

# Tillett and Hague Technology Guidance and Control System

## Reference manual for implement manufacturers

### Inter-row



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#### 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. We recommend that it is made clear to operator's that it is their 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 users should be encouraged to contact their dealer or implement manufacturer for advice.



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## 1. Introduction to this manual

This manual has been written to provide implement manufacturers incorporating Tillett and Hague guidance and control systems into their products with the technical information they need.

This manual is not intended for use by implement operators. However, Tillett and Hague Technology Ltd do give permission for extracts from this manual to be used by their customers in the production of implement operator manuals.

It is the responsibility of the implement manufacturer to ensure that all implements are sold with the information necessary for safe and effective operation. Tillett and Hague Technology Ltd will on request provide reasonable assistance in the development of English language operator manuals and other training material.

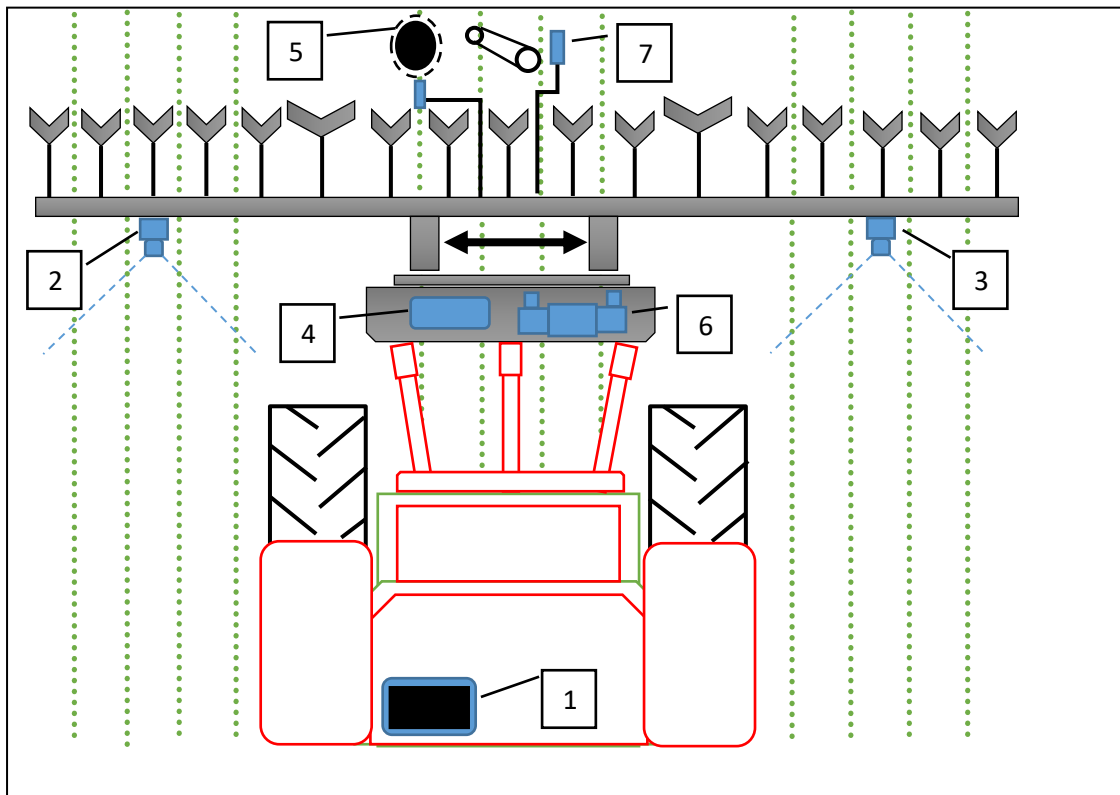
## 2. Product description

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 relative to those crop rows.

Tillett and Hague's software has been refined over 15 years of commercial use and development and has to date been used to guide over 1000 vision guided implements around the world. The very latest version of this software has been loaded onto a new hardware system incorporating touch screen technology with a bright high contrast display. This provides operators with highly visible user-friendly information including live images with graphical overlay. Highly efficient processors and CMOS imagers produce world leading row tracking performance from a robust purpose designed package that is simple and cost effective to install.

There are 3 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 taking in several rows each.
- A cab mounted console **(1)** containing a computer to analyses camera images and find exact row centres.
- An implement mounted control box **(4)** housing the 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.



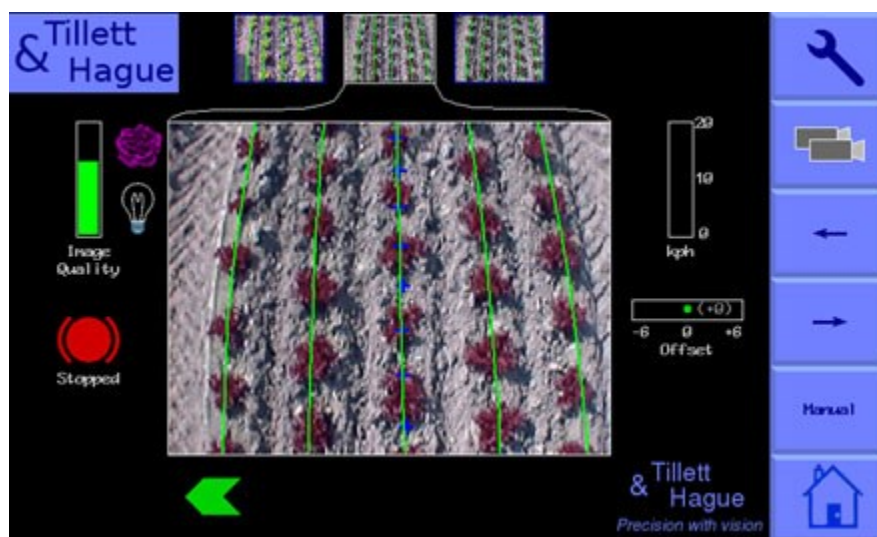
*Schematic of a rear mounted inter-row guidance system with side shift*

The system uses a colour camera to pick out green crop and weed from backgrounds containing soil, stones and trash. (Systems to work in other crop colours are also available.) Crop rows are located 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 planting geometry and implement configuration. Different configuration files can be created for different crops and implement configurations.

Live video allows user to check for a good match between template and crop rows, which is important for accurate row following.

Touch screen buttons are activated by a finger press on the button area which will change to a darker shade when a press has been detected. The button functions are activated when the finger is released.



*Console working screen showing a typical live video image for a 3-camera machine with the template superimposed as green lines over crop rows.*

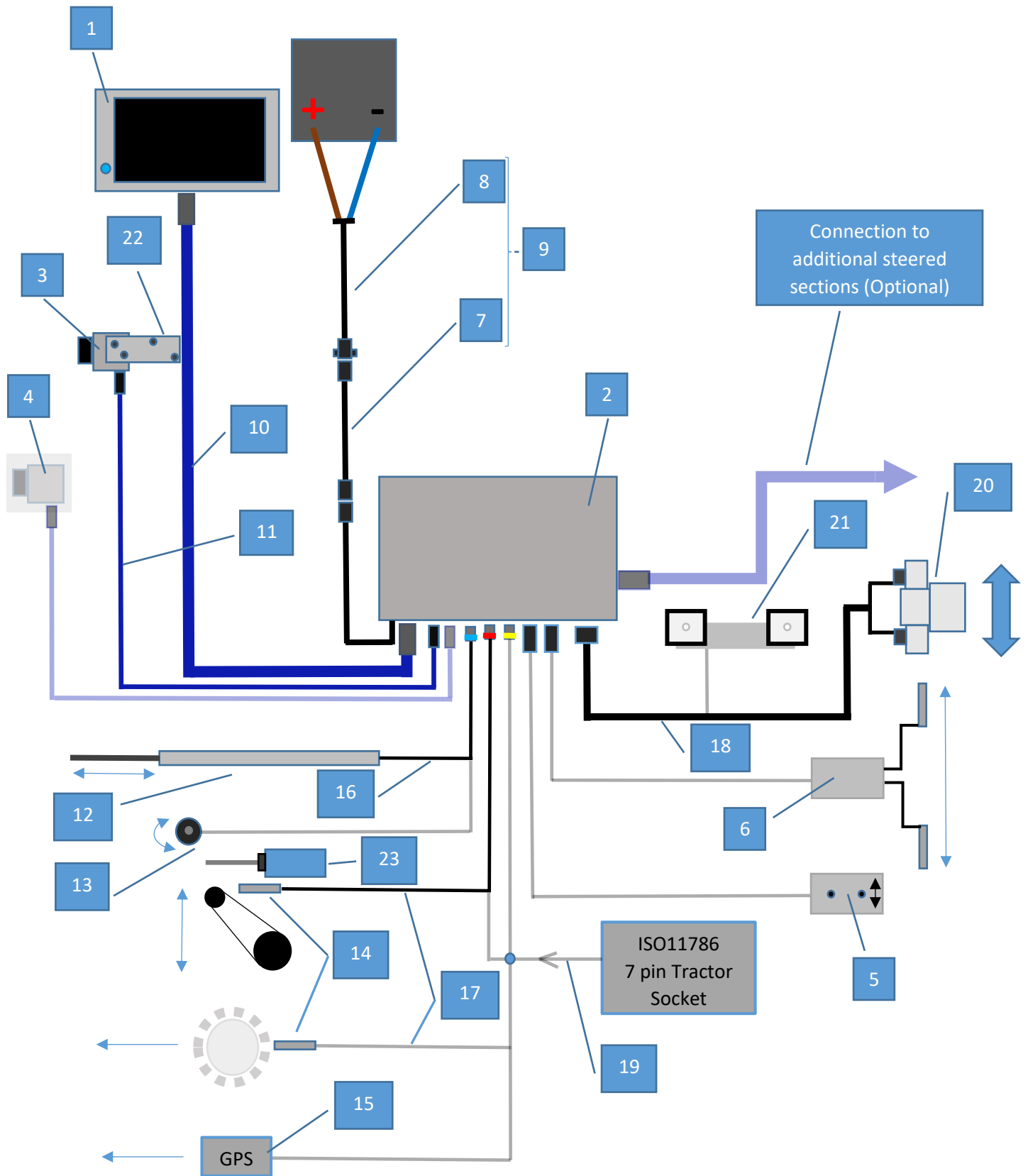
### Electrical system

The system is designed to operate from a tractor nominal 12V supply fused at no more than 20A for short circuit protection. The power consumption for electronic parts including the console is only 20W, but solenoid valves driven by the system will increase that substantially when they are activated. The system is tolerant to voltage surges up to 27 V and will continue to operate for short periods down to 6V providing continuity during tractor starts.

