Garford

Robocrop

Precision Guidance System

Manual
Version 6.4 (Draft)

Disclaimer

Considerable effort has gone into making Robocrop reliable under normal commercial conditions. However, it is possible that under some adverse circumstances the guidance system will be unable to operate reliably. It is the operator's responsibility at all times to ensure that the machine is operating in a satisfactory manner. Should excessive crop damage occur operation should cease and if necessary, your Garford dealer should be contacted for advice.

Contents

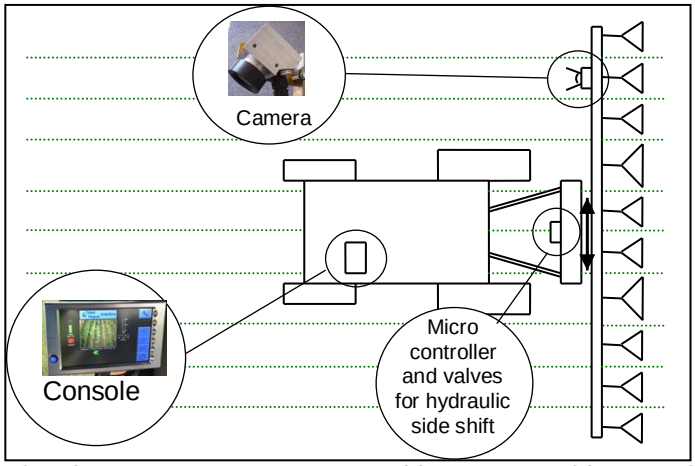
1. Preface

Congratulations on purchasing a Robocrop precision guided implement.

Robocrop precision guided implements are guided by a computer controlled steering system.

There are 3 main components to the system.

1. A digital camera or cameras mounted on the implement looking ahead at a wide area of crop normally taking in several rows.
2. A cab mounted console containing a computer to analyses camera images and find exact row centres.
3. A hydraulic side shift (or steered discs) controlled by the computer to keep the camera centrally over crop rows and the implement precisely on track.

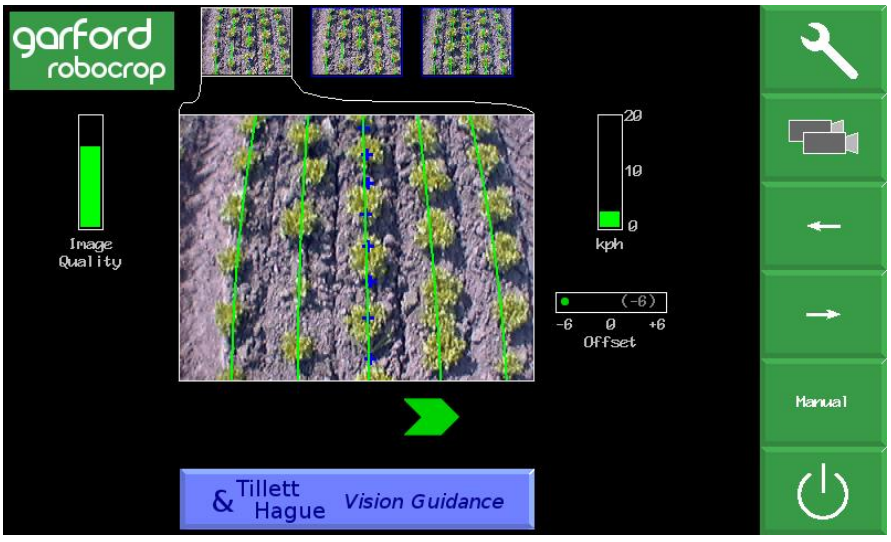


Schematic of Robocrop on a rear mounted inter-row cultivator with side shift

Robocrop uses a colour camera to pick out green crop and weed from backgrounds containing soil, stones and trash. (Consult your Garford dealer for systems to work in red crops.) Robocrop locates crop rows within a scene by matching a template corresponding to the known planting pattern with crop rows as they appear in the camera image. That image is displayed live on the console with the template overlaid as green lines.

Matching a template to a broad area of crop rather than locating individual rows improves reliability especially when parts of those rows are not present or obscured by weeds. Template shape is determined by a configuration file pre-programmed to suit a particular crop planting geometry and implement configuration. Different configuration files can be created for different crops and implements.

A good match between the template and crop rows is very important for accurate row following.



Console working screen showing a typical live video image with the template superimposed as green lines over crop rows.

2. Safety

1. **When carrying out repairs or adjustments to a side shift, steering discs or implement, ensure that the Robocrop system is switched off and also that the hydraulic supply is off.**

   Be aware that spurious speed signals can be generated potentially causing the side shift/steering discs to move unexpectedly. This is most likely if odometry is generated via GPS, which is inclined to drift, or via computer vision, particularly if people are moving in the camera field of view.

2. **Never conduct maintenance work on the side shift mechanism while it is supporting the implement.**

3. **The side shift and steered disc mechanisms forms pinch, trap and shear points. Be aware of these when carrying out maintenance.**

4. **Regularly check the condition of hydraulic hoses and fittings.**

5. **Do not allow other persons to ride on or work near the implement when it is in operation.**

6. **The power supply cable has a 20Amp fuse fitted near to the battery terminals. This is for short circuit protection and must not be omitted.**

7. **When routing the loom and power supply cables ensure that they do not cause a restriction or trip point in the cab.**

3. Assembly

The following steps outline how the Robocrop precision guided implement should be set up.

Step 1 - Mounting the console
Mount the console in the tractor cab in a position where it can be clearly seen, but does not obscure operator's visibility. Four M6 tapped holes at a square 100mm pitch in the rear of the console facilitate mounting to a bracket. A number of alternative mounting arrangements are possible, but it is recommended that the chosen method should provide some vibration isolation.

Caution

- The console should be protected from severe vibration.
- Do not use longer screws than those supplied otherwise damage to the console may result!

Step 2 – Hitching to the tractor
Position the tractor and implement on a level surface. Check that the tractor's lower link arms are evenly adjusted and hitch the tractor to the 3-point linkage points on the side shift frame.

Caution

- The side shift 3-point linkage points are to standard category 2 dimensions and so must be attached to a similar tractor linkage.
- Once the 3-point linkage is correctly fitted stop the tractor and apply the handbrake.

Step 3 – Reducing lateral movement
Adjust the stabiliser links to prevent lateral movement of the lower link arms.

Caution

- For side shifting front mounted systems it is particularly important that there is no lateral movement in the linkage.

Step 4 – Levelling the implement
With the cultivator on the ground, adjust the top link so that the cultivator is level, front to rear (camera pole(s) should be vertical).
The control system loom and hydraulic hoses can now be routed from the implement to the tractor.

Caution

- Clipping the loom and hoses to the top link should keep them clear of catch points.
- Make sure that the linkage can be operated over its full range without stretching or chaffing the loom conduit or hoses.

Step 5 – Connecting the hydraulic hoses
Plug the hoses into a suitable double acting valve connection on the tractor. Markers on the hoses indicate the following:

Supply – RED Return - BLUE.

Step 6 – Connecting the implement to the console
The cable/conduit from the implement module should be routed into the tractor cab and through to the console.

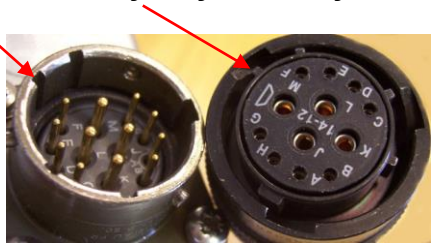
Caution

- Do not to allow the loom to restrict access to or exit from the cab or act as a trip point.

Plug the multi pin plug into the socket in the bottom of the console.

Caution

- Note the correct alignment of the tabs in the plug and socket and avoid excessive force in pushing the connector together. **If you have any problems with this connector consult your dealer as incorrect assembly may seriously damage the computer**.



Step 7 – Connecting the power supply

The 12V power supply cable running from the implement module should be connected directly to the tractor battery or via purpose designed power sockets. Cigarette lighter sockets are not suitable.

Caution

- Route the cable carefully ensuring that it cannot become trapped or chaffed.
- The 20amp fuse at the battery terminal end of the cable is for short circuit protection and must not be removed.
- The polarity is denoted by + and – marker rings on the cables. The fuse is on the + cable.

Step 8 – Start the tractor and console

With the implement still on the ground check that the spool valve is in neutral and all persons are well clear. Start the tractor then press the console power button which will remain illuminated. Wait for the system to "boot up" with a few text screens then a graphics start up screen with touch screen buttons should appear. Press the touch screen button labelled Inter-Row. A new screen with a live video image will appear, this is referred to as the working screen.

Step 9 – Checking hydraulic operation

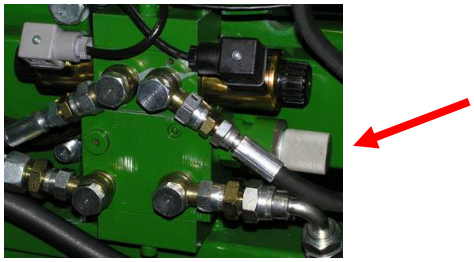
Set the tractors hydraulic control to provide a constant flow to the implement with the facility to disengage the supply immediately should a fault occur.

Once the system has booted up and the working screen is displayed, lift the implement clear of the ground and engage the hydraulic supply. The side shift or steered discs should centralise.

If the side shift or discs were already central and you wish to test them press the second touch screen button from the bottom on the right labelled “manual”. The hydraulic side shift/steering is now in manual mode and can be operated via the touch screen buttons labelled with left and right arrows. Each button press steps side shift/steering by 7% of its stroke. Repeated pressing (but not holding your finger down) will result in continuous travel up to the end of the stroke. This procedure can be used to check that hydraulic flow is in the correct direction and that the side shift rate is correct. A normal side shift rate would be 0.1m/s (e.g. 3s to travel a 0.3m stroke). To return to normal automatic mode press the same button again. The side shift/disc will stay in the position until the implement is lowered and raised again, or the machine starts to travel forward.

