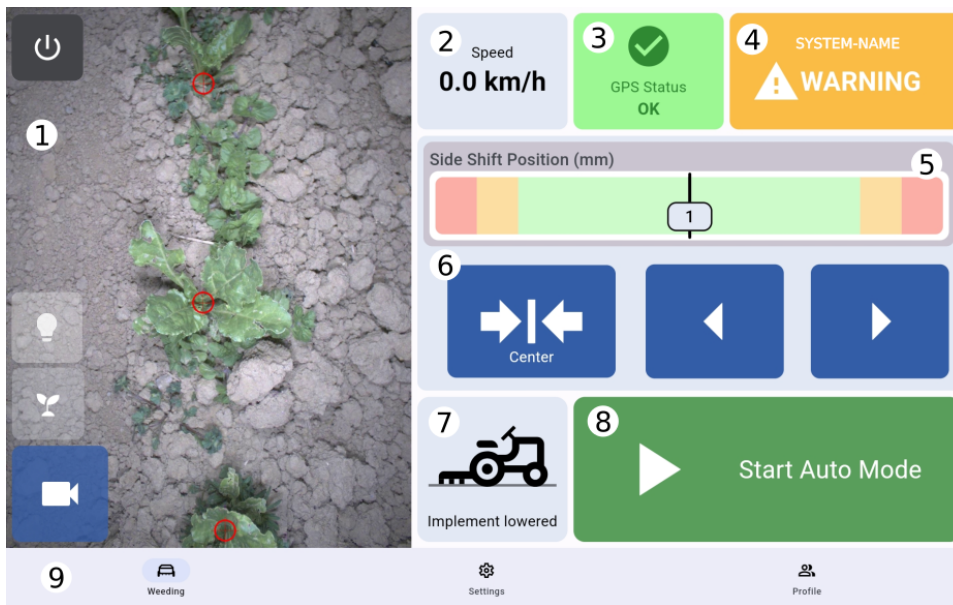






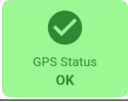
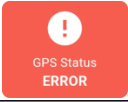


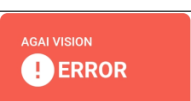




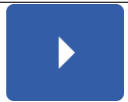
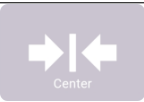


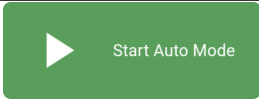
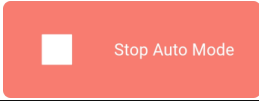

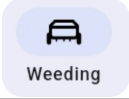
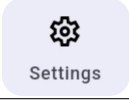
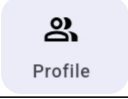


Figure 5.5: Weeding page

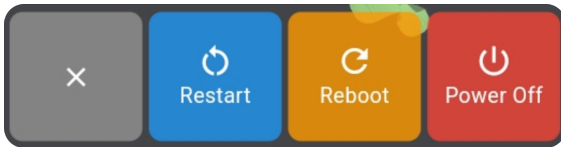
1	Camera live-view		
		Plant with marker of the recognised centre	Each marker shows the centre of what has been recognised as a crop plant. Markers are an overlay and can be deactivated.
		LED toggle button	Toggles the LED lights to be permanently ON/OFF during manual mode.
		Centre marker toggle button	Toggles visibility of the red markers that indicate the centre of detected crop plants.
		WM live-view selection button	Opens the drop-down menu to select which WM to see a live-view from.
		System-power management action button	Opens a drop-down menu to trigger a shutdown or reboot of the system. More details at the end of the section.
2	Speedometer		
		Tractor speed	Gives a live measurement of the tractor speed as estimated with the GPS-RTK signal.
3	GPS status overview		

		Status OK	The GPS signal is stable.
		Status ERROR	The GPS signal is not stable.
4	Diagnostics overview (opens the diagnostics page if clicked upon)		
		Status OK	The system is functioning in optimal conditions.
		Status WARN	The system is functioning in suboptimal conditions; no immediate action required.
		Status ERROR	An error has occurred that hampers base functionalities of the system.
		Status IDLE	The system is booting.
5	SSF position indicator		
		SSF position SSF limits	The number in the white box is the position in mm; positive verse is to the right (facing travel direction). The green area indicates the optimal range of motion; the areas next to the dead-ends are in yellow; the red areas are off-limit for motion.
6	SSF control cockpit		
		Self-centering button	When pressed, triggers the SSF to self-centre on its own.
		Move to the left button	Manually moves the side-shift to the left.
		Move to the right button	Manually moves the side-shift to the right.
		Manual control of SSF disabled	All commands are greyed out and not usable anymore: the implement is lowered and cannot be moved manually.
7	Implement position indicator		
		Lowered implement signal	The implement is lowered.
		Raised implement signal	The implement is raised.

8	Mode toggle control		
		Toggle automatic mode	Activates automatic mode when being in manual mode.
		Toggle manual mode	Activates manual mode when being in automatic mode.
		Automatic mode disabled	Automatic mode cannot be activated as a result of an error or of the implement being lifted.
9	Page navigation bar (visible in multiple other pages too)		
		Weeding page	Opens weeding page.
		Setting page	Opens setting page.
		Profile page	Opens profile page.

System Power Drop Down Menu

The power management menu of the system can be entered by clicking on the power action button described above.



X: closes the dropdown menu
Restart: restarts the software
Reboot: causes all hardware to reboot
Power off: turns all hardware off

If any power transition is selected by clicking on their icons, a dialog box will ask to confirm the action.

5.2.1.5 Diagnostics Page

Shows the details about the state of the system with diagnostic messages and suggestions for how to solve the issue.

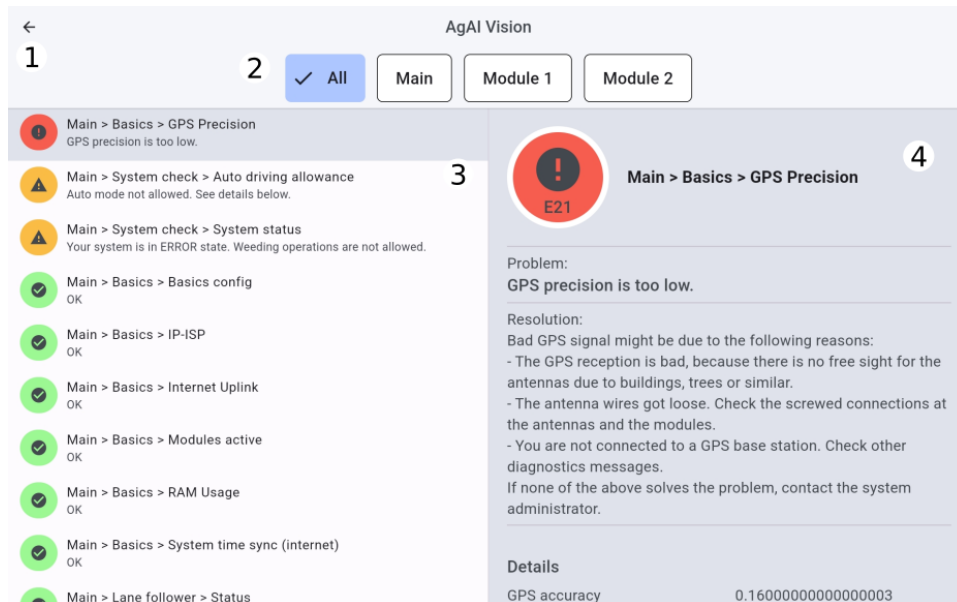


Figure 5.6: Diagnostics page

#	Element	Description
1	Return button	Brings back to the weeding page
2	Filter for device	Allows to filter diagnostics from different devices, i.e. CM (main) and single WMs (Module x)
3	Diagnostics dashboard	Shows all selected active diagnostics issues sorted by relevance: errors are displayed in red first; warnings follow in yellow; lastly come OK messages.
4	Details about issue	Shows all relevant information regarding the selected issue, with description of the problem and of possible resolutions. Colour coding is consistent with dashboard's. The number in the icon represents the message number.

5.2.1.6 Settings Page

This page allows the user to set all the parameters most commonly needed during weeding operations. It also gives access to more rarely-needed parameters. The page is only available when all WMs have correctly booted: more details at the end of this section.

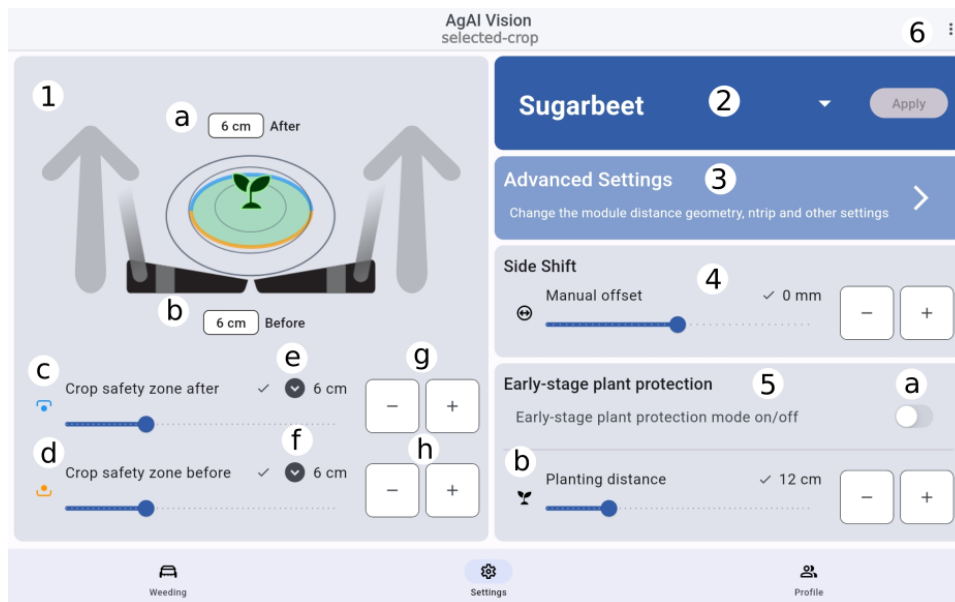


Figure 5.7: Settings page

#	Sub-element	Description
1	Crop safety zones setting	
	a, b	Overview of the current values of the crop safety zones after (a) and before (b) the plant. The arrows display the direction of motion. In case a safety zone is common to all WMs, its value will be displayed; otherwise, INDV (individual) will be shown.
	c, d	Allows the user to set the values for both safe zones with drag bars.
	e, f	Shows the current value of both crop safety zones. By clicking on the arrow, a dropdown menu will be opened where the desired value can be specified for every WM individually.
	g, h	Allows to increment or decrement the value of the safe zones for all WM together by 1 cm per tap.
2	Selection of algorithm for crop recognition	
		Shows what crop the AgAI Vision system is working with; if clicked on, opens the drop down menu of available crops to select from. Changes must be confirmed with the "Apply" button before they are active.
3	Advanced settings	
		Gives access to Advanced Settings; more details on that in the following section.
4	SSF manual offset	
		Applies a constant offset to the position of the SSF.
5	Early-stage plant protection	
	a	Toggles the Early-stage plant protection behaviour.
	b	Specifies the planting distance, via drag-bar or via increments (+/- 1 cm per tap).
6	Turn off / change machine	
		By clicking on the 3-dot symbol, a drop-down menu is opened that allows the user to change to a different AgAI Vision system or reboot the current one.