### Hydraulic system

The system normally operates 12V solenoid operated 4/3 directional control valves that meter hydraulic oil into cylinders linked to side shift or disc steering mechanisms. It is normal for the implements hydraulic circuit to include components that facilitate manual adjustment of the rate of cylinder movement, though it may also be possible to do this via the tractors hydraulic control system. For further discussion of hydraulic systems including the use of proportional valves see Annex 1.

### 3. System overview - with optional additional equipment (faint lines)



	Part Name	Part number
1	Console/Cab mounted terminal	BOX001
2	Interrow implement control module	BOX002
3	Camera 1	BOX003
4	Camera 2 (optional)	BOX003
5	Manual override control box (optional)	BOX004
6	Feeler override system (optional)	BOX005
7	Euro "D" plug power cable	CBL004
8	Euro "D" plug receptacle to battery cable (optional)	CBL007
9	Direct to battery power cable (optional)	CBL020
10	Console to implement module cable	CBL001
11	Implement module to camera cable	CBL002
12	Linear potentiometer position sensor	SEN002
13	Rotary potentiometer position sensor for disk steering applications (optional)	SEN005
14	Proximity sensor for lift input/optional speed input	SEN001
15	GPS alternative speed sensor (optional)	SEN003
16	Potentiometer sensor cable	CBL003
17	Proximity sensor input cable	CBL005
18	Valve connection loom	CBL006
19	ISO11786 speed and lift input cable (optional)	CBL016
20	Hydraulic control valve block assembly (optional)	HYD001
21	LED night operation light assembly (optional)	BKT002-2LED
22	Universal camera bracket (optional)	BKT001
23	Snap action limit switch for lift detection (optional)	SEN004

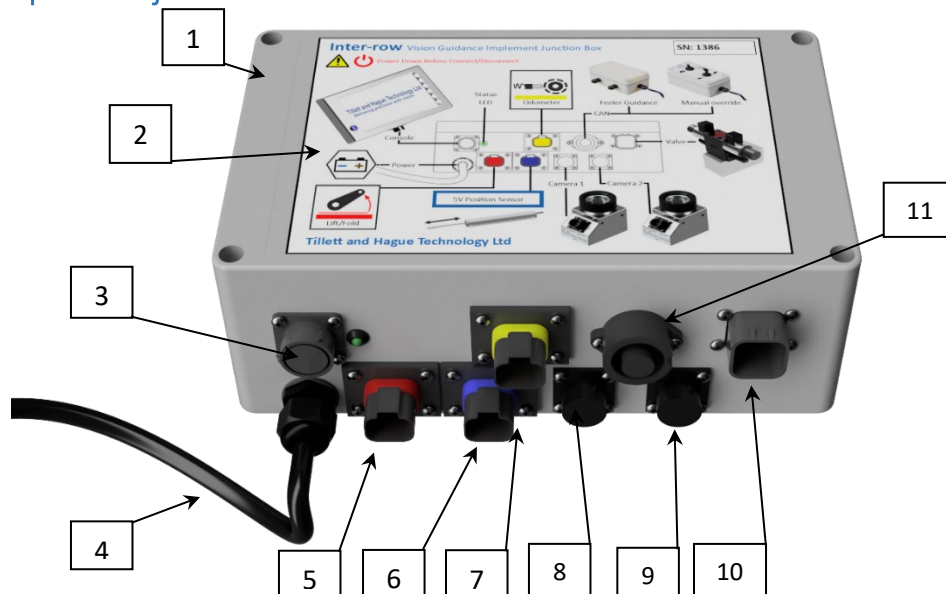


### 3.1 Console (cab mounted terminal.) PN: BOX001



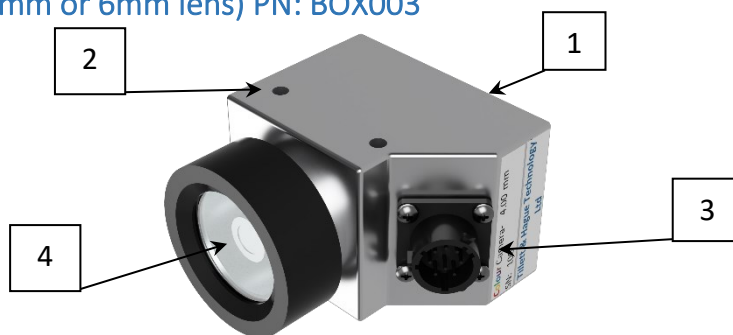
	Features
1	Cab mounted console.
2	Power button
3	12-way Console cable connection.
4	USB socket (For system updating/backup via USB stick & keyboard connection)
5	ISO mounting holes (100x100mm)
6	Optional RAM mounting plate. (1" ball).

### 3.2 Implement junction box PN: BOX002



	Features
1	Implement junction box.
2	Junction box connection label.
3	Main Console cable connector.
4	Power supply cable (12V non-switched should be externally fused to 20 amp)
5	Lift and fold cable connector (Proximity, reed, micro-switch). <b>(Red)</b>
6	Slide/steer position (Potentiometer 3-10 KΩ or Hall effect sensor 12v or 5V) <b>(Blue)</b>
7	Odometer cable connector. (GPS/ Proximity sensor input) <b>(Yellow)</b>
8	Ethernet Camera Connector No: 1
9	Ethernet Camera Connector No: 2
10	Control valve cable connector. (3-amp solenoid control)
11	CAN connector (Manual override pendent/Feeler control box)

### 3.3 Camera (4mm or 6mm lens) PN: BOX003



	Features
<b>1</b>	Ethernet camera
<b>2</b>	2 x M6 mounting threads each side
<b>3</b>	8-way camera cable connection.
<b>4</b>	4mm (wide angle) <b>BOX003-4</b> and 6mm (narrow angle) <b>BOX003-6</b> lens options available depending on requirements

### 3.4 Console cable 6m PN : CBL001-6, CBL018-6, CBL029-6, CBL039-6



	Features
<b>1</b>	12-way console cable [Female-Male] 6m and 10m lengths as standard CBL001-L
<b>2</b>	12-way console extension loom [Male – Female] 6m length as standard CBL018-L
<b>3</b>	12-way console extension loom [Female – Male] 6m length as standard CBL029-L
<b>4</b>	12- way console extension loom inline [Male - Female] 6m length as standard CBL039-L

### 3.5 Camera cable 5m PN: CBL002-5



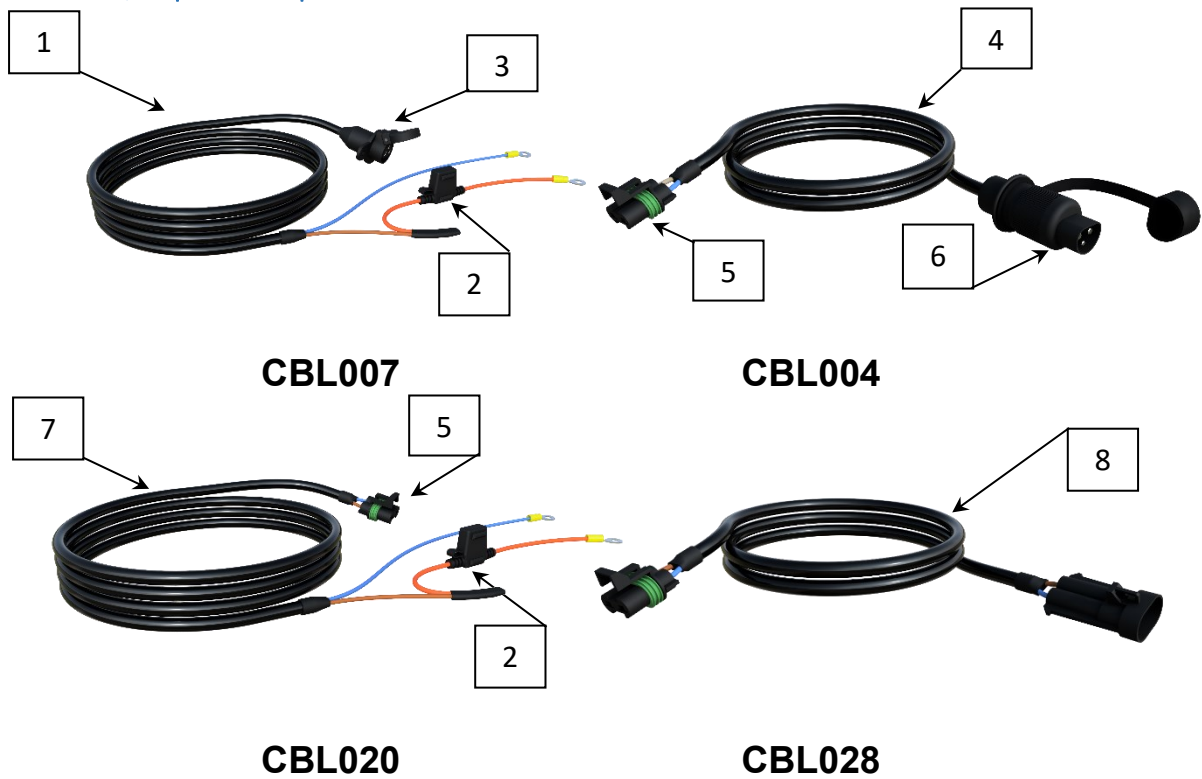
	Features
<b>1</b>	Camera cable, 2m, 5m, 7m and 10m lengths as standard CBL002-L
<b>2</b>	8-way female plug. (To Camera)
<b>3</b>	8-way Male plug. (To Implement junction box)

