



**OPERATOR REFERENCE
MANUAL**
HARVEST VEHICLE HV-100



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Safety

To avoid serious personal injury or damage to the HV-100, please read all instructions before attempting to operate the HV-100. Please note that the following residual hazards remain as further safety mechanisms would interfere with proper HV-100 function.

	WARNING	Lifting Hazard: The HV-100 weighs approximately 105 lbs (48 kg). Single Person Lift may cause back injury or muscle strain. Use assistance when lifting.
	WARNING	Clamping/Collision/Entrapment Hazard: HV-100 may grip, move or collide with persons or objects inside bed. Do not stand in front of an operating HV. Pull flag before servicing.
	WARNING	Pinch Point Hazard: Keep hands and fingers clear of the manipulator while in motion.
	WARNING	Electrical Shock Hazard: Remove batteries before servicing.
	NOTICE	Washing HV-100 with a high pressure hose may cause damage. Do not pressure wash. Ensure that the battery box is closed and latched during cleaning.
	NOTICE	The HV-100 must always be secured during transport.

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HV-100 Identification

A robot identification label is located on the manipulator side of the electronics box (Figure 1).



Figure 1: Robot Identification Label

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HV-100 Product Description and Intended Use

The HV-100 is an autonomous mobile robot intended for use as a plant-container mover in both indoor and outdoor environments. The HV-100 is rated for use in temperatures between 32 F and 110 F (0 to 43 C). The A-weighted emission sound pressure level is less than 70 dB(A).

You can gain access to the User Interface (UI) from the rear of the robot and can make adjustments to the manipulator from the front of the robot.

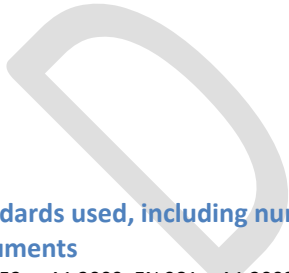
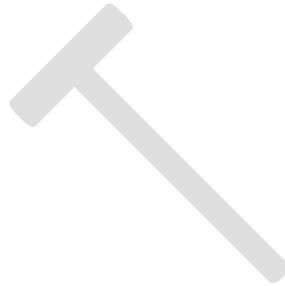
These use restrictions apply:

- Do not ride on the HV-100
- Do not step on the HV-100
- Only operate the HV-100 under the conditions and parameters specified in the HV-100 Operator Reference Manual
- Do not attempt to exceed the maximum weight lift limit of the HV-100 (22lb, 10kg)
- Always ensure that the Boundary Tape is in place prior to operating the HV-100
- HV-100 operator to provide warning signs at all approach angles to the designated working area to warn of the use of automated equipment inside the robot's operating bed
- The HV-100 weighs approximately 105 lbs (48 kg). Do not attempt to lift the HV-100 individually – use a minimum of two people to lift it
- Ensure that only trained and authorized personnel operate the HV-100
- Do not use the HV-100 in an environment with an explosive atmosphere

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Standards used, including number, title, issue date and other relative documents

EN 953: + A1 2009; EN 981: +A1 2008; EN ISO 12100: 2010; EN ISO 13732-1: 2006; EN ISO 13849-1: 2008; EN ISO 13849-2: 2008; EN ISO 13850: 2008; EN ISO 13857: 2008; EN 14892: 2009; EN 55011: + A1 2010; EN 60204-1: + A1 2009; EN 61000-4-2: 2009; EN 61000-4-4: + A1 2010; EN 61000-4-3: 2009; EN 61310-1: 2008 & EN 61310-2: 2008



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Declaration

I declare, as the Manufacturer, that the above information in relation to the supply / manufacture of this product is in conformity with the stated Standards and other related documents following the provisions of the above Directives and their amendments.

Person empowered to draw up Declaration

Name:

Signature: _____



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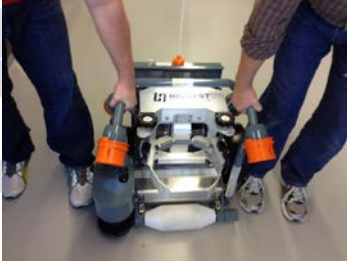
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1 Reference Documents

Harvest Document Number	Document Description
9020-001	Harvest Automation Customer Log Retrieval Setup Procedure
9025-004	Harvest Automation Customer Log Retrieval Procedure
9000-008	Harvest Automation Shipping Procedure
9005-009	Harvest Automation HV-100 Error Guide
9025-005	Harvest Automation HV-100 Field Troubleshooting and Workaround Guide
9025-008	Harvest Automation 4-Bay Battery Charger Manual
xxxx-xxx	User Guide

2 Getting Started

2.1 Removing the Robots from their Crate

Step	Action	
1	Refer to the Harvest Automation Shipping Procedure to uncrate the robots. Unpack the robots from their crates and inspect them for damage.	
2	Remember: the robot is a two-person lift.	

2.2 Removing the Welcome and Accessory Kit and Batteries

- Open the accessory kit boxes and package. Verify that the accessory kit contains:
 - o Harvest Automation tote bag
 - o Boundary Tape and Dispenser
 - o Bag of 40 stakes
 - o 2 pairs of Boundary Sensor Shrouds
 - o Battery charger
 - o 2 Bungee cords
 - o Quick Start Guide and Error Guide
 - o End of Field Marker
- Open the welcome kit. Verify that the welcome kit contains:
 - o Lens wipes
 - o Spray lubricant
 - o Hammer
 - o Promotional items
- Remove the batteries from their boxes and discard the red terminal protectors.



4. Unpack the battery chargers.

2.3 Charging the Batteries

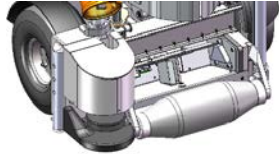
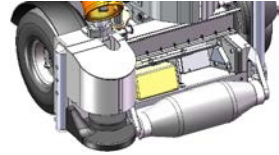
Step	Action	
Charging Batteries using the Individual Chargers		
	NOTE: The batteries arrive with enough charge to start working, but they are not fully charged.	
1	Plug the charger into a standard power outlet, 15A/120V. IMPORTANT: Do not plug more than 23 chargers into a single outlet at the same time.	
2	Attach the battery to the charger by matching the contacts.	
3	The light located on the face of the charger indicates battery status: • Green: Full charge • Blinking Yellow: Stand By • Steady Yellow: Charging • Red: Charging Error If the battery is inserted and the light is flashing red, verify that the battery is seated properly.	
NOTE: Batteries take approximately 8 hours to charge. Batteries included with the HV-100 are part number HV-BAT-251 Lithium-Ion dual-battery packs. They supply 32 VDC to the system.		



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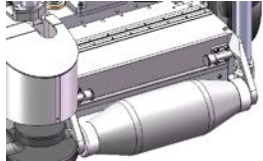
Step	Action
Charging Batteries using the 4-Bay Charger	
	The 4-bay charger can charge 1 to 4 batteries simultaneously in 4 hours or less. Insert a battery into an empty bay. Charging begins automatically. LED will turn steady green when charging is complete. Refer to the 4-Bay fast charger manual for details on operation and LED indicator lights.
	

2.4 Installing the Batteries

Step	Action
1	Confirm that the Power Switch is in the OFF position. 
2	Open the battery box cover by either lifting the stainless steel latches or by pulling the black plungers and lifting the cover. If the plungers are difficult to disengage, press down on the battery box cover to relieve the pressure on the plungers and allow them to be disengaged. If you are changing the batteries, slide the batteries straight out. Clear the battery connectors of debris. 
3	Insert the batteries. Be certain to match the contacts on the battery to the contacts on the HV. NOTE: The two batteries are not installed in the same orientation, so match each battery separately. Do not force the batteries or push on them. They must slide right in. 



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Step	Action	
4	Close and latch the battery door by pressing down on both sides. Secure the latches and check to ensure door is closed by pulling up on bottom lip. If the door will not close, check the battery orientation and check for buildup of debris under the door or within the battery compartment itself.	

2.5 Changing the Batteries

Step	Action	
1	When the battery is low, the robot stops and beeps to indicate an error. Pull the Flag, then put it back in to see the BATTERY DISCHARGED error message.	BATTERY DISCHARGED 
2	If the robot is carrying a pot, remove it from the gripper before continuing: - Press and hold the Start button until the robot beeps. - The gripper will release the pot. If the manipulator arm is down in either the PICK or PLACE position, retract the arm to provide access to the battery compartment: - Press the Start button. - The manipulator arm retracts. Wait for it to retract all the way. - Pull the Flag to stop the robot. - If the battery compartment door is excessively muddy, clear it off to prevent debris from entering the battery compartment. - Follow Step 1 in Section 2.4.	



WARNING

Clamping/Collision/Entrapment Hazard: To avoid HV-100 starting unexpectedly, always turn off the HV-100 when changing batteries.

NOTICE

Keep battery contacts and battery compartment clean and dry.



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3 Robot Features

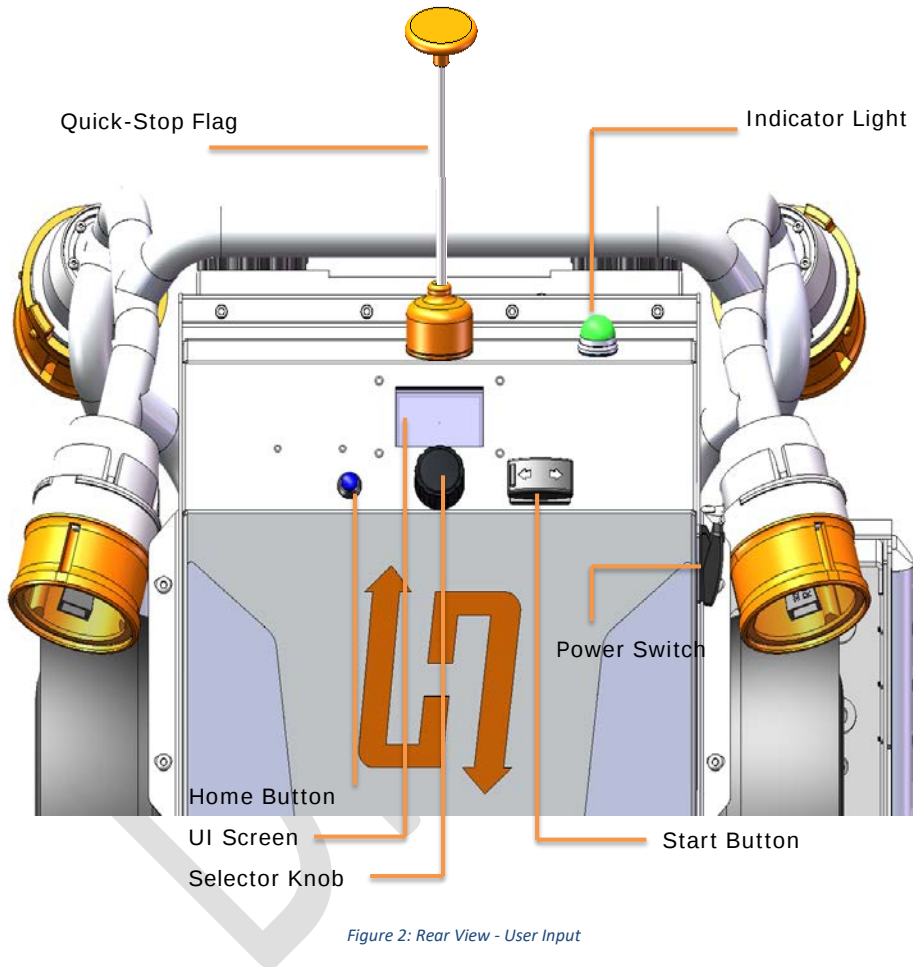


Figure 2: Rear View - User Input

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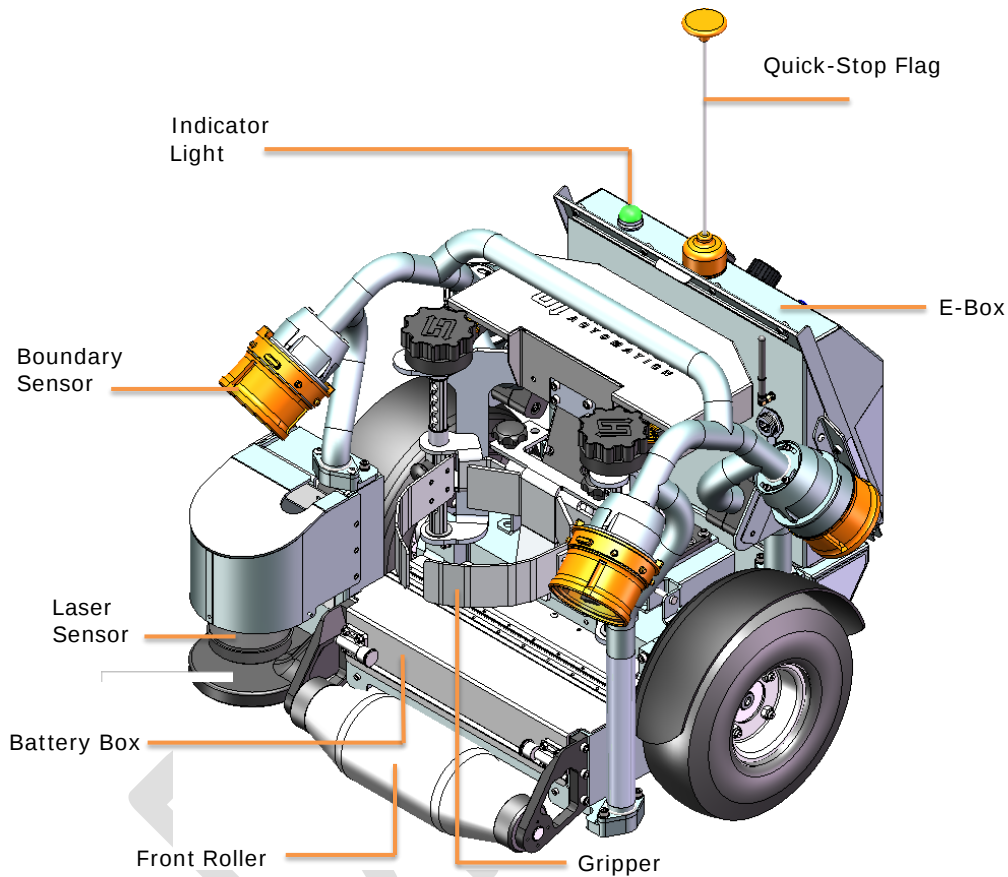
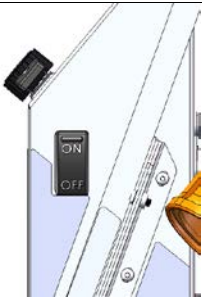
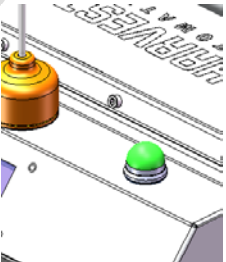


