

Tillett and Hague Technology Guidance and Control System Brief Operators Guide

Inter-row



Disclaimer:

Considerable effort has gone into making Tillett and Hague guidance and control systems 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 to ensure that the machine is operating in a satisfactory manner. Should a fault develop, or excessive crop damage occur, operation should cease and if necessary, advice sought from your dealer or implement manufacturer.

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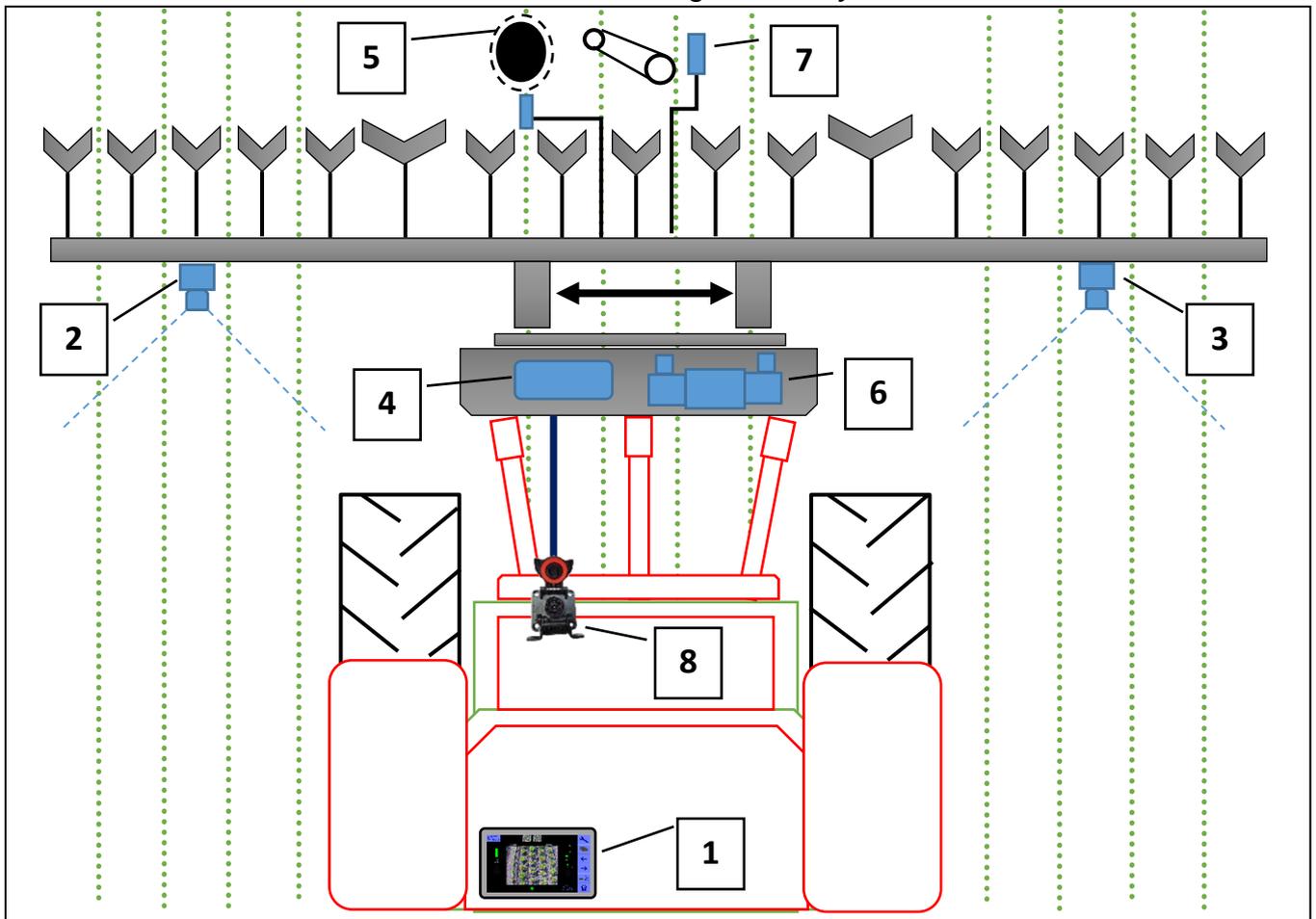
1. Product description

This vision guidance system analyses data from digital cameras to identify crop rows. Rows are tracked over successive images and their position be used to steer an implement laterally relative to those crop rows.

There are 4 main components to the system.