3.6 Camera disconnect at headstock extension cable PN: CBL013



	Features
1	Camera cable, 1.5, 2m lengths available CBL013-L
2	8-way female plug (mounted box towards camera/toolbar), ideal for quick hitch toolbar applications
3	8-way Male plug. (To Implement junction box)

3.7 Tractor/implement power cable



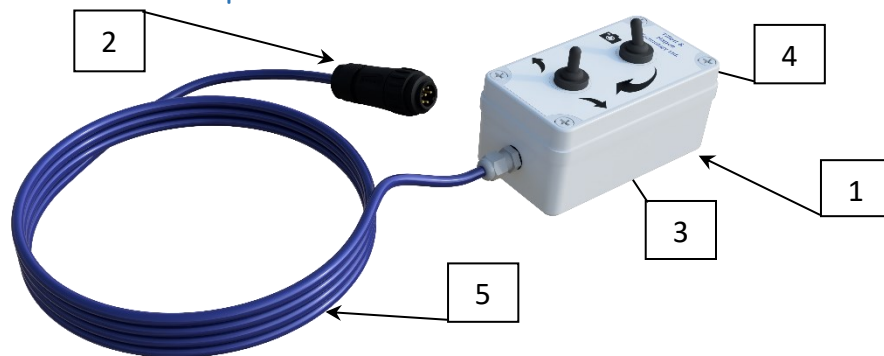
	Features
1	Optional tractor power cable (3 Meters long as standard) CBL007-L
2	Fuse holder (20-amp MAX)
3	3-way Female 'D' plug.
4	Implement junction box power cable (3 Meters long as standard) CBL004-L
5	2-way power connector.
6	3-way Male 'D' plug.
7	Optional direct to battery power cable (5m and 8m variants) CBL020-L
8	Power extension cable CBL028-L

3.8 Optional GPS speed sensor with 2m cable. PN: SEN003



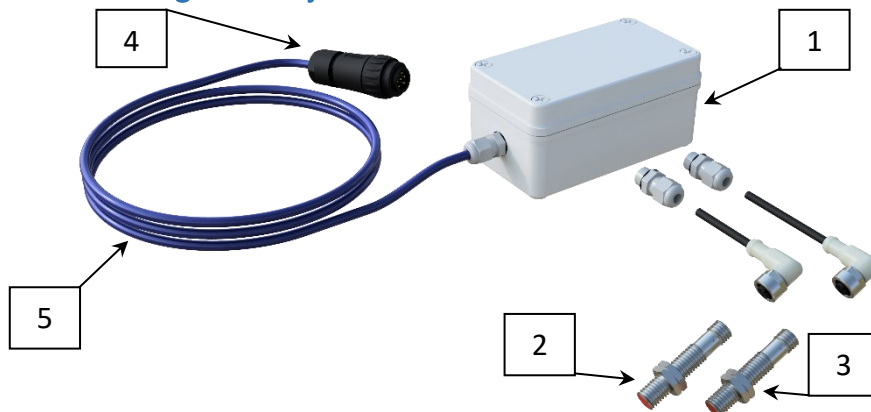
Features	
1	GPS Speed sensor loom.
2	4-way female plug. (To connector No:7 <b>Yellow</b> implement Junction box)
3	GPS module/ antenna.

3.9 Optional Manual override pendant with 5m cable PN: BOX004-5



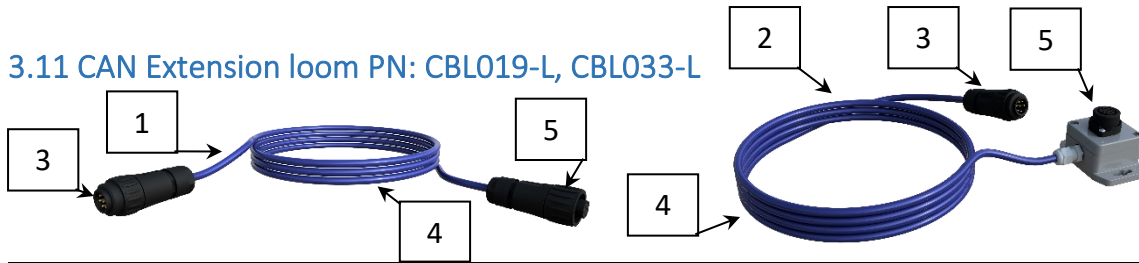
Features	
1	Manual override pendant.
2	6-way Male CAN plug. (To CAN connector No:11 implement Junction box)
3	Manual movement Left-Right Toggle.
4	Manual override/camera guidance toggle switch.
5	5m communication lead as standard, BOX004-L

3.10 Optional Feeler guidance junction box. PN: BOX005-5



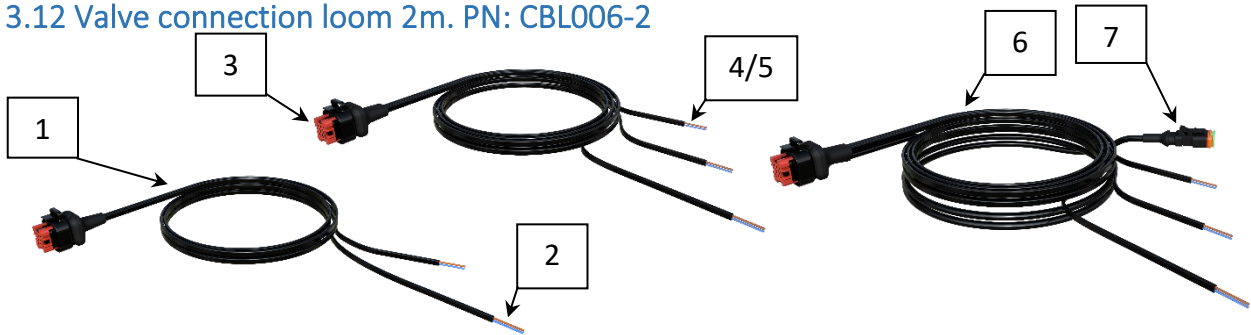
Features	
1	Feeler guidance system
2	Left Proximity sensor (To sense movement from a feeler arm)
3	Right Proximity sensor (To sense movement from a feeler arm)
4	6-way Male CAN plug. (To CAN connector No:11 implement Junction box)
5	5m communication lead as standard, BOX005-L

3.11 CAN Extension loom PN: CBL019-L, CBL033-L



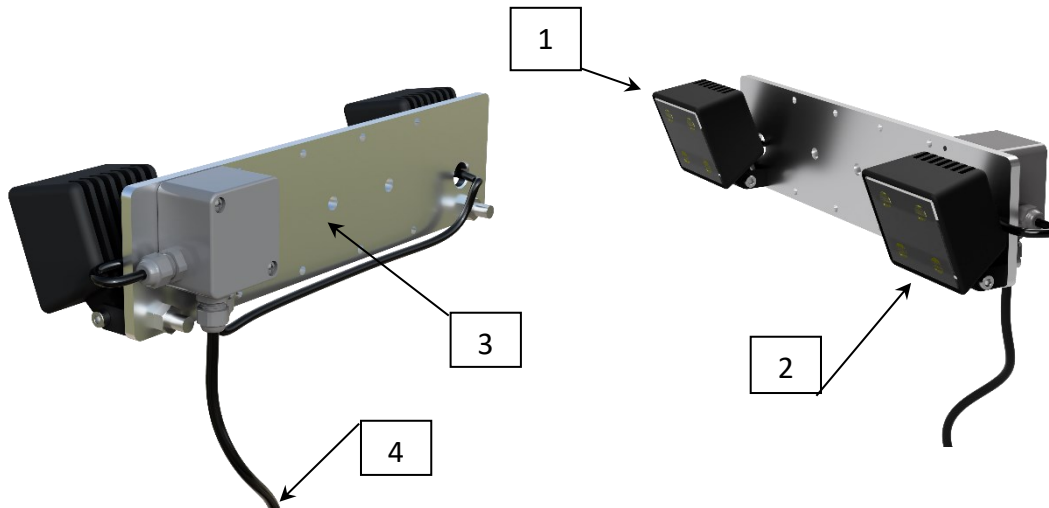
Features	
1	Low power CAN extension loom inline, CBL019-L
2	Low power CAN extension loom (panel mounted version), CBL033-L
3	6-way Male CAN plug. (To CAN connector No:11 implement Junction box)
4	Communication cable
5	6-way Female CAN plug. (To CAN Device)

3.12 Valve connection loom 2m. PN: CBL006-2



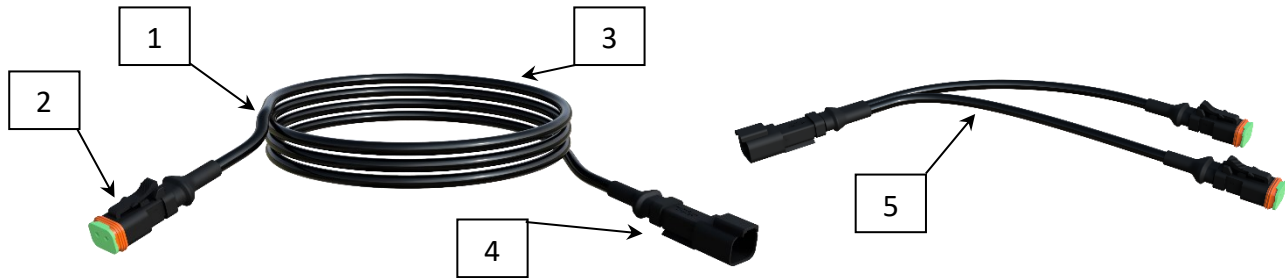
Features	
1	Valve connection loom.
2	2m Open wire tails to take 2-way valve connector plugs. (Solenoid control valve)
3	8-way Male plug (To connector NO:10 implement junction box)
4	CBL006-2-W2D integrates 2m hydraulic dump valve solenoid connection
5	CBL006-2-W2L integrates screen activated night operation light connection (2m length)
6	CBL006-2-W2D2L integrates both 2m dump valve and 2m night operation lights into the loom
7	Various connector options available e.g. DIN, Deutsch DT etc.