Caution

- Side shift/disc travel all the way to one side on lifting the implement may indicate that the hydraulic supply is connected the wrong way.
- Rapid side shift/disc oscillations back and forth about the central position indicate that the hydraulic flow rate is too high. The tractor flow control should be turned down. Alternatively, the hydraulic flow control valve on the implement may be adjusted, see picture.
- Only adjust the flow control valve with the implement on the ground and the tractor engine switched off.



The machine is now ready for work, though before proceeding to the operational phase it is worth familiarising yourself with the working screen.

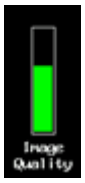
4. Start up and working screen

Turn the system on by pressing the console button for about a second until the button is illuminated. After some PC start up text the user is presented with a start-up screen offering the choice between starting the guidance system, going directly to the set up screen, opening the service menu or shutting down.

To get to the working screen press touch screen button with the crop row symbol. When a press has been detected the touch screen button will become darker, though the function is only activated when your finger is released.

The working screen as illustrated below has the following features:

- A live camera video image over which are superimposed two sets of markings. The first are green lines representing the template to which crop rows are matched. The second are a series of eight crosses arranged from the top to the bottom of the image. These represent how well the template lines up at different levels up the image. Blue crosses indicate a good match. Yellow and red crosses indicate a poor match.
- Systems with multiple cameras display live thumbnail videos along the top of the display.
- An image quality gauge to the left of the screen giving relative indication of likely tracking performance. The higher the green bar the better. A low bar indicates either a poor template match or poorly defined crop rows. Guidance will, under most circumstances, operate down to an indication of approximately 20% albeit at reduced accuracy.

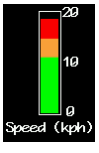


- Information symbols at the bottom left of the display:
    - A warning triangle indicating poor tracking is displayed if estimated error in lateral position exceeds 25mm. The number between the arrows is the section to which the warning applies. On seeing this warning users should check performance on the ground. If enabled the warning triangle will be accompanied by an audible warning.

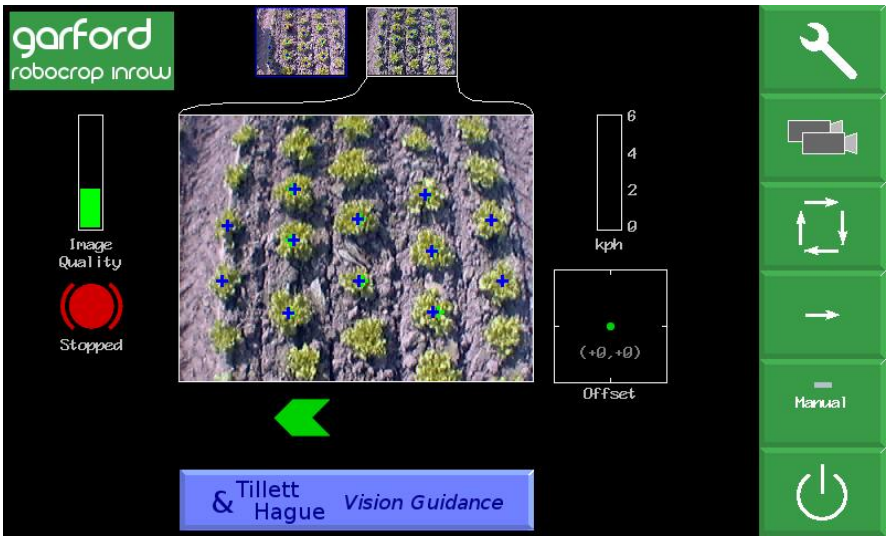
    - An implement lift symbol is displayed if the lift sensor detects the implement is lifted.

    - A circular red braked symbol is displayed if the implement is down but not moving.

- A speed gauge on the right shows forward speed which should match tractor speed. The speed bar is green up to 11kph and red over 15kph, which is normally a sensible operating limit, though guidance is good to 20kph where soil/crop conditions permit.



- A green dot and red/green chevrons below the image indicate side shift position. A red chevron with a vertical bar indicates the limit of travel has been reached. This should not be allowed to occur for extended periods.
- The fine offset gauge shows the amount of left or right bias set by the user. This is used to compensate for minor lateral camera misalignment, but can also be useful on side slopes. By default, fine offset has six 1cm steps in either direction, though the number and size of steps is configurable.



The function of touch screen buttons located along the right of the screen are given below:

- Spanner symbol, this button accesses the setup menu (section 9).
- "Select" on multi camera systems and blank for single camera systems. This touch screen button toggles between cameras affecting the main image displayed and fine offset context. Alternatively, pressing on a thumbnail image will also select it for full size display.
- ← moves fine offset left 1cm, or when in manual mode, side shifts/steers 7% left.
- → moves fine offset right 1cm, or when in manual mode, side shifts/steers 7% right
- Touch screen button labelled "Manual" disables vision steering and allows the user to move left or right manually in steps of 7% of potentiometer stroke for each press of the arrow buttons. For disk steered machines this is achieved by automatically steering the discs to maintain the desired slide position. To prevent mechanical damage these functions only operate when lifted or moving.

  In manual mode green lines representing the template and purple cross hairs are locked on the screen whilst retaining a live video image. These are useful when adjusting cameras.

  Return to vision guidance by pressing same button, now labelled "Camera", again. By default the side shift/discs remain in the position they were placed manually until forward movement under vision guidance is commenced, or an implement lift is detected. The later will centralise the side shift/discs. Alternatively, systems can be configured such that side shift/discs centralise on entry into manual mode (section 9.3).

  For single section side shift machines manual control is retained with a normal tracking screen when moving forward so operators can see if vision guidance is likely to succeed.

  For machines with mechanical guidance feelers the "Manual" button cycles between manual mode, feeler and vision guidance. In manual or feeler guidance mode the fine offset slide bar is replaced by Text in red capitals indicating the mode in use. For machines fitted with a remote override manual control box the text would say "REMOTE MANUAL" when the box was switched on.
- Pressing the touch screen button with the power switch logo enters a shutdown screen from which you can confirm shutdown.

5. Getting to work in the field

The most important procedure to ensure good guidance is to match the template, as illustrated by the green lines, to crop rows as they appear in the live video image. The following steps outline how to get the best match and hence achieve good guidance.

Tip
For the first few hundred meters of running after commissioning Robocrop learns a term known as camera skew (see section 7.3) Camera skew compensates for minor errors in camera orientation in the horizontal plane. Wherever possible we recommend that set up runs (step 4) are conducted in crop showing the clearest rows available so that camera skew is learned as quickly and accurately as possible. High visibility rows also help manual alignment checks (step 3). We also recommend that side slopes and intense partial shadows are avoided during initial running. Once set up is complete more challenging situations can be tackled. It is also possible to view the current value of camera skew and reset it manually (see section 7.3).

Step 1 – Selecting configuration file and crop size

From the working screen press button labelled with a spanner symbol to reach the setup screen.

The top line of this screen indicates crop size (height) settings under categories of small (<5cm) medium (5-15cm) and large (>15cm). The second line lists the available configuration files. Use the buttons labelled with arrows to ensure that the highlighted options correspond to the crop and crop size being used for setup and initial running.

Check details at the bottom of the screen to ensure selected configuration file settings match crop and camera geometry.

If either crop geometry or configuration settings are not correct refer to section 7 for instructions on making the necessary changes.

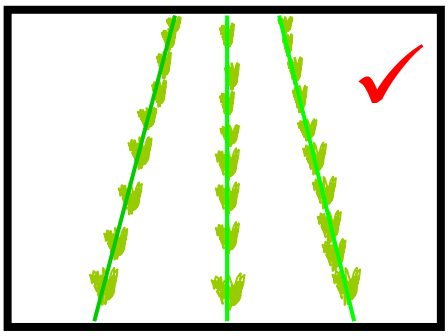
To return to the working screen by pressing the button labelled “OK”.

Step 2 – Checking camera height and inclination angle in the field

Draw into the crop and set the cultivator down onto a typical section of crop row. The cultivator should be level and set onto the rows as accurately, and as straight as possible with the camera at its normal operating height (displayed in the “set up” screen).

Press button labelled “Manual”, The overlaid green lines representing the template should lock in the centre of the screen.

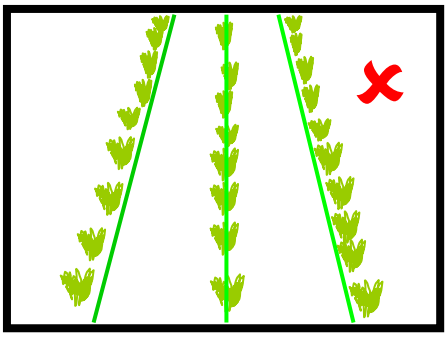
Green lines superimposed over the live image should align with crop rows as illustrated below.



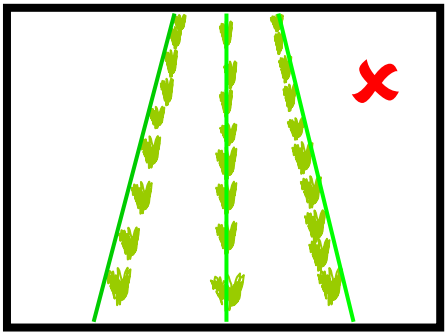
Tip
If crop rows are difficult to see in the live video image you can enhance them by placing high visibility objects such as a strip of wood exactly over the row centre line.

Caution
If the overlaid green lines are not symmetrical on the screen (by more than 4 degrees) the camera skew value may need resetting. Refer to the advanced set up & diagnostics menu in section 7.3.

However, if the green lines appear narrower or wider than the real crop rows check the “crop size” selected in the “set up” screen and change if appropriate. If this does not resolve the problem, it may be that the camera height (measured from centre of lens to ground level) does not match the figure displayed in the “set up” screen. The best solution is to measure the correct position and move the camera accordingly. A less accurate, but sometimes satisfactory alternative, is to adjust camera height until the “picture” looks correct as illustrated below.