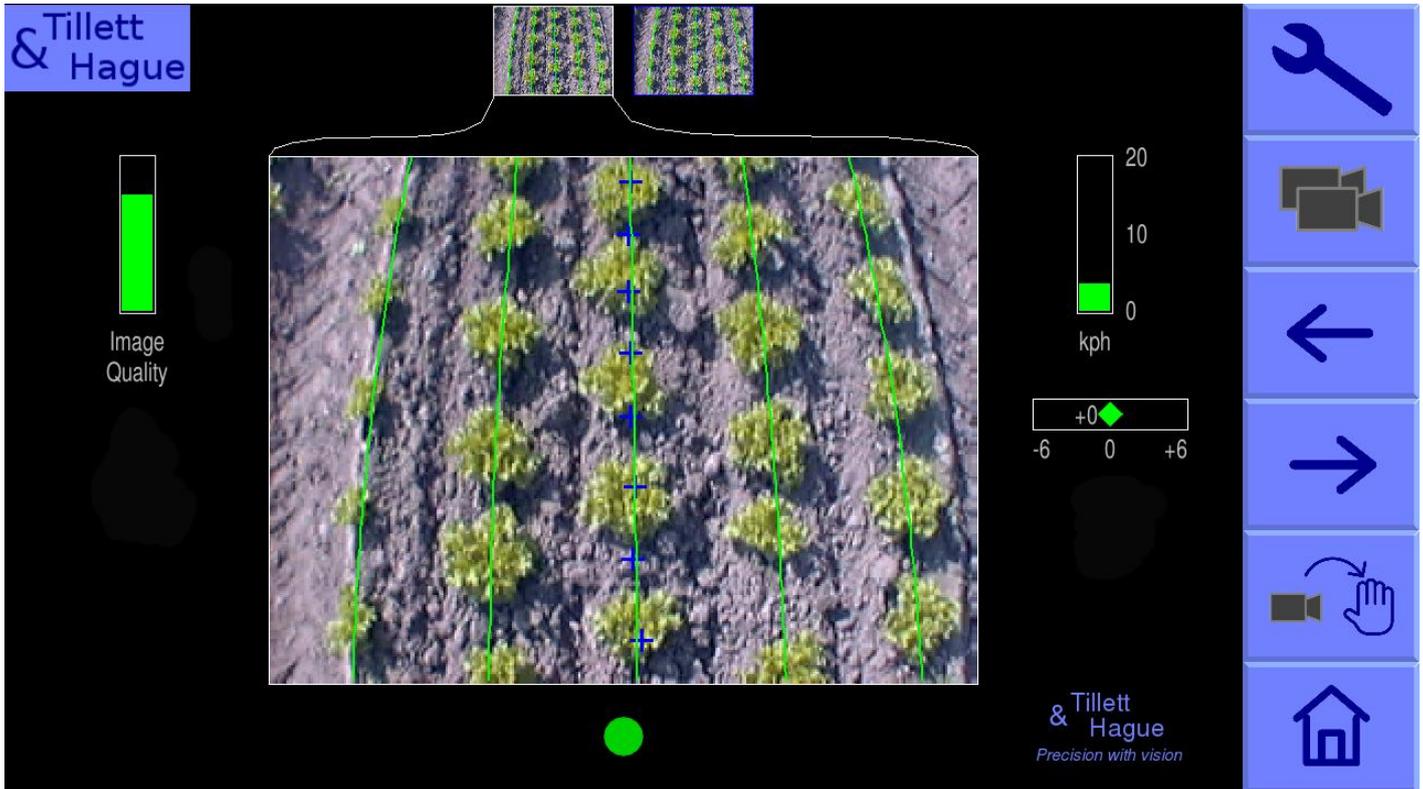
- A digital camera **(2)** or cameras **(2/3)** mounted on the implement looking ahead at a wide area of crop normally viewing several rows each.
- A cab mounted console **(1)** containing a computer to analyse camera images and find crop rows
- An implement mounted control box **(4)** housing an electronic board that controls hydraulic valves **(6)** for side shift or disc steering. That board also accepts input from position and proximity sensors **(5/7)** necessary for closed loop control.
- Some systems also have a ISOBUS connection capability **(8)** for lift and odometer inputs.

Schematic of a rear mounted inter-row guidance system with side shift



The system uses a colour camera to pick out green crop and weed from backgrounds containing soil, stones and trash. (Systems can also be configured to work in crops of other colours.) Crop plants are located within a scene by matching a template corresponding to the known planting pattern with crop plants as they appear in the camera image. That image is displayed live on the console with crop row template overlaid as green lines.

Live video display allows users to check for a good match between template and actual crop geometry, which is important for accurate row following.



Console working screen showing a typical live video image for a 2-camera interrow machine with the green template lines superimposed with 8 blue template match indication crosses up the centre of the camera view

2. Safety

1. Machines should be operated under general safety and accident prevention regulations.
2. The operator is responsible for safe operation of the machine even when automatic steering is operating.
3. The guidance system is only intended to guide agricultural implements within agricultural fields.
4. When carrying out repairs or adjustments to an implement, ensure that the hydraulic supply is **OFF**, and hydraulic pressure is **ZERO**.
5. Never conduct maintenance work on a side shift mechanism while it is supporting the implement.
6. Side shift and steered disc mechanisms form pinch, trap and shear points. Be aware of these when carrying out maintenance.
7. Regularly check the condition of electrical cables, hydraulic hoses and fittings.
8. Do not allow other persons to ride on or work near an implement when it is in operation.
9. Ensure that the 12V supply is fused appropriately (20Amp max).
10. When routing the loom and power supply cables ensure that they do not cause a restriction or trip point in the cab.

3. Information screens

Home Screen

Switch the console on by pressing the button for a second or two until the button is illuminated. Wait for the system to “boot up”. After a few screens of PC boot up text the start up screen should appear.