Figure 3: Front View

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Robot Features Power Switch Turns the robot on and off.	
Quick-Stop Flag - Cuts power to the motors so the robot stops immediately. - The flag has a magnetic base and can be pulled in any direction. IMPORTANT: - Without power, the motors will not hold their position, so the robot may drift to a stop or roll downhill - Always pull the flag before servicing the robot	
Indicator Light (green) - Illuminates continuously when the robot is powered on. IMPORTANT: - When flashing, the robot is operating and could be dangerous. Pull the Quick-Stop Flag before approaching.	
Audio Alerts The robot sounds an audio alert in various conditions to alert the operator of pending action. - When the robot first starts, it produces a single beep to indicate that it is ready for operation - If the start button is pressed before the robot has initialized all of its sensors, it beeps continuously until initialization is complete. Once initialization is complete, the robot begins operation. - When the robot encounters an error it produces a single beep every few seconds - When the robot pauses it produces a double beep every few seconds - When the robot is commanded to release a plant it produces a triple beep before it opens the gripper - The robot is equipped with an alarm test function. To activate the function, press the Home button for 3 seconds. The alarm sounds and the indicator light flashes.	

Robot Features

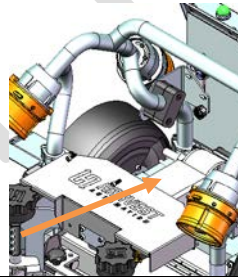
Boundary Sensors

- Locate the Boundary Tape (see below for description). They project an IR light (invisible to humans) and look for the reflection of the tape. They are adjusted and calibrated at the factory. Do **not** open them.
- Clean the lenses with lens wipes:
 - **At the beginning of the day, every day**
 - When the batteries are changed
 - If the lenses become contaminated with dust, dirt, mud, or water
- The sensors must be able to see the Boundary Tape when the robot is holding a plant. If the robot is carrying a bushy plant, the plant material could obscure the sensor. Use the shrouds (see below) included in the accessory kit.



Manipulator Arm

- Moves the gripper up and down. When the robot starts it retracts all the way back – **keep your hands and head out of the way.**
- The maximum pot weight is 22 lbs (10kg). Pots heavier than this can cause errors
- The arm does not require lubrication or maintenance

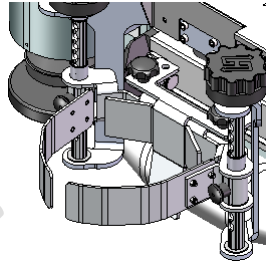


Robot Features

Gripper

The gripper is the assembly at the end of the manipulator arm and is used for grabbing and holding plant containers. The gripper is comprised of three main components: right and left paddles and either a fixed or adjustable pusher bar. The manipulator extends the gripper outward from the robot and opens the gripper paddles to receive a plant container. Once the robot is in the proper position the gripper paddles are closed to hold the container firmly and the manipulator lifts the plant and gripper assembly to carry the plant to a new position.

To adjust the gripper, see [Adjusting the Gripper](#) on page 31.

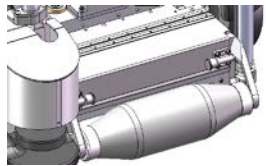


Pusher bar

- There are two settings for this bar. They are based on the diameter of the pots being picked up.
- Adjust the pusher bar forward for smaller pots (1 and 2 gallon containers)
- Adjust the pusher bar to the rear for larger pots (3 and 5 gallon containers)
- To adjust, unscrew the retaining nuts and move the bar to the desired position, then replace the retaining nuts

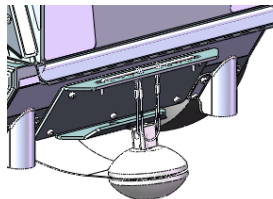
Front Roller

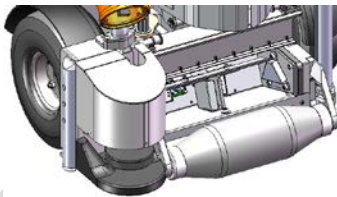
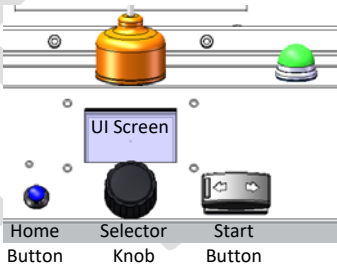
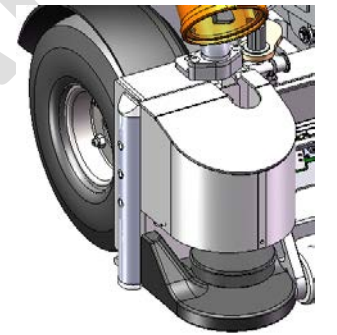
- The front roller stabilizes the robot and allows it to easily turn and navigate rough terrain.



Rear Stabilizer

- The rear stabilizer keeps the robot from tipping back on inclines or when accelerating
- The rear stabilizer can be adjusted to a higher position for operation in rough terrain. Contact Harvest Automation support for details.

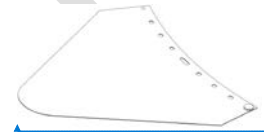


Robot Features Battery Compartment - Secure the latches when the robot is operating, the batteries could rattle loose, causing the robot to power down - There is a drainage hole in the bottom to permit water to escape - When you insert batteries, first check for debris on the contacts and remove it by hand.	
UI Screen - View and configure the robot parameters - Error messages will be displayed on this screen Home Button: - Press this button to return the UI to the Main Menu Selector Knob: - Rotate left and right to change selection - Press the knob in to confirm a selection Start Button: - Toggle the switch with left and right arrows, to indicate the position of the Boundary Tape when starting the robot	
Laser Sensor - This is the primary sensor for the robot. This is how the robot locates pots, sees obstacles, and knows where to place the pots. - The laser sees the world as a plane 5-inches off the ground. It cannot see above or below that. It cannot detect holes in the ground or ditches. It also cannot detect bedding forks that are above this. - If the robot tilts down by driving into a rut, the laser can see the ground in front of the robot as a wall and will stop - The laser cannot distinguish plant material from the pot, so plants with a lot of overhanging material can cause inaccuracy and errors It is very important that the lens remain clean and free of debris	

Robot Features

Robot Accessory Kit

- Boundary Tape
 - The reflective Boundary Tape is used to determine the field position. The robot must drive alongside the tape in order to localize and establish the edge of the field.
 - It is important that the tape is straight
 - The tape must be clear of debris and visible. If it is obscured by debris, dust, dirt, water, or mud the robot may not see it and will require assistance.
 - The placement of all the pots is based on the Boundary Tape. If the tape shifts while the robot is operating, placement accuracy will suffer.
- Boundary Sensor Shrouds
 - When the robot moves bushy plants, the leaves could obscure the boundary sensors. The shrouds help deflect the plant material.
 - Put the shrouds on by wrapping around the features on the boundary sensors and securing the button. The flat button must be against the boundary sensor housing – it will be difficult to snap them if they are reversed.
- Stakes
 - A bag of 40 stakes is provided to secure the Boundary Tape. Stake at least every 25 feet, more frequently in windy conditions or if the ground is uneven.



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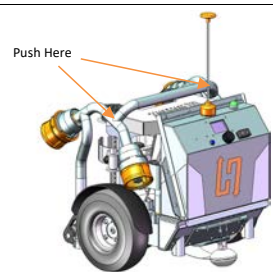
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4 Moving the Robot

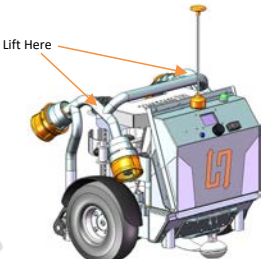
4.1 General Guidelines

Pushing the HV

To move the robot, grab the top bar (the tube frame) and push.



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Lifting the HV - The robot weighs approximately 90 pounds, so it requires two people to lift it - Lift using the bars on top or on the side Do not grab the boundary sensors	
Transporting the HV - Secure to a wagon/trailer using bungee cords around the tube frame - Do not pull tight enough to deflect the frame – the boundary sensor positions are calibrated Do not allow the cords to rub against the laser sensor lens	
IMPORTANT: When shipping an HV, use only HAI-approved crates. Refer to the <i>Harvest Automation Shipment Procedure</i> for instructions.	



WARNING

Lifting Hazard: The HV-100 weighs approximately 105 lbs (48 kg). Single person lift may cause back injury or muscle strain. Use assistance when lifting.

NOTICE

The HV must always be secured during transport.

4.2 Using Follow Mode

The robot can be put into Follow Mode to make it easier to transport. To do so:

- From the Main menu, highlight FOLLOW ME.
- Press the Start Button.
 - The robot will look for a leg in front of it (about 1ft) and track the target
 - The robot will attempt to follow at about a 3ft distance and will back up if the target gets closer
 - If the robot loses the target, it stops moving and retracts the gripper
 - If the robot doesn't see the target within 30 seconds, it times out



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6. Warnings:

- The robot cannot detect holes, ditches, or obstacles below 5 inches
- The robot cannot detect obstacles above 5 inches, such as fork lifts or vehicles
- The robot cannot detect anything behind itself, so it can back into pots, obstacles, or ditches

5 Setting up the Field

5.1 Definitions

7. Source Plants

- The pots that the robot will pick up
- Pots can be either tight or spaced out
- Pots must not be too close to the edge of the field (6 inches)

8. Spaced Plants

- The location where plants will be placed, determined by the Seed Plant

9. Seed Plant

- The Seed Plant (the plant closest to the boundary) determines where the first row of plants will be
- The Seed Plant can be placed either on the Boundary Tape or inside the bed close to the Boundary Tape

10. Boundary Tape

- The reflective tape placed along the edge of the bed
- The robot follows the boundary when carrying a plant to be spaced

11. Frontier distance

- The frontier distance is the distance between the Source Plants and the Spaced Plants
- To properly determine the robot's orientation relative to the bed (localization), the robot needs to travel along the Boundary Tape (in a straight line) for a certain distance.
- The optimum frontier between the Source Plants and the Spaced Plants is 10-12 feet (3.6 m). When the frontier is shorter than this, robot performance will degrade and the robot will be more prone to errors. The robot will not operate at all with a frontier distance below 7 feet.
- In normal usage, the frontier will likely fluctuate as the robot works on an entire field. Harvest Integration Services can help you find the right balance.
- If the frontier is very long:
 - The robot takes longer to move pots, resulting in a lower throughput
 - The robot can create ruts on soft ground, which may affect how well it can follow the Boundary Tape
 - The robot can create a washboard effect on the ground, causing bumpiness and reduced ability to follow the Boundary Tape
 - The position error incurred from driving down the field to look for pots means the robot is uncertain about its location in the field. This can cause it to pick pots on an adjacent bed, or to have difficulty ascertaining the location of the Boundary Tape.
 - Frontiers above 30' or a bed that is sloped or has low traction can hinder robot operation, requiring more frequent assists





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- If the frontier is too short:
 - The robot beeps to indicate a poor localization
 - The robot stops and displays an OUT OF SPACE error message. The robot operator must then manually move pots to increase the frontier.
 - The robot places pots with poor accuracy
 - The robot may stop as a result of other errors due to poor localization, such as TROUBLE FOLLOWING BOUNDARY, CAN'T FIND SEED PLANT, or OBSTACLE, when it looks at the seed pot
 - If two robots are operating in the same field (teaming), they will interfere with each other below 12 feet and deadlock – neither robot will be able to keep working. Remove one of the robots and let the other continue.
- Sections 7, 8, and 9 describe techniques for managing the frontier distance