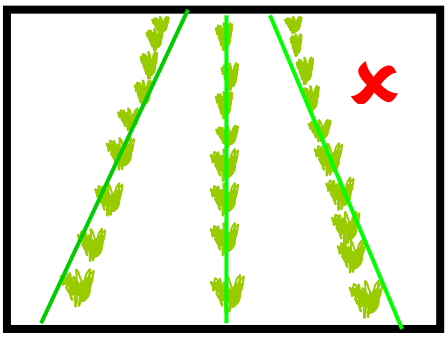
If the camera is too low, then the template will appear narrower than crop rows. In this case raise the camera.



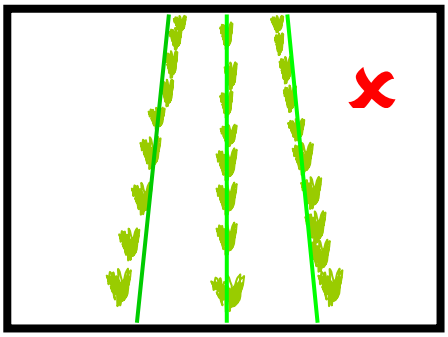
If the camera is too high, then the template will appear wider than crop rows. In this case lower the camera.

If the template matches mid screen, but not at the top or bottom, check that the implement is level. If it is camera inclination angle may need adjusting. Again the best solution is to make careful measurements and adjust accordingly. This may be done as follows. Go into the “set up” screen and make a note of a distance called “look ahead”. Return to the working screen and press Sk5 labelled “manual”. Purple cross hairs will appear in the image. Now mark a point on the ground directly below the camera lens (ideally using a plumb bob). From that point measure forward along the ground and place an object at the “look ahead” distance. When viewed on the screen the object should now coincide with the cross hairs intersection in the image centre. If it does not camera inclination should be adjusted until it does.

Again a less accurate, but sometimes satisfactory alternative is to adjust camera inclination until the “picture” looks correct as illustrated below.



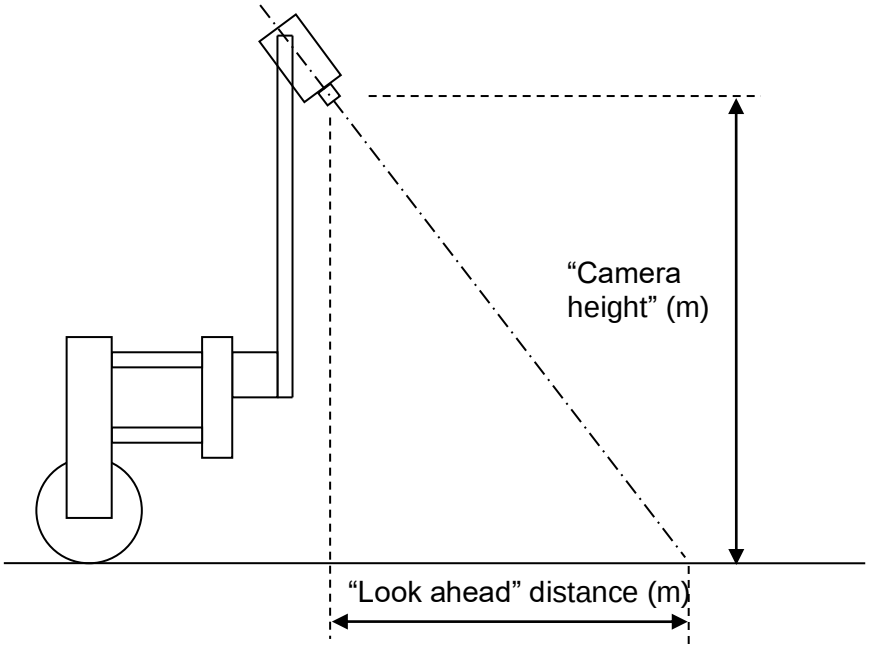
If template lines appear narrower than crop rows at the top of the image but wider at the bottom, then the camera is inclined down too far. In this case rotate the camera up so it views further ahead.



If template lines appear wider than crop rows at the top of the image but narrower at the bottom, then the camera is inclined up too far. In this case rotate the camera down so it views less far ahead.

Good tracking will only be achieved if template lines are centred on all of the rows being tracked.

Note Remember to tighten any bolts loosened in the process of adjustment.



Step 3 – Initial running and adjusting camera lateral position
When you are happy you have a good template match press the button labelled "Manual" again to return to the normal working screen ready for tracking. You can be sure that the machine is ready for tracking if a line of blue crosses has appeared down the centre of the display.

Note
For initial set up runs almost all the crosses should be coloured blue and form a relatively straight vertical line. If this is not the case, or a triangular tracking warning symbol is displayed, either the machine is not correctly set up, or crop rows are not sufficiently well defined for initial running.

If tracking appears good set off slowly into the crop. The implement should quickly align with crop rows. It is likely that after a short distance it will have settled at a small lateral offset. Small offsets can be corrected using the fine offset facility available from the working screen. Buttons labelled with left and right arrows adjust fine offset whose current position is displayed centrally below the live video image. Each press of an arrow key biases the side shift in steps of 1cm (3/8"). Continue down the field stopping occasionally to check lateral position. If the required fine offset exceeds the available number of steps the camera should be physically moved as described below and step 3 repeated.

It is the operator's responsibility to decide at which point the vision guidance system becomes 'lost'. If the system losses track of crop rows the operator should carefully guide the implement through to the next good reference.

Garford accept no responsibility for damage to or loss of crop whatsoever.

After approximately 200m of running Robocrop should have learnt camera alignment ("camera skew") and lateral bias should therefore have stabilised. If fine offset is set to greater than two steps, we recommend physically moving the camera along the toolframe by the equivalent distance and resetting fine offset to zero.

Tip
If fine offset is set to the left, then the camera should be moved right as viewed from behind looking forward.

Once you are confident that Robocrop is tracking accurately and reliably forward speed can be increased. Working speeds up to 12 kph can be accommodated with Robocrop, however the mechanical interaction of shares and shields on the soil and its effect upon plants will determine if this is achievable.

6. Notes on daily operation with a correctly set up machine

- Before operation check that electrical and hydraulic connections are secure and that there are no obstructions to side shift/disc movement.
- On first setting the implement down in the field check that the green overlaid lines representing the template line up with crop rows and that overlaid blue crosses have appeared approximately central in the image.
- Proceed with caution for first few meters checking that Robocrop's speed gauge matches the tractors and that implement alignment is good. If performance is satisfactory speed can be increased. Robocrop's tracking should be satisfactory up to 12kph, though soil movement considerations may dictate a lower operating speed.
- Robocrop remembers fine offset settings from previous sessions and so there should not normally be any need to adjust this unless changes have been made to camera position.
- Operating on side slopes will result in some lateral error due to the tractor "crabbing" across the slope. Normally this is not significant, but in extreme cases it may be necessary to use the fine offset function to compensate. If operating in this way remember to reverse the bias when heading in the opposite direction and to return to a neutral setting when stopping work or moving to a flat area. A similar technique can be used to compensate for crop bent laterally by a cross wind.
- Each time the implement is lifted at row ends it will centralise ready for the next run.
- At the end of the day shut down by pressing the bottom right touch screen button labelled with the power symbol and confirm with the "exit" button. This will shut down power to the entire system though the console power button will briefly flash every 5 seconds to indicate that the 12V supply is connected. In this state the current draw is negligible.

If in doubt about any machine settings or operating procedures, please contact Garford Farm Machinery on +44 (0)1778 342642.

7. Information screens and menus

Robocrop has a graphical working screen that conveys all the information necessary for normal operation. A description of this screen is given in section 4.

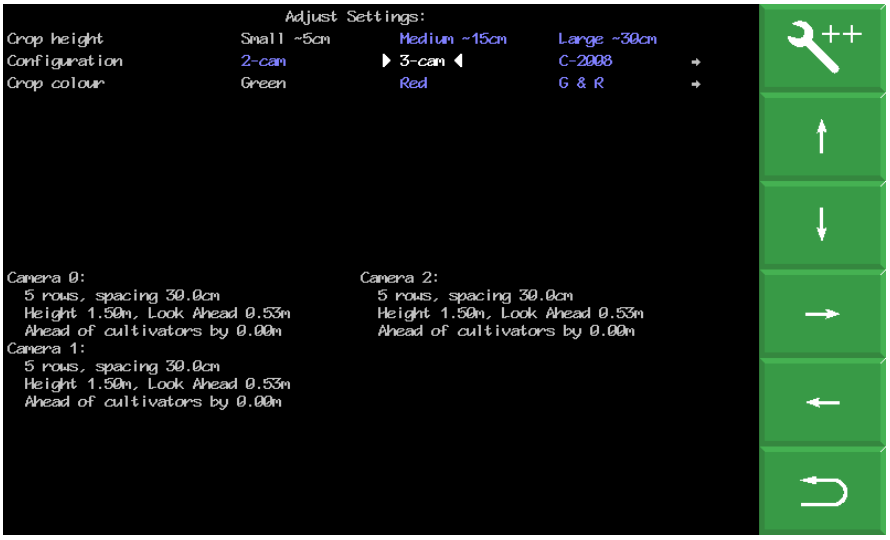
A series of six touch screen buttons along the right of the display allow operators to access user controls such as fine offset and manual control of side shift/steered discs. Their function is described by labels superimposed on each button.

Set up procedures and more advanced information can be accessed via additional screens that can be navigated to via the working screen. The function of the touch screen buttons changes with each screen, but is always described by its label.

7.1 The Setup Menu

The setup screen can be reached by pressing the spanner button from the working screen. Three settings "Crop size" and "Configuration" and "Crop Colour" (optional facility) can be altered in this screen.

Navigation within the set up screen is achieved by moving the cursor over options using buttons labelled with arrows. When the cursor is over an appropriate setting it can be selected by pressing the button labelled "OK".