Definition: Crop Safety Zones

They define the behaviour of the AWTs around the plant by setting the target distances before and after the centre of a recognised plant at which the blades should open and close, respectively. Smaller safety zones mean a tighter weeding in the vicinity of the plants but can result in a higher stress on the roots of the crop plants. The rationales to define their values are:

- Plant size: generally speaking, the bigger the plant, the closer the blades can get to it without uprooting it. The underground morphology of the plant radical system must anyway be taken into account to avoid damaging it with the AWTs.
- Weeding speed: at higher weeding speeds (around 5 km/h) precision might decrease so that the weeding performance can benefit from wider safety zones.

Definition: Early Stage Plant Protection

The early stage plant protection is an optional setting that can be enabled in the settings page of the Dahlia Mobile App. Whenever enabled, the system expects a plant at a semi-regular interval that is specified with the "planting distance" parameter. If the plant is not detected, this setting instructs the corresponding AWT to keep its blades open until a new plant is detected on the same row. This is designed to prevent late-germinating plants from being chopped in early weeding passages.

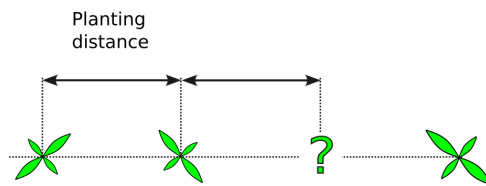


Figure 5.8: Early stage plant protection

Accessing the Settings Page Before the Complete Boot

Some settings cannot be modified before the system has booted completely. If this page is opened while the system is still booting, an overview of system availability will be displayed. The user will anyway have the option to move to the "Advanced settings page".

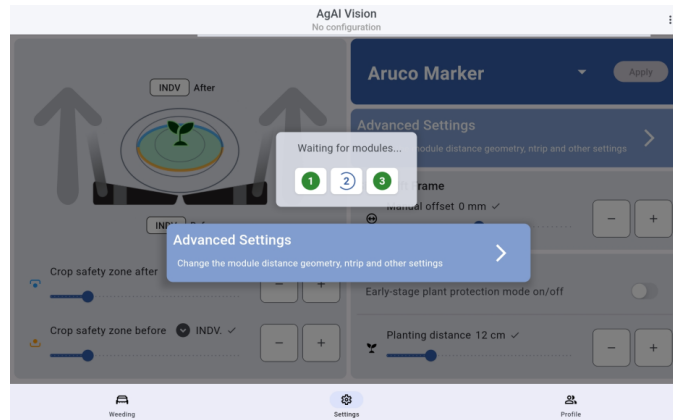


Figure 5.9: Settings page during system boot

5.2.1.7 Advanced Settings

This page gives access to more rarely utilised settings, needed only in special occasions:

- the configuration of the NTRIP client for RTK GPS;
- the description of the geometry of the complete implement;
- The configuration of the SIM card;
- The self-test function.

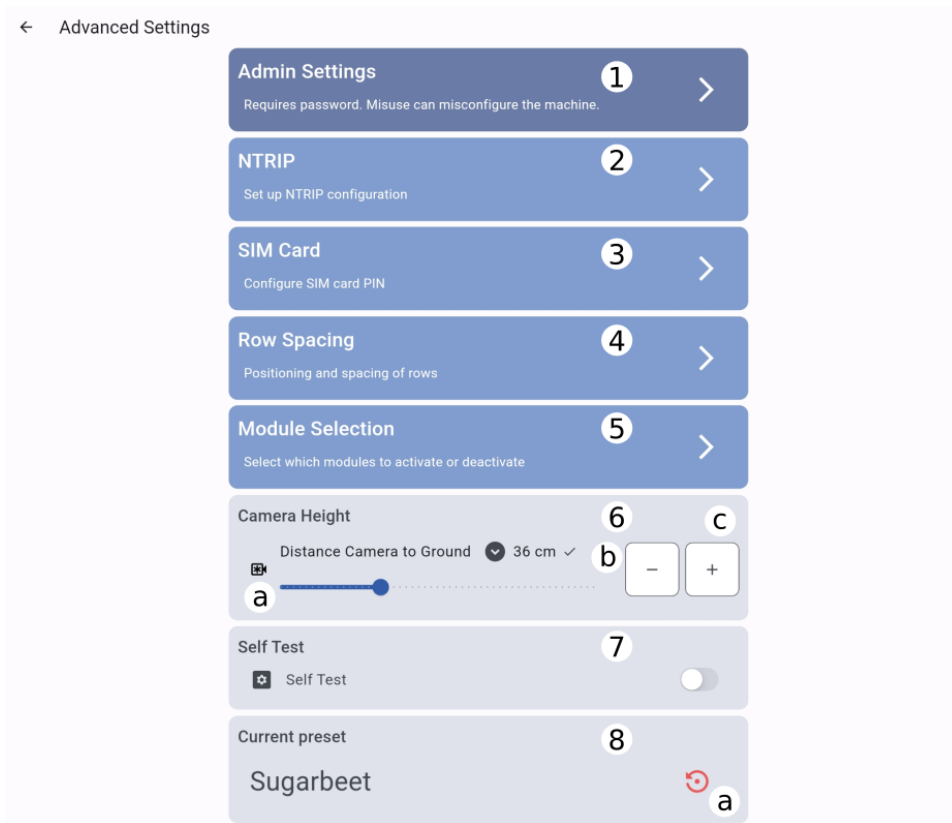


Figure 5.10: Advanced Settings page

#	Sub-element	Description
1	Admin Settings	
		Opens some advanced settings that are not available to standard operators. This sub-menu is protected by PIN and intended for specialised technicians only.
2	NTRIP settings	
		Opens the NTRIP configuration page; used in case your GPS setup needs changes to it.
3	SIM Card	
		Opens the "SIM card page" where the user can set the correct PIN.
4	Row spacing	
		Opens the "Row spacing" page on which the disposition of WMs can be specified. This is needed when converting the same combined machine to a new field setup (different crop row spacing).
5	Module selection	
		Opens the "Module selection" menu, where the operator can select what modules of the available ones will be used.
6	Camera height	
	a	Specify the height of all WMs with a dragbar.
	b	Shows the current values of WM heights: if the height is the same for all WMs, then its value is shown; otherwise, INDV is shown. Clicking on the arrow will open the dropdown menu where a value can be specified for every WM individually.
	c	Allows to modify the values of the WM height for all WMs by increments (+/- 1 cm per tap).
7	Self-test function toggle	
		Allows the user to toggle the self-test function. For more details, refer to Self Test Function.
8	Parameter preset	

#	Sub-element	Description
		Shows the name of the currently employed parameter preset. If clicked upon, it opens up the menu of parameters presets, allowing to save the currently applied parameters or to load an old saved preset.
	a	Overwrites all changes to the preset parameters and restores the factory default parameters for the selected crop.

Definition: Parameter Preset

It is a set of parameters that the user can store for convenience and use later. The preset consists of:

- Safety zones (before and after);
- Early-stage protection;
- Disposition of the WMs.

5.2.1.8 NTRIP Configuration

This page allows the end-user to enter the relevant data for receiving the RTK corrections from the preferred host. This must be performed only once as the data will be saved until the next modification.



This data must be requested by the operator to the NTRIP provider.

Figure 5.11: NTRIP Configuration page

Field	Use
Host	The host of your NTRIP stream: the URL of the entity providing the RTK data for this AgAI Vision system.
Port	The port to connect to (usually 2101).
Mount point	The name of the mount point for the NTRIP stream.
Username	The username for the NTRIP stream.
Password	The password for the NTRIP stream.



The user must contact a valid RTK provider before the machine can be used on their farm.

5.2.1.9 SIM Card Settings

This page allows the user to enter the PIN number of the card in use. The PIN is known by the user; the router password is provided by Dahlia Robotics together with the other credentials and details about the machine.

← SIM Card

SIM PIN (SIM 0)
Enter 4-digit PIN 0/4

Router Password
Enter router password

After applying the configuration, the router will take some time to restart the mobile connection.

To check if the process has worked, check the machine diagnostics if an internet connection can be established.

Apply

Figure 5.12: SIM Card Settings page

5.2.1.10 Implement Geometry Settings

This page allows the user to specify a change to the geometry of the machinery, which happens every time the same system is adapted for a different field setup, i.e. different number or disposition of rows.

← Module Position Config

1

Base link X
y CM

WM 1 WM 2 WM 3 WM 4

View: back

Caution: values can be negative
To add a minus sign, press the '-' button twice.

2 **Main Module Pos (Red)**
From the system's base to the weeding module's (WM) middle of the lowest surface

Y: -0.5 m

3 **Module Distance (Blue)**
Distance between the weeding modules, i.e. the row distance

0.5 m

Apply

Figure 5.13: Implement Geometry Settings page

#	Element	Description
1	Geometry measurements overview	The overview shows the baselink and the relevant distances to be taken. For more details, refer to Changes to the Lateral Spacing of WMs.
2	Main module position	Allows the operator to enter the lateral position of WM3 (the main module).
3	Module distance	Allows the operator to enter the distance between modules, which should be equal to the crop row distance.

5.2.1.11 Module Selection Page

Some applications will require different numbers of WMs than the maximum number, for example when weeding 4 rows with a 6-module system. More details on when this must be done are in Mechanical Adjustments.

The "Module selection" page allows the user to select what modules are actually in use. The page shows two pieces of information:

- What WMs have been selected, i.e. will be used for weeding:
 - Selected WMs are in blue;
 - the unselected ones are in grey;
- What WM are active, i.e. powered and communicating with the CM:
 - Active WMs have a green label that says "Active";
 - Inactive WMs have a grey label that says "Inactive".

Clicking on any WM will toggle its selection. After the right WMs have been selected, the restart button in the top right must be pressed.

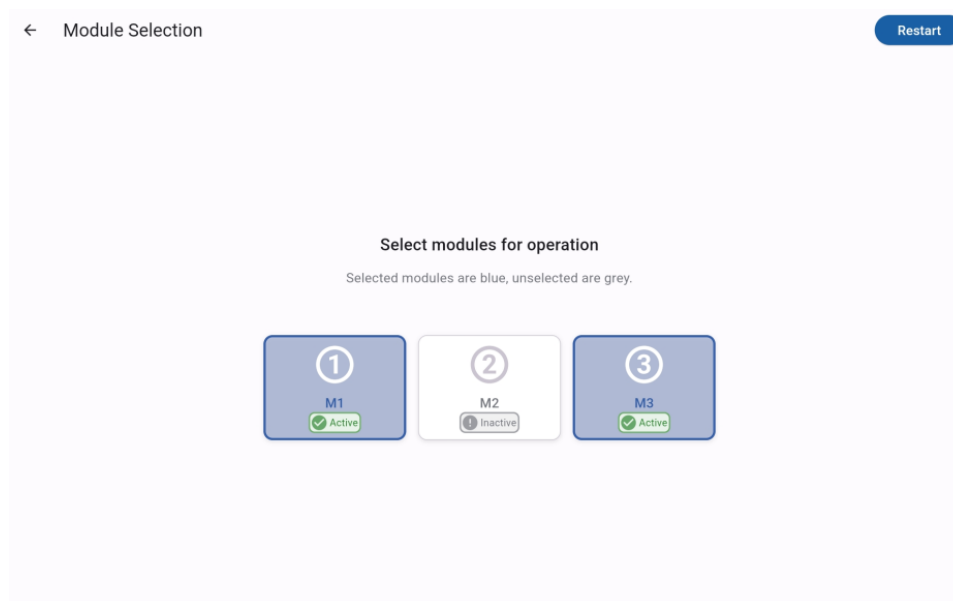


Figure 5.14: Module Selection page



Running an AgAI Vision system with wrongly configured WMs might lead to erratic behaviour, compromising the weeding performances as well as the overall machine safety.