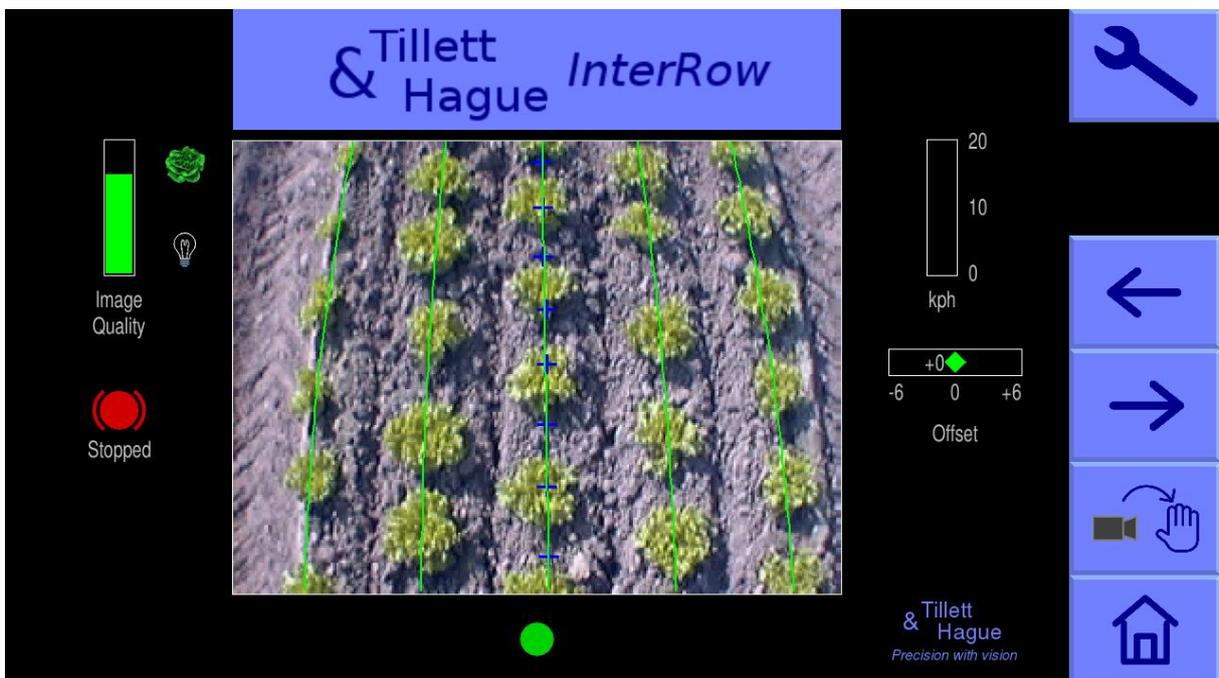


From this screen you have the option to enter the Inter-row working screen (Three green crop rows symbol), Service Tools Menu (Spanner and screwdriver symbol) or the Configuration File Editor (Pen and paper symbol). This abbreviated version of the manual only covers the working screen. For more information consult the full reference manual.

Use the touch screen button with a 3 crop rows symbol to enter the inter-row working screen.



Working Screen



The inter-row working screen has the following features:

- Live video 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 in the centre 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 operating with multiple cameras will display live thumbnail video along the top of the display.

- Touching thumbnails selects them for full size display. Alternatively, the button labelled with a multiple camera graphic, toggles between thumbnails for full size display.

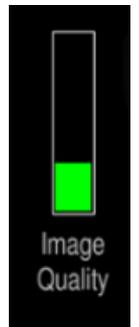


- Briefly touching on the main video images switches to a full screen video mode. Guidance continues in this mode, but the information symbols, speed, position indicator etc are obscured. Touching again reverts to the normal size image.

- Pressing and holding on a camera image with a multicamera implement turns off the tracking from the selected camera displaying a large red "X" over that image. To restart guidance from the selected camera press and hold again to remove the "X".



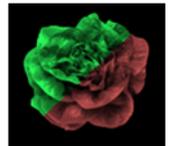
- An image quality gauge to the left of the screen giving relative indication of likely tracking performance. The higher the green bar the better. A low bar indicates either a poor template match or poorly defined crop plants. Guidance will, under most circumstances, operate down to an indication of approximately 20% albeit at reduced accuracy.



- If red crop colour option is activated and selected a plant symbol is shown at the top and to the right of the image quality gauge.



- If a "R & G", red and green colour option is selected a plant symbol of half red and half green plant symbol is shown to the right of the image quality gauge. If it only recommended to use R&G mode when crop plants are a mixture of red and green colouring or green and red plants are present simultaneously.



- If custom colour is selected a plant symbol is shown at the top and to the right of the image quality gauge. Its colour reflects the custom colour choice used for detecting crop plants.



- Touching on the plant symbol pops up an adjustment tool. In that pop-up tool touching the colour band itself selects a colour bias. For fine adjustment use the arrow buttons.

Note

- It is recommended to contact your dealer before using custom colour settings. In general, use of custom colour is likely to degrade rather than improve tracking performance. It should only be used with expert advice if absolutely necessary.