5.2 Inspecting the Field

12. The field must be clear of debris such as branches or trimmed plant material
13. The ground cloth must be secured, flat, and tight
14. The field must be clear of weeds that the robot may see as obstacles or pots
15. Look for holes or deep ruts that the robot cannot detect and fill them in if possible, or adjust the robot's operating bed to avoid them
16. Refer to document 9025-005, *Harvest Automation HV-100 Field Troubleshooting and Workaround Guide* for tips and techniques to aid in field setup

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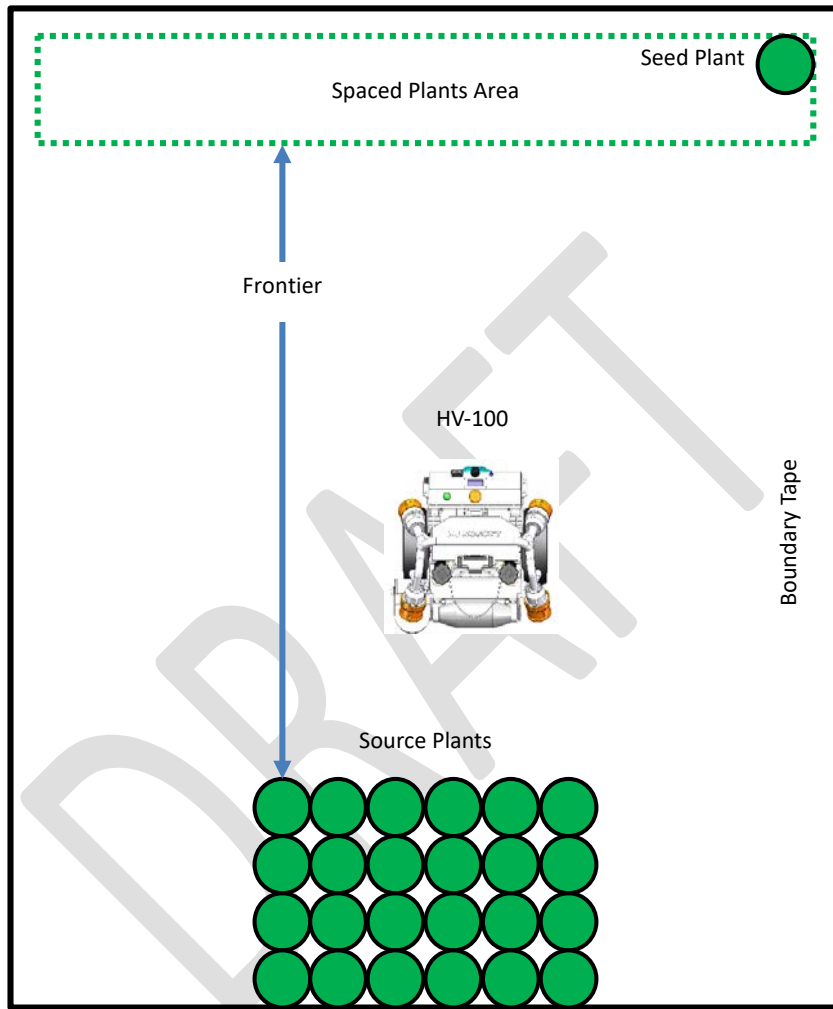


Figure 4: Field Setup

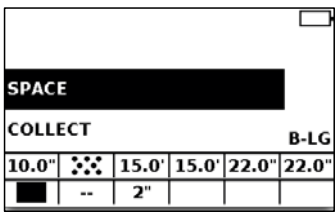
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5.3 Laying the Boundary Tape

Step	Action	
1	- Place the boundary tape, reflective side up, along the edge of the bed - Choose the side of the bed with more consistent terrain	
2	- Stake the Boundary Tape down at a minimum of 25 feet - If conditions are windy it may be necessary to stake the Boundary Tape at shorter intervals to ensure good performance - It is important that the Boundary Tape be clean and flat on the ground	
3	Place a plant next to the Boundary Tape in a location where spacing plants will begin NOTE: The starting plant is referred to as the Seed Plant	
4	- The Boundary Tape must be on firm, level ground and clear of local undulations - There can be no obstacles inside the bed near the Boundary Tape. When the robot is following the Boundary Tape it cannot drive around obstacles. - The Boundary Tape must be approximately 6 inches away from any obstacles on the outside of the bed, such as hoophouse walls, curbs, sprinklers, or posts - Robots on adjacent beds can share a Boundary Tape. - Use a boundary offset of 6 inches or more to keep the spaced plants away from the Boundary Tape - If the adjacent bed plants are closer to the Boundary Tape, the robot slow down when passing them, leading to decreased throughput - Robots must be moving plants in the same direction when they are using a shared boundary	

6 Operating the Robot

6.1 Turning on the Robot

Step	Action	
1	Turn the Power Switch to the ON position.	
2	The indicator light illuminates immediately.	
3	The HV-100 beeps and the UI illuminates within 30 seconds.	
4	The HV-100 is on and ready for use when this screen is displays.	



WARNING

Clamping/Collision/Entrapment Hazard: The HV-100 may grip, move, or collide with persons or objects inside bed. **Do not stand in front of an operating HV. Pull the flag before servicing.**



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6.2 Selecting a Task

The robot is programmed to perform a number of tasks. To select a task:

1. Press the Home button to display the Main Menu on the UI.
2. Use the Selector knob, located directly below the UI screen, to select the desired task. The selected task appears as white text on a black background. (SPACE in the figure above.) Rotate the Selector Knob to change the selected task.
3. Press the Selector knob. The selected task appears on the UI screen. In the illustration, the selected Task is selecting the Space/Container Size.
- 4.

Task Description

Dashboard

SPACE/CONTAINER SIZE



(9 plants across bed)

B-LG

10.0"		15.0'	15.0'	22.0"	22.0"
10.0"	--	2"			

Note: The bolded box indicates focus of task description.



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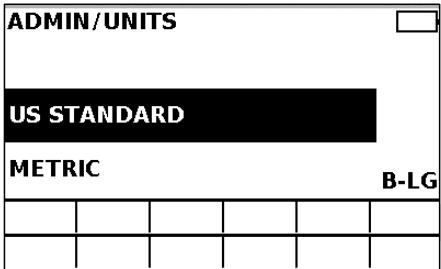


HV-100 Operator Manual

6.3 Selecting the Metric UI Option

To change units to metric, select ADMIN>UNITS and choose between METRIC and US Standard

1. Highlight ADMIN>UNITS from the home screen and push the Selector Knob. The ADMIN/UNITS screen appears.



2. Highlight the METRIC option and push the Selector Knob. All measurements are now expressed as metric units.

To return to US units, return to the ADMIN/UNITS screen and select US STANDARD.

6.4 Selecting the Gripper Configuration

Depending on customer needs, the robot may be equipped with several field-swappable attachments that enable it to pick up different pot sizes. These attachments are labeled A, B, and C, and are recommended for different pot diameters and heights.

In addition, gripper attachment B has two pusher bar settings:

- B-SM for smaller pots
- B-LG for larger pots

The chart indicates the correct gripper attachment for each size pot. Pot Diameter is the pot top outer diameter.

HV-100 Operator Manual

		Gripper Type			
					
Container Diameter	Examples	A	B-SM	B-LG	C
13.5"				✓	✓
13"				✓	✓
12.5"				✓	✓
12"				✓	✓
11.5"	Pro-Cal 15			✓	✓
11"	NSI PF-1200 Pro-Cal TFR05G00			✓	✓
10.5"	NSI 030			✓	✓
10"	NSI C1000 Dillen 10" STD			✓	✓
9.5"	NSI PF-1000			✓	✓
9"	NSI PF-800		✓	✓	✓
8.5"			✓		
8"	East Jordan SP400	✓	✓		
7.5"	NSI PF-400 East Jordan SP750 JanoPort 15cm	✓	✓		
7"		✓	✓		
6.5"	Landmark X-65NTGT TEKU VCC16.5	✓			
6"	Dillen STG06000 TEKU VCC15	✓			
5.5"		✓			
Container Height		5.75" - 8"	7.5" - 12"	7.5" - 12"	>12"



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To ensure placement accuracy, the robot must have accurate knowledge of the gripper attachments and pusher-bar settings. To configure gripper settings:

1. Select the Gripper Attachment you want to use from the chart above.
2. On the robot, navigate to GRIPPER SETUP>TYPE.

GRIPPER SETUP

TYPE: B-LG

ADJUST GRIPPER

B-LG

The TYPE highlighted is the gripper that is currently selected.

3. Push the Selector Knob to select TYPE.
4. Rotate the Selector Knob to choose the desired setting, based on the chart above. Gripper types scroll as you rotate the knob.
5. When the desired gripper type is highlighted, push the Selector Knob. In the example screen below, the B-LG gripper is selected:

GRIPPER/TYPE

B-SM (7.0" - 9.0")

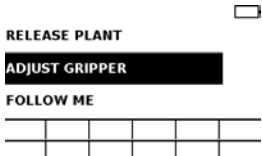
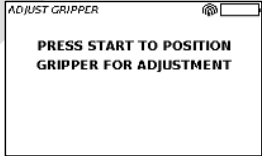
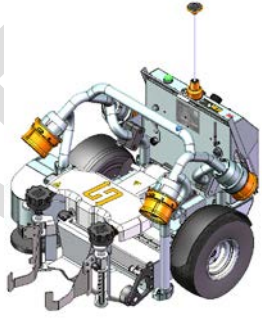
B-LG (9.0" - 13.5")

C (TALL 9.0" - 13.5")

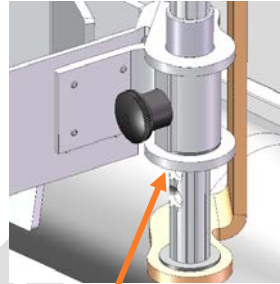
B-LG

6. You can now adjust the gripper if desired. With the TYPE selected, rotate the Selector Knob to highlight ADJUST GRIPPER and push the Selector knob to select it. See Section 6.5 for details.

6.5 Adjusting the Gripper

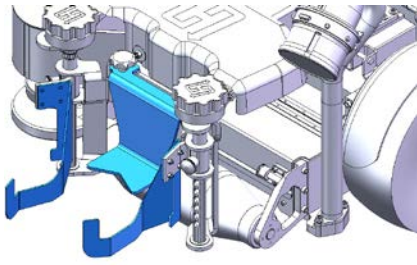
Step	Action
1	Highlight ADJUST GRIPPER from the home screen or from the GRIPPER SETUP screen and push the Selector Knob. 
2	When prompted, press the Start Button in either direction to lower the gripper for adjustment. 
3	The robot beeps, then extends the manipulator arm and puts the gripper in the closed position. The robot beeps again and the Indicator Light illuminates continuously to indicate it is safe to adjust the gripper. The HV-100 is not active at this time You can safely adjust the gripper. 
4	CAUTION: While in the ADJUST GRIPPER behavior, pressing the Start Button (in either direction) toggles the gripper between OPEN and CLOSED. Be careful when doing this, as it could catch your fingers between the gripper and the pot.

Step	Action
5	Height Adjustment: 1. Grasp the two black height adjustment locks, pull forward, and turn each one 60° to the open position. 2. Lift/lower the gripper from the collar around the vertical shaft just below the height adjustment locks. Do not attempt to adjust the height by lifting the gripper paddles. 3. Move the gripper up or down until the top edge of the jaw is approximately one inch below the top of the pot. 4. Turn the height adjustment locks 60° and snap them back into place. Ensure that no part of the pin is visible when the locks are closed.
6	Diameter Adjustment: 1. Pull up on the adjustment knobs and turn the knobs to open the gripper wide enough to place a pot into the center of the gripper. 2. Turn the knobs to matching positions so that they are touching the pot. 3. Grasp the pot firmly by the jaws but ensure that the jaws do not distort a filled pot. Slight distortion of an empty pot is acceptable. The pointer on the knob indicates the position. 4. Push the adjustment knob down to lock in the position. 5. When properly adjusted, the pot must be snug in the gripper but not deformed.

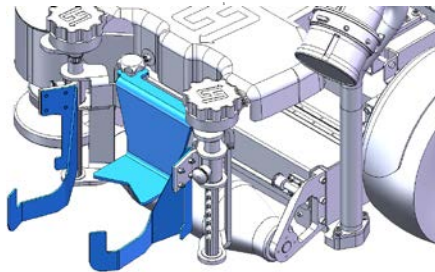


Support Gripper Here



Step	Action
7	Pusher Bar Adjustment 1. Unscrew the pusher bar retainer knobs. 2. Lift the pusher bar from the gripper and move to the desired position: Fully forward for 5.5-inch pots; fully back for large pots. 3. Screw the pusher bar retainer knobs back on to lock the pusher bar in place. 
8	4. Check the gripper adjustment by pressing the start button to toggle the gripper open/closed: 17. If the gripper closes successfully, it will remain closed and beep three times 18. If the gripper is unable to close, it will produce one long beep and reopen 19. Continue to watch the robot as it operates to determine if further adjustments are needed • The gripper must be able to completely close when picking. If not, the robot will shake forward and back to grasp the pot or display a Can't Pick Plant error. • The robot will carry the pot above or on the battery compartment door. If the pot slips in the gripper while being lifted and hangs too low, it may rest on the front roller and impede movement. Tighten the gripper. 20. Note: The Adjust Gripper behavior will also make the robot forget that it had a plant.
9	21. Pull the flag to stop the ADJUST GRIPPER behavior. 