"Crop size" increases template size to compensate for the crop canopy getting closer to the camera as it grows. This avoids the need to physically adjust camera height when moving between crops of different heights. Robocrop has settings for small, medium and large crops. As a guide, crops up to approximately 5cm (2") high are regarded as small, 5cm (2") to 15cm (6"), medium and greater than 15cm (6") high, large. On initial set up the default will be medium, though Robocrop remembers crop size from the previous session regardless of which configuration file was used.

"Configuration" allows users to select between alternative pre-programmed configuration files for different crop planting geometries requiring different templates.
The main parameters of the chosen configuration file are displayed at the bottom of the setup screen, they are:
Camera number
Viewing - Number of rows being used for tracking.
Spacing - The row spacing between the rows being viewed.
Camera height - Distance vertically from lens to ground when in work
Camera look ahead – Horizontal distance along the ground from a point vertically below the lens to the centreline of sight (marked by cross hairs in "Manual" mode).

"Crop colour" (optional facility) – For green crops select "Green". Selecting "Red" inverts colour segmentation so that plants that are completely red are tracked. Where crops have red outer leaves and a green centre, users should select "R & G". It is also possible to select "Custom" colour which can bias the colour used by the system to search for foliage. This can be advantageous on crops such as brassicas or alliums with a blue/green colour (a value of about 50 has often be found to be satisfactory).

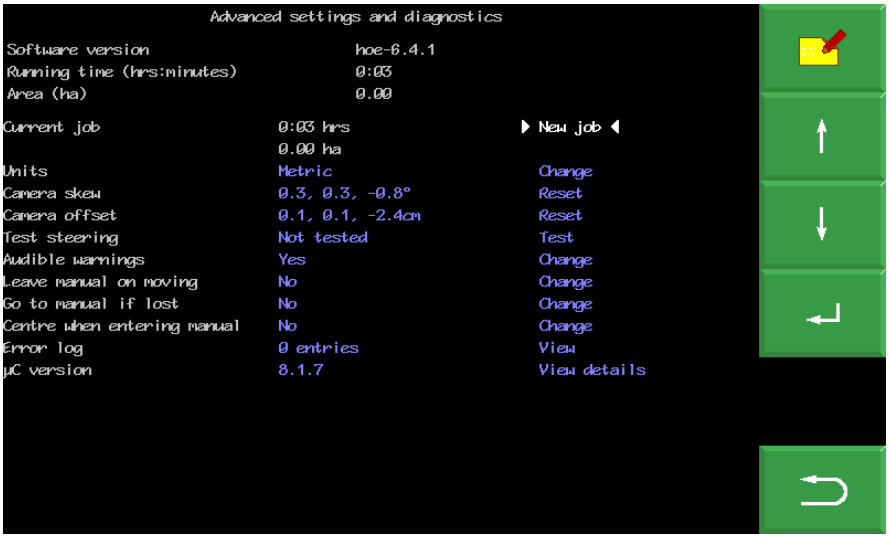
For plants with particularly unusual colours that cannot be tracked using any of the normal colour options an Infra-Red camera can be fitted. This will be automatically detected and is recognisable by monochrome video images.

If a suitable configuration is not available, it can be created. We recommend customers ask their Garford distributor for an appropriate configuration file. However, experienced users can use the configuration file editor (section 7.4) to create their own.

7.2 Advanced set up & diagnostics menu

This screen is reached from the set up screen by pressing the top right button labelled with a spanner ++ symbol. Navigation within this screen is similar to the set up screen.

The first three items on this screen are for information only and cannot be changed by the user. Area worked is based on distance x width.



The remaining items on this screen are as follows:

Current job

Provides resettable counters for elapsed time and area treated.

Units

Selecting toggles between metric and imperial units. This change affects all user screens and the configuration file editor.

Camera skew

Camera skew is a measure of camera angular misalignment in the horizontal plane. This angle is estimated by Robocrop's computer programme during field operations. Rate of change is highest during initial runs and after resetting to zero. It stabilizes after approximately 100m of running. During this initial learning phase, it is sometimes necessary to readjust the fine offset (section 7.1).

The purpose of estimating angular misalignment and automatically compensating is to avoid the need for very accurate mechanical setting up.

As camera skew relates to a particular camera poise it is necessary to reset it to zero manually and allow it to estimate a new value each time the camera is moved either deliberately or by accident. Small lateral camera adjustments by sliding within the stroke of the supplied camera bracket should not however require a reset, as camera poise should not be significantly affected. A reset to zero is achieved by using arrow buttons to highlight reset and pressing the return button.

Caution
After resetting camera skew it will probably be necessary to adjust fine offset.

Camera skews in excess of 3 degrees indicate poor camera alignment requiring improvement.

Camera Offset (only present with multiple cameras on the same section)

Camera offset is the lateral error between two or more cameras fitted to the same section. Like skew it is estimated by Robocrop's computer programme during field operations. Rate of change of this estimated displacement is highest during initial runs and after resetting to zero. It stabilizes after running approximately 100m. There are as many offsets as there are cameras on a section. The first camera is master from which offsets are derived and so it always has zero offset.

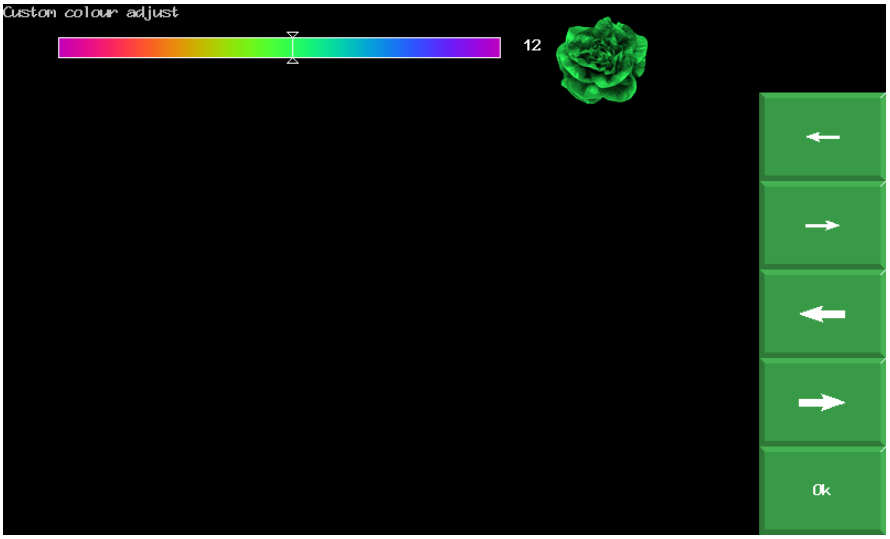
The purpose of estimating lateral misalignment and automatically compensating is to avoid the need for very accurate mechanical setting up.

Camera skew relates to camera offset so that resetting skew resets both figures for all cameras fitted. However, resetting offset does not automatically reset skew.

Custom colour (only present if enabled and custom colour selected)

Selecting "adjust" provides a tool allowing users to bias the colour used for detecting plants. For example, a small deviation from the standard green (0 on this scale) towards blue (e.g. 30) can improve detection of some brassicas and alliums. Arrow keys shift the current selected colour value which is reflected in plant icon colour. Large arrows move in steps of 10. Small arrows in steps of 1.

Enabling custom colour is discouraged unless it is absolutely necessary as it adds complexity and can, if not set correctly, dramatically reduce performance.



Test steering

This test function checks a number of components and settings relating to side shift or steering angle movement. Included are micro-controller communication with the main computer, direction of hydraulic flow, rate of flow (too fast or too slow), correct side shift/disc potentiometer connection polarity and continuity over the stroke. It also detects mechanical obstructions preventing full travel. This is achieved by exercising the hydraulic cylinder and recording the response. It is therefore necessary to turn the hydraulic supply on. For multi section machines you are prompted to select which section to test.

Caution
Ensure the side shift/disc steering mechanism is clear of obstructions and people before running.

Audible Warnings

When selected “Yes” a buzzer inside the console sound when warning symbols such as the poor tracking symbol appear on the working screen. The default is “Yes”.

Auto select feelers (only shown with mechanical crop guidance feelers fitted)

When selected “Yes” automatically drops from vision guidance to feeler guidance when one of the feelers is deflected by the crop. The default is “No”.

Leave manual on moving

When selected “Yes” automatic camera control takes over when motion is detected. The default is “No”.

Go to manual if lost

When selected “Yes” control will be switched to manual if the system is unsure of row position and the buzzer will sound for four seconds. If “No” is selected it will attempt to relocate the rows and continue vision guidance. The default is “No”.

Centre when entering manual

When selected “Yes” the side shift or steering discs will centralise whenever manual is selected. If “No” is selected the side shift or discs will stay in their current position until a manual steering input is made. The default is “No”.

Error log

This is a log of automatically generated error messages (e.g. camera connections, microcontroller connections and excessive camera skew). Selecting “view log” displays single line messages that can be helpful with diagnostics. Not all messages indicate serious faults. On exit you have the option to select “clear” which erases messages or close which returns to the advanced set up & diagnostics menu without erasing. These messages are saved between sessions.

Tip When seeking advice over the telephone it is very useful to have an exact word for word record of any error messages and to make a note of numeric error codes.

µC version

Displays the version numbers of any microcontroller boards fitted.

To exit the advanced set up and diagnostics screen press the bottom right button labelled “OK”.

7.3 Configuration file editor

Configuration files store information relating to a specific crop planting pattern and implement/tractor geometry that is necessary for row tracking. Each combination of a different crop pattern or implement geometry requires its own configuration file.

The configuration file editor allows experienced users to create and edit configuration files, but also provides a method of changing general machine settings such as language and units. It is reached from the advanced set up and diagnostics menu by pressing the top right button labelled with a pen and file editing graphic. Users are required to enter a PIN to prevent accidental entry to the editor. The default is 1,2,3,4.