- If lights are configured a light bulb symbol is shown at the bottom right of the image quality bar. Touching the symbol turns lights on and the bulb yellow.

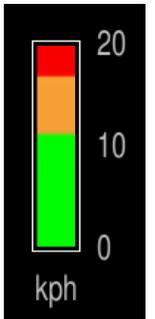


- Information symbols at the lower left of the display:

- A warning triangle indicates poor tracking. If it is displayed with a horizontal double headed arrow lateral implement position error is estimated to exceed 25mm.
- If enabled the warning triangles 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.



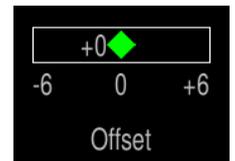
- A speed gauge on the right shows forward speed and should match tractor speed. The speed bar is normally green, an amber section indicates the machine is operating at over 75% of maximum speed and a red section indicates over speeding.



- A green dot and red/green chevrons below the image indicate side shift or slide 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, right, forward or backward bias set by the user. This is used to compensate for minor lateral camera misalignment, but the lateral fine offset can also be useful on side slopes.



- The fine offset flip symbol, activated in the advanced setup screen, allows quick reversal of fine offset. Useful when changing direction of travel on side slopes or in crops blown by a cross wind for example.



- “Left arrow” moves fine offset left 1cm, or when in manual mode, side shifts/steers 7% of total stroke to the left.



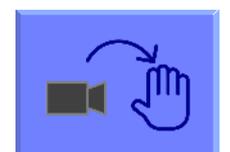
- “Right arrow” moves fine offset right 1cm, or when in manual mode, side shifts/steers 7% of total stroke to the right.

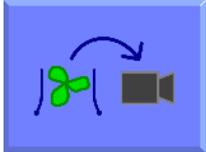


Note

Arrows appear thicker when in manual mode

- A button with a Camera → Hand symbol enables manual mode and disables vision guidance. The fine offset adjustment arrow buttons are replaced by thicker left and right arrow buttons. The user can manually steer the side-shift or steering discs to test their function. To avoid mechanical damage these functions only operate when lifted or moving.



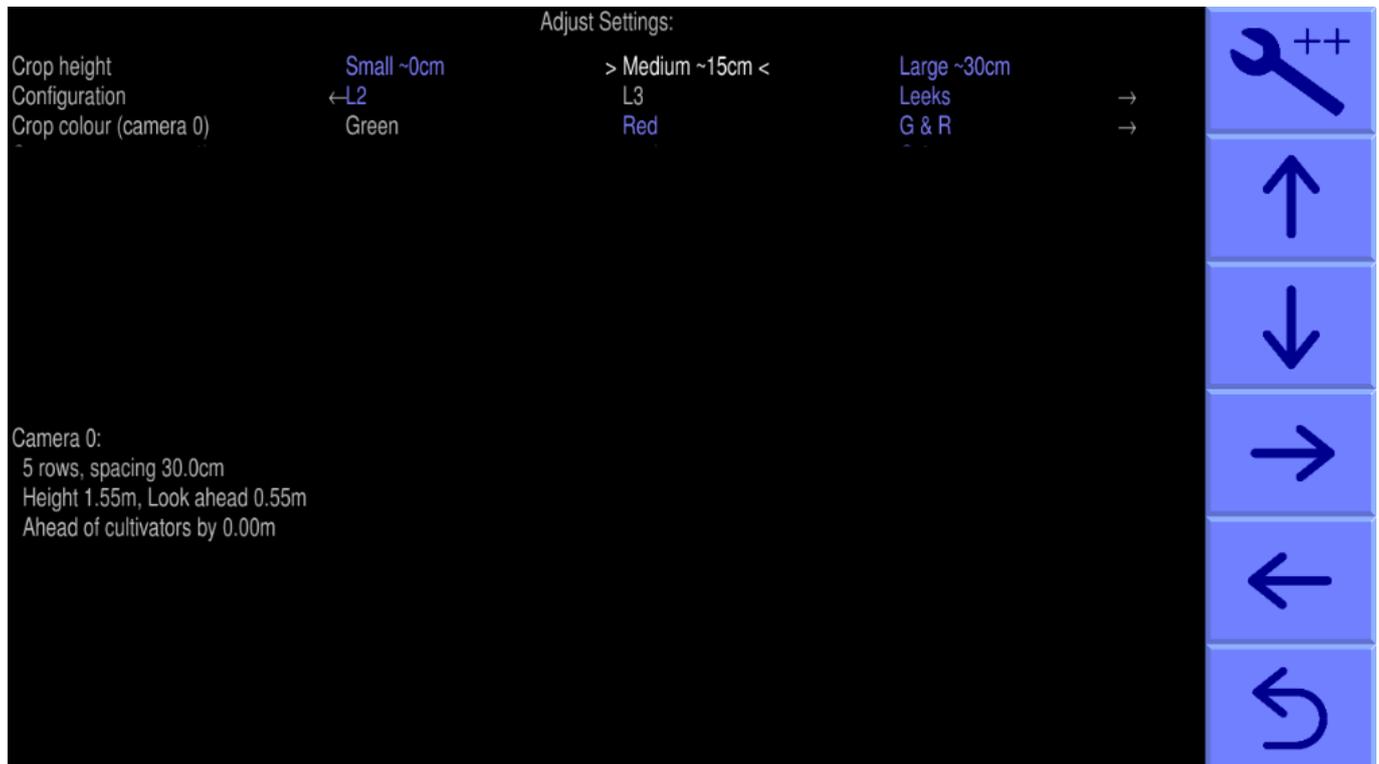
- Manual mode can also be used to set camera geometry. In manual mode a blue centre crosshair is displayed at the centre of video images which can be used for camera alignment.
- Return to vision guidance by pressing the same button which is now labelled with a Hand → Camera symbol. 
- By default, manual control is retained when moving forward with a live camera video displayed so the operator can see if vision guidance is likely to be successful.
- If configured to do so within the advanced setup and diagnostics screen (Spanner ++), Manual mode can be activated automatically if the guidance system is deemed to be “Lost”. Consult your dealer or the full reference manual if you wish to use automatic lost mode preferences.
- For machines with mechanical guidance feelers the mode selection button cycles between manual mode, feeler and vision guidance. 
- For machines with a remote override manual control box the button displays a hand symbol when the box was switched on. 
- The button with the house symbol returns you to the start-up screen. 
- The button with the spanner symbol will take you to the setup screen. 