Step	Action
10	Installing the Optional Field-Swappable Small Container Gripper Some versions of the HV-100 are equipped with an optional field-swappable small container gripper. This gripper attachment must be installed for container heights between 5.75-inches and 6.5-inches and container diameters between 6-inches and 8-inches. To install the gripper attachment: 1. Unscrew the pusher bar retainer knobs. 2. Remove the existing pusher bar and replace it with the small container pusher bar. 3. Reinstall the retainer knobs. 4. Unscrew the gripper paddle retainer nuts using a 7mm wrench or socket. 5. Remove the gripper paddles and replace them with the small container gripper paddles. 6. Reinstall the retainer nuts.



7 Robot Behaviors

When the HV-100 is running it displays the Robot Running screen and exhibits these behaviors, in sequence:

1. Searching for Container
 - The robot enters this behavior mode when it determines that it does not have a container
 - The robot is using the laser to identify something that is pot-shape
 - **Caution: Many things can look similar to a container: a person's leg, an animal, an irrigation head, a weed, or even a dust cloud**
2. Picking Container
 - Once the HV-100 has decided which container to pick and is aligned to the container, it transitions to Container Pick behavior mode
 - The robot then lowers the manipulator arm, it is not looking any more, and will drive forward, close the gripper, and retract
 - The gripper must close all the way for the robot to consider it a successful pick
3. Seeking Boundary Tape
 - Once the robot has picked a pot, it will turn toward the boundary and move slowly in an attempt to locate the Boundary Tape.
 - The robot may back up first to be sure that it has not passed the Boundary Tape.



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- The front boundary sensors are active, looking for the boundary reflection.
- 4. Acquire Boundary Tape
 - Once the robot sees the Boundary Tape, it turns 90 degrees in the direction of the Spaced Plants Area to begin following
 - Now the front and back sensors on the boundary side are active.
- 5. Follow Boundary Tape
 - As the robot is driving, it is building up a confidence level of the boundary location, based on the boundary sensors and the wheels.
- 6. Find Seed Plant
 - The Seed Plant indicates where to place containers
 - The container will go in the row in front of the Seed Plant
 - As the robot builds rows, the Seed Plant advances to the first container in the closest row
- 7. Turn into Row
 - After the robot finds a Seed Plant it looks for the farthest unoccupied spot to place the container it is carrying
 - If the unoccupied spot is far away the robot turns in and drives along the row to find the destination
- 8. Place Container
 - After placing, the robot heads back down the field to look for another pot
 - If the pot that was just placed is near the boundary, the robot first escapes the boundary
 - It heads in the general direction of known pots
 - The robot generally builds rows from the outside in, but it builds the first row from the inside out
- 9. Hole Filling
 - If the previous row is missing a pot and the robot is able to reach it, the robot will fill in the empty slot.
 - If the previous row was half-filled (for example, if a person or debris was in the way), it will fill the entire row, from the inside out.



WARNING

Clamping/Collision/Entrapment Hazard: HV-100 may grip, move or collide with persons or objects inside the bed. **Do not stand in front of an operating HV.** Pull the flag before servicing.



WARNING

Pinch Point Hazard: Keep hands and fingers clear of the manipulator while in motion.

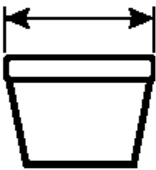


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8 Spacing Plants

8.1 Configuring the Robot for Spacing

SPACE/CONTAINER SIZE [Battery Icon]



(9 plants across bed) B-LG

10.0"	[Pattern Icon]	15.0'	15.0'	22.0"	22.0"
[Selector Knob Icon]	--	2"			

Container Size	Pattern	Pick Width	Spacing Width	Spacing Across	Spacing Along
Aisle Type	Aisle Width	Boundary Offset	Frontier Mode	Target Frontier	

UI Selector Knob and Home Button

1. Rotate the Selector Knob to highlight a parameter and press it in to edit that parameter.
2. When the UI is in edit parameter mode, the selected parameter is white-on-black.
3. Turn the Selector Knob to change the parameter.
4. Push the Selector Knob again to return to parameter selection mode.
5. Press the blue Home Button to return to the main menu.
6. Keep turning the Selector Knob to the right to enter the second row of parameters.

SPACE configuration parameters

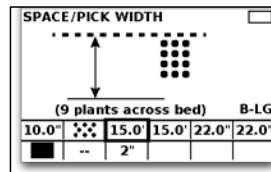
- Container Size
 - 5.5-inch to 13.5-inch containers
 - Large pots can be the Regular size that has the same diameter as a smaller pot, but not the squat ones or the very tall ones
 - The gripper can handle pots down to about 6-inches tall. If the 5.5-inch pots are shorter they may need a modified gripper
 - The gripper must still be adjusted for the containers to be moved

NOTE: the pusher bar must be adjusted based on the container size dialed into the UI. The pusher bar must be in the forward position for 5.5-inch to 7-inch containers and in the back position for larger containers.



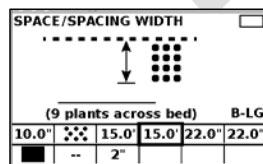
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- Pick Width



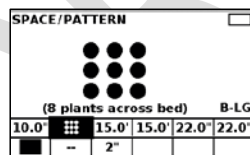
- This is the size of the bed that the robot will pick from
- Values range from 5-feet to 25 feet in 0.5-foot increments
 - When the pick width is above 18 feet the word OVERRIDE displays to warn you of reduced accuracy and other issues

- Spacing Width

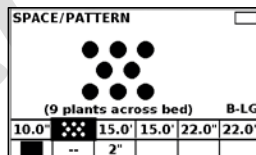


- This defines the width the robot will space plants
- Values range from 5-foot to 25-foot in 0.5-foot increments
- When Pick Width is changed, Spacing Width will change to match it, but Spacing Width can be selected and changed individually to be larger or smaller than Pick Width
- When the Spacing Width is above 18 feet the word OVERRIDE displays to warn you of reduced accuracy and other potential issues

- Pattern



Square

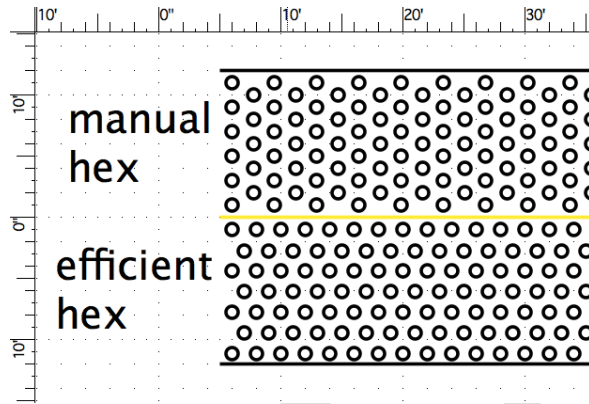


Hex

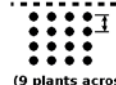
- Square or Hex
- The robot hex pattern is slightly different from what is typically done manually, this is known as Efficient Hex.
 - When done by hand, the spacing distance is maintained across the bed, using a spacing guide
 - The robot places with the spacing distance along the Boundary Tape and there isn't a clear line from left to right. This allows more pots to be placed in the same area.



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- Square Spacing
 - Spacing Across

SPACE/ACROSS THE BED					
					
(9 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	--	2"			

- Set the (center-to-center) pot-spacing distance, going away from the Boundary Tape
- The range of values depends on the pot size selected:
 - For 5.5-inche-7-inche pots, values range from 9-inche to 32-inche in 0.5-inche increments
 - For 8-inche-9-inch pots, values range from 10-inches to 32-inches in 0.5-inch increments
 - For 9.5-10.5-inch pots, values range from 11-inch to 32-inch in 0.5-inch increments
 - For 11-inch and larger pots, values range from 15-inch to 32-inch in 0.5-inch increments

- Spacing Along the Bed

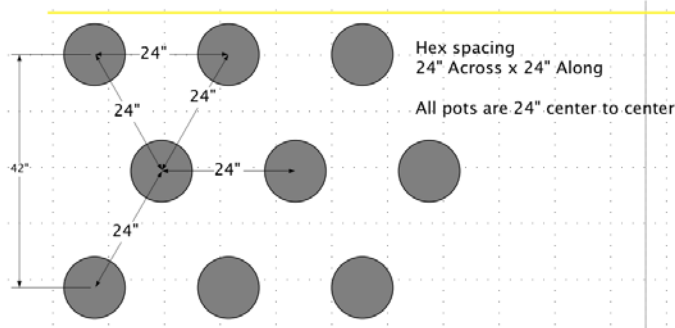
SPACE/ALONG THE BED					
					
(9 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	--	2"			

- The value range is the same as for Spacing Across

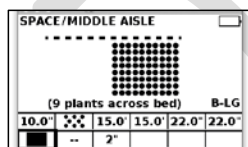


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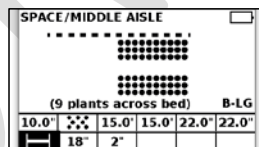
- When the Spacing Across value is changed, the Spacing Along value is automatically changed to match. However, the Spacing Along value can be selected independently to be adjusted either larger or smaller than the Spacing Across value. This can be helpful to dial in the spacing length, to accommodate for out of space errors or inaccurate spacing due to terrain and field conditions.
- Hex Spacing
 - Center-Center Spacing Distance with Hex:
 - Spacing Across and Spacing Along values aren't as simple as with a square pattern. The Spacing Along value is used as specified and determines the spacing from one full row to the next full row.
 - The Spacing Across value will stretch them across, but since the rows are offset there isn't a 1-to-1 correlation.
 - In general, the numbers are kept the same in order to achieve a constant C-C distance, but it is possible to adjust them separately.



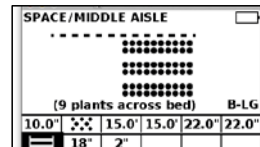
- Middle Aisle



No Aisle

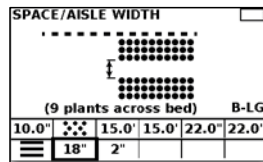


Single Aisle

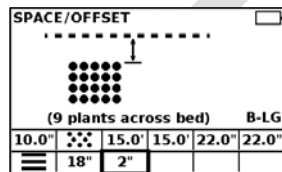


Double Aisle

- Choices are: None, Single and Double
- The Single Aisle will be in the center of the bed
- The robot will automatically determine how many pots to put on either side of the aisle(s). See Appendix A for details on how the pots will be arranged with two aisles.
- Aisle Width

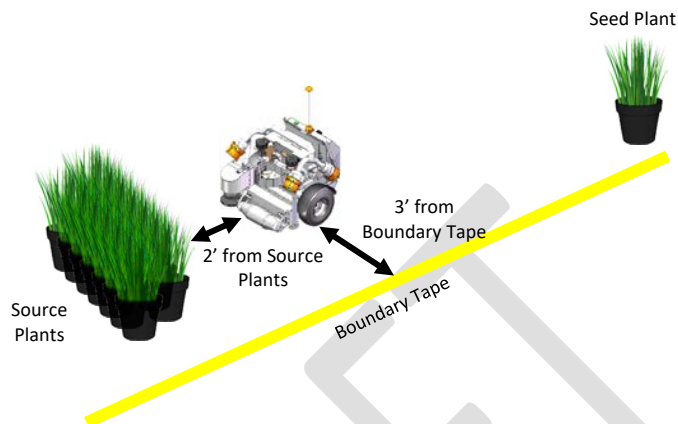


- Set the desired aisle width. This is the distance between the edges of the pots.
- This value is only visible if an aisle (Single or Double) has been selected. Otherwise the value is blank.
- Values range from 3-inch to 60-inch in 1-inch increments
 - Above 48 inches the word OVERRIDE appears, indicating the potential for issues (accuracy and misplaced pots) with this configuration
- Boundary Offset



- Select an offset from the Boundary Tape. This will shift the entire pattern of pots away from the tape.
- Values range from 2-inch to 36-inch in 1-inch increments. Harvest recommends a minimum value of 4 inches.
- This won't affect where the robot drives, only where the pots are placed.
- If robots are running on both sides of a Boundary Tape (sharing the boundary), set the offset to 6 inches or more to avoid interference
- The robot automatically determines the Number of Pots across
 - The value will change as spacing parameters are adjusted
- Automatic Frontier Management
 - See Frontier Management Modes descriptions in [Section 16](#)

8.2 Starting Spacing



10. Requirements for starting the robot:

- The robot must be parallel to the boundary (Within 10-15 degrees either left or right)
- The robot must be pointed towards a source pot
- Sufficient frontier must exist between the source pots and the seed pot (about 10 feet)
- No obstacles/pots between the robot and boundary

11. Start the robot by pressing the Start button in the direction of the Boundary Tape.

- When the robot is running this screen display:



12. The robot progresses through the standard behaviors for every circuit. These behaviors are:

- Search for and pick a pot
- Turn to the boundary and seek the boundary
- Turn to acquire and follow the boundary
- Search for seed pot and unoccupied space
- Turn into row and place pot
- Go back down the field searching for a pot

13. Row positioning is relative to the Seed Plant.

- If you adjust the Seed Plant location along the Boundary Tape the placed row is modified as well
- Seed Plant location across the bed is not significant for spacing unless it is far enough so that it isn't detected as a Seed Plant

14. Verify the operation.



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- Is the pot spacing accurate?
- Is the # of pots across correct?
- Is the aisle the right width and in the right location?