5.2.1.12 Profile Page

This page provides some tools to change the behaviour of the app and log out of the current session.

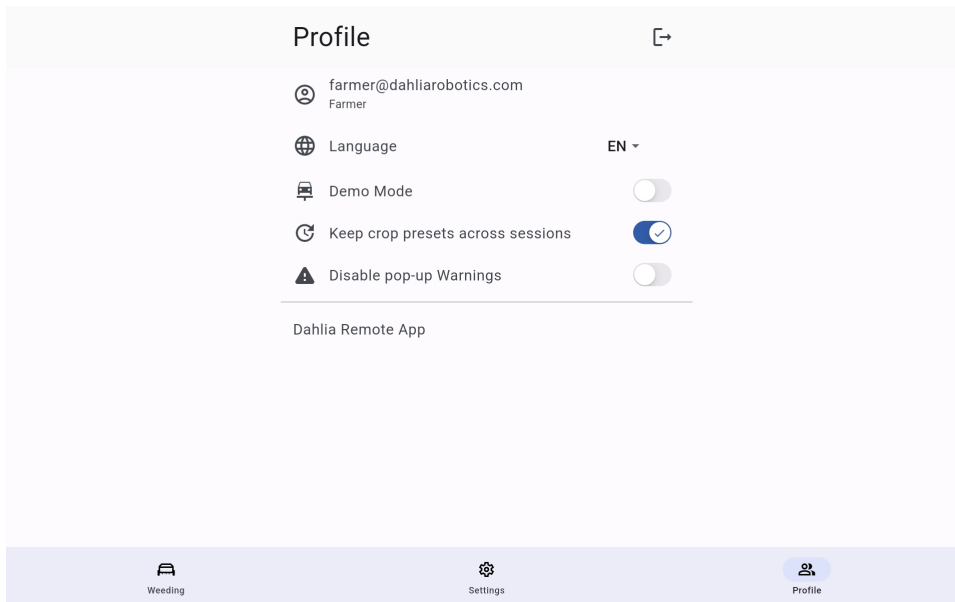


Figure 5.15: Profile page

#	Element	Description
1	Account info	Shows the user-name and the credentials levels of the user ("farmer" stands for end-user).
2	Language selection	The dropdown menu of the available languages can be accessed by clicking on the arrow next to the active language.
3	Demo mode toggle button	Toggles demo mode, in which no tractor needs to be connected and the functionalities of the app can be freely tested.
4	"Keep presets" toggle button	If activated, the changes to parameters that are performed during a use session will remain applied also at the next start of the system; otherwise, the parameters of the chosen preset will be applied again.
5	"Disable popup warnings" toggle button	If deselected, the incurrance of an error during automatic mode will not generate a pop-up. The use of pop-ups are suggested for quicker reaction times.
6	Log-out	The button logs the user out from the app and brings back to the login page.

5.2.1.13 Error Popup Window

This popup is shown every time an error occurs during automatic mode. The error by itself will not deactivate automatic mode but the user can do that with the button in the centre. This popup will be associated with acoustic signals so that the message is not missed.

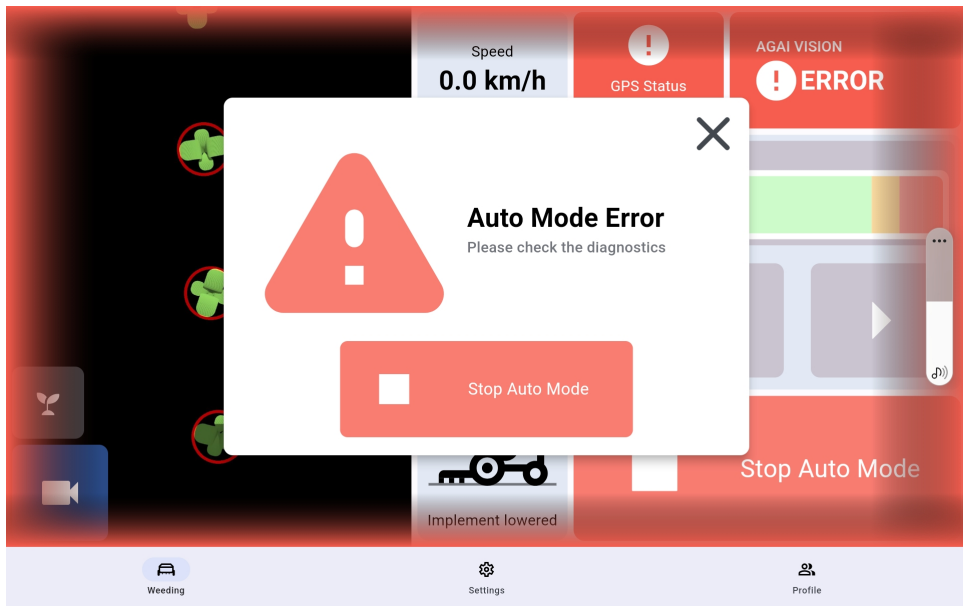


Figure 5.16: Error popup window

6. Technical Specifications

6.1 Central Module (CM)

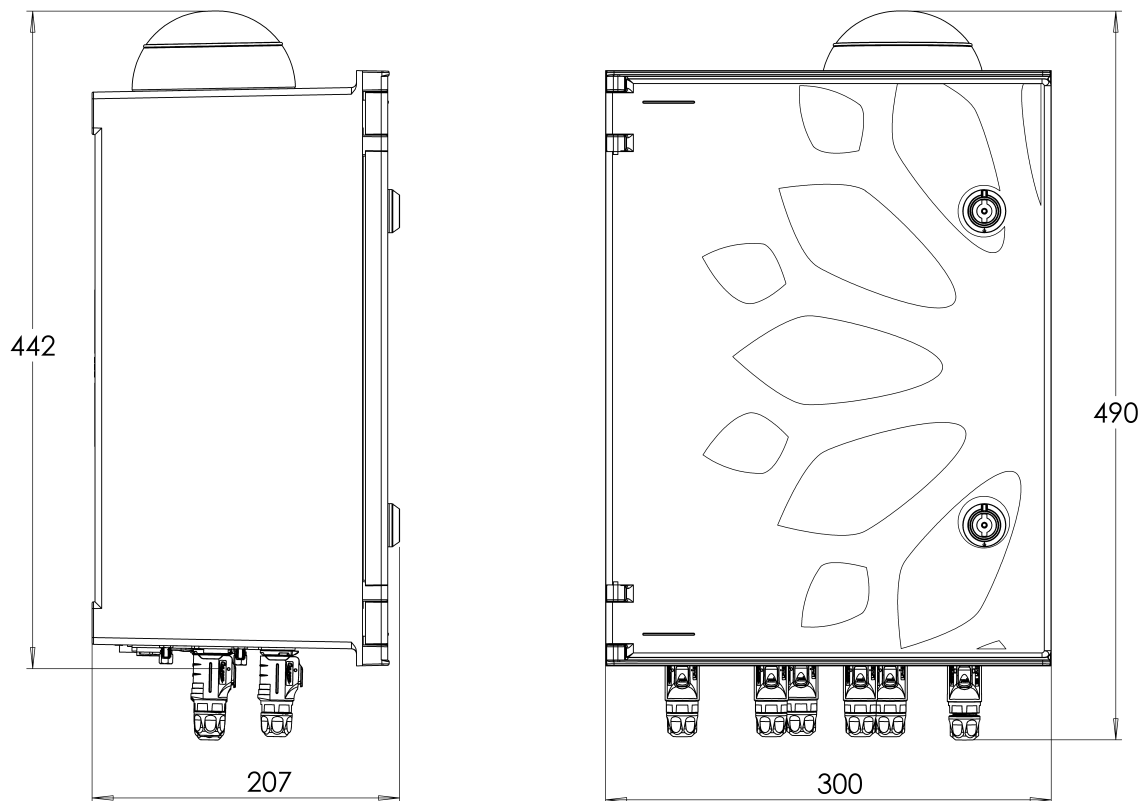


Figure 6.1: Central Module (CM) — dimensions

Designator	Value	Unit
Height (without connectors)	442	mm
Height (with connectors)	490	mm
Width	300	mm
Depth	207	mm
Weight	5.2	kg
Degree of protection	IP65	-
Operating temperature	0 – 40	°C
Storage temperature	-15 – 60	°C
Operating voltage	12	V
Maximum current consumption	5	A

Designator	Value	Unit
Maximum electric power	60	W

6.2 Distribution Module (DM)

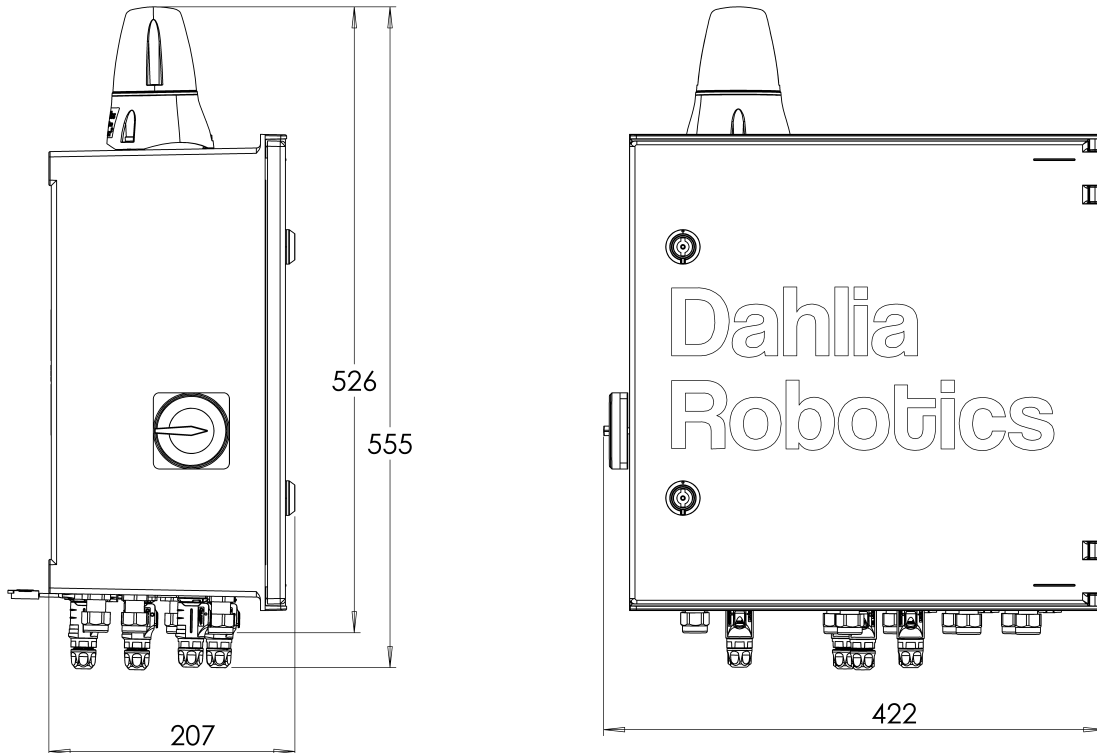


Figure 6.2: Distribution Module (DM) — dimensions

Designator	Value	Unit
Height (without connectors)	526	mm
Height (with connectors)	555	mm
Width	422	mm
Depth	207	mm
Weight	15	kg
Length of the power extension cord (not shown in the image)	2000	mm
Degree of protection	IP65	-
Operating temperature	0 – 40	°C
Storage temperature	-15 – 60	°C
Operating voltage	8 – 17	V
Maximum current consumption (6 WMs)	35	A
Maximum electric power	420	W