3.13 Night operation lights and mounting bracket assembly PN: BKT002-2LED



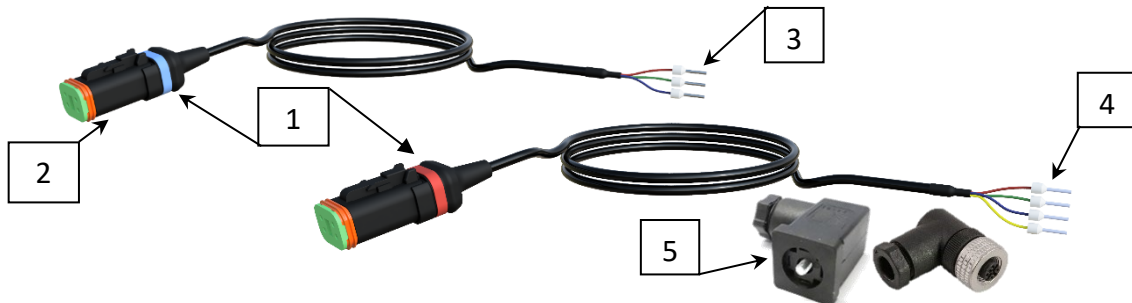
Features	
1	Night operation lights activated by touch screen display
2	x2 12W 1080 Lumen LED worklamps
3	Universal mounting bracket to camera pole
4	2-way Deutsch DT connector

### 3.14 Night operation light extension and “Y” adaptor cable PN: CBL017-L, CBL027-0.25



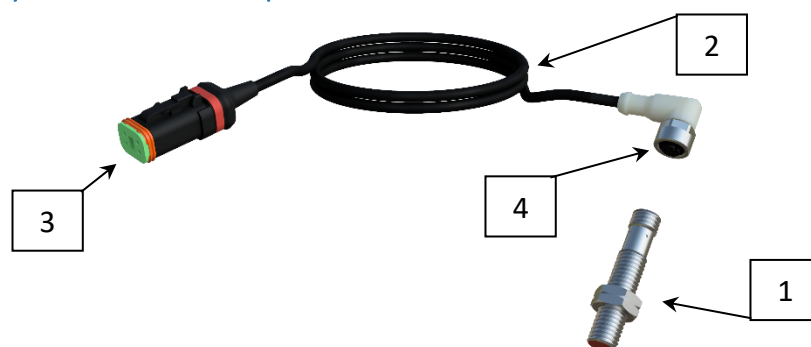
	Features
1	Night operation light extension cable
2	2-way Deutsch DT connector female
3	2 core cable available in various lengths (3m, 4m, 5m, 6m) CBL017-L
4	2-way Deutsch DT connector Male
5	“Y” adaptor cable enabling connection to multiple lights CBL027-0.25

### 3.15 Position sensor cable 2m PN: CBL003-2 and CBL035-2



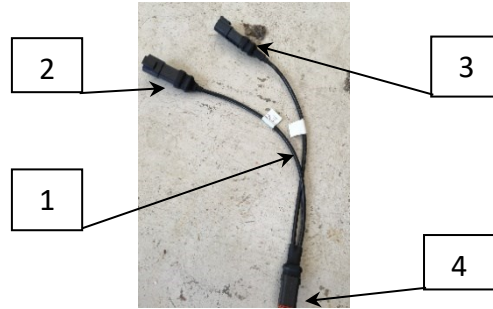
	Features
1	Position or lift/fold sensor cable.
2	4-way Female plug (To connector NO:5 <b>Red</b> (lift/fold), NO:6 <b>Blue</b> (position) implement junction box)
3	3 core open cable CBL003-L (Lift, Steer pot)
4	4 core open cable CBL035-L (Lift + Fold, Steer pot + Lightbar Pot)
5	Various connector options available e.g. DIN, M12, TE3, ferrule etc.

### 3.16 Proximity sensor and Lift/Speed sensor lead 5m PN: SEN001 & CBL005



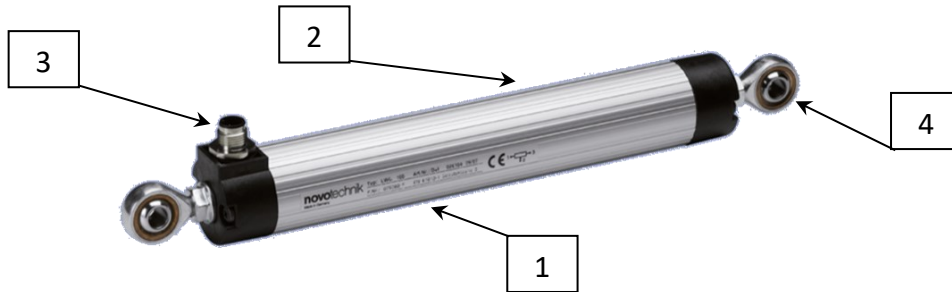
	Features
1	Ferrous metal sensing NPN proximity sensor
2	5m sensor lead
3	4-way Female plug (To connector NO:4/8 implement junction box)
4	M12 connector to sensor
5	12mm mounting hole for sensor

3.17 Lift & Fold, Position sensor 1&2 'Y' Cable 0.5m. PN: CBL008 (only used when a fold interlock is required)



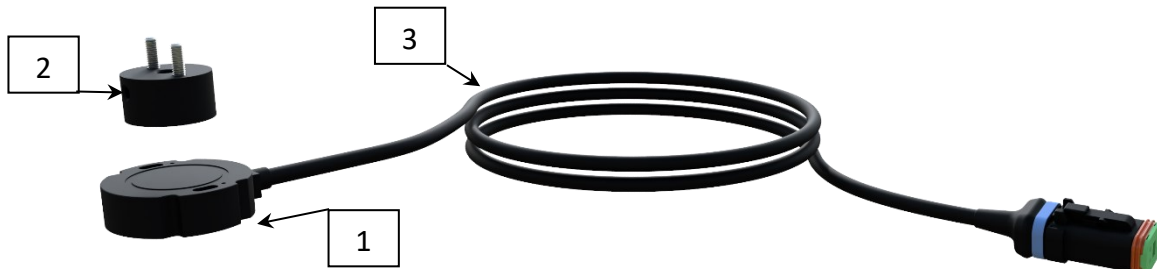
	Features
<b>1</b>	Lift & Fold, Position sensor 1&2 'Y' Cable
<b>2</b>	4-way Male socket plug NO:1 (Connects to Lift/Main potentiometer input)
<b>3</b>	4-way Male socket plug NO:2 (Connects to Fold/Second potentiometer input)
<b>4</b>	4-way Female plug (To connector NO: 5 (Red) /6 (Blue) implement junction box)

3.18 Linear potentiometer for machine position PN: SEN002-L



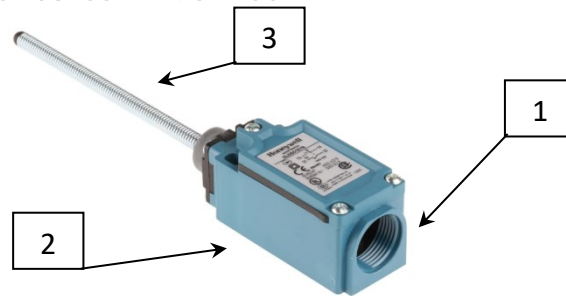
	Features
<b>1</b>	5K Linear potentiometer
<b>2</b>	Available in three variants depending on required stroke 300mm, 500mm, 600mm
<b>3</b>	M12 connector to sensor lead
<b>4</b>	8mm mounting points

3.19 non-contact rotary position sensor PN: SEN005-L + SEN005-M



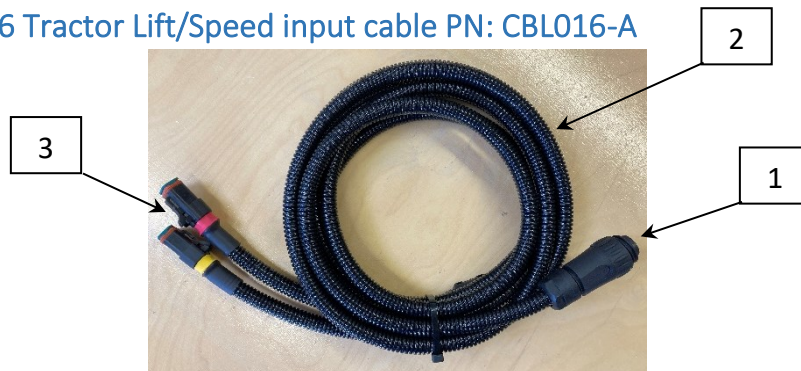
	Features
<b>1</b>	5V non-contact position sensor with cable SEN005-L
<b>2</b>	Position sensor magnet SEN005-M
<b>3</b>	2.5m cable length
<b>4</b>	Can be connected directly to NO: 6 (Blue) using Deutsch DT connector