15. Remember that

- Robots can operate in teams (if the frontier is at least 12 feet)
- Robots can operate on both sides of the boundary tape (shared boundary)

DRAFT



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9 Collecting Plants

Collection places plants together tightly into blocks.

9.1 Configuring the Robot for Collection

COLLECT/CONTAINER SIZE B-LG



10.0"	●●●●	15.0'	6	12.0"	12.0"
	--	30"	●●●●	--	

Container Size	Pattern	Pick Width	Plants Across	Spacing Across	Spacing Along
Aisle Type	Aisle Width	Boundary Offset	Frontier Mode	Frontier Param	

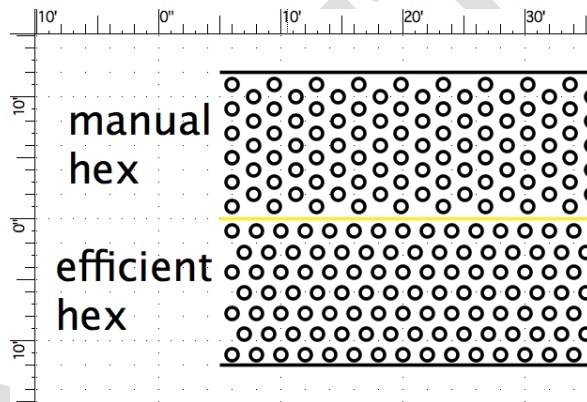
16. UI Selector Knob and Home Button.

- Rotate the Selector Knob to highlight a choice and press it in to confirm the selection
- Press the Home Button to return to the main menu
- Keep turning the Knob to the right to enter the second row of parameters

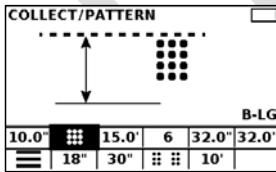
17. COLLECT configuration parameters.

- Container Diameter: 5-inch to 12.5-inch diameter pots
- Consult the gripper attachment chart for the proper gripper attachment and pusher bar setting
- You must adjust the gripper for the pots you are picking
- The gripper can handle pots down to about 5.75 inches tall on a concrete surface and 6 inches tall on a gravel or dirt surface
- Container Size:
 - When collecting 5-inch or 6-inch pots to a can-tight configuration, the gripper may open wide enough to move the adjacent pots. It may not be possible to collect small pots tightly.
 - 9.5-inch pots can be the Regular that has the same diameter as a 7.5-inch, but not the squat ones or the very tall ones
 - You must adjust the gripper for the pots you are picking
 - The gripper can handle pots down to about 6 inches tall. If the pots are shorter than this they may need a modified gripper.

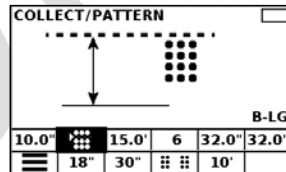
- Pattern:
 - There are three possible patterns: Square, Hex, and Modified Square. The robot's Hex pattern is different from a hex pattern that is done manually.
 - The Modified Square pattern is only available in collection and introduces a 2-inch gap between the seed pot (the one closest to the boundary) and the one next to it. This improves collection performance if the robot encounters Can't Find Seed Plant errors.
 - When done manually, the spacing distance is maintained across the bed, using a spacing guide
 - The robot places with the spacing distance along the boundary tape and there isn't a clear line from left to right. This lets the robot put more pots into the same area. The method is called Efficient Hex.



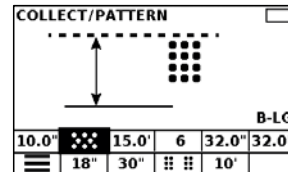
- Square (Uniform or Gap) or Hex



Square (Uniform)



Square (Gap)



Hex

- When it is collecting to a square pattern the robot may not be able to distinguish the Seed Pot because the next pot in the row wasn't pushed back fully into the row

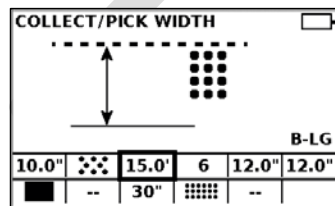


- If a robot is having difficulty pushing this pot into the pattern and frequently reports Can't Find Seed Plant errors, the Square (Gap) pattern will help. This pattern leaves a 2-inch gap between the outside pot and the next one in the row:



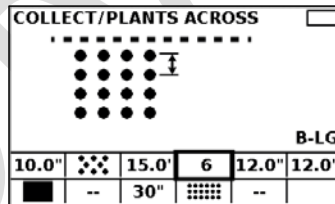
- This will reduce the Can't Find Seed Plant error messages, but could require you to clean up the outside pots and push them together

- Pick Width:



- Values range from 5 feet to 25 feet in 0.5-foot increments
- When the pick width is above 18 feet, OVERRIDE displays to warn you of reduced accuracy and other potential issues.

- # Plants Across:

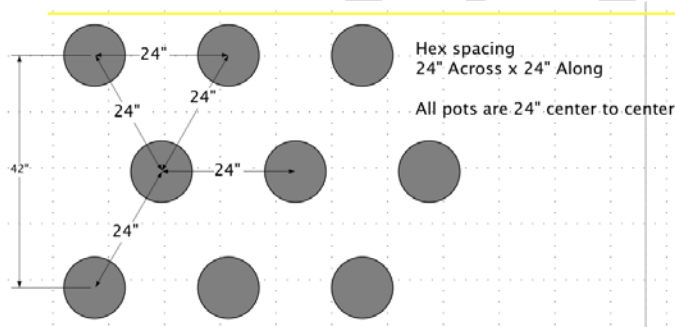


- Values range from 1 to 20
 - Above 10, the word OVERRIDE displays, indicating the potential for issues (accuracy and misplaced pots) with this configuration
- It is possible to set this value higher than what will actually fit on the bed. The robot will only put the number that will fit in the spacing width. If the spacing width is too narrow, the robot simply won't put any more pots in the row, it will move on to the next row

- Center-Center Distance:

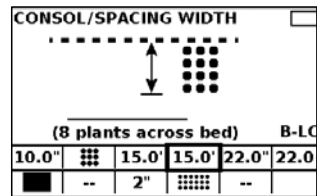
COLLECT/CENTER-CENTER					
					
B-LG					
10.0"		15.0'	6	12.0"	12.0"
	--	30"		--	

- Center-Center Spacing Distance with Hex:
 - The Along the Bed value is used as specified and determines the spacing from one full row to the next full row
 - The Across the Bed value stretches them across, but since the rows are offset there isn't a 1-to-1 correlation
 - In general, the numbers are kept the same in order to achieve a constant C-C distance, but you can adjust them separately

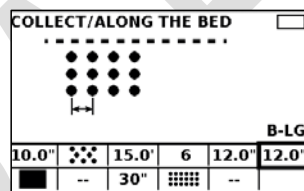


- Spacing Along the Bed
 - The value range is the same as for Across the Bed
 - When the Across value changes, the Along value automatically changes to match. However, you can select the Along value independently to be adjusted either larger or smaller than the Across value. This can be helpful to dial in the spacing length to accommodate for OUT OF SPACE ERRORS or inaccurate spacing due to terrain and field conditions.

- Spacing Width



- Defines the width available into which to space plants. The robot will not stretch the pattern to fill this width.
 - When Pick Width changes, Spacing Width changes to match it, but you can select and change Spacing Width individually to be larger or smaller than Pick Width
 - Values range from 5-foot to 25-foot in 0.5-foot increments
 - When the width is above 18-foot OVERRIDE is displays to warn you of reduced accuracy and other potential issues
- Spacing Along Distance

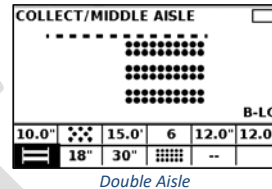
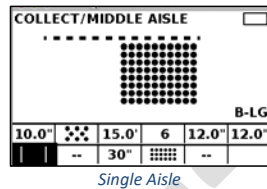
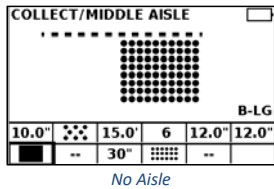


- When the Center-Center distance value is changes, the Spacing Along value changes automatically to match. You can select the Spacing Along distance independently to be larger or smaller. This can help the robot give pots an extra push into the collected block.

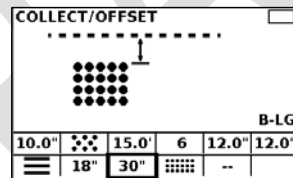


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- Middle Aisle
 - Choices are: None, Single and Double
 - The Single Aisle is in the center of the bed
 - The robot automatically determines how many pots to put on either side of the aisles. See Appendix A for details on how the pots are arranged with two aisles.



- Aisle Width
 - Set the desired aisle width. This is the distance between the edges of the pots.
 - This value is only visible if an aisle (Single or Two) is selected. Otherwise the value is blank.
 - Values range from 3 inches to 60 inches in 1-inch increments
 - Above 48 inches OVERRIDE displays, indicating the potential for issues (accuracy and misplaced pots) with this configuration
- Offset from Boundary:



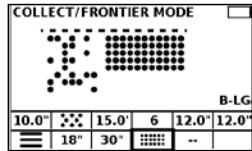
Select an offset from the boundary tape. This will shift the entire pattern of pots away from the tape.

- Values range from 2 inches to 36 inches in 1-inch increments
- This won't affect where the robot drives, only where the pots are placed
- If you are running robots on both sides of a boundary tape (sharing the boundary), set the offset to 6 inches or more to avoid interference

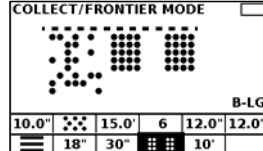
NOTE: The number of pots across is automatically determined by the robot. The value will change as you adjust spacing parameters.

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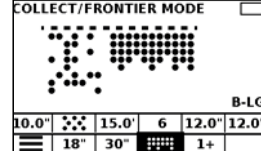
- Frontier Mode



None



Gaps



Pots Across

- Used to manage long frontiers. When the frontier gets long the robot can automatically react.
- Can be set to None, Gaps, or Pots Across:
 - None – the robot will not react to long frontiers.
 - Gaps - When the frontier grows, the robot will shorten the frontier by placing a new seed pot, which will create a gap in the consolidated pots.
 - Pots Across – As the frontier grows, the robot will reduce the number of pots spaced across the bed to gradually reduce the frontier. If the frontier shrinks, it will increase the number.
- Frontier Parameter (Frontier Gap or Pots Across).
 - Depending on the Frontier Mode selected, this parameter will be either FRONTIER GAP or POTS ACROSS.
 - Frontier Gap:
 - The minimum gap that will be left by the robot.
 - Gap value can range from 5-foot to 40-foot, in 5-foot increments.
 - Note that if the frontier is very long, the robot may leave a larger gap.
 - Pots Across:
 - The minimum number of plants across. The robot will determine how many plants to space, between this minimum and the maximum:
 - The lowest value is 1+
 - The maximum is the value set in the # Plants Across parameter:
- See [Section 16](#) for details on Frontier Management.

9.2 Starting to Collect

18. Requirements for starting the robot:

- Robot must be parallel to the Boundary Tape.
- Robot must be pointed towards a Source Plant (Within 10-15 degrees left or right).
- Sufficient frontier between the source pots and the Seed Plant (roughly 10 feet).
- No obstacles/containers between the robot and boundary.

19. Start the robot by pressing the Start button in the direction of the Boundary Tape.

20. The robot will progress through the behaviors for every circuit:

- Search for and pick a pot
- Turn to the boundary and seek the boundary
- Turn to acquire and follow the boundary
- Search for seed pot and unoccupied space

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- Turn into row and place pot
- Go back down the field searching for a pot

21. Two behaviors are more common in collection:

- When the robot places a pot, it lowers the gripper and then pushes the pot into position. This is to prevent the gripper from coming down on top of previously placed pots when placing pots close together.
- The robot places the pots from the outside (away from the Boundary) toward the inside. However, the final two pots are placed in reverse order. The pot closest to the boundary is placed first, followed by the second one.
 - This helps keep the robot from having to drive on the Boundary Tape.
 - This makes it easier for the robot to locate the seed pot, so it isn't obscured by the pot next to it.
- These behaviors can also occur in spacing, but are less common. The robot automatically determines when to do this, based on the pot spacing and offset from the boundary.

22. Row positioning is relative to the Seed Pot .

- If the Seed Plant location along the Boundary Tape is adjusted the placed row will be modified as well.
- Seed Plant location across the bed is not significant for collection, unless it is far enough so that it isn't detected as a Seed Plant.

23. Verify the operation

- Are the pots placed tightly enough? You can reduce the spacing distance below the actual diameter of the pot to jam them tighter together
- Is the # of pots across correct? If they won't fit in the spacing width they will be automatically cut off
- Is the offset the right width?