6.3 Weeding Module (WM)

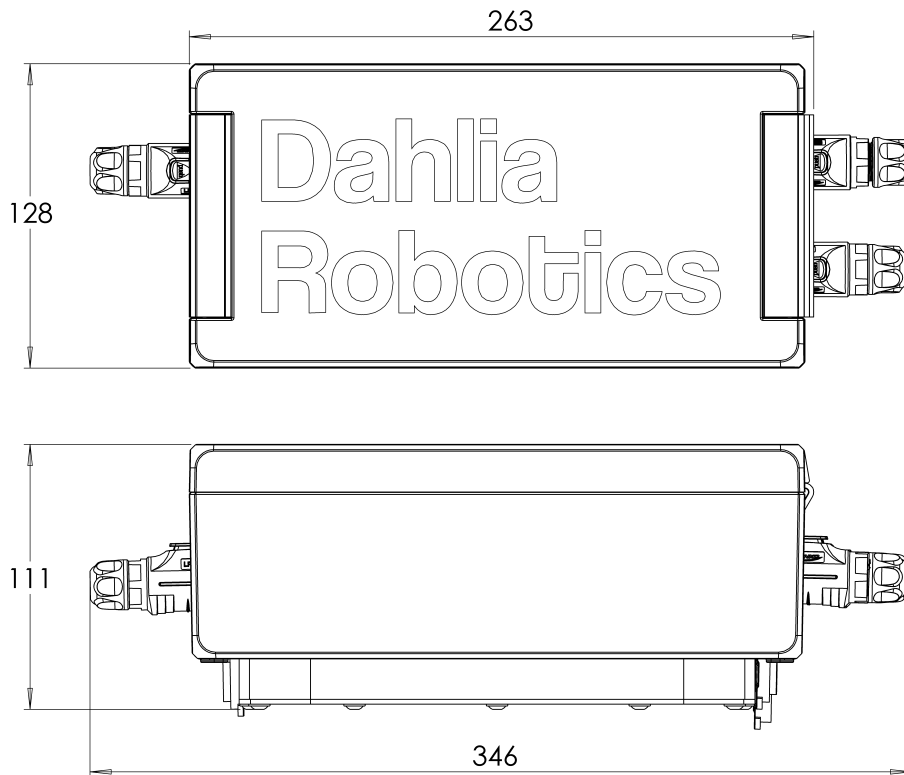


Figure 6.3: Weeding Module (WM) — dimensions

Designator	Value	Unit
Height	128	mm
Width (without connectors)	263	mm
Width (with connectors)	346	mm
Depth	111	mm
Weight	3.3	kg
Degree of protection	IP65, IP67	-
Operating temperature	0 – 40	°C
Storage temperature	-15 – 60	°C
Operating voltage	12	V
Maximum current consumption	4	A
Maximum electric power	48	W

6.4 User Interface (UI)

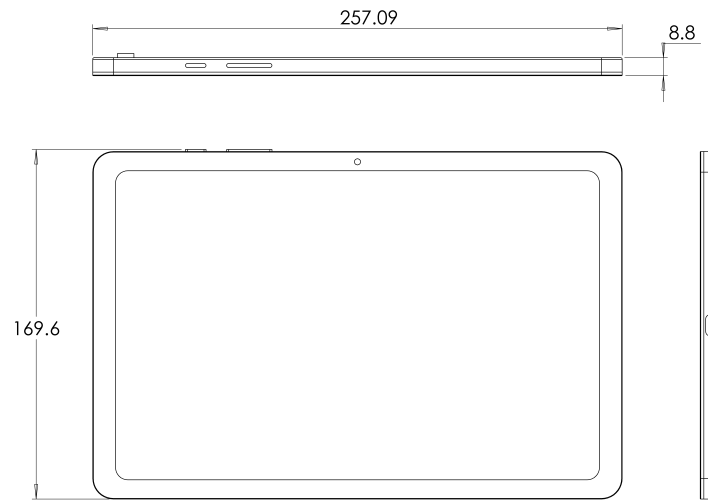


Figure 6.4: User Interface (UI) — dimensions

Designator	Value	Unit
Height	170	mm
Width	257	mm
Depth	8.8	mm
Weight	0.332	kg
Operating temperature	0 – 40	°C
Suggested storage temperature*	10 – 40	°C

* The suggested storage temperature will ensure a longer lifetime for the battery of the device.

7. Preparing the Product

7.1 Fundamental Prerequisites for the Commissioning

The preparation and use of the AgAI Vision system is impossible without the end-user taking care of the following points. It is therefore crucial that they be tackled by the day of the delivery of the combined system (AgAI Vision system incorporated into a compatible weeding implement).

7.1.1 End User Supplied SIM

A SIM card with a suitable mobile data-plan is required for the system to be operational. The SIM is not supplied by Dahlia Robotics. The requirements for the SIM and data-plan are:

- Shape factor: mini SIM, aka 2FF (a smaller size with an adapter is also fine);
- Data-plan:
 - 5 GB of monthly mobile data at least, 10 GB suggested;
 - 4G connectivity required, 5G suggested;
 - Automatic payment is strongly recommended so as to avoid interruptions of service because of unexpected and unnoticed run-outs of the available data plan;
 - Messages or calls are not needed.

7.1.2 Registration to a Local NTRIP Provider

The end-user shall register an account on a local NTRIP provider and communicate the needed data to the technician performing the delivery and commissioning of the machine. The needed data is:

- URL of the host;
- Number of utilised port (normally 2101);
- Name of the mount point;
- Username and password.

7.2 Sequence of Preparations

7.2.1 Occasional Preparations

These operations only need to be performed once in the life cycle of the product or when otherwise strictly necessary.

Name	AgAI Vision System	Tractor	Section
Connection to the DC Power Source — wiring of the battery extension cord / connection to ISOBUS socket	OFF	OFF	Connection to the DC Power Source
Insertion of the Data SIM in the Router	OFF	OFF	Insert the SIM in the Router

Name	AgAI Vision System	Tractor	Section
Installation of the User Interface	ON	ON	Installation of the User Interface (UI)
Configuration of the NTRIP Client	ON	ON	Configuration of the NTRIP Client
Mechanical Adjustments	OFF	OFF	Mechanical Adjustments
System Software Settings Update	ON	ON	System Software Settings Update
Software Updates	ON	ON	Software Updates

7.2.2 Regular Preparations

These operations need to be performed daily or as part of maintenance (more details in Maintenance) or regular mounting and unmounting of the complete implement from the tractor.

Name	AgAI Vision System	Tractor	Section
Regulation of the Implement Position Sensor	OFF	OFF	Regulation of the Implement Position Sensor (IPS)
Connection of the DM to the Battery Extension Cord	OFF	OFF	DC Power from the Tractor Battery
Transport to and from Field on Public Roads	OFF	OFF	Transport to and from Field on Public Roads



Performing the above operations without turning the tractor or the AgAI Vision System off as requested can result in hazard for which Dahlia Robotics is not responsible.

7.3 Switching the System On and Off

7.3.1 Switching the System On

The checklist to do so is:

1. Check all requirements in the manual of the weeding implement;
2. Start the tractor's motor;
3. Make sure that there is no pressure in the hydraulic circuit that supplies the complete implement;
4. Start the AgAI Vision system with the switch at the side of the DM, turn the UI on and start the Dahlia Mobile App;
5. Connect to the system with the Dahlia Mobile App and wait for the booting phase to end (IDLE state gone).

The system is now ready to be used.

7.3.2 Switching Off and Securing the System

The checklist to do so is:

1. Turn the hydraulics supply to the weeding implement off;
2. Turn the AgAI Vision system off via software by using the turn-off feature in the Weeding page (more details in Weeding Page).
3. Wait for the countdown in the app to be over before shutting the system electrically down.
4. Turn the AgAI Vision system off by using the switch on the side of the DM.



Refer to the instructions provided from the implement manufacturer to know when the complete implement can be worked on.



Failing to comply with steps 2 and 3 of the above list can lead to hardware damages that are not covered by warranty: always turn the system off via software before you do so with the main power switch.

7.4 Leaving the Cabin

Whenever the operator must leave the cabin for short periods of time, it is his responsibility to make sure that:

1. The tractor is secured as explained in the tractors manual;
2. The hydraulic pressure to the complete implement is switched off;
3. The UI is with the operator or otherwise its screen is blocked and secured by a password / secret combination.

Never leave the AgAI Vision system unattended while turned on; in case of longer leaves, turn the system off. At all times observe the indications of the tractor and the machine manufacturer.

7.5 Prior to Weeding Operations

Operations to perform before the AgAI Vision system is started and used on the field.



Both the tractor and the AgAI Vision system must be turned off for the whole duration of those operations that require the operator or technicians to enter the hazard zone (see Safety for more details).

7.5.1 Regulation of the Implement Position Sensor (IPS)



An erroneous installation of the implement position switch will result in a loss of functionality and safety for the system. This regulation shall be performed every time:

- the weeding implement is newly attached to a tractor,
- as a regular maintenance operation (see Maintenance),
- additionally as specified in the machine manufacturer manual.

Make sure you follow the guidelines provided in this Operator's Manual and in the manual of the weeding implement.

7.5.1.1 Correct Location for the Implement Position Sensor (IPS)

The correct position of the IPS is defined so that:

1. It is above the upper link of the 3-point hitch.
2. The coil spring that activates the switch is pressed against this link hard enough for the latter to be reliably toggled every time the implement is lowered completely, also considering the elastic behaviour of the coil spring.
3. The switch is reliably released as soon as the implement is raised out of the ground.

7.5.1.2 Correct Installation and Adjustment of the Implement Position Sensor (IPS)

The correct procedure is:

1. Switch the system off and secure it as explained in Switching the System On and Off.
2. Lower the implement to its working position (step A in figure below), turn the tractor off and secure it. Refer to the instructions of the implement manufacturer to know more about it.

3. Adjust the fixture of the IPS so that the coil-spring touches the upper side of the higher link of the 3-point hitch mechanism (step B in figure below). Refer to the weeding implement's manual for more details about this regulation.
4. Push the sensor further down until the coil spring makes contact with the link of the 3-point hitch and causes the internal mechanism to click (step C in figure below).
5. Push the sensor further downward for 1–2 cm.
6. Fix the sensor in this position.
7. Test the consistency of the implement position signal as explained in Inspection of the Installation for the IPS.