Less experienced users are advised to contact their Garford dealer who can supply them with customised configuration files.

The editor is available in English language only though use of graphical symbols makes many functions independent of language.

The editor uses the touchscreen for navigation and data entry.

Configuration file editor screen

Overview of screen display and how to edit files

On entry to the configuration editor users are presented with a list of available pre-entered configuration files in blue text. Touching on a file name selects that file, highlights it in white and prefixes it with a “>” character.

Buttons on the right-hand side of the screen perform actions on the selected file, create new files, or change language settings.

- The top right button with a drawing of a single file and a “+” symbol creates a new file. If pressed users are presented with a series of choices regarding the type of machine that they want to create a file for. Following these choices will eventually lead to a default configuration that offers the best starting point for a new configuration. The newly created file will be added to the list, given the name “new” and selected ready for editing.

  NB It is very rarely advisable for users to create a new configuration from defaults in this way. It is usually easier and safer to use the copy function (see below) to create a new file based on one that was factory installed and is already known to work.

- The second button down depicting two files copies the selected file and adds that copy to the list with the name “new”. It is selected and ready for editing. This is the preferred method for creating new files on a working machine.

- The third button down depicting a file and a pen starts the editing process on the selected file, presenting a list of configuration file parameters that are available for editing. Touching

on one of the list either pops up an appropriate keyboard (Letters for editing name, numeric for entering numbers) or presents another lower level list of parameters to select from. To remove the keyboard from the screen, press it's return key.

In editing mode three buttons are present at the bottom right of the screen:

- The top button marked with a spanner and two "+" symbols selects the advanced version of the editor. This offers a wider range of settings, but is rarely necessary under normal circumstances and should only be used by experts, and even then with caution. See below for the additional functions offered in the advanced editor.
- The second button from the bottom switches between metric and imperial units.
- The bottom button labelled with a loop back arrow returns users to the next level up.

- The fourth button down on the top configuration editor page depicting a bin deletes the selected file.
- The next button depicts the flag of the country whose language is currently selected for working screens. On pressing users are presented with a choice of flags, which if pressed, will change the language used.
- The bottom button labelled with a loop back arrow returns to the start menu.

Note: When you next run the system you need to select the appropriate configuration file as editing a file does not automatically select it.

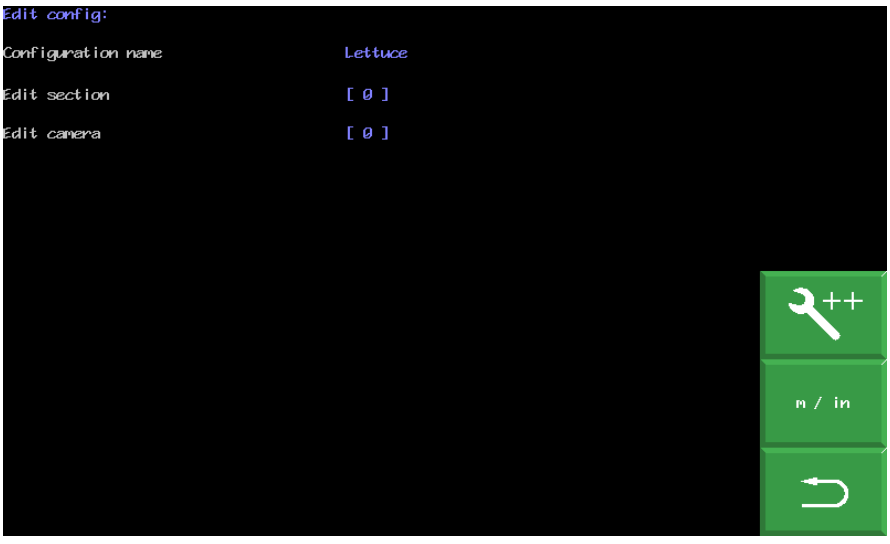
Settings available from the standard editor

General settings

The first provides an opportunity to change the configuration file name. Touching on this will pop up a touch keyboard.

The remaining categories of settings relate to machine sub components. It is possible to have more than one of these sub components on a single machine. For example, a machine may have two or more cameras so there will be the option to edit settings for each of these cameras independently. For reasons relating to internal computing conventions numbering of these sub components always starts at zero, e.g. the first camera has index number 0 and the second 1.

To edit settings for any of these subcomponents touch on the blue index number in "[ ] for the sub component that you wish to edit. This will get you into the edit page for that particular component. Once you have completed editing that sub component you can return to the previous page by pressing the button with a loop back arrow.



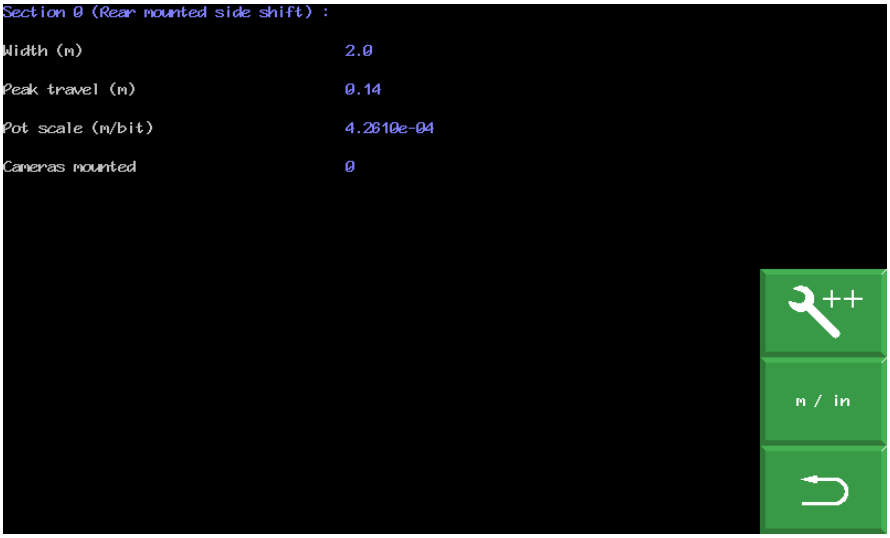
Configuration file editor screen with standard settings selected

Section settings

A section is defined as a frame that has independent steering. Most implements will have only one section. However, it is possible to have an implement with multiple independently steered sections. This is useful when it is required to span multiple drill/transplanter bouts.

The settings are; “Width” is the width of that section and is only used to calculate area worked, “Peak travel” which is stoke of the side shift mechanism, “Pot scale” refers to calibration of the linear potentiometer that measures side shift position and the final setting allocates which cameras are fitted to that section.

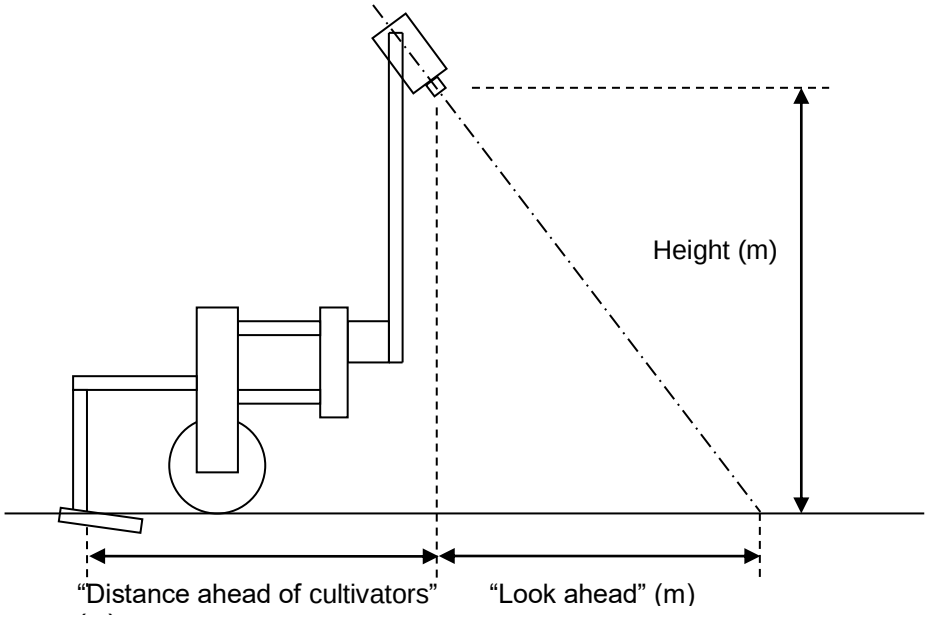
It is also possible to have settings (if appropriate defaults are installed) for disc steered machines. For disc steer machines the second, third and fourth settings relate to; maximum angular deflection from the central position, distance between the steering disc pivot axis and disc ground contact point, and calibration of the rotary potentiometer that measures steer angle.



Configuration file “Section” standard editor screen

Camera settings

The first three settings relate to camera mounting geometry as illustrated below. Camera height is the vertical distance in m (or inches with imperial units set) from ground level to the camera lens when the implement is at its normal working height. Look ahead is the horizontal distance from a point directly below the centre of the camera lens the centre of the image in the ground plane (depicted by cross hairs in “manual” mode). “Distance ahead of cultivators” is the horizontal distance in m (or inches with imperial units set) from a point vertically below the camera lens back to the cultivator blades. (If In-row software is installed this distance is referred to as “Distance ahead of rotors/nozzles” even if operating in inter-row mode)

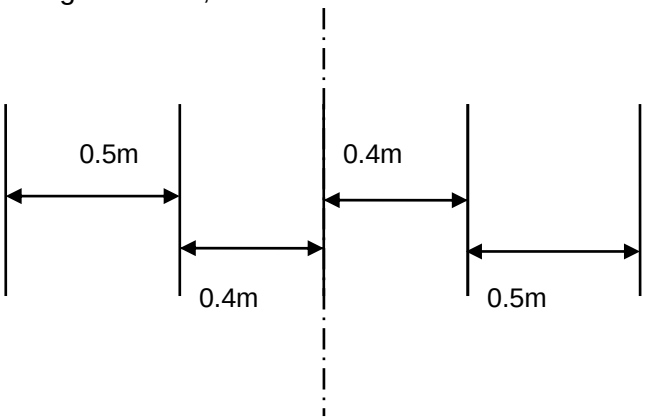


The next settings relate to what is seen in the image. The number of, and spacing between rows.