### 3.20 Snap action limit switch sensor PN: SEN004



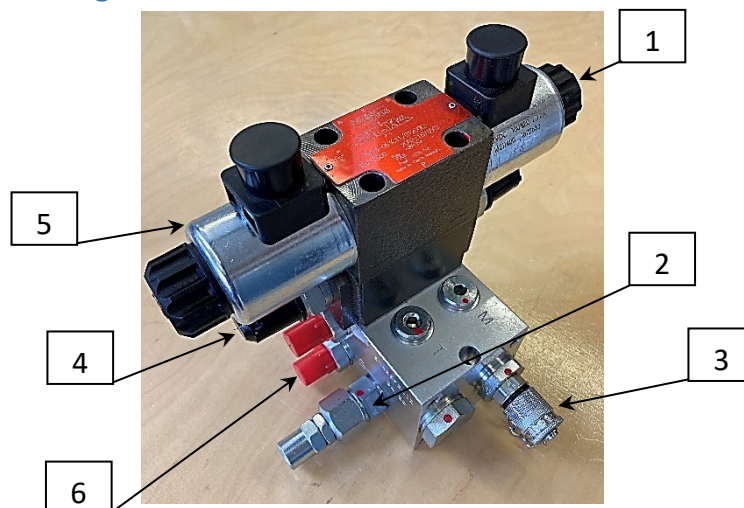
	Features
1	SPST limit switch
2	NO/NC contacts for use as lift or fold input
3	Coil spring actuator for ease of mounting
4	For use with CBL021-L to connect to implement module NO:5 (Red)

### 3.21 ISO11786 Tractor Lift/Speed input cable PN: CBL016-A



	Features
1	ISO11786 connector for tractor speed/lift connection
2	4m cable length
3	X2 4-way Female plug (To connector NO: 5 (Red) /7 (Yellow) implement junction box)

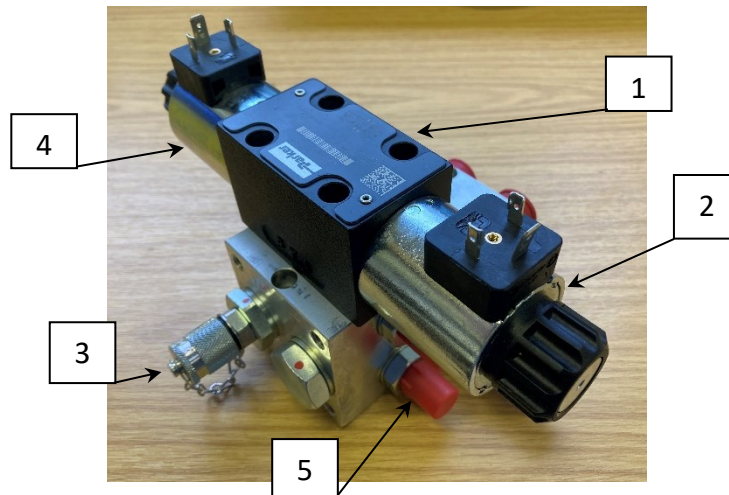
### 3.22 Hydraulic steering control valve PN: HYD001



	Features
1	Open centre directional control valve
2	Pressure reducer integrated into manifold block
3	Test point fitting for setting circuit pressure (gauge available HYD003)
4	Flow control for metering steering speed
5	12V solenoid coils
6	BSPP fittings, Hydraulic piping kit available if required PN: HYD002



### 3.23 Proportional hydraulic steering control valve PN: HYD004



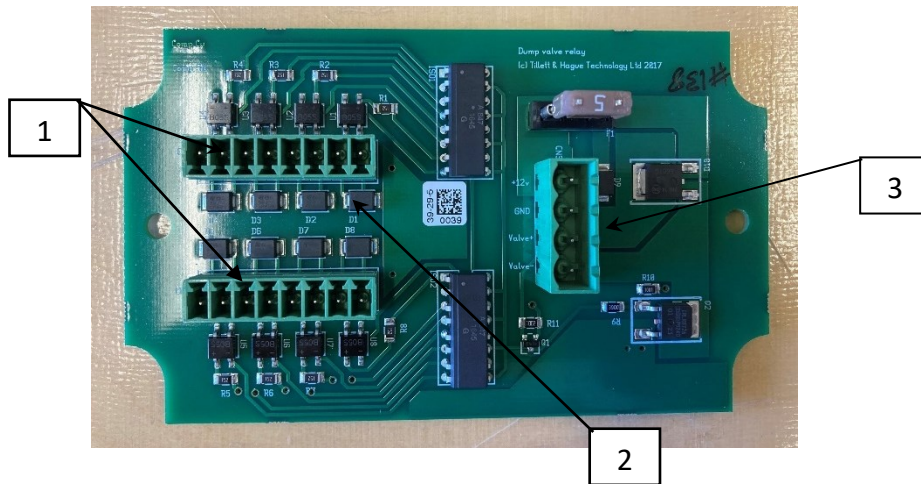
	Features
<b>1</b>	Closed centre proportional directional control valve
<b>2</b>	Pressure reducer integrated into manifold block
<b>3</b>	Test point fitting for setting circuit pressure (gauge available HYD003)
<b>4</b>	Proportional solenoid coils
<b>5</b>	BSPP fittings, Hydraulic piping kit available if required PN: HYD002

### 3.24 Condition Monitoring Microcontroller Module PN: BOX012



	Features
<b>1</b>	Hydraulic and Spray condition monitoring options
<b>2</b>	X2 Hydraulic Pressure, x1 Temperature, x1 Filter blockage inputs (BOX012-H)
<b>3</b>	X3 Spray pressure, x1 Master pressure inputs (BOX012-S)
<b>4</b>	Panel Mount CANbus connector for use with CBL019

### 3.25 Opto-isolated input/output board PN: PCB008



	Features
1	12 opto-isolated input channels
2	Electrically isolated inputs to trigger a single output
3	12V supply and single valve output channel
4	107mm x 70mm x 20mm board dimensions
5	4mm x 104.5mm mounting holes

## 4. Safety

1. These guidelines only cover aspects of safety specific to this guidance product. 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 pressure is zero.

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.

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. The optional tractor power supply cable has a 20Amp fuse fitted near to the battery terminals. This is for short circuit protection and must not be omitted. If connecting to an existing 12V power outlet, ensure that it is appropriately fused.
10. When routing the loom and power supply cables ensure that they do not cause a restriction or trip point in the cab.

## 5. Assembly

The following steps outline how a Tillett and Hague inter-row guidance system should be fitted to an implement.

It is assumed here that the implement is fitted with a hydraulic side shift or disc steered system actuated by a pair of “on/off” **12V** solenoid valves taking less than **3 amps** when operated. It is further assumed that the hydraulic circuit includes the means to regulate the flow of oil and thus the rate of side shift or steering. This can be achieved with the Tillett and Hague supplied valve block (see Annex), but other options including proportional steering control are available.

### Step 1 – Mounting the implement control box

The implement control box is best mounted centrally on the implement to reduce cable lengths. The metal box is water resistant to IP67, but we recommend providing a cover to protect against mechanical damage and direct rain. The box measures 260mm x 160mm x 91mm with 6.67mm diameter fixing holes at 240mm x 110mm centres.

### Step 2 – Mounting a side shift or steering sensor

Ensure the sensor has a stroke greater than implement movement and is mounted symmetrically so that mid stroke of the sensor represents mid stroke of the implement. (Offset configurations are possible, but best avoided in the interests of simplicity). Potentiometers should have a resistance of between **3K $\Omega$**  and **10K $\Omega$** . Our standard potentiometer has a 300mm stroke and a maximum resistance of **5K $\Omega$** . It is also possible to use Hall effect-based position sensors (12V or 5V).

### Step 3 – Mounting the odometry proximity sensor

Our standard proximity sensor (**NPN** type) picks up ferrous metals up to a gap of **4mm**. It is normally fitted to a depth wheel to which a spoked plate has been attached. In some cases, it may be possible to pick up on wheel hub bolt heads. We recommend that a speed pulse is generated about every 10cm of forward movement.

If it is not convenient use proximity detector-based speed information, there are three alternatives. One uses vision based odometry derived from the video images, another uses a GPS based speed sensor, and if an ISO 11786 socket is available on the tractor, that can be used to supply both lift and odometric data.

### Step 4 – Mounting the lift proximity sensor

The lift proximity sensor is identical to the one used for odometry. It should be fitted in a position that ensures it detects metal when the implement is lifted. This might be achieved by mounting on a depth wheel unit that drops as the implement is lifted or mounting on a bracket that detects three-point linkage position. (Micro switches/Reed switches can also be used). In any case it is important that the lift sensor cannot be triggered spuriously while in working position, by passing over a wheel rut for example.

### Step 5 – Mounting the camera(s)

Under normal operating conditions cameras should be mounted on a vertical pole approximately 1.6m above soil level at an angle of approximately 40 degrees to the horizontal (though both these can be refined during the commissioning process). It is important that the camera is held rigidly and square to the implement. It should be mounted over the centre of the crop rows to be followed. A second camera may be fitted on the other side of the implement to improve performance at field margins where

crop failure, or severe weed infestation may have occurred near a headland. It also helps cope with converging drill bouts, especially when section control implements are being used.

### Step 6 – Connecting hydraulic valves and sensors

Use cables provided according to the system overview in section 2. Route cables carefully ensuring they cannot become trapped or chafed making allowance for normal movement such as side shift or implement lift.

### Step 7 - 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 mounting holes on a square 100mm pitch at the console rear are designed to accept VESA standard brackets. We recommend "RAM" type ball and socket style mounting brackets, but other mounting methods are available.

#### *Caution*

- The console should be protected from severe vibration.
- The console is water resistant but should not be mounted where it will be exposed to direct rain. (A more waterproof version is available)

### Step 8 – 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 to the 3-point linkage points on the side shift frame.

#### *Caution*

- Once the 3-point linkage is correctly fitted stop the tractor and apply the handbrake.

### Step 9 – Reducing free lateral movement

Adjust the stabiliser links to prevent lateral movement of the lower link arms to give the implement a rigid reference to steer against.