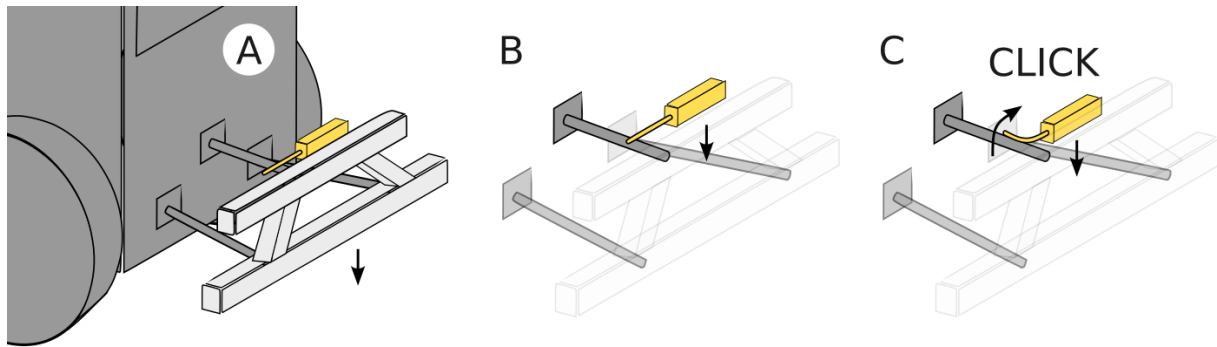


Figure 7.1: IPS installation

7.5.1.3 Inspection of the Installation for the IPS

The procedure is:

1. Start the tractor and the AgAI Vision system.
2. Raise and lower the implement and check with the Dahlia Mobile Application that the IPS behaves correctly:
 - a. The weeding implement is detected as lowered when it is in its working position;
 - b. The weeding implement is detected as raised as soon as it is raised from its working position.

See Dahlia Mobile Application for more details on how to use it.

7.5.2 Connection to the DC Power Source

The AgAI Vision system needs a 12V DC power source to work. This can come from:

- The tractor battery (see DC Power from the Tractor Battery);
- An 9-pin IBIC ISOBUS socket compliant with ISO-11783-2 (see DC Power from the Tractor ISOBUS Socket).

This is a variant of the AgAI Vision system product. Other powering solutions must be agreed with Dahlia Robotics beforehand.

7.5.2.1 DC Power from the Tractor Battery

For the battery-connection variant, AgAI Vision system kits come with an extension cable for the battery. One end is terminated with fork lugs, the other one with a waterproof receptacle.

Electrical Connection to the Battery

The electrical connection of the extension cord to the battery must respect at all times the instructions provided by the tractor manufacturer for the connection of an external device to the tractor's battery. Refer to

the weeding implement manufacturer for further assistance and use all the relevant PPEs there listed. The minimum suggestion is:

- Insulated tools;
- Protective glasses.

The steps suggested by Dahlia Robotics to connect to the tractor battery are as follow:

1. If allowed and possible, detach the ground pin of the battery, usually marked as "-" on batteries;
2. Connect the red core of the extension cord to the 12 V pin of the battery, usually marked as "+" on batteries by using the fork cable lug;
3. Connect the black core of the extension cord to the disconnected ground line;
4. Finally reconnect the ground terminal to the ground pin of the battery.
5. Check the polarity at the receptacle with a DC measurement instrument.

Fastening of the Power Receptacle

The receptacle must be fixed to the back of the tractor considering the following:

- The receptacle is fixed to the tractor (not the implement) and can remain in place even if the complete implement is removed.
- The connection to the DM power cable to the receptacle must be possible; the DM power cable is 2 m long (more details in The Components of the AgAI Vision System).
- The risk of the cable being snatched by movements of the 3-point hitch should be carefully considered:
 - Consider moving parts;
 - Consider possible changes in distances.
- The cable does not get caught in other moving tractor parts.
- The cable does not get caught in obstacles that the tractor drives over and is not subject to friction and wear.
- Use e.g. cable ties to fix the cable if necessary.

Connection of the DM to the Battery Extension Cord

The DM power cord is terminated with a special plug that is compatible with the receptacle at the end of the battery elongation cord: polarity inversion is not possible when connecting these two.

Make sure that both the terminations have their caps on when they are disconnected.

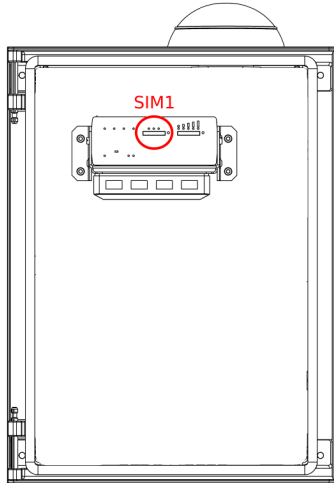


The main switch on the DM (see Distribution Module for more details) must be switched off when the connection to the tractor battery is made.

7.5.2.2 DC Power from the Tractor ISOBUS Socket

For AgAI Vision systems variants with power through ISOBUS, the DM comes with a prewired extension cord. This must be connected to the tractor's ISOBUS socket. The same suggestions of DC Power from the Tractor Battery hold for this cord.

7.5.3 Insert the SIM in the Router



The end-user must provide the SIM for data coverage. See Preparing the Product for more details about its requirements. The SIM is fundamental for the AgAI Vision system to work. It must be inserted in the SIM tray marked as SIM1 of the router that is located in the CM. The procedure is as follows:

1. Turn the AgAI Vision system OFF;
2. Open the CM with the provided key;
3. Extract the SIM tray from the Router and place the end-user-provided SIM inside of it; use the SIM adapter if needed. Details on the SIM insertion procedure are in the "Quick Installation Guide" for the router;
4. Insert the tray again;
5. Close the CM again and start the system.

7.5.4 Installation of the User Interface (UI)

7.5.4.1 Mechanical Installation

The UI must be mounted in a position that can be conveniently kept in sight by the end-user while driving the tractor. This additional control may obstruct the driver's view with its display, increasing accident risk and potential injuries. In installing the UI, adhere to country-specific regulations on visibility.

7.5.4.2 Configuration of the UI

Installation of the Dahlia Mobile App

The Dahlia Mobile App can be installed for free from Google Play Store. In order to do so, the user must possess a valid gmail account; no paid subscription is needed for that.

Connection to an AgAI Vision System

A UI can work with any AgAI Vision system that the logged-in user has access to (i.e. that he has bought): any AgAI Vision system owned by the same user can be controlled by any UI on which the user is logged in; there is no 1-to-1 link between the AgAI Vision system and the control UI.

The procedure for login is as follows (see Dahlia Mobile Application for details):

1. In the "login page", login in the Dahlia Mobile app with the credentials provided by Dahlia Robotics. This step is usually only needed once: the user will not be logged out automatically.
2. Make sure that all of the following conditions are respected:
 - a. The tablet's WiFi is turned on;
 - b. The tablet is connected to the WiFi generated by the desired AgAI Vision system: the WIFI name is the same as the machine's, e.g. AV000023.
3. In the "System Selection page", select the desired System and press on "Connect".
4. The connection should be established automatically and its status will be shown in the "Connection page".



Once a system has been selected and connection was established, the UI will automatically try to reconnect to it by default. To select another system, return to the connection page. Should the connection not happen automatically, contact the technical support.

7.5.5 Configuration of the NTRIP Client

The configuration of the NTRIP Client happens on the Dahlia Mobile App, in the NTRIP Configuration Page. The user must enter the data provided by the NTRIP service provider; more details about this data are available in Registration to a Local NTRIP Provider.

This configuration needs to be performed once before the first use; it must be repeated only if changes to the Client are needed.

Details on the NTRIP Configuration Page of the app can be found in NTRIP Configuration.

7.5.6 Mechanical Adjustments

These adjustments must be reflected in the app, in Advanced Settings.

7.5.6.1 Adjustment of the Height of WMs

Modifications to the WM Fixtures

The height over the ground of WMs shall be modifiable to different levels by acting on their fixtures. Details of how to do that must be provided by the manufacturer of the weeding implement.

The main reason for a modification to this setting is the need to use the same complete implement on different crops of significantly different dimensions (both width and height): for details, see System Accuracy. These changes must be reflected in the Dahlia Mobile App. The procedure is:

1. Make sure that the system and the tractor are both turned off;
2. Follow instructions from the manufacturer of the weeding implement concerning the height regulation.
3. Measure the new regulation heights: it is the distance between the ground level and the lower surface of WM when the AWTs are in their working condition (as defined by the manufacturer of the weeding implement). See Height Adjustment of the WM to know more about its reference surface. A level of accuracy of +/- 2 cm is enough.
4. At the first occasion, enter these values in the Dahlia Mobile App; once saved, they will be stored until edited again.

Other Means

The height of the WM over the ground can be influenced by changes in the depth of soil-engaging tools (such as the active blades or other passive hoes or similar tools), for example by means of height-adjustable support wheels. Details of how to do that must be provided by the manufacturer of the weeding implement. Such changes must also be reflected in the app, considering the requirements stated in System Accuracy.



If changes to the WM height are not reflected in the app, the system's performances will degrade. Mismatches between the real WM's height and its app-stored value that are smaller than 5 cm will not produce any noticeable loss of performance.

7.5.6.2 Changes to the Number of WMs

In case the same equipment is used on crops with different numbers of rows, the unutilised WMs must be excluded from the system. To do so:

- Power the unused WMs down:
 - Turn the system OFF (see Switching Off and Securing the System);
 - disconnect the power cable that goes to that module,
 - fix it so that it cannot get damaged and seal it off with the corresponding cap (more details in Spare Parts and Tools);

- Seal off the corresponding socket as well with its lid (part of the socket).
- Reflect WMs selection in machine configuration:
 - Start the system anew;
 - In the “Module Selection page” on the Dahlia Remote app, unselect the WMs that have been deactivated. More details are in Module Selection Page.



Running an AgAI Vision system with wrongly configured WMs might lead to erratic behaviour, compromising the weeding performances as well as the overall machine safety.



In case WMs are removed from the weeding implement and later mounted back into it, they will have to be mounted back in the same original order, lest the system’s behaviour be erratic. Please consider:

- Prefer switching WMs and leaving them on the weeding implement, if possible;
- Mark every WM when it is removed;
- Turn to the machine manufacturer for help in case WMs have been confused.

WMs numbering is progressively increasing from left to right (see Figure below).

7.5.6.3 Changes to the Lateral Spacing of WMs

The main reason for a modification to the lateral spacing of WMs is the use of the same combined machine on crops with different row distances: the former must reflect the latter. The maximum deviation between the centres of a row and of the overlooking WM is reported in WM Position Specifications.

In case of changes to the position of the WMs, these must be entered in the Advanced Settings of the Dahlia Mobile App: see Advanced Settings for details. Every new disposition of WMs must be described using two parameters (see figure below for details):

- The Y position of WM3 (main module), i.e. YWM3: it is the distance between the baselink (its definition follows) and the centre of WM3; the sign is positive when the latter is more to the left than the former, as in the figure below;
- the lateral spacing of WMs, i.e. WWM: it is the distance between two subsequent WMs, which must reflect the crop row distance in the target field.

Details of how to perform the change mechanically must be provided by the manufacturer of the weeding implement. In case an unequal spacing of rows is needed, please contact Dahlia Robotics.