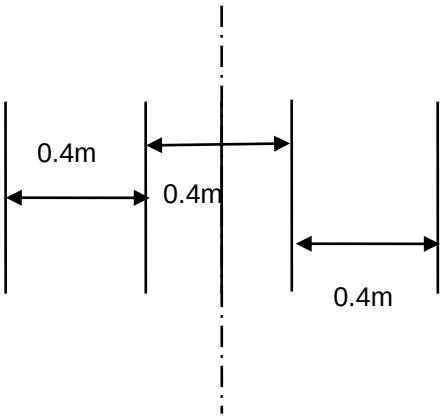
The number of rows entered here determines how many rows are used to construct the template.

Spacing between rows is normally uniform across the field of view and is therefore a single figure. However, some crop geometries with a number of different row spacings in the same scene require a more complex arrangement. Syntax for this is based on the assumption that the pattern is symmetrical about the centre line and starts with the central row spacing working out to the edge. Figures are comma delimited. In the case of an even number of rows the first figure is always the whole row spacing, not the distance from the centre line to the next row. The following examples cover likely configurations.

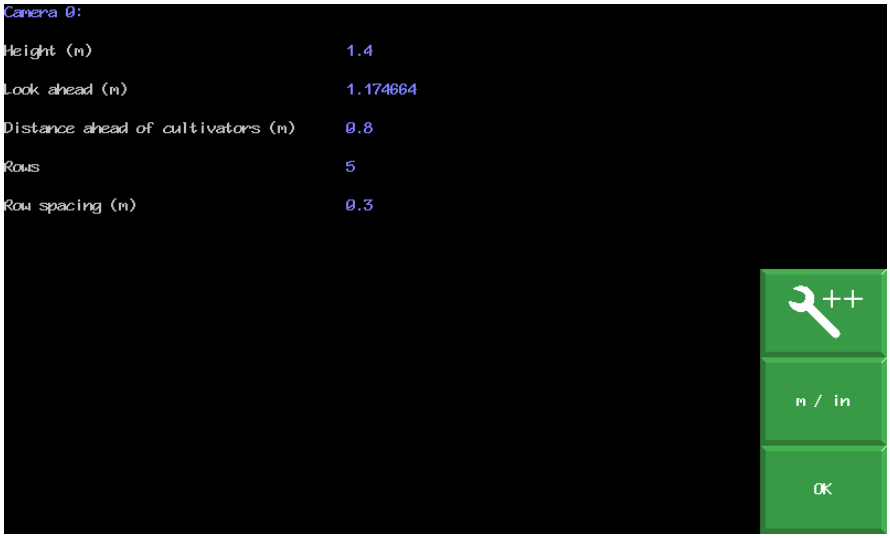
Odd no of rows irregular spacing example
Rows 5 Spacing 0.4,0.5



Even no of rows regular spacing example
Rows 4 Spacing 0.4



In the special case of following only one row the most accurate tracking will be achieved with row spacing set to between two and three times crop foliage width with an absolute minimum of 20cm.



Configuration file "Camera" standard editor screen

Tip Context sensitive help is available within the configuration editor by pressing the **?** key with the cursor on the relevant title.

Additional settings available from the advanced editor

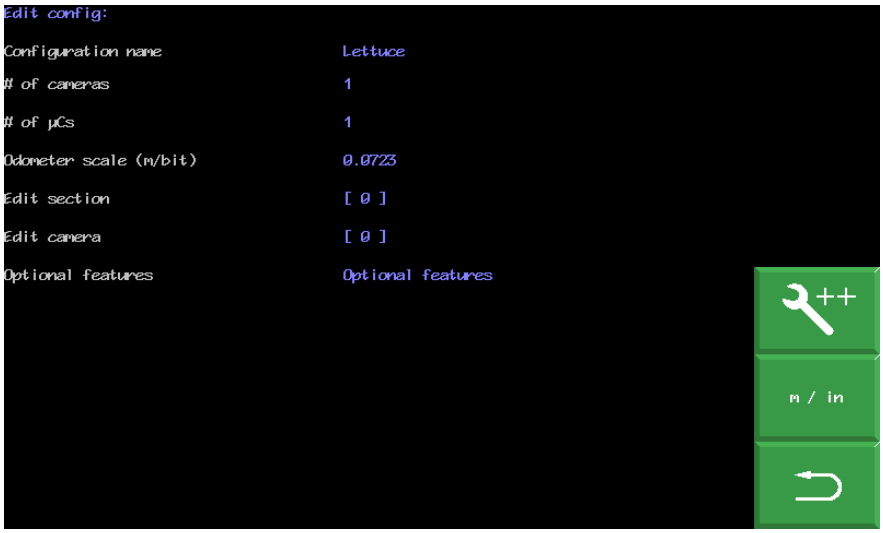
Under normal circumstances it should not be necessary to alter any of the additional parameters listed in the advanced editor. Please consult Garfords before making any changes.

Additional general settings

The advanced version allows the user to enter the number of cameras and microcontrollers fitted.

It is possible to add additional cameras that are not used for guidance, but instead provide a CCTV function. To add a camera for this purpose, on the configuration file editor screen (advanced) increase the number of cameras fitted by one. Do not allocate that camera to a section so the cameras mounted on the configuration edit section page remains unchanged. On the configuration edit camera page relating to the additional camera enter 0 rows and do not enter a row spacing. The camera will then produce an image on the working screen with no overlaid graphics that can be selected from the thumbnails in the usual way.

Odometer scale relates to distance travelled between counts from the odometer wheel encoder. It is calculated from the pulses per revolution (PPR = 12 normally) of the encoder and ground engaging wheel diameter according to the formula: PI x Wheel diameter / PPR.



Configuration file editor screen with advanced settings selected

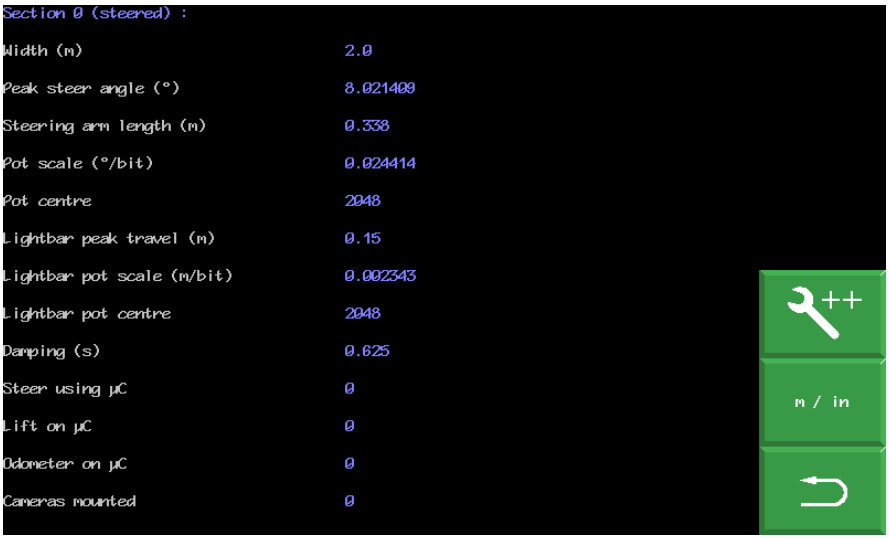
Additional section settings

This version of the screen allows users of side shifted machines to alter the value of potentiometer reading that is defined as central (normally 2048).

Disc steered machine users can alter linear slide potentiometer parameters used for the working screen light bar as well as the rotary steering potentiometer. The value defined as central (normally 2048) can also be altered for both potentiometers.

The damping term relates to disc steering.

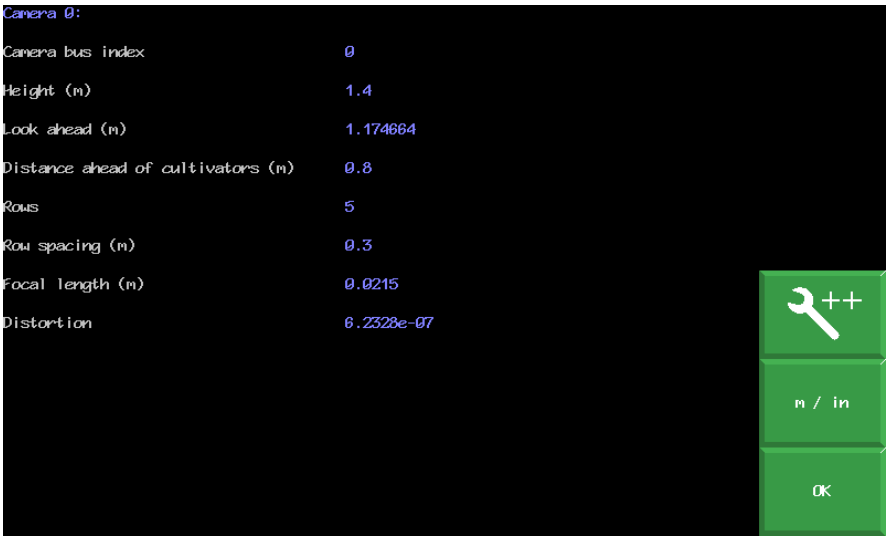
It is also possible to define which microcontroller is used to control section steering and from which microcontroller that section should take its lift status and odometric speed. If no microcontroller number is given for the odometer, odometric speed will be calculated from the flow of features through successive images. Finally, the cameras mounted on that section are allocated by listing then with comma delimiting by index number. E.g. a two camera machine might have Cameras mounted 0, 1.