#### *Caution*

- For side shifting front mounted systems it is particularly important that there is no lateral movement in the linkage.
- For large rear mounted side shifting implements it is beneficial to use fixed discs attached to the non-side shifting part of the frame so that the moving section has a firm reference to push against. This also allows for implement influence on tractor position to be reduced. When using fixed discs for stability, it is advised to have a small amount of free lateral movement in the lower link arms of the tractor as the stabiliser discs are giving the machine a rigid reference point.

### Step 10 – Levelling the implement

With the cultivator on the ground, adjust the top link of the tractor linkage so that the cultivator is level, front to rear (camera pole(s) should be vertical). Once camera height and angle has been set, top link adjustment should not be changed as this will have an adverse effect on camera setup.

### Step 11 – Connecting the implement cable to the console

The cable from the implement should be routed into the tractor cab and through to the console.

#### Caution

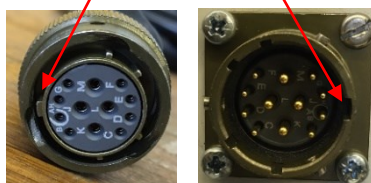
- Do not to allow the cable to restrict access to or exit from the cab or act as a trip point.

Connect 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.

Ensure alignment tab and slot are lined up when inserting the plug into the socket



#### Caution

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

### Step 12 – Connecting the power supply cable

The implement control box power supply cable should be connected to one of the tractors auxiliary 3 pin power sockets. Cigarette lighter sockets are not suitable. If auxiliary power sockets are not available a cable for connecting direct to the battery can be provided. It is important that this cable includes a 20amp fuse at the battery end for short circuit protection.

#### Caution

- Check polarity of power connections if fitting direct to the battery!
  - **BROWN = +12V**
  - **BLUE = 0V**

When the system is connected to 12V supply the console power button will flash every 5 seconds, indicating the console is ready to boot. If no flash occurs, please check connections for breaks or errors.

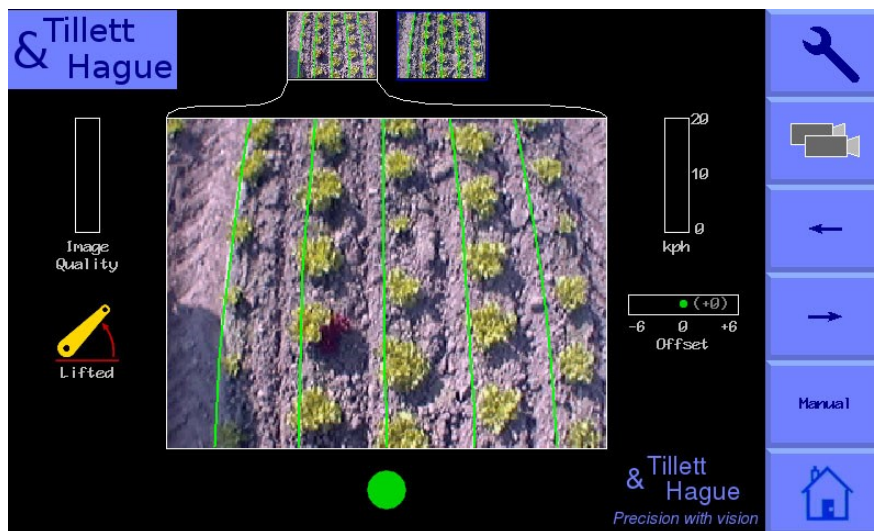
### Step 13 – Connect the hydraulic supply hoses

It is important that hydraulic flow rate and therefore side shift/steer rate can be controlled. This is best done via the tractors hydraulic control system, but if that is not possible some form of hydraulic flow control must be fitted to the implement. For more information see the annex.

### Step 14 – 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 switch on the console by pressing the button for a second or two until the button is illuminated. Wait for the system to "boot up". After about 40 seconds of PC boot up text the start-up menu should appear. Select Inter-row using the touch screen button with a crop row symbol to enter the working screen incorporating a live video image as described in section 6.

If the implement is lowered to its normal working position the "stopped" (red brake) symbol should be displayed, and the speed bar should read zero. Taking care to ensure that the hydraulic supply is off, spinning the odometer wheel (if fitted) should register a green speed bar. Lifting the implement should result in the "stopped" symbol being replaced by the "lifted" (yellow lift arms) symbol.



*Console working screen showing the implement is lifted and centred*

### Step 15 – Checking hydraulic operation

Set the tractor's hydraulic control to provide a constant flow to the implement with the facility to disengage the supply immediately should a fault occur. Ideally flow from the tractor should be reduced to an appropriate level (typically 10% or less) as full tractor spool flow is unnecessary for steering.

With the system running, lift the implement clear of the ground and engage the hydraulic supply.

From the working screen touch the top right "spanner" touch screen button in the working screen. Touch in the same area again (this time marked by a spanner++ symbol) to reach the advanced settings and diagnostics page. Use the arrow buttons to move the cursor down to "Test steering" and touch on the return button to start an interactive process that will set up the steering and prompt you should any adjustments be required. Left and right are defined when looking forward in the direction of travel.

At the end of the test the side shift or steered discs should centralise.

If you wish to test steering manually return to the working screen using the loop back button and touch on the button labelled "manual". The hydraulic side shift/steering is now in manual mode and can be operated using the touch screen buttons labelled

with left and right arrows. Each press of a button steps the side shift/steering by 7% of its stroke. Repeated pressing and releasing (but not holding) will result in continuous travel up to the end of the stroke denoted by a red vertical bar. This procedure can be used to check that hydraulic flow is in the correct direction and that 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 (now with “camera” highlighted) again. The side shift/disc will stay in the position it was placed under manual control until the implement is lowered and raised again, or the machine starts to travel forward.

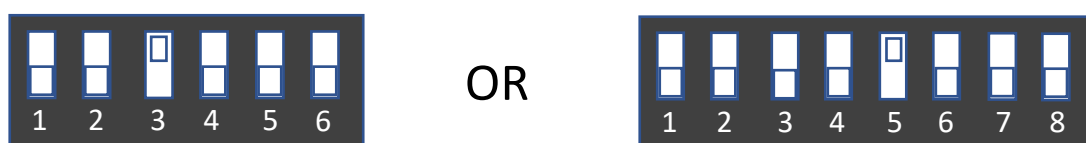
#### Caution

- 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 indicates that the hydraulic flow rate is too high. The tractor flow control should be turned down. Alternatively, if fitted the hydraulic flow control valve on the implement may be adjusted.
- “Reverse oil flow” message can sometimes be falsely triggered by side-shift hydraulic flow control being fully closed.
- Only adjust the flow control valve with the implement on the ground and the tractor engine switched off.

### Step 16 – Activating night operation lights or the ON while moving output

In addition to steering valve outputs the module is equipped with an extra output that can be configured to either switch on when moving, potentially useful for spraying, or on when switched on from the console. The later being intended for activating night lights. Which mode the module operates in is determined by a DIP switch as outlined below.

The Function DIP switches are located on the right-hand side of the implement microcontroller. To turn on light option the switch should be into the “UP” position. Switch “3” on 6 switch models and switch “5” on 8 switch models.



**Note:** Other DIP switches may or may not be activated for other system functionality reasons.

The machine is now ready to be taken to the field.

Before proceeding it is worth familiarising yourself with the working screen.



## 6. Start up and Working screens – the basics



*Start-up screen.*

To turn the system on press the console button for a second or two 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 inter-row guidance system, going directly to the configuration file editor, opening the service tools menu, or shutting down.

To get to the working screen press the 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 operating with multiple cameras will display live thumbnail video along the top of the display.
- Briefly touching on a thumbnail selects that image for the main display and other parameters such as offsets relate to the section that camera is fitted to. Alternatively, the button labelled with a multiple camera graphic toggles between thumbnails for full size display.
- Touching and holding on an image, or its thumbnail, stops images from that camera being used for guidance, making guidance solely reliant on any remaining cameras. When a camera is disabled in this way a red cross is superimposed over the image which remains live. Touching and holding again restores normal function.
- 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.

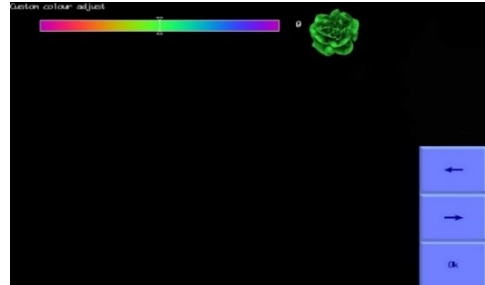
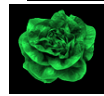
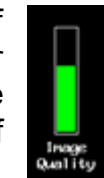
- An image quality gauge to the left of the screen giving relative indication of likely tracking performance. The higher the green bar the better. A low bar indicates either a poor template match or poorly defined crop rows. Guidance will, under most circumstances, operate down to an indication of approximately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

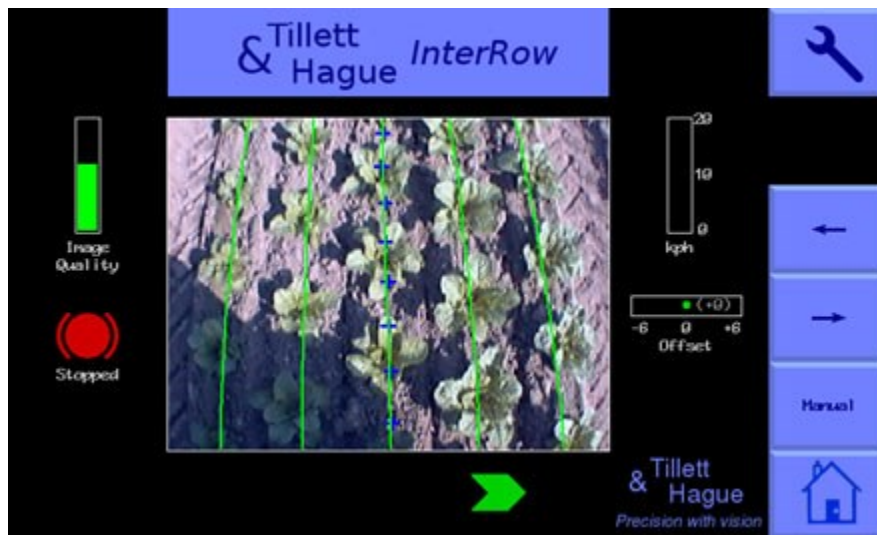
Touching on the plant symbol pops up an adjustment tool.