Definition: Baselink

The baselink is the reference point for all measurements on the complete implement. It is defined by the machine manufacturer (see their Operator’s Manual) and must be clearly marked on the frame. The baselink is usually defined to be:

- In the mid plane of the the side-shifted section of the weeding implement;
- On the top of the profile of the structural beam.

An example is provided in the following figure.

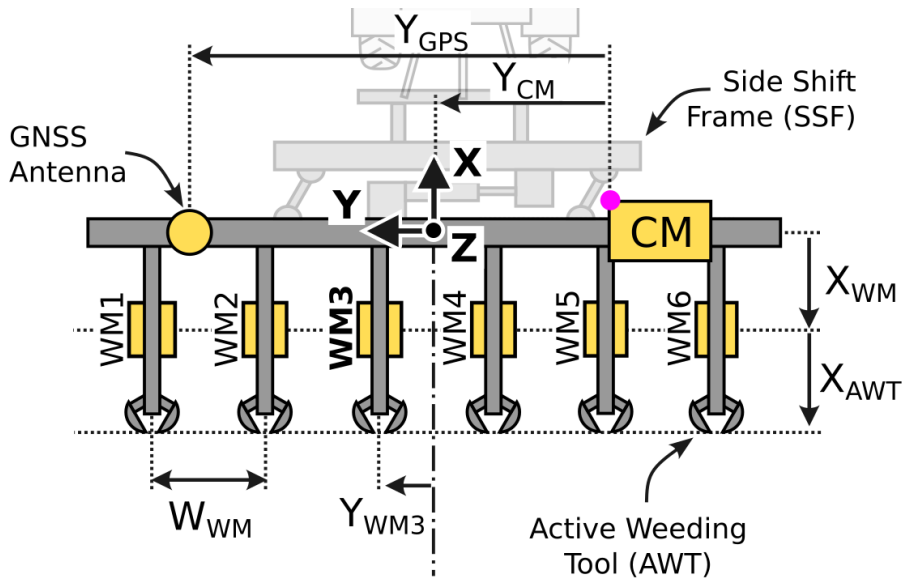


Figure 7.2: Definition of Baseline

i The main WM is WM number 3 even when WM3 is not present: in such case Y_{WM3} cannot be directly measured but must be calculated from the closest existing module, for example WM2: $Y_{WM3} = Y_{WM2} - W_{WM}$, where Y_{WM2} is the Y position of WM2.

! If changes to the lateral disposition of WM are not reflected in the Dahlia Mobile App, the system's behaviour might be erratic, with consequent deterioration of safety and performances.

7.5.7 System Software Settings Update

7.5.7.1 System Software Settings

Any changes to the following physical system properties will have to be reflected in the software state with the Dahlia Mobile App.

#	Physical property	Requires software changes	App page
1	Camera height	If the difference between real and registered height is greater than 5 cm.	Advanced settings
2	Row-crop distance & main module position	Every time any of the two is changed.	Advanced settings / machine geometry
3	Crop plant	Every time a new crop is weeded.	Settings

7.5.7.2 Set Crop Plant

The AgAI Vision system is based on a suite of state-of-the-art machine vision algorithms. Different algorithms must be used for different crop plants so that a mismatch can seriously hamper the functionalities of the system. The size of plants can also play a role in the performance of the system. A list of the supported crop plants can be known by contacting Dahlia Robotics.

Make sure that:

1. The correct algorithm is selected for the desired crop; this can be done in Settings Page.

2. The crop plants are being recognised stably by the algorithm: check the live-view of cameras on the Dahlia Mobile App and make sure that all plants are recognised. In case the images are too dark, consider starting the LEDs by activating automatic mode.



Failure to reflect in the Dahlia Mobile App any change to the above working conditions will lead to degradation of system performances.
Consult the technical support to know what crops are supported and how to use them at best.

7.5.8 Transport to and from Field on Public Roads

During transportation of the system on public roads, the system must satisfy the relevant road circulation regulations for the country of use. Every time before driving to or away from the site of use of the system, the operator must make sure that:

- The AgAI Vision system is turned off;
- The SSF is centred.

Refer to Weeding Page to know how to centre the SSF.

7.5.9 Software Updates

7.5.9.1 Updates to the AgAI Vision System

Software updates for a purchased AgAI Vision system will be made available by Dahlia Robotics. The download and installation of the same will be managed by Dahlia Robotics technicians.

7.5.9.2 Updates to the Dahlia Mobile App

Software updates for the Dahlia Mobile App will be made available by Dahlia Robotics on Google App Store.

8. Operation

8.1 Status Light Coding

The status light on the DM (see Distribution Module for more details) is used to remind the user and the third parties about possible hazards and reflects the position of the implement. It has three possible states:

- No light (lamp off): the system is not powered;
- Solid yellow light: the system is ON and the implement is raised;
- Flashing yellow light: the system is ON and the implement is lowered.

The flashing light is used to attract the attention of the user, since active blades could potentially move only when the implement is detected as lowered.



In case the status light does not correspond to the behaviour reported above, check the IPS; if the problem persists, stop operations, turn the AgAI Vision system off and contact technical support.

8.2 Standard Operating Modes

8.2.1 Software Modes

The AgAI Vision system has two main software-defined operating modes, i.e. manual and automatic mode:

- Manual mode is the default mode of the system, in which AWTs are deactivated. It is used for preparations for weeding operations such as software parameters tuning and manual centering of the SSF.
- Automatic mode: it is the mode in which the AgAI Vision system performs the weeding, with automatic actuation of the SSF and the AWTs and operation of the LED in the active vision system. Automatic mode is only allowed when the system is apt for weeding, that is when the implement is lowered and no errors are detected by the diagnostics.

8.2.2 Other Influencing Factors

The expected behaviour of the complete implement in both Manual and Automatic mode is determined in conjunction with three other factors:

- System diagnostics state: it is determined by the automatic software checks that monitor the state of the system at all times. Four states are possible, see Diagnostics Page.
- Implement position: it is determined by the implement position switch located in the area of the highest joint of the three point hitch mechanism. Two possible states are possible:
 - Implement raised: the soil-engaging parts of the implement are out of the ground in mid air;
 - Implement lowered: the lifting mechanism of the 3-point hitch has been released, the implement rests on its supports wheels and all blades are in the soil.
- Tractor speed: it is measured with the RTK GPS signal. Two possible states are used:
 - The tractor is standing still (null speed);

- The tractor is moving (at any speed, in any direction).

8.2.3 Expected System Behaviour

8.2.3.1 Manual Mode

Following is an overview of AgAI Vision system behaviour in manual mode; tractor speed is not shown as it does not play any role in the determination of the behaviour. Manual mode is always possible.

Case	Implement position	Diagnostics	Side-shifter motion	AWTs motion	LED illumination
1	Raised	OK / WARN	Manual control allowed	Motion disabled	Manually toggleable
2	Raised	ERROR / IDLE	Depends on error	Motion disabled	Depends on error
3	Lowered	OK / WARN	Motion disabled	Motion disabled	Manually toggleable
4	Lowered	ERROR / IDLE	Depends on error	Motion disabled	Depends on error

8.2.3.2 Automatic Mode

Automatic mode cannot be activated when:

- The system diagnostics is in ERROR or IDLE state;
- the implement is raised.

In case automatic mode is active and these events happen:

- Implement is raised: manual mode is automatically enforced;
- An error occurs:
 - The end-user is informed with the error popup screen (details in section "Error Popup Window") and sound notifications;
 - The AWTs are blocked open but the SSF continues working; this way the least damage to the crop plants is made.

In the following table, impossible combinations are not reported.

Case	Implement position	Tractor speed	Diagnostics	SSF motion	AWTs motion	LED illumination
1	Lowered	0	OK/ERROR	Motion disabled	Motion disabled	ON
2	Lowered	>0	OK	Automatic control	Automatic control	ON
3	Lowered	>0	ERROR	Automatic control	Motion disabled	ON



In case an error occurs during automatic mode, the system might behave erratically: it is best to stop the tractor at once, deactivate automatic mode and refer to the diagnostics for details on the error and how to resolve it.

8.2.4 Mode Transitions

It is always possible to transition from automatic mode to manual mode. In case the implement is raised, manual mode will be automatically enforced.

It is only possible to transition from manual mode to automatic mode if the system has no errors and the implement is lowered.

8.2.5 Self Test Function

Self test function is an advanced test condition in which:

- the AWTs are toggled with a frequency of 5 Hz;
- The LEDs are strobed.

The mode can be toggled with the toggle button on the Advanced Settings page. It can be activated at all times at a system level but only WMs that have correctly booted will behave accordingly. The same restrictions specified in Expected System Behaviour hold, in that the AWTs will not move if the implement is raised.



The self-test function should only be used for the purpose of checking the integrity and correctness of system functions. It is not by no means indicated for other purposes than that, such as (the list is by no means exhaustive):

- Cleaning the blades;
- Lighting the soil up;
- Performing weeding without using automatic mode.



During execution of self-test, the operator must make sure at all times that:

- He fulfills all the safety requirements from the machine manufacturer;
- Unauthorised people do not enter the hazard area.

In emergency cases, auto mode can be stopped with the E-stops on the implement or by interrupting the supply of hydraulic fluid to the combined machine.

8.3 Fieldwork

The order of operations to follow for field work is reported here. The details for each operation follow in the text. These steps must only be performed when on the target field.



The system must be turned off and the SSF must be centred when the combined machine is transported on public roads. The road traffic regulations must be adhered to at all times by the end-user under his/her full responsibility.

#	Operation	Performed when	Required implement position	Hydraulic pressure
1	Switching the AgAI Vision system on	After reaching the target field	Raised	Off
2	Centering on the crop rows	At start of pass	Raised	On
3	Automatic weeding	During pass	Lowered	On
4	Setting up for the next pass	At start of pass	Raised	On
5	Switching the AgAI Vision system off	Before leaving the field	Raised	Off

8.3.1 Switching On

Refer to Switching the System On to know how to start the system. Wait for it to boot completely, i.e. for the IDLE state not to be shown anymore in the diagnostics of the Dahlia Mobile App. The diagnostics will eventually turn into one of the following states:

- ERROR state: refer to Troubleshooting.
- WARN state: the system is able to work but it will do so in a suboptimal way — refer to the diagnostics messages to know how this can be improved.

- OK state: the system is running in optimal conditions.

The rest of this section is only possible if the AgAI Vision system is turned on and running in WARN or OK state.

8.3.2 Selecting the Correct Crop

The same AgAI Vision system can be used on different crops so it is important to choose the right crop every time before weeding. This is done in Settings Page of the Dahlia Mobile application.



When selecting a new crop for the first time ever, the system might take up to 5 minutes to apply the change. This wait time is a one-timer: after the first time, any change between crops will happen in few seconds.

8.3.3 Centering on the Crop Rows

The procedure is as follows:

1. Determine a set of rows to weed.
2. The implement is raised.
3. Drive the tractor on the rows so that the implement is roughly aligned with the rows. Small angles or lateral offsets are anyway managed by the SSF but its maximum stroke must be considered. This value is specified by the machine manufacturer.
4. Give pressure to the hydraulic circuit of the weeding implement.
5. In the Weeding page on the Dahlia Mobile app, use the live-view from cameras to centre the SSF exactly on the rows (± 2 cm is fine).
6. Lower the implement to its working position.