Setup Screen

The setup screen allows operators to select which of the pre-loaded configurations they wish to run and adjust parameters to suit the crop conditions in the field. Settings are remembered between sessions.

Navigation within the setup screen is achieved by moving the cursor over options using the touch screen buttons labelled with arrows. When the cursor is over a setting its text changes colour with two arrows highlighting the selection.



Three settings “Crop size”, “Configuration” and “Crop Colour” (optional facility) can be altered in the setup screen. “Crop size” and “Crop colour” settings will be stored from your previous session for the next time you run that same configuration.

“Crop Height” 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. There are settings for small, medium and large crops. The definition of small, medium and large is scaled according to camera height in accordance with this table.

Camera Height	“Small”	“Medium”	“Large”
< 0.5m	0	5cm (2”)	>10 (4”)
0.5m – 1m	0	10cm (4”)	>20cm (8”)
>1m	<5cm (2”)	15cm (6”)	>30cm (12”)

“Configuration” allows users to select between alternative pre-programmed configurations for different crop planting geometries that require different templates. The main parameters of the chosen configuration are displayed at the bottom of the setup screen, they are:

Camera number (Note - camera numbers start at zero)

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).

Ensure that an appropriate configuration file is selected before starting work. If such a configuration is not available, please ask your dealer to create one for you.

“Crop Colour”(optional facility) If the selected configuration has had colour choice selection activated this option will be show, allowing tracking of crop colours other than standard green. Colour choice selected will also be displayed on the working screen. If no colour choice is displayed on the working screen, standard green tracking is selected.

Colour options available are “Green”, “Red”, “Red & Green” and “Custom”

Colour option selected should reflect the crop colouring in field. Contact your dealer before operating implement with custom colour setting.

Advanced Settings & Diagnostics Screen



The advanced setup & diagnostics screen is accessible from the setup screen by pressing the button with the spanner ++ symbol. This screen provides test functions of the implement and displays some diagnostic information.

Navigation around the advanced settings screen is performed in the same way as the setup screen. Diagnostic tests can be selected using the return key.

Advanced settings and diagnostics		
Software version	master-2041c1d	
Running time / Area	0:05 hrs / 0.0 ha	
Current job	0:05 hrs / 0.0 ha	> New job <
Units	Metric	Change
Camera skew	0.0, 0.0°	Reset
Test steering	Not tested	Test
Audible warnings	Yes	Change
Leave manual on moving	No	Change
Go to manual if lost	No	Change
Centre when entering manual	No	Change
Side slope compensation	No	Change
Fine offset flip	No	Change
Error log	0 entries	View
µC version	8.0.20	View details
ISOBUS Hitch setpoint	50 : 50	Adjust
ISOBUS diagnostics		View

The top of the screen lists the implement software version, total running time and total area covered.

“Current Job” provides a resettable counter for elapsed time and area treated.

“Units” selecting toggles between metric and imperial units.

“Camera Skew” is a measure of the angular misalignment of the camera in the horizontal plane. This angle is automatically estimated by the system while in field operation and is generally learnt and stable after approximately 100m of field running in clearly defined rows. Camera skew does not need to be routinely reset and should only be reset if camera alignment may have changed, for example if the camera pole has been damaged. To reset camera skew, select “Reset” and press the return key to zero camera skew.

“Camera Offset” is an estimate of the lateral error between two or more cameras fitted on the same frame. Like skew it is automatically estimated during field operations.