In that pop-up tool touching the colour band itself selects a colour bias. For fine adjustment use the arrow buttons.

- 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. To activate the lights option see Section 5 step 16.
- 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 lightning bolt within brackets indicates a steer valve in an open circuit state
  - A lightning bolt with lines radiating indicates a steer valve direct short
  - A CAN warning triangle with a “?” or “!” indicated unknown, conflicting, or dropped CANbus messages suggesting CAN connection issues

- A speed gauge on the right shows forward speed which should match tractor speed. By default, the speed bar is green up to 11kph and red over 15kph, which is normally a sensible operating limit, though guidance will continue at higher speeds.
- A green dot and red/green chevrons below the image indicate side shift or disc steer 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.
- It is possible to reverse applied fine offset in a single press, using the fine offset flip tool that can be activated in the advanced menu.





*Working screen in work but stationary*

**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).
- Double camera symbol 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.

Additional cameras are normally used to provide extra guidance information, but it is possible to configure the system so that an additional camera, or cameras, provide a CCTV function. See “settings available from the advanced editor” for instructions on how to achieve this.

- ← moves fine offset left 1cm, or when in manual mode, side shifts/steers 7% to the left.
- → moves fine offset right 1cm, or when in manual mode, side shifts/steers 7% to the right
- Touch screen button labelled “Manual” disables vision steering and allows the user to move left or right manually in steps of 7% of position sensor stroke for each press of the arrow buttons. For disc steered machine with a free-shift 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 (section 7).

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 by default manual control is retained when moving forward with a normal tracking screen shown so the operator can see if vision guidance is likely to be successful. It is also possible to configure the system from the “System information & diagnostics” page to jump into camera guidance as soon as motion is detected.

For machines with mechanical guidance feelers fitted 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.

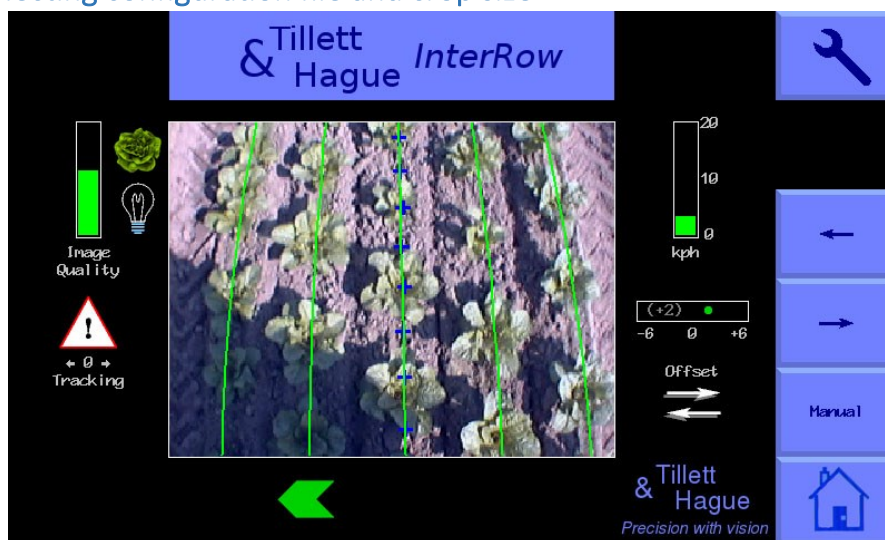
- Pressing the touch screen button with a house logo image enables you to return to the start-up screen
- Pressing the touch screen button with the power switch logo enters a shutdown screen from which you can confirm shutdown.

## 7. Getting to work in the field

To ensure good guidance it is important 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 the guidance system learns a term that compensates for minor errors in camera orientation. Wherever possible we recommend that set up runs (step 3 below) are conducted in crop showing the clearest rows available so that this term known as camera skew is learned as quickly and accurately as possible. High visibility rows also help manual alignment checks (step 2). We also recommend that side slopes are avoided during initial running. Once set up is complete more challenging situations can be tackled. It is also possible to view camera skew and reset it manually (see section 9.3).

### Step 1 – Selecting configuration file and crop size



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

The top line of this screen indicates crop size (height) settings under categories of small, medium and large. The heights assigned to these labels vary with camera height and are displayed. Ensure that the highlighted option corresponds to the crop being used for setup and initial running.

Check details at the bottom of the screen to ensure selected configuration file settings match crop geometry. E.g. that the number of rows viewed by the camera corresponds to the number being tracked and that row spacing on the ground correspond to the numbers on the screen.

Also, ensure that selected configuration file settings match the number of cameras fitted.

If either crop or implement geometry do not match the selected configuration file settings, select an alternative configuration. If a suitable configuration does not exist refer to section 9.3 for instructions to create one.

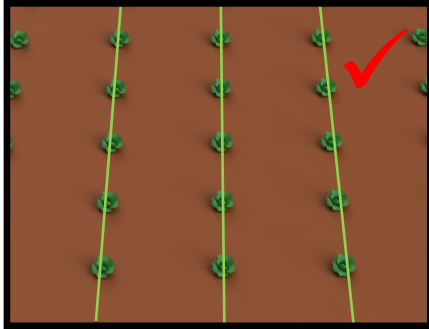
To return to the working screen press touch screen button labelled with a loop back arrow.

## 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 (as displayed in the “set up” screen).

Press touch screen 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*

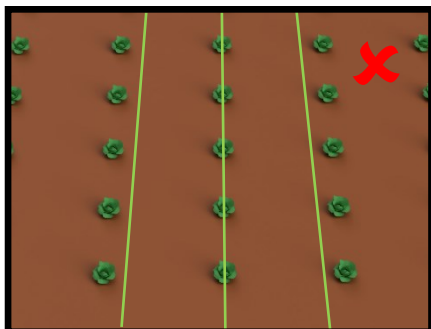
If crop rows are difficult to see in the live video image you can enhance them by placing high visibility objects such as a strip of wood exactly over the row centre line.

### *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 9.

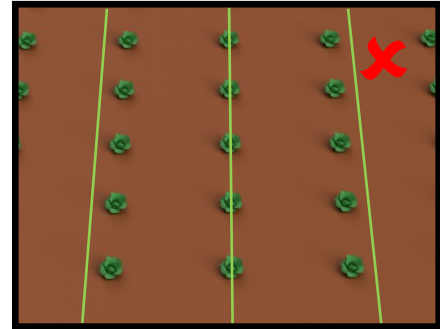
If the green lines appear narrower or wider than the real crop rows check the “crop size” selected in the “set up” screen and change if appropriate. If this does not resolve the problem, it may be that the camera height (measured from centre of lens to ground level) does not match the figure displayed 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:

### **In field camera set up by eye**

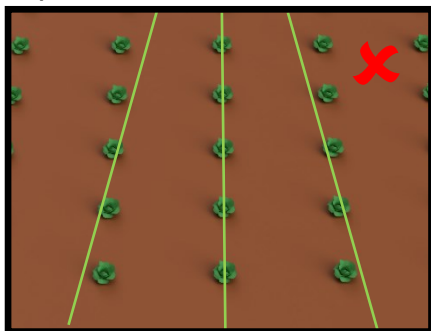


If the camera is too low, then the template will appear narrower than crop rows. In this case raise the camera.

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

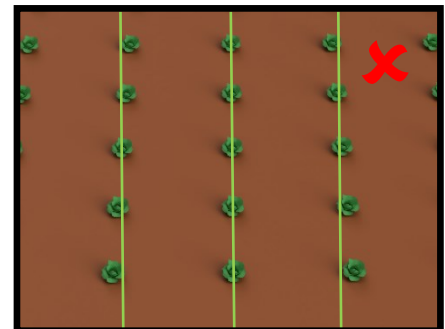


If the template matches mid screen, but not at the top or bottom, check that the implement is level. If it is camera inclination angle may need adjusting.



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.



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

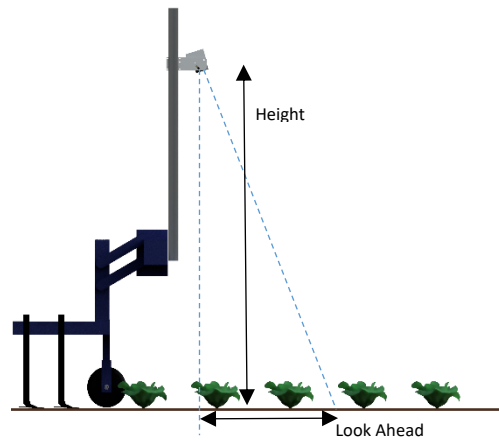
It is not always convenient to set the camera up in a field with crop. It is also possible, and often more accurate, to align the camera by measurement as follows:

### Camera set up by measurement

From the working screen go into the “set up” screen by touching the spanner button. Select the configuration file you require using the arrow buttons (blue text turns white when selected). Make a note of distances called “look ahead” and “camera height”.

Having checked that the implement is fully lowered and at its normal working depth adjust camera height so that it matches the figure given in the configuration. 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 as illustrated in the diagram below. Return to the working screen and press the touch screen button labelled “manual”. Purple cross hairs will appear in the image. Adjust camera inclination so that the cross hairs align with the object in the image set at the “look ahead” distance.