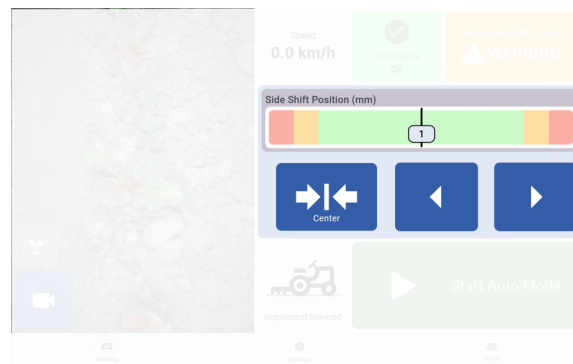


Figure 8.1: Centering on crop rows

8.3.4 Automatic Weeding

The procedure is as follows:

1. Make sure that the cameras in all WMs have a clear view of their rows and that their protective windows are not dirty.
2. Make sure that the crop plants are being recognised stably by the algorithm in the live-views of the cameras available on the Weeding page of the app. If they are not:
 - a. Make sure that the visibility of recognised crop plant centrepnts is activated (see Weeding Page);
 - b. Consider starting the LEDs to brighten up the images: do that by activating automatic mode in the Weeding page of the app;

- c. Check that the correct algorithm for the crop plants was selected in the Setting page;
 - d. Check that the height of WMs over ground is within specifications (see Height Adjustment of the WM);
 - e. Check diagnostics and call customer support.
3. Make sure that the hazard area is clear of obstacles and people.
 4. Activate Automatic mode on the Weeding page in the app.
 5. Start driving along the rows while keeping roughly aligned with them.
 6. Keep the Dahlia Mobile App on the Weeding page and check that the recognition performances of the cameras are satisfactory at all times.

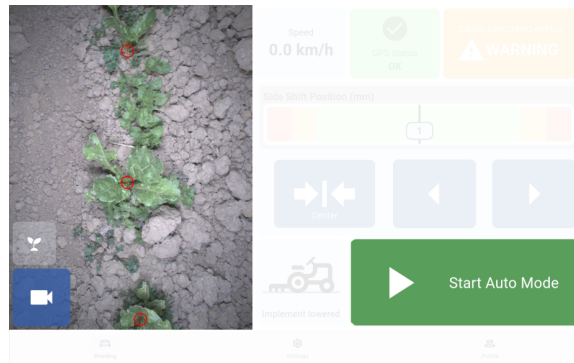


Figure 8.2: Automatic weeding operations



The operators must always make sure that the hazard area is clear of obstacles and people before automatic mode is activated. If any obstacle or person enters it when automatic mode is activated, turn it off, stop the tractor and bring the complete implement to a safe state.



It is strongly recommended to check the performances after the first few meters of weeding on a new crop, a new field or on a new day. If needed, all relevant software (safety zones, WMs' height) and hardware parameters on the AgAI Vision system shall be modified before resuming operations as detailed in this manual and in the manual provided by the machine manufacturer.

8.3.5 Setting up for the Next Pass

The procedure is as follows:

1. At the end of the field, stop automatic mode (to resume manual mode) and raise the implement.
2. Turn into the next rows to weed and repeat all operations in Centering on the Crop Rows.
3. Repeat the procedure detailed in Automatic Weeding.

8.3.6 Switching Off

Once weeding operations are concluded and before the complete implement can be transported away from the field, the following steps must be followed:

1. Raise the implement and centre the Side Shifter Frame using the Dahlia Mobile App.
2. Turn the AgAI Vision system off by deactivating the main switch.
3. Turn the UI off.

8.3.7 Night Time Operations

The system is suited for night time operations and these can be carried out exactly as explained above.



In the absence of background illumination, the impulsed lights might pose a risk for people with photosensitive epilepsy. This system is not suited for operators belonging to that category. Moreover, the use of additional sources of light — like a headlamp and/or the tractor's lamps — is suggested for all operations that require inspection of the weeded area during night-time, so as to reduce the contrast between the flashing lights and the dark background and the resulting stress on the eye.

9. Troubleshooting

9.1 In Case of Damages

In case of damages to the hardware of the AgAI Vision system, the operator must stop the system, contact the Dahlia Robotics and stick to their indications. If the system is not in warranty or has been used in ways that are not allowed in this Operator’s Manual, the costs of reparations will be on the end-user.

9.2 Faults Overview

#	Fault	Possible Causes	Possible Remedies	Refer to Section
1	The status light remains OFF when the main switch is turned ON	The emergency buttons are pressed.	Release the emergency buttons.	Emergency Stops
		The connection to the DC power source is damaged / wrong.	Check the extension cords and their extremities.	Connecting Wires / Connection to the DC Power Source
2	The UI does not turn on.	The batteries of the User Interface are empty.	Connect the UI to power. Read the User Manual of the UI for more info.	User Interface
3	The UI cannot find the AgAI Vision System	The AgAI Vision system is OFF.	Turn the Main Switch ON.	Switching the System On
		The UI is connected to the wrong WiFi.	Connect to the right WiFi.	-
		The AgAI Vision system was not configured before.	Contact support.	Configuration of the NTRIP Client
		The AgAI Vision system does not provide WiFi.	Check the power cable of the CM. Check the corresponding fuses and the circuit breakers in the DM.	Central Module (CM) / Management of the Electrical Safety Elements
		Other.	Restart the User Interface. Restart the AgAI Vision system.	Switching the System On and Off
4	The diagnostics shows an ERROR state.	Multiple causes possible.	Check the details of diagnostics to find more instructions.	Use of the Control Application
5	The position of the implement in the app is not consistent with its actual position	The IPS is not correctly installed.	Correctly install the sensor.	Regulation of the Implement Position Sensor (IPS)
6	The UI does not display the images from one or more WM	The WM has been turned OFF on purpose (not in use for a particular field setup).	Nothing to do: correct state.	System Software Settings Update

#	Fault	Possible Causes	Possible Remedies	Refer to Section
		The WM's power and/or data connections are faulty.	Check the power and the data connection between DM and WM.	Connecting Wires
		A fuse has been blown in the DM.	Check the corresponding fuses in the DM.	Management of the Electrical Safety Elements
		Other	Restart the AgAI Vision system.	-
7	The image quality from WM cameras is bad.	The protective window is dirty.	Clean the protective window.	Maintenance Intervals Overview
		The protective window is damaged.	Inspect the protective window first, call assistance only if substitution is needed.	-
8	The plants in the image are not stably recognised: no marks on the plants' centres.	The red markers that indicate the centre of detected crop plants are disabled.	Toggle the visibility of the output of the recognition algorithm.	Weeding Page
		The wrong crop was selected in the settings.	Choose the correct crop. Contact support if this crop is not available.	Set Crop Plant
		The crop plants are overgrown by weeds.	Operating out of system's specification. Move to a less weedy area.	Accuracy of the Crop Plant Detection
		Crop plants are too big: close to the cameras or wider than the picture.	Set an adequate, greater height over ground for the WMs.	Accuracy of the Crop Plant Detection
		Crop plants are too small and not visible in the images.	Set an adequate, lower height over ground for the WMs. Wait for plants to grow more. Contact support for new algorithms.	Accuracy of the Crop Plant Detection
		Operating speed is too high.	Moderate the operating speed.	Accuracy of the Crop Plant Detection
		The crop plants have an unusual morphology / are covered up by soil.	Try on a different spot. Check the output from other WMs.	Accuracy of the Crop Plant Detection
		The crop plants are otherwise out of specifications.	Check specification, move onto plants that satisfy them.	Accuracy of the Crop Plant Detection
		The illumination of the image is insufficient.	Activate the LED lights. Clean the protective windows.	Maintenance Intervals Overview
9	The weeds in the image are recognised as plants.	The wrong crop was selected in the settings.	Choose the correct crop.	Set Crop Plant
		The weeds look very similar to the crop.	Contact support.	-

#	Fault	Possible Causes	Possible Remedies	Refer to Section
10	Bad GPS signal quality.	Bad GPS reception: high objects (like trees or buildings) obstruct the GNSS antennae.	Move away from obstacles.	Field Specifications
		No internet connection: this is visible in the diagnostics.	Move to a part of the field with better reception. See fault 23.	Field Specifications
		The antennae are damaged or not correctly connected.	Check the antennae and the connection to them.	GNSS Antennae
		There is no signal from the RTK-GPS provider: this is visible in the diagnostics.	Contact your provider of RTK service.	-
11	The side shift frame cannot be moved manually.	The implement is lowered.	Raise the implement.	-
		Insufficient or no supply of hydraulic fluid from the tractor.	Provide pressure from the tractor. Check hydraulic connections.	-
		The SSF reached a dead end.	Move away from the dead end.	Centering on the Crop Rows
12	The SSF and/or the AWTs move too slowly.	Insufficient or no supply of hydraulic fluid from the tractor.	Check the specifications from the machine manufacturer.	-
		Other.	Contact assistance.	-
13	The Dahlia Mobile Application does not respond to commands	Application has jammed.	Close the application and start it anew.	-
		The UI has frozen.	Brute force restart the UI, see its user manual.	-
14	Automatic mode cannot be started	The implement is raised.	Lower the implement.	-
		There is an active error in the diagnostics.	Refer to the error message and resolve the error first.	Settings Page
15	The LEDs do not emit light when they should.	The power cable to WM is damaged.	Check the integrity of the cable.	Connecting Wires
		A circuit-breaker in the DM has opened the circuit.	Reset the circuit breaker.	Management of the Electrical Safety Elements
		Other	Power-cycle the system. If persistent, call support.	-
16	AWTs do not move in automatic mode	Insufficient or no supply of hydraulic fluid from the tractor.	Provide fluid as specified in the complete implement's manual.	-
		The plants are not stably recognised.	Check the output from the cameras of WMs.	Accuracy of the Crop Plant Detection
		An error has occurred during weeding.	Refer to the error message and resolve the error first.	Settings Page

#	Fault	Possible Causes	Possible Remedies	Refer to Section
		Early-stage plant protection is active and no plants are detected.	Intended behaviour: turn the protection OFF if not needed.	Advanced Settings
		The coil cable is unplugged.	Plug the coil cable back in.	Weeding Module (WM)
		A circuit-breaker in the DM has opened the circuit.	Reset the circuit breaker.	Management of the Electrical Safety Elements
17	AWTs remain closed in automatic mode	Plants are not detected	Check the output of the WM's cameras.	Diagnostics Page
		Insufficient or no supply of hydraulic fluid from the tractor.	Provide fluid as specified in the complete implement's manual.	-
18	The AWTs move during manual mode	Self-test function is active	Stop the self-test function.	Self Test Function
		The coil plugs are not stably connected.	Check the connection of the coil plugs.	Weeding Module (WM)
		Other	Contact support.	-
19	The SSF does not follow the crop rows in automatic mode	Rows are out of specs (zig-zag, curve)	Move onto rows that satisfy the specifications.	Accuracy of the Crop Row Detection
		The SSF has reached the end of its stroke.	Recenter manually the SSF. Drive more precisely along rows.	Centering on the Crop Rows
		Insufficient or no supply of hydraulic fluid from the tractor.	Provide fluid as specified in the complete implement's manual.	-
		Plants are not stably recognised.	See fault 8.	-
		Misconfiguration of the implement geometry in the app.	Perform configuration anew.	System Software Settings Update
		More crop rows are visible in the image of one WM.	Reduce WM's height.	WM Position Specification
		Some WMs are not used (more WMs than crop rows) but have not been unselected.	Check that unused WMs are actually unselected in the Module Selection page.	Module Selection Page
20	The AWTs are not accurately weeding around plants positions	Plants are not stably recognised.	See fault 8.	-
		The wrong plant safety zones have been selected.	Perform a tuning of safety zones.	Settings Page
		The geometry of the machine is not reflected in the app.	Check WMs' heights. Check implement geometry.	Mechanical Adjustments
21	Plants are systematically chopped in automatic weeding mode	Plants are not stably recognised.	See fault 8.	-
		Plant safety zones are too tight.	Increase plant safety zones.	Settings Page