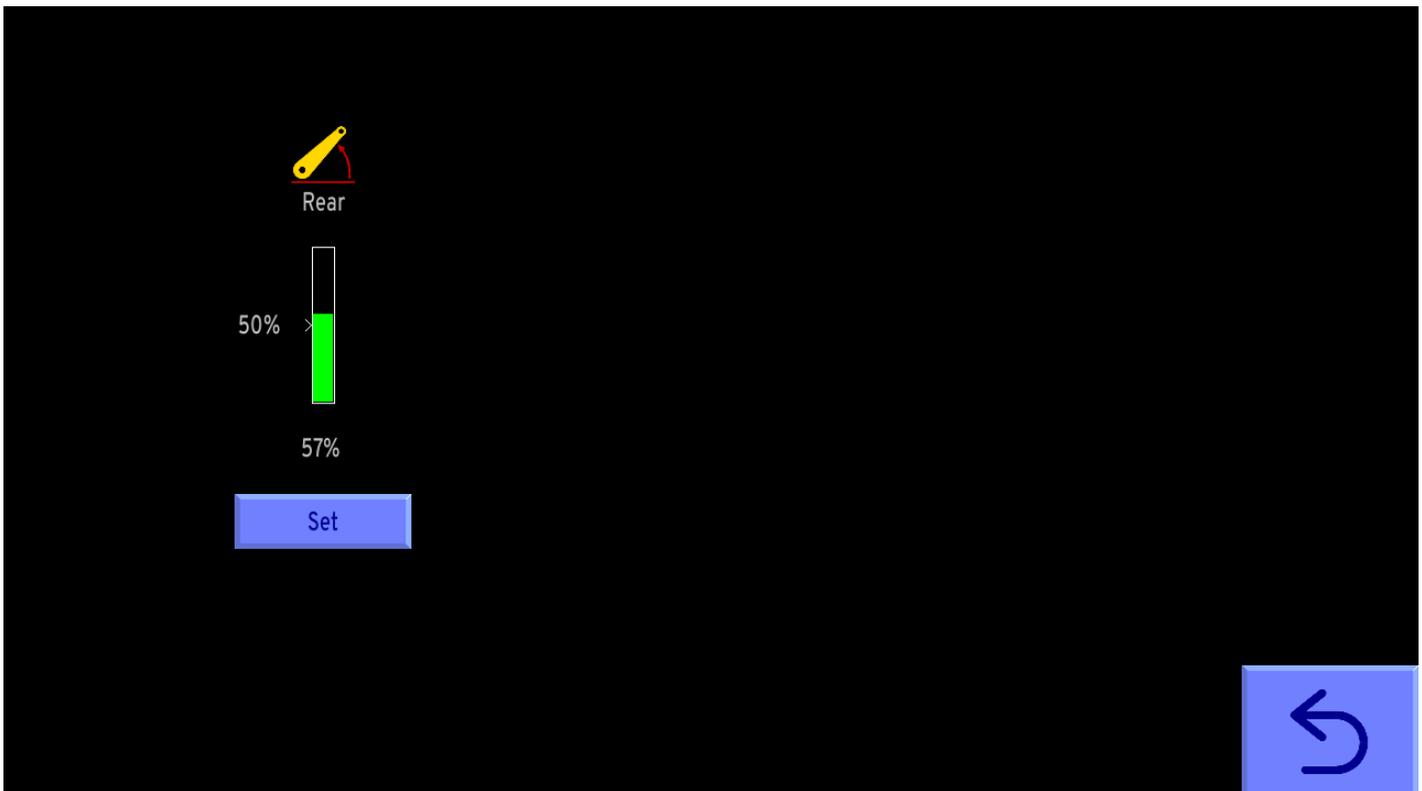
The first camera (camera 0) is the datum from which offset is calculated. The purpose of this measure is to reduce the requirement for very accurate mechanical set up. Camera offset should only be reset if camera lateral position has changed.

“Test Steering” this utility tests position sensor output, steering rate and calibrates steering direction. In the case of a successful steering test an “OK” message will be returned. If “too slow” or “too fast” messages are returned this could be due to insufficient or excessive oil flow. If a proportional steer valve is fitted, the steering test also calibrates the proportional valve flow characteristics.

Caution

Ensure steering mechanism is clear of obstructions and people before running.

“ISOBUS Hitch Setpoint” this utility provides a means of adjusting the hitch transition point between in-work and out of work. The green vertical bar is a live representation of tractor hitch position read from the ISOBUS. Pressing the “Set” button changes the transition point to the current hitch position which is then displayed as a percentage of full stroke at the base of the bar.



“ISOBUS Diagnostics” this utility allows for observation of live ISOBUS data. Useful in ensuring that connection between tractor and implement has been achieved and sensor data is available for implement operation.

Note

Hitch point and ISOBUS diagnostics are only applicable for implements fitted with ISOBUS connectivity.

The other settings listed on this screen relate to operating preferences and fault diagnostic information. Refer to your dealer or the full reference manual for explanation of these features.

4. Start-up Checks

Step 1 – Connecting the implement

Connect the implement to the tractor ensuring that the camera pole is vertical and that there is no lateral movement in the 3 point linkage.

Mount the console in the tractor cab and connect to the implement so that the cable does not restrict cab access. Connect to the tractors fused 12V supply or the tractor's ISOBUS 12V/Communication socket.

Also connect the hydraulic hoses.

If the implement is lowered to its normal working position the “stopped” (red brake) symbol should be displayed on the working screen and the speed bar should read zero.