24. Some tips:

- In some instances the robot will have difficulty distinguishing the Seed Pot and raise the error Can't Find Seed Plant. This can help:
 - Run with a 12-inch or more offset from boundary. By positioning the pots farther in, it is easier for the laser to sight between the first and second pots. If running clockwise, this will be more significant (16 inches to 20 inches).
 - Run the robot in CCW (counter-clockwise) operation. This positions the laser so it can get a better view of the seed pot.
 - Run in Hex pattern. This makes the gap between the seed pot and second pot larger, and positions them so they are easier to identify.
- Frontiers
 - Often, collection will result in stretching frontiers because the bed is not completely full or because the collected configuration is denser than the spaced configuration the robots are starting in. Use the Frontier Management features discussed earlier to maintain a short frontier.
- Separating the collected pots into loads
 - If the robot will be spacing these collected pots in the future, it is important to make sure the pots are separated into loads to manage the frontiers for spacing.

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- The field configuration must have a specified load distance from Harvest Integration Services.
 - If the plants will be picked up by bedding forks, it is better to separate them to make it easier to pick up.
 - The robot's normal behavior will be to continue collecting pots indefinitely.
 - If a new Seed Plant is manually placed in the frontier next to the boundary, the robot will automatically start collecting in a new block.
- Robots can operate in teams (if the frontier is at least 12 feet)
- Robots can operate on both sides of the boundary tape (shared boundary)

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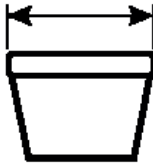
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10 Rearranging Plants on a Picked-Over Bed (Consolidation)

Consolidation is used for rearranging plants on a picked-over bed. Consolidation is the same operation as SPACING, but with extra capability added to accommodate long frontiers.

10.1 Configuring the Robot for Consolidation

CONSOL/CONTAINER SIZE



(9 plants across bed)

B-LG

10.0"		15.0'	15.0'	22.0"	22.0"
	--	2"		--	
Container Size	Pattern	Pick Width	Spacing Width	Spacing Across	Spacing Along
Aisle Type	Aisle Width	Boundary Offset	Frontier Mode	Frontier Param	

25. UI Selector Knob and Home Button:

- Rotate the Selector Knob to highlight a choice, and press it in to confirm the selection.
- Press the blue Home Button to return to the main menu.
- Keep turning the Knob to the right to enter the second row of parameters.

26. CONSOLIDATION configuration parameters:

- **The first 9 parameters are identical to SPACING.**
- Container Size
 - 5.5-inch to 13.5-inch containers.
 - Large pots can be the Regular size that has the same diameter as a smaller pot, but not the squat ones or the very tall ones
 - The gripper can handle pots down to about 6-inch tall. If the 5.5-inch pots are shorter than this they may need a modified gripper.
 - The gripper must still be adjusted for the containers to be moved.
 - **NOTE:** the pusher bar must be adjusted based on the container size dialed into the UI. The pusher bar must be in the forward position for 5.5-inch to 7-inch containers, and in the back position for larger containers.
- Pattern
 - Square or Hex
- Pick Width
 - This is the size of the bed that the robot will pick from
 - Values range from 5-foot to 25-foot in 0.5-foot increments

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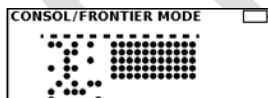


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- When the width is above 18 feet the word OVERRIDE displays to warn you of reduced accuracy and other potential issues.
- Spacing Width
 - This defines the width available to space plants into
 - Values range from 5 feet to 25 feet in 0.5-foot increments
 - The robot will not stretch the pattern to fill this width.
 - When Pick Width is changed, Spacing Width will change to match it, but Spacing Width can be selected and changed individually to be larger or smaller than Pick Width
- When the width is above 18 feet the word OVERRIDE displays to warn you of reduced accuracy and other potential issues.
- Spacing Across the Bed
 - Set the distance (center-to-center) the pots must be spaced at, going away from the boundary tape
 - The range of values depends on pot size selected:
 - For 5.5-inch-7-inch pots, values range from 9-inch to 32-inch in 0.5-inch increments
 - For 8-inch-9-inch pots, values range from 10-inch to 32-inch in 0.5-inch increments
 - For 9.5-inch-10.5-inch pots, values range from 11-inch to 32-inch in 0.5-inch increments
 - For 11-inch and larger pots, values range from 15-inch to 32-inch in 0.5-inch increments
- Spacing Along the Bed
 - The value range is the same as for Across the Bed
 - The minimum distance for 11-inch or larger pots is 15-inch
 - When the Across value is changed, the Along value will be automatically changed to match. However, the Along value can be selected independently to be adjusted larger or smaller than the Across value. This can be helpful to dial in the spacing length, to accommodate for out of space errors or inaccurate spacing due to terrain and field conditions.
- Middle Aisle
 - Choices are: None, Single, Two
 - The Single Aisle will be in the center of the bed
 - The robot will automatically determine how many pots to put on either side of the aisles. See [Appendix A: Aisle Sections](#) for details on how the pots are arranged with two aisles.
- Aisle Width
 - Set the desired aisle width. This will be the distance between the edges of the pots.
 - This value is only visible if an aisle (Single or Two) has been selected. Otherwise the value is blank
 - Values range from 3-inches to 60-inches in 1-inch increments
 - Above 48-inch the word OVERRIDE displays, indicating the potential for issues (accuracy and misplaced pots) with this configuration

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- Offset
 - Select an offset from the boundary tape. This can shift the entire pattern of pots away from the tape.
 - Values range from 2-inches to 36-inches in 1-inch increments
 - This won't affect where the robot drives, only where the pots are placed
 - If you are running robots on both sides of a boundary tape (sharing the boundary), set the offset to 4-inch or more to avoid interference
- Number of Pots across is automatically determined by the robot
 - The value will change as you adjust spacing parameters
- Frontier Mode
 - Used to manage long frontiers. When the frontier becomes long the robot can automatically react
 - Can be set to None, Gaps, or Pots Across
 - None – the robot will not react to long frontiers
 - Gaps – When the frontier grows, the robot will shorten the frontier by placing a new seed pot, which will create a gap in the consolidated pots
 - Pots Across – As the frontier grows, the robot will reduce the number of pots spaced across the bed to gradually reduce the frontier
- Frontier Mode:
 - Frontier Modes are used to manage long frontiers. When enabled, if the frontier gets long the robot will automatically react.
 - Frontier Mode can be set to None, Gaps, or Pots Across.
 - None – the robot will not react to long frontiers
 - Gaps - When the frontier grows, the robot will shorten the frontier by placing a new seed pot, which will create a gap in the consolidated pots
 - Pots Across – As the frontier grows, the robot will reduce the number of pots spaced across the bed to gradually reduce the frontier
- Frontier Parameter (Frontier Gap or Pots Across).

CONSOL/FONTIER MODE					
					
(8 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	18"	2"		--	

None

CONSOL/FONTIER MODE					
					
(8 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	18"	2"		10'	

Gaps

CONSOL/FONTIER MODE					
					
(1-8 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	18"	2"		1+	

Pots Across

- Depending on the Frontier Mode selected, this parameter will be either FRONTIER GAP or POTS ACROSS.
- Frontier Gap
 - The minimum gap that will be left by the robot.
 - Gap value can range from 5-foot to 40-foot, in 5-foot increments.



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- Pots Across
 - The minimum number of plants across. The robot will determine how many plants to space between this minimum and the maximum.
 - The lowest value is 1+
 - The maximum value is the number of plants across as determined by the robot automatically
- See [Section 16](#) for details on Frontier Management.

10.2 Starting Consolidation

27. Starting the robot:

- The robot must be parallel to the boundary
- The robot must be pointed towards a source pot (Within 10-15 degrees left or right).
- There must be sufficient frontier between the source pots and the seed pot (roughly 10 feet)
- There can be no obstacles or pots between the robot and the boundary

28. Start the robot by pressing the START button in the direction of the Boundary Tape.

29. The robot progresses through the behaviors described earlier for every circuit.

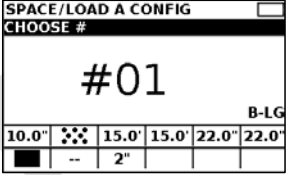
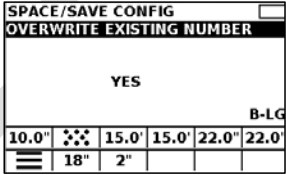
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11 Saving and Retrieving Configurations

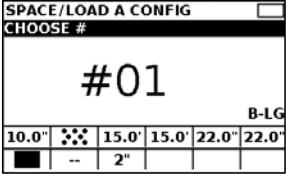
HV-100 configurations can be saved and retrieved for later use.

11.1 Saving a Configuration

Step	Action
1	Once you have entered a configuration from the Space UI Task Level you can save the configuration for later use by holding the Selector knob down. The next available number displays. 
2	To use a different number, turn the Selector Knob until the desired number is located. If there is already a configuration saved, you are prompted to override the existing configuration. To replace the existing configuration with a new configuration, select YES. 

NOTE: Presently, only spacing configurations can be saved.

11.2 Retrieving a Saved Configuration

Step	Action
1	From the top-level menu, scroll down to SAVED and press the Selector Knob. This displays all the saved configurations. Turn the Selector Knob to scroll to the number of the desired configuration and press the Selector Knob to retrieve the configuration. 



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12 Releasing a Plant

To release a plant from the gripper:

1. Pull and replace the flag to end the robot's current task.
2. Either scroll to RELEASE PLANT on the top level menu and press the Selector Knob or hold down the Start Button until the robot beeps three times.
3. The gripper opens and the robot releases the plant. Hold the plant container, as otherwise it will fall from the robot's grasp.
4. The robot locks the wheels in place. Pull the flag to release the wheels.

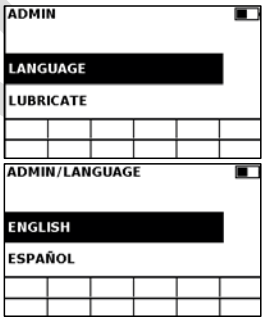
You can now move or restart the robot.

13 Using the Administration Menu

The HV-100 UI has an administration menu that contains advanced robot setup options.

13.1 Language

The Language menu allows an operator to switch UI language between English and Spanish.

Step	Action
1	Scroll to ADMIN on the top level menu and then choose LANGUAGE. Using the Selector Knob scroll to either ENGLISH or SPANISH and press the Selector Knob to activate. 



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Step	Action
3	To turn off Wifi, scroll to ADMIN on the top level menu and then choose WIFI. Using the Selector Knob, scroll to TURN OFF and press the Selector Knob to turn off.
4	The Wifi status screen does not refresh automatically. To refresh the Wifi screen, scroll the Selector Knob to REFRESH, then press the Selector Knob.

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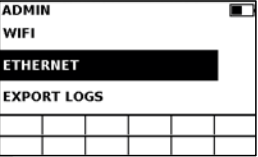
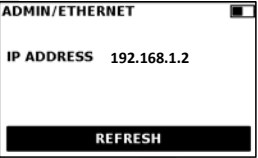
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13.6 Ethernet

The Ethernet menu allows an operator to view the robot IP address.

The Ethernet status screen will not refresh automatically. To refresh the Ethernet screen:

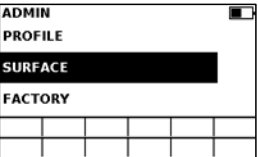
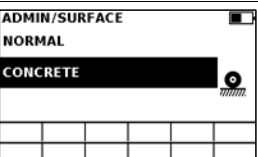
Step	Action
1	Using the Selector Knob, scroll to REFRESH and press the Selector Knob.

13.7 Surface

When operating on smooth, flat, concrete surfaces, the robot motion parameters can be adjusted to be more aggressive, resulting in a throughput increase of 10% or more.

Step	Action
1	In the ADMIN menu, select SURFACE.
2	Choose either NORMAL or CONCRETE.
3	When CONCRETE mode is enabled, a special icon will be shown in all menus:


Do not run the robots in CONCRETE mode on loose surfaces such as gravel.



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13.8 Battery Status

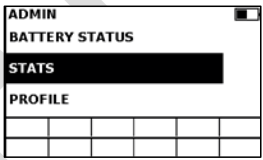
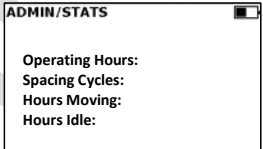
The Battery Status menu allows an operator to view details of the battery.

13.9 Stats

The Stats menu item allows the user to view stats of the robot's performance, including:

- Operating Hours
- Spacing Cycles
- Hours Moving
- Hours Idle

To view the robot stats:

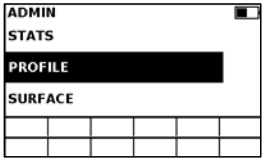
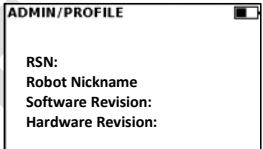
Step	Action	
1	Scroll to ADMIN on the top level menu and then choose STATS.	
2	The LCD screen will display an image similar to this for the HV-100.	

13.10 Profile

The Profile menu item allows the user to view the robot's current setup, including:

- Robot Serial Number (RSN)
- Robot Nickname
- Software Revision
- Hardware Revision (not presently used)

To view the robot profile:

Step	Action
1	Scroll to ADMIN on the top level menu and then choose PROFILE. 
2	The LCD screen will display an image similar to this for the HV-100. 