#	Fault	Possible Causes	Possible Remedies	Refer to Section
		AWTs are too slow.	Double check implement's requirements for hydraulics. Moderate the operating speed.	-
22	Automatic weeding mode deactivates itself on its own.	The implement has been raised.	Correct default behaviour.	-
		An error has occurred.	Correct default behaviour.	-
		The implement is not completely lowered.	Lower the implement completely.	-
		The IPS is wrongly installed.	Perform installation anew.	Regulation of the Implement Position Sensor (IPS)
23	The AgAI system cannot connect to internet (diagnostic error)	There is no internet coverage in situ.	Check internet coverage with another means, like a cellphone.	-
		The SIM card has been inserted in the wrong slot on the router.	Move the SIM into slot "SIM1".	Insert the SIM in the Router
		The SIM card has been wrongly setup.	Check the PIN inserted in the "SIM card" menu in settings.	SIM Card Settings
24	The diagnostics reports about some WMs not being available.	Some WMs are enabled (i.e. expected) but not active (i.e. not found).	Check that all enabled WMs are actually active in the Module Selection page.	Module Selection Page / Changes to the Number of WMs
			Check that only needed/present WMs are actually enabled.	-

10. Maintenance

10.1 Maintenance Intervals Overview

10.1.1 Every 10 Operating Hours or Daily

Maintenance work to be carried out	Reference
Clean the protective windows of WMs.	Cleaning the Protective Windows of WMs
Clean the area around the IPS and the correctness of its installation.	-
Check if the User Interface is dirty.	Cleaning the User Interface
Check if all electrical connectors fit correctly.	-

10.1.2 Every 100 Operating Hours or Monthly

Maintenance work to be carried out	Reference
Clean the area surrounding connectors of all components.	Cleaning the Electronic Connectors
Check the strain relief of all connectors.	-
Check all cables for damage, especially the power cables.	-
Clean the area surrounding the hydraulic valve connectors.	-
Check the tightening of the screws on the lower surface of WMs.	-

10.2 Management of the Electrical Safety Elements

The electrical safety elements are located in different positions in the system and might need actions from the user from time to time. They are all of the same form factor, namely ISO 8820-3 mini blade.



The system must be turned off before any of the following actions can be undertaken.

10.2.1 Electrical Safety Elements in the DM

The enclosure can be opened with the dedicated key (see Distribution Module and Central Module for more details). Details about the number and type of elements are reported in the next table.

Element	Size	Quantity	Location	Function	Label	Cause	Action
Fuse	2 A	1	Terminal block	Power-on signal for the safety relay	ON SIG REG	Short circuit	Substitute
		1		Protect status light	STAT LIGHT		
		1		Protect Ethernet switch	ETH SWITCH V+		
Fuse	3 A	1	Terminal block	Protect 12 V supply to CM	CM LOG	Short circuit	Check cables and substitute
		2-6		Protect supply to WMs	WMx LOG*		
Diode	1 A	1	Terminal block	Inverse polarity protection	ON SIG	Overcurrent	Check cables and substitute
		1		Protect 12 V supply	HYD SHUT -		
Circuit breaker	5 A	1	Terminal block	Protect 12 V supply to CM	CM PWR	Over consumption	Check cables and restore with screwdriver
		1		Protect relief valve	HYD SHUT +		
		2-6		Protect 12 V supply to WMs	WMx PWR*		

- x stands for the number of the WM and goes from 1 to 6.

Details about the disposition of the safety elements within the terminal block are available in the next table, which is also reported in DM, on the internal side of the door. The table must be read keeping in mind that:

- Each 2-cell slot represents a contact of the fusemount;
 - The first cell in each slot indicates the used protection;
 - The second cell in each slot indicates the function of the contact.
- The disposition of slots reflects the layout on the fusemount as seen from an observer of the DM.

2 A FUSE	ON SIG REG	5 A CIRC BRK	WM 6 PWR	3 A FUSE	WM 6 LOG	5 A CIRC BRK	HYD SHUT +	2 A FUSE	ETH SWITCH +
1 A DIODE	ON SIG	5 A CIRC BRK	WM 5 PWR	3 A FUSE	WM 5 LOG	5 A CIRC BRK	WM 4 PWR	3 A FUSE	WM 4 LOG
2 A FUSE	WARN LGHT	5 A CIRC BRK	WM 2 PWR	3 A FUSE	WM 2 LOG	5 A CIRC BRK	WM 3 PWR	3 A FUSE	WM 3 LOG
1 A DIODE	HYD SHUT -	5 A CIRC BRK	CM PWR	3 A FUSE	CM LOG	5 A CIRC BRK	WM 1 PWR	3 A FUSE	WM 1 LOG

The actual position of the fusemount in the DM is visible in the image below, marked in red.

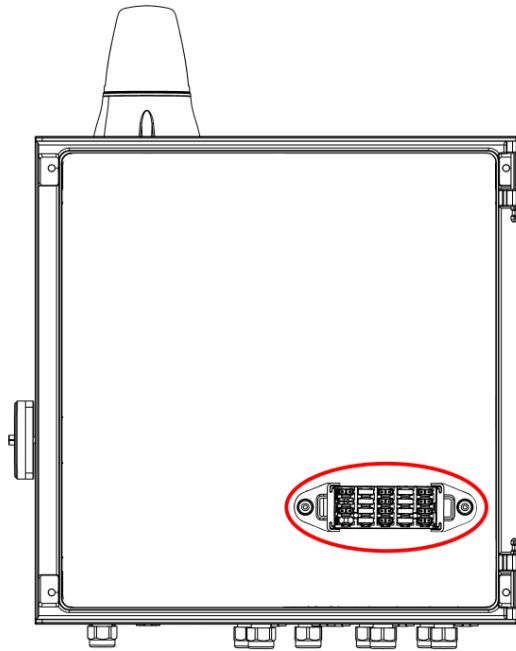


Figure 10.1: DM fuse location

10.2.2 Electrical Safety Elements in the WM

The fuse in the WM can be exposed by opening its lid with a Torx screwdriver size T25. In case the swing door of the WM cannot be opened because of other parts being in the way, it might be necessary to remove it from its support. Before doing that, unplug all cables from it. The fuse is mounted on the PCB on the internal side of the cover lid.

Element	Specs	Quantity	Location	Cause	Action
Fuse	ISO 8820-3 mini blade, 3A	1	Hydraulic tool PCB	Short circuit in the coil	Substitute

10.3 Cleaning



Inadequate cleaning of the components may lead to damages.

10.3.1 Cleaning the User Interface

In order to clean the User Interface:

- Switch off the Main Switch of the AgAI Vision system and secure the tractor implement.
- Clean the User Interface with a moist cloth.
- Do not use a high-pressure water jet.
- Do not use abrasive, aggressive or scratching cleaning agents.
- Ensure that water does not enter the User Interface.

10.3.2 Cleaning the Protective Windows of WMs

In order to clean the protective windows of WMs:

- Switch off the Main Switch of the AgAI Vision system and secure the tractor implement.

- Clean the protective windows of WMs with a moist cloth.
- Do not use a high-pressure water jet.
- Do not use abrasive, aggressive or scratching cleaning agents.

10.3.3 Cleaning the CM and DM

In order to clean the Central Box or the Distribution Box:

- Switch off the Main Switch of the AgAI Vision system and secure the tractor implement.
- Clean the Central Box or the Distribution Box with a moist cloth.
- Do not use a high-pressure water jet.
- Do not use abrasive, aggressive or scratching cleaning agents.

10.3.4 Cleaning the Electronic Connectors

In order to clean an electronic connector:

- Switch off the Main Switch of the AgAI Vision system and secure the tractor implement.
- Make sure that the electronic connector is either plugged in or covered by its protective cap.
- Clean the external part of the electronic connector with a moist cloth.
- Do not use a high-pressure water jet.
- Do not use abrasive, aggressive or scratching cleaning agents.

11. Putting out of Operation and Disposal

11.1 Disposal Procedure

At the end of life of the AgAI Vision system, the system should be disassembled from the complete implementation. This can be done by using standard tools with usual personal protective equipment.

The dismantled parts should be given to a recycling facility which can deal with electronic scrap. If appropriate, the European waste numbers to be used are:

- 20 01 40 for metal and
- 20 01 36 for electronic scrap.

No hazardous materials have been used for the AgAI Vision construction.

The AgAI Vision system must not be disposed into the environment or in the general household waste. Always follow the local regulations for the disposal of industrial waste.

12. Technical Terms and Abbreviations

12.1 Units

All utilised units are according to the The International System of Units (SI).

12.2 Common Terms

Short form	Meaning
The weeding implement	The tractor-mounted, hydraulically-controlled weeding implement in which the AgAI Vision system is to be incorporated.
The complete implement, the combined machine	The machinery resulting from the incorporation of an AgAI Vision system into a weeding implement.

12.3 Abbreviations

Abbreviation	Description
CM	Central Module
DM	Distribution Module
WM	Weeding Module
AWTs	Active Weeding Tools
SSF	Side Shift Frame
IPS	Implement Position Sensor
App	Dahlia Mobile Application
UI	User Interface
FOV	Field of View (of the camera)
FOVx	Length of the Field of View in travel direction
FOVy	Width of the Field of View in transverse direction
E-stop, E-button	Emergency stop button
max.	Maximum
min.	Minimum
I.e.	That is
W.r.t.	With respect to
BOM	Bill of Material
HW	Hardware
SW	Software
SN	Serial Number

13. Limitations of Liability

13.1 Liability Statement

Dahlia Robotics is not liable for any direct, indirect or consequential loss or damage to people or property, including loss of revenues, increase in costs, loss of income or reputational damages caused by or arising in connection with the AgAI Vision system or its use.

Dahlia Robotics is not liable for any direct, indirect or consequential loss or damage to people or property, including loss of revenues, increase in costs, loss of income or reputational damages caused by or arising in connection with the AgAI Vision system or its use if the AgAI Vision system has been repaired, modified, or has undergone alterations or replacements not explicitly detailed in this Operator's Manual or performed by personnel not authorised by Dahlia Robotics.

The limitation of liability described herein does not apply in the event of intent or gross negligence on the part of Dahlia Robotics. This provision does not exclude liability to the extent that the liability of Dahlia Robotics cannot be limited or excluded by law.

Dahlia Robotics makes no implied or explicit representation as to the minimum performance level of the AgAI Vision system in the context of its intended use.

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