Step 2 – Checking Hydraulic Steering 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. Typically, side shifts only require about 10% of full flow.

Lift the implement clear of the ground. The side-shift or steered discs should centralise and the “stopped” symbol replaced by the “Lifted” (yellow lift arms) symbol.



Note

- Side-shift/disc travel all the way to one side on lifting the implement may indicate the hydraulic supply is connected the wrong way.
- Rapid side-shift/disc oscillations back and forth about the central position indicates that the hydraulic flow rate is too high.

Perform a steering test accessed via the Advanced Setup and Diagnostics screen.

ON/OFF Steering Valves – Answer on screen prompts for left and right orientation as sat in the tractor looking in the direction of travel. If steering test responds with “To fast” or “To slow”, hydraulic flow may require adjustment. A steering rate of between 6cm/second and 10cm/second is generally a good starting point. Flow rate is normally regulated using adjustable flow restrictors connected to the steer valve. Also ensure that flow from the tractor is not a limitation.

Proportional Steering Valves – Run steering test utility and answer left and right orientations as per the ON/OFF valve steer test. Following this an additional full stroke movement to calibrate steering rate is performed. If the maximum steering rate cannot be achieved, hydraulic flow from the tractor may need to be increased.

From the working screen you can go into manual mode and exercise the steering using the arrow buttons.

Note

If you wish to set camera alignment before going to the field follow the procedure outlined in the Annex at the end of this manual, “Camera Setup by measurement without reference to crop rows”.

5. Getting to work in the field

An accurate template match is critical to reliable guidance. Camera height is measured in relation to ground level. In the case of raised beds, this is the level at which the crop is planted.

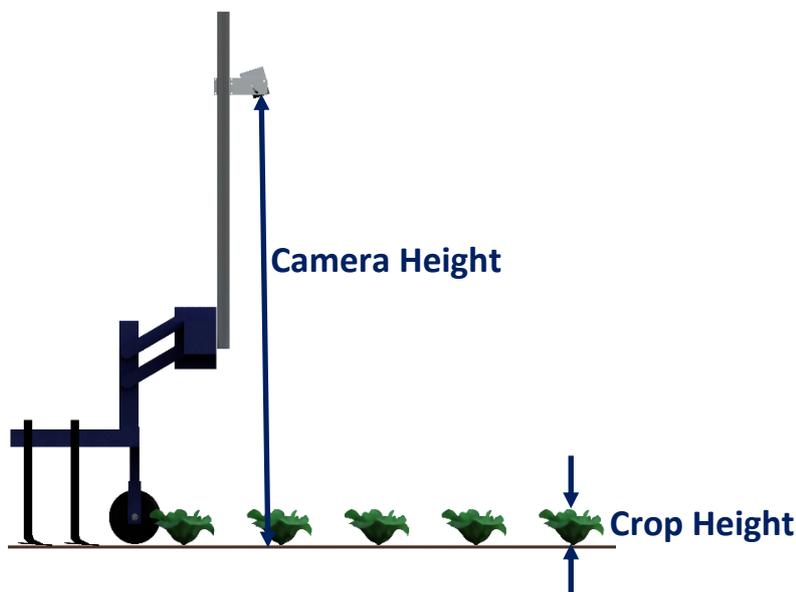
Step 1 – Selecting configuration file and crop height

From the working screen press the button labelled with a spanner symbol. This switches the display to the setup screen.

Select the most appropriate crop height setting to match actual crop height in the field.

If multiple configurations are loaded, select the configuration that matches your crop.

Ensure fine offset is central with zero offset.



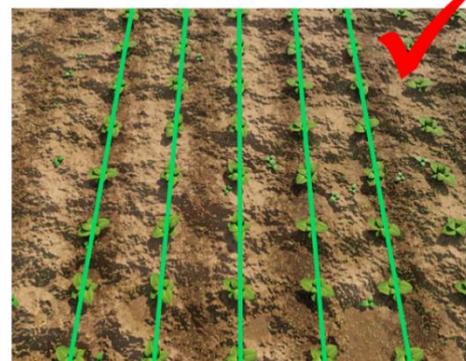
Step 2 – Checking camera height and inclination in the field

Set the implement down onto a typical section of crop aligned with the rows. Draw forward a few cm to ensure it has settled at its normal operating depth. If necessary, adjust the top link to level the implement keeping the camera pole vertical. If necessary, physically adjust the camera's height above soil level to match the figure in the selected configuration. (Displayed as "Height" in the "set up" screen).

Step 3 – Check template match with crop rows

Return to vision guidance mode in the working screen, the overlaid green lines representing the template should lock onto the crop rows. (If the template is at an angle and will not settle on crop rows go to [Step 5](#) to check for excessive skew angles. This is most likely to be necessary on initial commissioning.)

All the template lines should align with crop rows from the top to the bottom of the image. If alignment looks like this then you are ready to start running.



If the green lines appear to be parallel to but narrower or wider than the real crop rows check "Crop Height" selected in the "Setup" screen and change if appropriate. If the crop height setting is correct, it is permissible to slide the camera up or down on the pole until the template lines are completely aligned with crop rows.