Configuration file "Section" advanced editor screen for a disc steered machine

Additional camera settings

Additional camera parameters are the lens focal length and a figure relating to correcting for camera lens distortion. It is also possible to change the camera bus index though this should not be changed from the camera number in blue above without taking very expert advice.



Configuration file "Camera" advanced editor screen

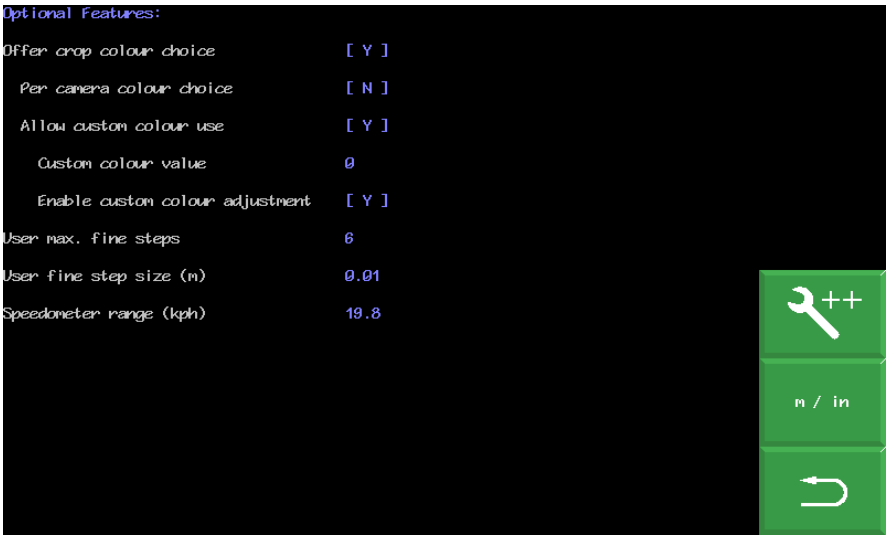
Optional Features

These allow users extra facilities. The first allows users to select crop colour choices other than the standard green via the setup screen. As a refinement that choice can be offered per camera.

To reduce complexity, we recommend not enabling any more colour choices than are essential for good performance. The default colour choice is between “Green”, “Red” (for red leafed crops) and “R & G” (for crops with a mixture of green and red leaves). A custom colour of fixed hue can be selected as an additional colour choice. A further optional graphical tool can be enabled allowing that custom hue to be varied from the advanced settings screen.

There are two options relate to customising fine offset which can be useful if extra stroke is required working across steep slopes for example. One allows the maximum number of fine offset steps to be changed (default is 6) and the other allows the size of those steps (default 10mm) to be modified.

Finally, the range of the speed bar displayed on the working screen can be changed from the default 20kph.



Configuration file “Optional Features” advanced editor screen (Y=selected N=not selected)

Tip Context sensitive help is available by pressing the **?** key

Example of context sensitive help obtained using the red ? key

8. Maintenance and Storage

Please follow the maintenance and storage instructions below in order to ensure your Robocrop precision guided implement stays in first class working order

1. There are no lubrication points on the side shift.

2. Check that dirt does not build up on the side shift rails and rollers and clean if necessary. However, take care not to pressure wash electrical components such as the potentiometer, camera, solenoid valves, or micro-controller box.

3. Regularly check the routing of hoses and cables and protect against chaffing.

4. Store the hoe fully undercover. Although the camera, loom and implement box are shower proof damage may result if they are exposed to wet weather for extended periods.

5. The console and camera should be stored in a dry atmosphere.

6. Always ensure the correct 20 amp fuse is fitted in the power supply.

7. Always ensure the correct supply polarity is adhered to.
   Blue = negative, Brown/Orange/Black + (fused side) = positive.

8. Always ensure the correct oil flow direction is followed Red=supply, Blue=return.

9. Service menu

From the start up screen it is possible to select a service option by touching the “tools” button which offers the following service tools:

“*View archived logs”*

This displays a list of error messages that have been cleared from the log file.

“Back up configuration to a USB device”

This will copy configuration files and error logs to a USB stick inserted in the socket at the base of the console. This file named hoe-backup.tgz can be e-mailed to Garfords to aid remote diagnosis.

“Restore configuration from a USB device”

This looks for a backup file on a USB device and will install configuration files from that backup. Previously installed files will not be deleted, but files with the same name will be overwritten.

“Apply updates from a USB device”

This will list any update files found on the USB device and offer a choice as to which to install.

“Capture images to a USB device”

This allows users to take still images of crop scenes as seen by the machine. These can be e-mailed to Garfords for evaluation of issues relating to the camera or crop scene.

“Adjust camera allocation”

This allows users to change the order in which cameras appear in multi-camera systems.

“Remove software”

Great thought should be applied before selecting this option!

“Reset PIN”

Allows users to reset the PIN (default = 1,2,3,4) required to enter the configuration file editor

10. Trouble shooting

LED Blink codes

As an aid to fault finding most system components are fitted with LEDs whose mode of illumination can provide information on system status and any error conditions.

Console front panel button LED

Under normal conditions with 12V power connected via the implement module, but with the console switched off the front panel LED gives a very brief single blink at 5 second intervals. When switched on and running normally the LED is illuminated continuously.

Other patterns of illumination indicate error conditions that use the following codes:

- Single 0.2 s blink followed by 1 s off indicates The ITX board has failed to start up
- Two 0.2 s blinks (i.e. 0.2s on 0.2s off 0.2s on) followed by 1 s off indicates a touch screen error
- Three 0.2 s blinks followed by 1 s off indicates a touch screen error
- Four 0.2 s blinks followed by 1 s off indicates another touch screen error

Implement module

The implement module has a green LED fitted on the main microcontroller board that can be seen by removing the cover from the box. It is not illuminated at all when the system is powered down. For about 10 s on initial start-up it is continuously on indicating that it is waiting for CAN devices to register. It will then normally go into a period of slow blinks (1.6 s on 1.6 s off) on a continuous cycle indicating that the system is ready, but idle, with no demands coming from the console via Ethernet. This state will continue until the working screen is displayed and crop row tracking has commenced. Once demands are received from the console a rapid (0.2 s on 0.2 s off) continuous blink cycle starts indicating Ethernet data is being transferred. The LED will revert to a slow blink on entry to the set up screens or configuration editor.

Other patterns of illumination indicate error conditions that use the following codes:

- Single 0.2 s blink followed by 1 s off indicates 2 devices found with the same CAN address
- Two 0.2 s blinks (i.e. 0.2s on 0.2s off 0.2s on) followed by 1 s off indicates too many CAN errors to operate
- Three 0.2 s blinks followed by 1 s off indicates a component is connected that does not conform to known types.

Manual and Feeler modules

Both these modules contain a microcontroller board that has a single green LED that can be viewed by removing the lid.

The green LED is continuously illuminated in an idle state and flashes 50% on 50% off at 2Hz when running normally. It blinks briefly at 2Hz if the power supply to the proximity detectors is short circuit.

The red LEDs are illuminated with their corresponding inputs.

Console fault codes (displayed in error messages and the error log)

These numeric fault codes can provide more specific information that the written description displayed on the screen. Make a note of these codes when reporting errors.

cttnn c=class, tt= 2 digit type, nn= channel/index

0xxxx internal error codes

00100 state/covariance dimension error
00200 variance sign error
00300 other numeric error

1xxxx camera error codes

101xx excess skew
10300 no port found
10400 no devices at all
10500 just the adaptor
106xx some devices, but no cameras found
107xx Unsupported camera
108xx Initialisation failure
109xx can't start capture
110xx can't start video transmission
111xx can't work out GUID assignments
112xx Timeout on a particular camera
11300 no data from ANY camera
11400 camera connection too slow

2xxxx uc error codes

201xx the device you want is not found
202xx timeout on data receive
203xx timeout on diag receive
204xx missing sync in packet
205xx checksum wrong
206xx received data packet not what we asked for
207xx other data format error
20800 no uCs at all

4xxxx hardware error codes

40100 odometer consistently seems wrong
40200 Pot error
40300 CPU fan alarm
40400 CPU Thermal alarm

5xxxx Operator errors

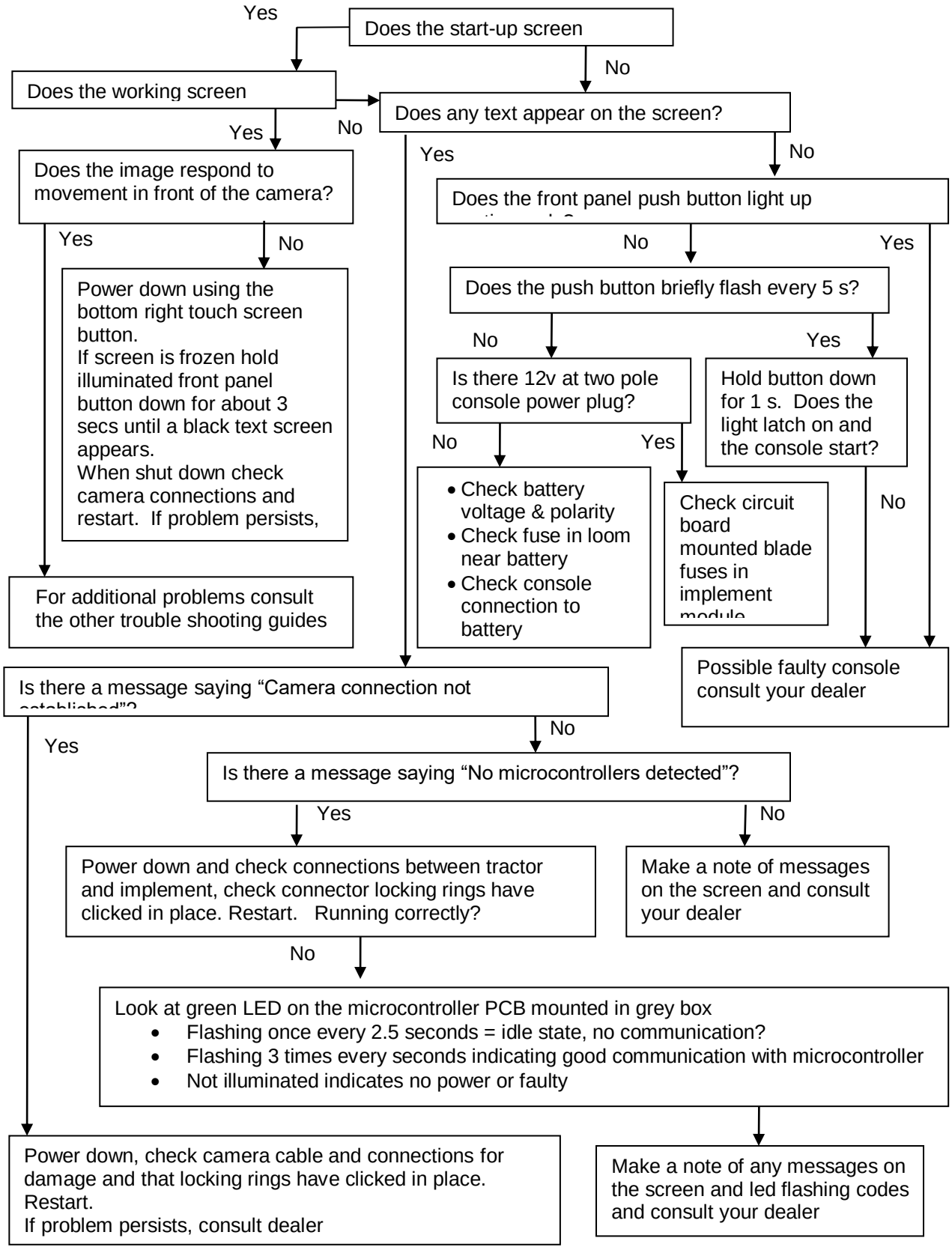
50100 Going too fast!