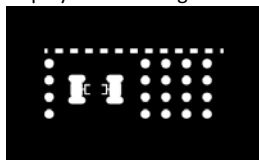
13.11 Factory

The Factory menu item allows a factory technician to test various components of the system.

14 Running Two Robots on a Field (Teaming)

14.1 Teaming

- Two robots can be run on the same field at the same time. This is called Teaming.
- The robots see the reflective dazzle tape on each other, and pause. **Make sure the dazzle tape is clean or the robots may not be able to see each other and may collide.**
- The robots must have **identical** Task Configurations, or the patterns will become distorted.
- The bed must be at least 9 feet wide or there is a risk of deadlock when both of the robots will stop for each other.
- The frontier must be at least 12 feet, or the robots will deadlock.
- When starting teammates, start the robot closest to the Source Plants, and make sure that the first robot has cleared the area and is on its way toward the Spaced Plants area before starting the next teammate.
- When the robot sees a teammate it displays the Waiting for Teammate screen while it is paused.



If the other robot does not get out of the way within 30 seconds, it PAUSEs and emits a double beep. When the teammate has been cleared, press the Start Button. The robot resumes operation.

- The robot automatically detects whether there is a teammate. When no teammate is present the robot optimizes its behavior to improve throughput. When it sees a teammate it modifies its behavior to avoid collisions.



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14.2 Shared Boundary

1. Robots can be run on both sides of a Boundary Tape. This is called Shared Boundary.
2. When a robot sees a teammate across the tape it waits for the teammate to clear before proceeding.
3. Configure the robots with a boundary offset of 6-inches or more. If the adjacent pots are too close to the Boundary Tape, the robot slows down, lowering throughput.
4. Very rarely, the robots enter a deadlock in which each robot is waiting for the other. If this happens, move the trailing robot (furthest back) to a position that is away from the boundary. Resume the leading robot, then restart the trailing robot.

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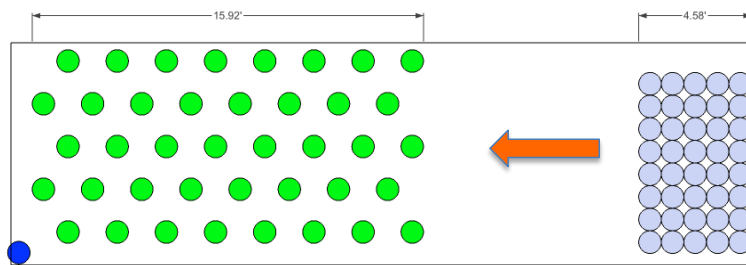
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15 Spacing Multiple Loads

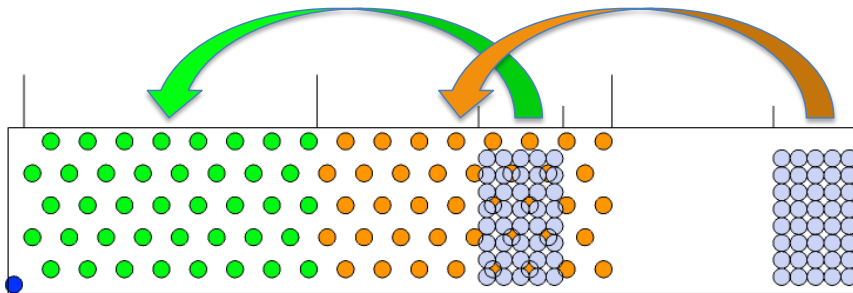
Managing the robot frontiers is very important to keep them operating continuously and efficiently. As plants are being brought in (by wagon or by bedding forks) they must be placed so that the plants fit into the space.

For example, a load of 40 can-tight pots from a bedding fork might take up only 5-feet of the bed length, but when they are spaced out the distance could be 16 feet or more, depending on the spacing.

- Position the first load so that even when the robot is moving the last pot there is a sufficient frontier.



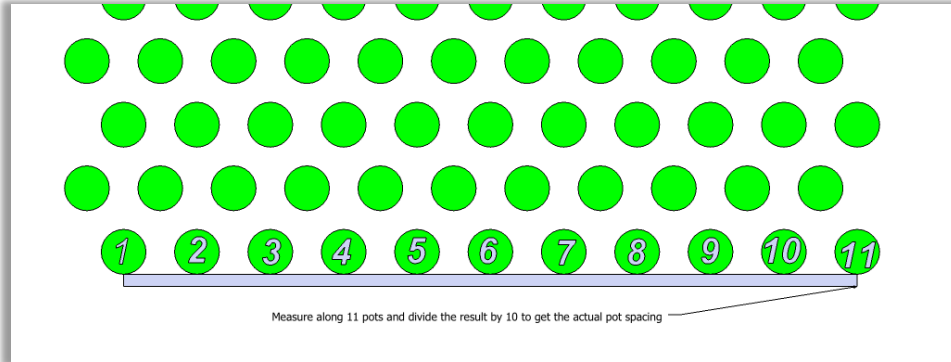
- Position subsequent loads so that the robot always has enough frontier to continue. Any changes in plant spacing may cause these values to change.
- Harvest Integration Services will work with you to calculate the load spacing and frontiers for different configurations.



- The calculated load separations are based on numbers and in the real world these don't always match up. Field and environmental conditions can change the way the robot spaces, so it is important to monitor robot performance.
 - For example, in loose gravel the robot wheels can spin, resulting in some inaccuracy for the driving distance. This often leads to the pattern becoming stretched along the field, taking up more room than expected. This can shrink the frontiers and lead to an Out Of Space condition.

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- Dust, water, or mud on the laser lens will cause the robot to measure distances inaccurately, and will lead to a stretched pattern.
1. Measure the pot placement accuracy by measuring the distance along 11 rows and divide by 10 to get the actual spacing dimension.



16 Frontier Management

16.1 Frontier Management for Spacing

Automatic Frontier Management (AFM)

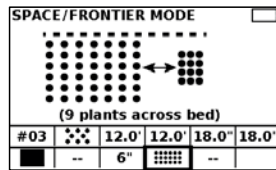
NOTE: AFM may not be enabled on your robot.

- During normal robot operation a certain amount of change to the frontier length is normal and expected. However occasionally the frontier can collapse or grow beyond what is expected due to subtle unavoidable conditions. Collapsing and growing frontiers during spacing can lead to problems:
 - If the frontier collapses the robot can run out of space and it's necessary to move a large number of pots to get back into operation.
 - If the frontier grows throughput suffers.
- Automatic Frontier Management mitigates collapsing frontier issues, as it monitors the frontier during spacing tasks and increases or decreases the spacing interval along the boundary to keep the frontier within a more optimal range.
 - The maximum allowable adjustment is 1.5-inch. For example, if spacing plants at 18-inch centers, the robot may compress the pattern to a minimum of 16.5-inch when it's running out of space, and stretch to a maximum of 19.5-inch if the frontiers get extremely long.
- As shown in the image below, a compressed spacing image appears in the selection box and in the parameter description when AFM is enabled. The user must also enter a Target Frontier. This is the average frontier that the robot must experience for a given configuration. The proper number to use is an output of the frontier calculator and must be

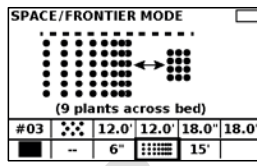


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supplied by Harvest Integration Services for each customer configuration. The average frontier, displayed as the frontier trend line is entered as the Target Frontier.



AFM Disabled



AFM Enabled, Target Frontier 15'

- Target Frontier may be calculated as:
 - Target Frontier = Initial Frontier – (Distance Between Loads ÷ 2) for loads with gaps
 - Target Frontier = Initial Frontier for a continuous load
- On each circuit the difference between the measured frontier and the target frontier is multiplied by a proportional factor and added to the nominal spacing interval parameter entered in the UI.

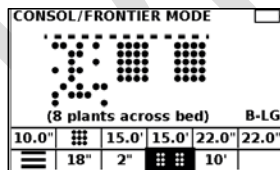
16.2 Frontier Management for Consolidation and Collection

When consolidating or collecting a bed that has been picked over, the robot frontiers can become very long. Long frontiers will cause:

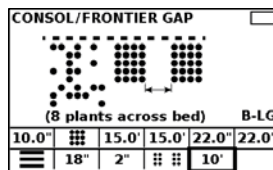
2. Low throughput, as the robot has to drive long distances.
3. As the robot repeatedly drives along the Boundary Tape, it will create ruts in soft terrain, or potentially create washboarding along the tape.
4. When the robot bounces on rough terrain, slips on looser surfaces, or slides downhill, it will be uncertain about its position, which can cause it to miss the Boundary Tape or pick pots from an adjacent bed.

There are two modes built into the COLLECT and CONSOLIDATE behaviors to handle long frontiers:

- Gaps - When the frontier grows, the robot will shorten the frontier by placing a new seed pot, which will create a gap in the consolidated pots.



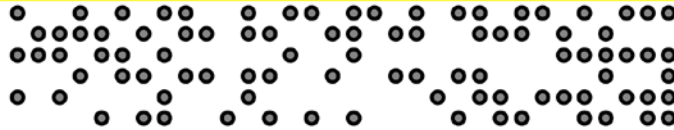
Gaps



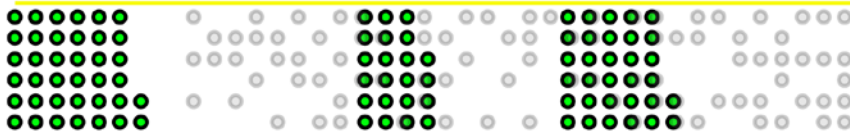
Pots Across

If starting with this picked-over bed:

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When the frontier gets long enough, the robot will leave a gap:



Resulting in the following bed:



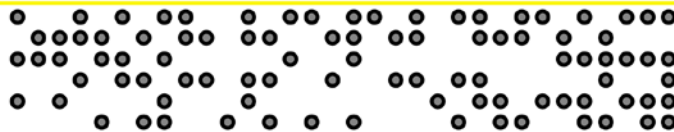
All the rows are filled, but there are gaps between the blocks.

- Pots Across – As the frontier grows, the robot will reduce the number of pots spaced across the bed to gradually reduce the frontier.

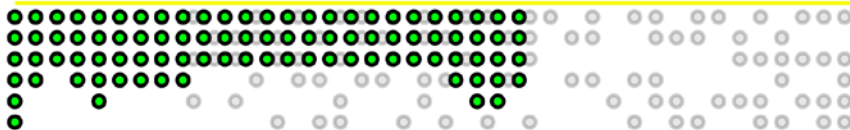
CONSOL/FONTIER MODE					
					
(1-8 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	18"	2"		1+	

CONSOL/PLANTS ACROSS					
					
(1-8 plants across bed) B-LG					
10.0"		15.0"	15.0"	22.0"	22.0"
	18"	2"		1+	

If starting with a picked-over bed:

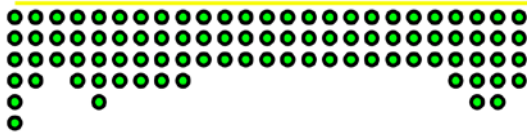


As the robot consolidates the plants, it will vary the # of pots across based on the frontier length



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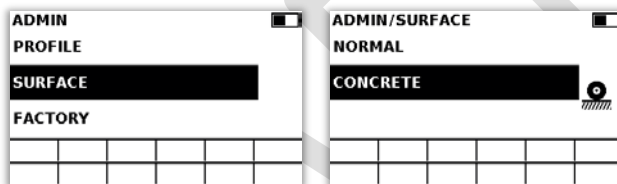
Leaving the consolidated bed looking like this:



There are no gaps between the rows, but the rows are not all completely filled

17 Concrete Mode

- When operating on concrete surfaces, the robot motion parameters can be adjusted to be more aggressive, resulting in a throughput increase of 5% or more. From the ADMIN menu, select SURFACE, then choose either NORMAL or CONCRETE.



- When CONCRETE mode is enabled, the special icon will be shown in all menus
- Do not run the robot in CONCRETE mode on loose surfaces such as gravel.



18 Replacing the Batteries

- When the battery is low, the robot will stop and beep to indicate an error
 - Battery life will vary depending on the operation of the robot and the terrain. Gravel, mud, and high-speed operation will drain the battery faster than smooth level concrete.
 - Estimate the batteries to last 4 hours on gravel, 5 hours on concrete.
- Pull the Flag, and put it back in to see the BATTERY DISCHARGED error message

BATTERY DISCHARGED



- If the robot is carrying a pot, you must get this pot out of the gripper before continuing
 - Press the Start Button and hold it down until the robot beeps
 - The gripper will relax to release the pot
- If the manipulator arm is down in the PICK or PLACE position, retract the arm to provide access to the battery compartment
 - Press the Start Button
 - The manipulator arm will retract. Wait for it to retract all the way up.