Crop height potentially set too small, or camera height is mounted too low.

Crop height potentially set too large, or camera height is mounted too high.



If the template matches mid screen, but not at the top or bottom, check that the implement is level. If necessary, without altering crop height adjust camera inclination so that the template lines match from the top to the bottom of the image. Having got the inclination correct in may be necessary to make small adjustments to camera height.

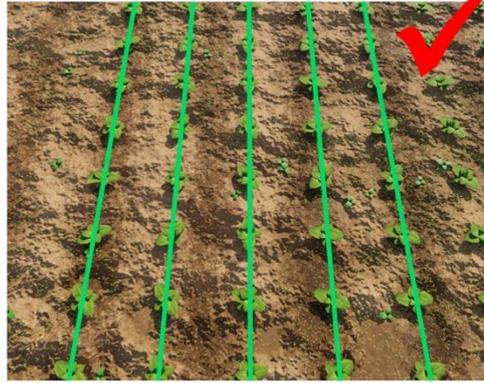


If template lines appear narrower than crop rows at the top of the image but wider at the bottom, rotate the camera up so it views further ahead.

If template lines appear wider than crop rows at the top of the image but narrower at the bottom, rotate the camera down so it views less far ahead.



Best tracking will be achieved when template lines are centred on all the rows being tracked.



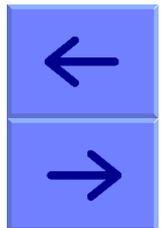
Step 4 – Initial running and adjusting lateral position

You may wish to consider taking most cultivators out of work for the initial pass.

When you are happy you have a good template match. With the working screen in vision guidance mode and a set of blue crosses up the centre of the row pattern, set off slowly. 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.

Apply the required fine offset in the desired direction. Each press of an arrow key biases the steering 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 laterally. If fine offset is set to the left, then the camera should be moved right as viewed from behind looking forward.



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

Once you are confident tracking is accurate and reliable, all the cultivators can be put into work and forward speed can be increased.

Step 5 (Only for initial commissioning) – Check for excessive skew angles

From the working screen press the manual mode button to get a fixed template of green lines representing the crop rows along with blue cross hairs. If the green lines are excessively skewed in the image go into the Advanced settings and diagnostics screen and reset camera skew. Go back to the working screen and reselect manual mode. The green template lines should now be symmetrical and centred over the live video image. This step should only be necessary for an implements initial run after which the skew angle should have settled at a stable very small angle (<3 degrees). Resume [Step 3](#).

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. Check also that any hydraulic filter indicators fitted do not show that the filter is blocked.
- On first setting the implement down in the field check for each camera that the blue crosses are present, and that template lines align with crop rows. There should be few to no yellow or red crosses.
- Proceed with caution for first few meters checking that the speed gauge matches the tractor's and that implement alignment is good. If performance is satisfactory speed can be increased.
Note
Soil and crop conditions may dictate maximum speeds.
- Vision guidance works in low light levels, but for full night operation lights are required.
- Fine offset is remembered from previous sessions and so there should not be any need to adjust this unless changes have been made to camera position.
- Setup parameters such as crop height and crop colour are remembered from last operation of selected configuration file.
- 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. The offset flip tool can be useful in these circumstances.
- When the implement is lifted at row ends it will centralise ready for the next run.
- At the end of the day shut down the system by pressing the touch screen button with the power button logo and the system will shut down automatically. The power button led go out but will continue to briefly illuminate every 5 sec indicating that power is still applied via the implement. In this state the current draw is negligible.
- It is also advisable to discharge any hydraulic accumulators by reversing the tractor's hydraulic spool briefly or setting the hydraulic spool into "float" position. The implements pressure gauge indicates if this has been achieved.

7. Maintenance and Storage

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

1. Regularly check the routing of hoses and cables and protect against chaffing.
2. Although all components are designed to be shower proof, we recommend that the console is housed in a dry environment and that the implement is not exposed to wet weather for extended periods when not in use.
3. Never pressure wash any part of the guidance system.
4. Always ensure power is supplied from a supply that is appropriately fused (10 - 20 amp).
5. Always ensure the correct supply polarity is adhered to.
BLUE = - negative, **BROWN** (fused side) = + positive.

For further reference materials including the full inter-row reference manual see the QR link below or go to www.thtechnology.co.uk

Tillett and Hague Technology Ltd
Delivering precision with vision



Annex – Camera Setup by measurement without reference to crop rows

Initial camera setup can be performed in a yard or barn without crop rows if required.

From the working screen enter the Setup screen by pressing the spanner button. Select the configuration you wish to set up the cameras for. Make a note of camera Height and Look ahead values.

Having checked the implement is fully lowered to its working position and that top link has been set so that the implement is level. Adjust the camera so that it matches the height in the selected configuration. Now mark a point directly below the camera lens (ideally using a plumb bob).

From that point measure forwards and place an object at the “Look ahead” point. As shown in the image. Return to the working screen and enter manual using the Camera → Hand button and two blue cross hairs will appear on screen. Adjust camera inclination to align the object placed at the look ahead point with the horizontal blue cross hair.

Your camera is now aligned. This same process can be repeated for each additional camera in turn.