Flow Charts

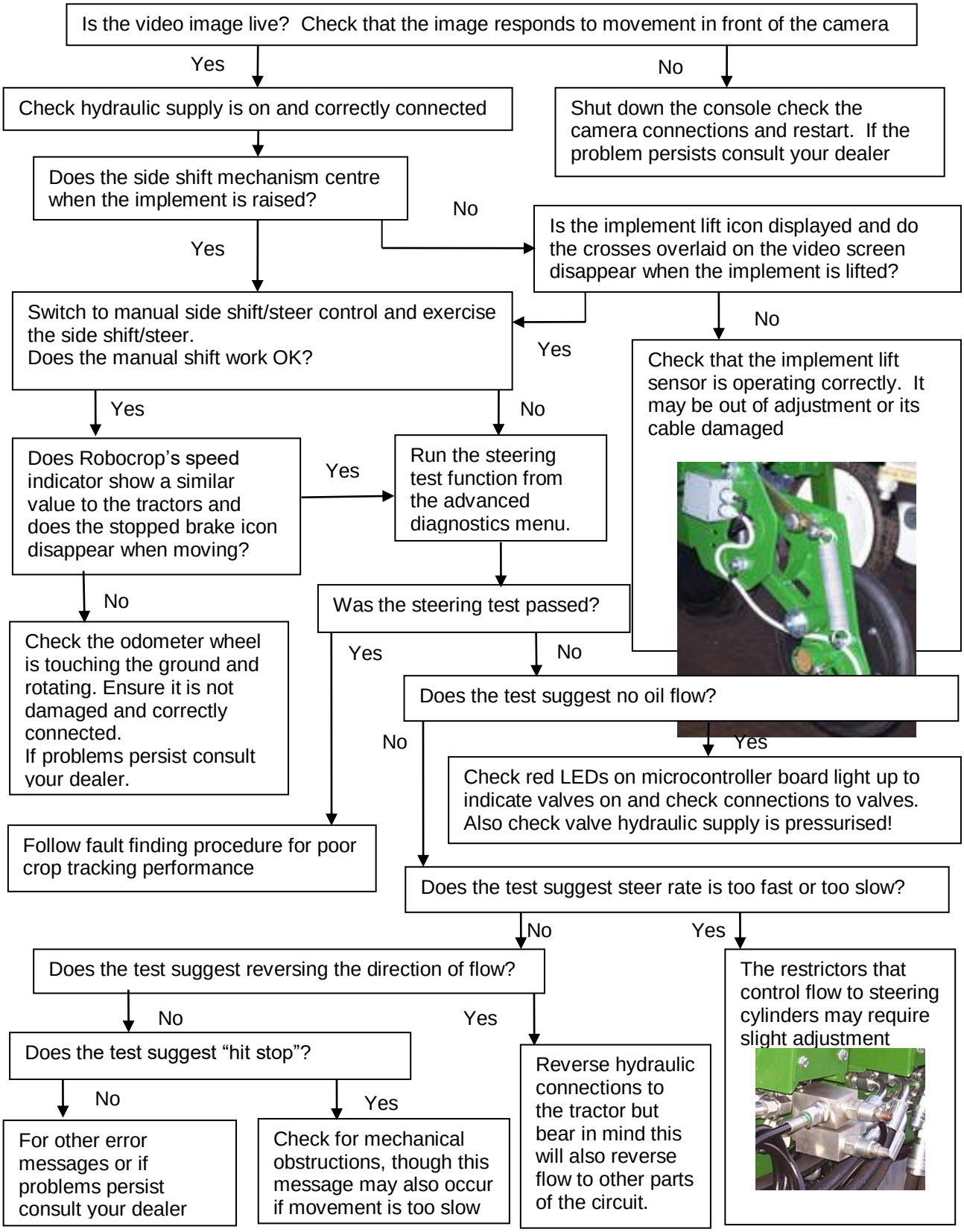
Problems have been divided into three categories listed below. Please consult your Garford dealer for any other problems.

1. Console fails to start up correctly
2. Console shows a working screen but the side shift/steered discs do not respond
3. All systems appear to be functioning but crop tracking performance is poor

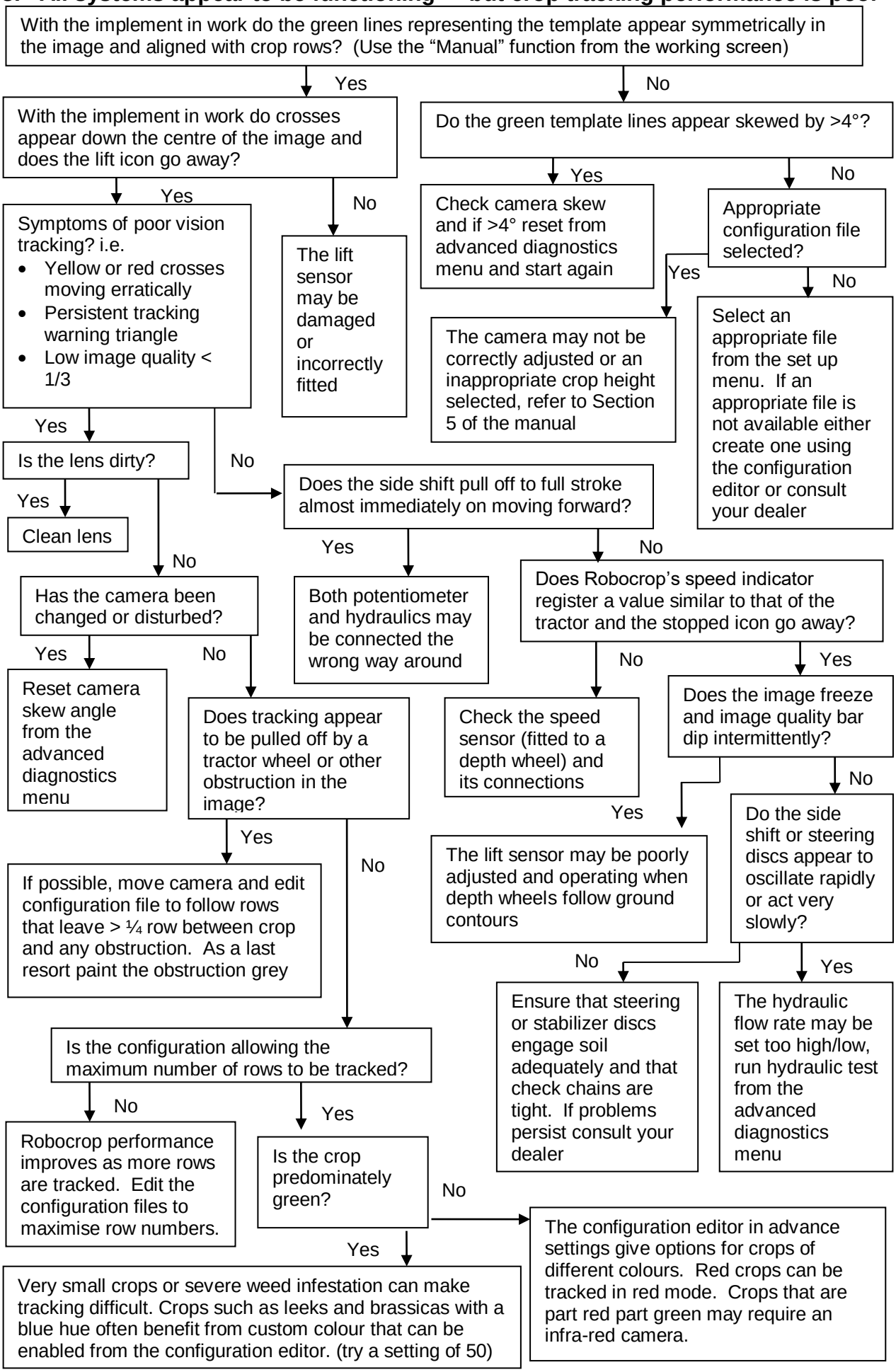
1. Console fails to start up correctly



2. Console shows a working screen but the side shift/steered discs do not respond



3. All systems appear to be functioning but crop tracking performance is poor



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