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- Pull the Flag to stop the robot
- 9. Put the Power Switch in the OFF position to power down the robot
- 10. If the battery compartment door is excessively muddy, clear it off to prevent debris from entering the battery compartment
- 11. Unlatch the battery compartment door and lift the door.
- 12. If the gripper is in a low position and the pusher bar is Forward, the battery door may not open fully. **Do not force the door against the pusher bar.** Instead, adjust the gripper higher or put the pusher bar in the Rear position to allow the door to fully open.
- 13. Slide the batteries straight out
- 14. Check for debris in the compartment, particularly around the connectors, and clear it out if necessary
- 15. Insert the fresh batteries. They will only go in a particular orientation, and the door will not close if they are not in correctly.
- 16. **Do not force the batteries or push on them. They must slide right in.**
- 17. Close the door and secure the latches. If the latches do not secure, check the battery orientation again or clear any debris that may be preventing the lid from closing all the way.
- 18. Put the Power Switch in the ON position and wait for the robot to boot up.

19 Common Issues

- 19. If there is a person standing on the bed:
 - HV-100 will try to pick the person; or
 - HV-100 could mistake the person for a seed pot, and place a new row.
- 20. If there is a person standing near the edge of the bed (boundary side):
 - The HV-100 will slow down as it passes, to reduce collisions,
 - This also happens with hoophouse walls, sprinklers, or other obstacles.
 - Set the Boundary Tape 6-inches away from walls, sprinklers, and obstacles.
 - If HV-100s are sharing a boundary, placing pots very close to the boundary, and one gets ahead of the other, it can slow the other one down.
 - Run with a boundary offset of 4-inch or more to prevent this.
- 21. If the HV-100 is started while at an angle to the boundary, it will pick a pot then head off in an angle, and will not find the boundary. The HV-100 must be parallel to the boundary when starting.
- 22. If the HV-100 is powered on and the user immediately presses Start, it will sit and beep for a while. It is waiting for all of the components to boot up and be ready. It will start automatically once everything is ready. The Wait Screen will be displayed during this period:





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23. Pick failure (too tight).
- If the gripper doesn't close all the way, the robot will first shake back and forth to correct the grasp.
 - If that doesn't work, it will open the gripper, raise the arm, back up, and try again.
 - It might not go after the same pot again.
 - It will retry twice (total of 3 attempts).
 - After 3 failed pick attempts, the robot will stop with a CANT CLOSE GRIPPER error
 - Adjust the grippers (looser).
 - Check for a plant rooted to the ground.
 - See if the robot is attempting to pick something other than a pot.
24. Pick failure (missed pick):
- If the gripper closes but isn't actually holding a pot, the robot will detect this as a phantom pick and attempt to pick again.
 - If the pot has tipped forward so that the plant foliage is close to the robot, it may not accurately detect, and could run a circuit with an empty gripper.
 - After 3 failed pick attempts, the robot will stop with a CANT PICK PLANT error.
25. Dust on the laser sensor lens can also contribute to pick failures.
- Clean the laser sensor lens with a lens wipe.

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20 Assists and Errors

Any time the user intervenes with the robot, it is called an Assist.

All flag pulls are counted as assists.

When the robot recognizes an issue, it will report an Error. There are several types of errors.

If the robot can be resumed without significant intervention, it is called a **Pause**.

If the Flag must be pulled and the robot restarted, it is called a **Stop**.

For a full description of the Errors, possible causes, and actions for resolution, refer to the **HV-100 Error Guide**.

20.1 Pause

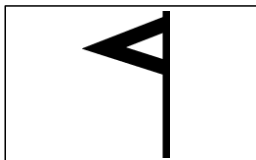
26. The robot will stop and provide a double-beep alert sound.
27. The UI will display an image with a black background to indicate the issue.
28. The robot will be holding the wheels in position.
29. The operator does NOT have to pull the flag to recover, if the robot does not need to be moved. Fix the issue as described below and press the Start Button.
 - It does not matter which direction the Start Button is pressed, the robot will resume the operation it was running.
30. The operator can still pull the Flag if desired, or if the robot needs to be moved.
 - Some situations may be difficult to simply resume from, pull the flag and recover
 - When the flag is pulled, the ERROR message will be displayed.

20.2 Error

31. The robot will stop and produce a single-beep.
32. The UI will continue to display the Robot Running image.



33. Pull the Flag to stop the robot.



- When the Flag is pulled, the robot will display the flag image.
 - Reinsert the Flag to see the error message.
34. Error images have a white background.
 35. The error message will be displayed above the image.



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20.3 Error While the Robot is Holding a Plant

If the robot is stopped for an error and is carrying a plant, it can be restarted without removing the plant. The robot will remember that it is holding a plant and won't pick another one.

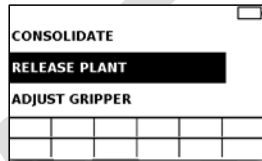
36. The rules for starting the robot still apply:

- Robot must be parallel to the boundary.
- Robot must be pointed towards a source pot (Within 10-15 degrees left or right).
- Sufficient frontier between the source pots and the seed pot (roughly 10 feet).
- No obstacles/pots between the robot and boundary.

37. The robot will drive toward a pot, then back up and turn toward the Boundary Tape and continue the circuit as normal.

To extract the plant from the robot's gripper, use the **RELEASE PLANT** behavior.

38. This behavior is also accessible from the Main Menu, called **RELEASE PLANT**.



20.4 System Fault

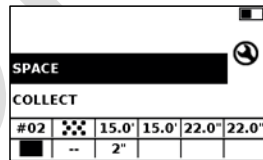
39. When a **SYSTEM FAULT** error message is shown, it means the robot has detected a potentially significant error in a mechanical or electrical component.

40. Often, the robot must be rebooted to recover from a system fault.

- Turn the Power Switch to the OFF position and back to the ON position.

41. If multiple System Fault messages are shown, upload log files and contact Harvest Automation Support and provide the messages from the **FAULT LOG**.

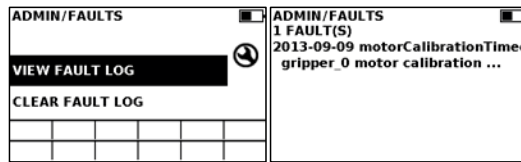
20.5 Wrench Icon



- Whenever the robot has a **SYSTEM FAULT**, the details are recorded in a Fault Log on the robot. In addition, there are some other errors that indicate potential service issues with the robot. These will now indicate a wrench on the main UI screen, similar to a check engine light.
- 42. When the wrench is shown, the robot will still operate, but Harvest Service personnel will want to know about the issue. Upload log files and contact Harvest Automation Support and provide the messages from the **FAULT LOG**.

20.6 Fault Log

- After seeing a System Fault, or if the Wrench icon is displayed, contact Harvest Automation Support and provide the messages from the **FAULT LOG**.
- On the robot UI, in the **ADMIN** menu, select **FAULTS** then select **VIEW FAULT LOG**.



- o Write down the messages to provide accurate information.
 - o **Do not clear the faults. This must only be done by trained Service personnel.**
- Contacting Harvest Automation Technical Support.
 - o When calling, have the following information ready:
 - The Serial Number or nickname of the robot.
 - Description of the behavior, what the operator was trying to do.
 - Any error messages displayed on the UI, and the approximate times.
 - The Fault information from the Fault Log.
 - Pictures or video of the behavior.

For tips and information about improving robot operation on fields please consult the **HV-100 Field Troubleshooting and Workaround Guide**.

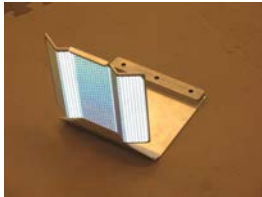
>> Contact Harvest Support
 Email: support@harvestai.com
 Phone: 978-528-4577

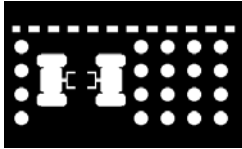
21 End of Field Marker

The End of Field Marker can be used to stop the robot. The retro-reflective tape appears like a robot, so it will stop with a Teammate Timeout error.

43. The Marker is used to stop the robot in these cases:

- At the last pot on the field.
- Between loads of different varieties, to separate them on the field.
- When collecting plants, to mark the point where a new block of plants must be collected.

Step	Action	
1	The marker must be placed about a foot behind the last pot of the load, so the robot will pick all the other pots first. The marker must be approximately in the center of the bed.  Source Plants End of Field Marker	
2	Place the Marker face down, so the reflective tape is pointed at the ground. Place a pot onto the back of the face, to hold it on the ground. Assure that the pot is between the robot and the back (upright) section of the end of field marker.	
3	When the robot lifts this pot, the Marker will tilt up and the reflective face will be visible.	

Step	Action	
4	After placing the last pot, the robot will stop spacing and time out. The robot will display the Teammate Timeout screen. Pull the flag to stop the robot.	TEAMMATE TIMEOUT 
5	On a very wide bed (above 15 feet) it is possible that the robot could miss a single marker. Use two markers in this instance.	

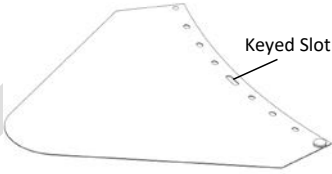
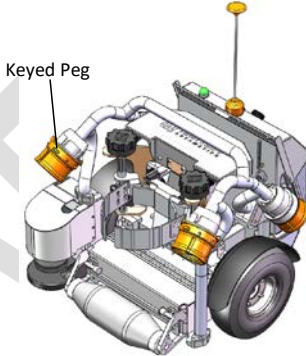
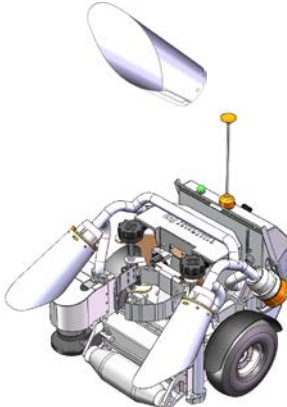


WARNING

Robots **must** be supervised at all times. It is the responsibility of the robot supervisor to prevent the robot from becoming damaged.

22 Boundary Sensor Shrouds

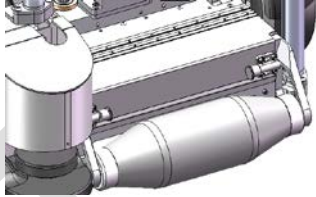
When moving bushy plants, the leaves could obscure the boundary sensors and prevent the HV-100 from finding the boundary. Boundary sensor shrouds will help deflect the plant material away from the boundary sensors.

Step	Action	
1	Locate the keyed slot on the boundary sensor shroud. The keyed slot is oblong and longer than the other holes on the shroud.	 Keyed Slot
2	Locate the keyed peg on the front boundary sensors. The keyed peg is oblong and longer than other pegs on the boundary sensor.	 Keyed Peg
3	Install the shrouds by wrapping them around the boundary sensors and aligning the pegs and slots as shown. The flat button must rest against the boundary sensor housing – it will be difficult to snap together if reversed.	

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23 Robot Care

23.1 Sensor Cleaning

Step	Action
1	HV-100 can be cleaned by washing with a low pressure hose. This must be done with the battery box closed and latched. 
2	The boundary sensor lenses and laser lens must be cleaned frequently: 44. At the beginning of the day's operation. 45. When the batteries are changed. 46. Any time there is contamination visible from dust, dirt, mud, water, or plant material. 47. The HV-100 must be cleaned with a lens wipe, do not use an oily/dirty rag as this may not properly clean the sensors and may scratch the lens.
3	Wipe the laser sensor at each battery change or if it appears dirty and a change in the HV's performance is noticed. Run the wipe in a single direction across the laser sensor. 
4	Wipe all 4 boundary sensors at each battery change or if the HV-100 reports errors related to the boundary. 

NOTICE

Washing HV-100 with a high pressure hose may cause damage. **Do not pressure wash.** Ensure that the battery box is closed and latched during cleaning.



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24 Boundary Tape Cleaning

- The Boundary Tape is reflective and must be clean so the robot can detect and follow it.
- Be careful to avoid damaging the tape when cleaning it, as scratches or blemishes will reduce the effectiveness.

Follow these guidelines for cleaning:

Boundary Tape Cleaning Methods	
Condition	Cleaning Method
Wet Mud	Clean off wet mud with a narrow squeegee: • Blade of squeegee must be soft to avoid scraping or scratching the tape. • Must be wet so that it can be wiped away, not ground in. Clean off wet mud with a hose.
Dried Mud	Using bucket(s) of water or a hose, first wet down the dried mud, then clean the mud off the tape with one of the following methods: • Use a soft cloth or paper towel to wipe the mud off. • Use a hose to wash the mud off. • Use a squeegee to wipe the mud off. Briefly submerge the tape in a bucket of water. The tape must be allowed to dry before using it.
Dust	Wipe tape with a soft cloth or paper towel without wetting the tape.



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25 Appendix A: Aisle Sections

- Single Aisle (Middle):
 - o If the number of pots across is even, there will be an equal number of pots on either side of the aisle.
 - o If the number of pots across is odd, the section closer to the boundary will have the larger number of pots.
- Multiple Aisle:
 - o The robot will divide the number of pots per section as described in the following table:

Plants per row	Section 1	Section 2	Section 3
3	1	1	1
4	2	2	0
5	2	2	1
6	2	2	2
7	3	3	1
8	3	3	2
9	3	3	3
10	4	4	2
11	4	4	3
12	4	4	4
13	5	5	3
14	5	5	4
15	5	5	5
16	6	6	4

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