The camera is now correctly aligned



*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 touch screen button labelled “Manual” again to return to the normal working screen. 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. Green lines will also be laid over and track individual crop rows.

#### *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. 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. Touch screen button labelled with left and right arrows adjust fine offset. 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.**

**Tillett & Hague Technology Ltd accept no responsibility for damage to or loss of crop whatsoever.**

After approximately 200m of running alignment (“camera skew”) should have been learnt so camera lateral bias should therefore have stabilised. If fine offset is greater than two steps, we recommend physically moving the camera along the tool frame 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.

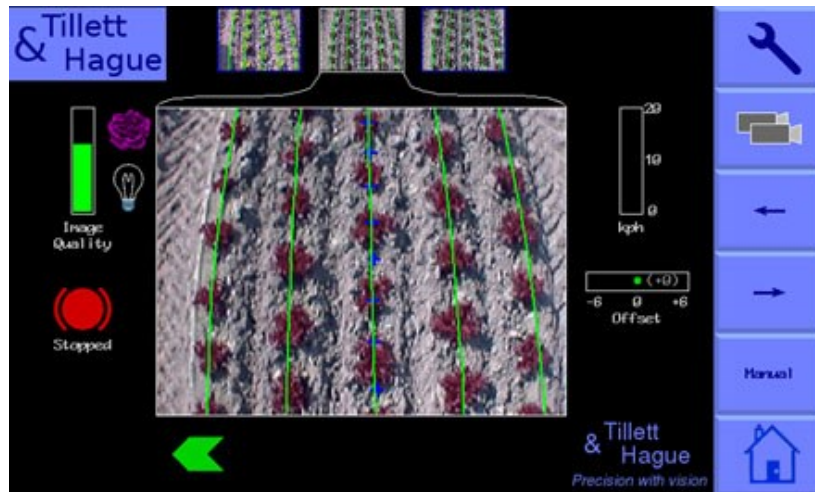
Once you are confident tracking is accurate and reliable, forward speed can be increased. Mechanical interaction of shares and shields on the soil would normally limit speed to below 15 kph though guidance will continue to operate at higher speeds, albeit at reduced accuracy. The speed bar goes red at speeds above 15 kph and an overspeed is logged in the error file.



## 8. 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 the on-screen speed gauge matches the tractors and that implement alignment is good. If performance is satisfactory speed can be increased. Tracking should be satisfactory up to 20 kph, though soil movement considerations will probably dictate a lower speed. The speed bar turns red at speeds above 15 kph. For lower speed applications it is possible to reduce the speed gauge to suit the application (section 9.3).
- Fine offset settings from previous sessions are saved 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 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.

## 9. Information screens and menus

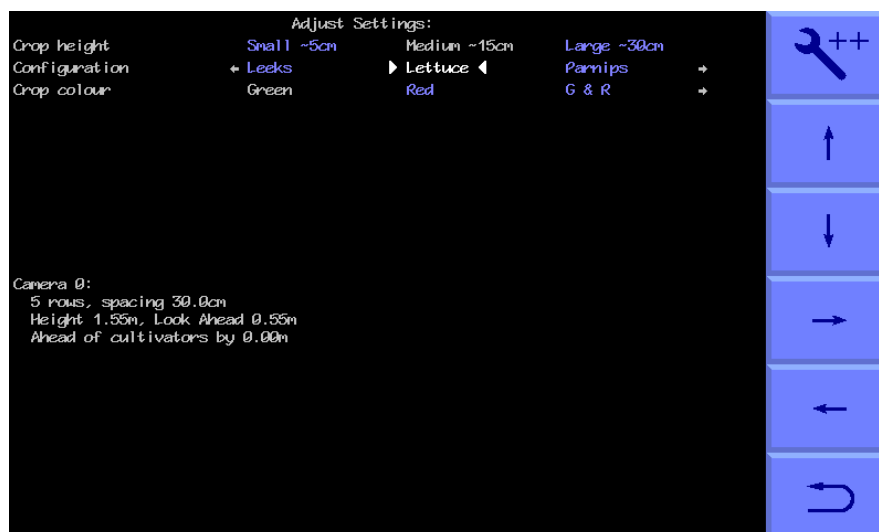


### 9.1 The Setup Screen

The setup screen can be reached from the top right “spanner” touch screen button in the working screen.

Navigation within the setup screen is achieved by moving the cursor over options using touch screen buttons labelled with arrows. When the cursor is over a setting it’s text changes from blue to white, indicating it is selected.

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 running a particular configuration ready for the next time running the configuration.



“**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. There are settings for small, medium and large crops. The definition of small, medium and large is approximately 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”)

On initial set up the default will be medium, though crop size is saved from the previous session regardless of which configuration file was last 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). Where custom colour is enabled, it can be adjusted by touching on the plant icon in the working screen. We discourage the enabling of custom colour unless it is absolutely necessary as it adds complexity and can, if not set correctly, dramatically reduce performance

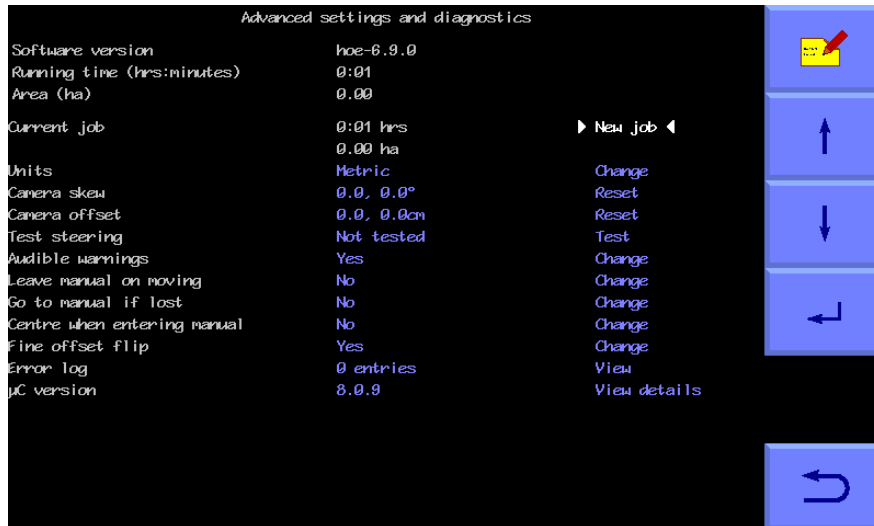
For plants with particularly unusual colours that cannot be tracked using any of the normal colour options an Infra-Red camera can be fitted which will be automatically detected. It is recognisable by monochrome video images. But it is advised to try all above options before resorting to monochrome cameras.

If a suitable configuration is not available, it can be created using the configuration file editor (section 9.3).

## 9.2 System information & diagnostics menu

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

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. Small lateral camera adjustments by sliding within the stroke of a camera bracket should not however require a reset, as camera poise should not be significantly affected. A reset to zero is achieved by highlighting reset and pressing the return button.

### Caution

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

Camera skews more than 3 degrees indicate poor 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 during field operations. Rate of change of this estimated displacement is highest during initial runs and after resetting to zero. There are as many offsets as there are cameras on a section. The first camera is master/datum 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.

### **Test steering**

This 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, side shift/disc potentiometer connection polarity and continuity over the stroke. It also detects mechanical obstructions preventing the expected full travel which result in the message "hit stop". 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. This test also serves as an initial calibration of steering direction (when viewed in the direction of travel) through a series of questions on screen.

#### *Caution*

Ensure 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".

### **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".

### **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".

### **Enable fine offset flip**

Selecting "Yes" adds a touch button on the working screen below the fine offset bar with opposing arrows which when touched flips fine offset direction. The default is "No" and should only be changed for work on side slopes or in cross winds.

### **Error log**

A log of automatically generated error messages (e.g. camera and microcontroller connections and excessive camera skew). Selecting "view log" displays messages that can help 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 menu without erasing. Messages are saved between sessions.

*Tip* When seeking advice over the telephone it is 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 status and diagnostics menu screen press the bottom right touch screen button labelled with a loop back arrow.

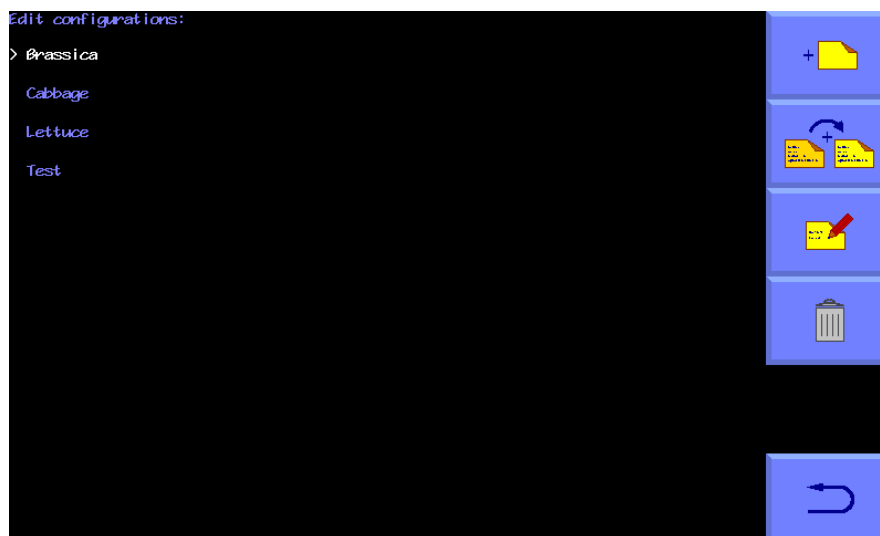
### 9.3 Configuration file editor

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. It is reached from the System information and diagnostics menu by pressing touch screen button labelled with a file and pen symbol. Users are required to enter a PIN to prevent accidental entry to the editor. The default is 1,2,3,4.

The editor is multilingual, though translations are not available in all languages. Where translations are not available, English will be displayed, though use of graphical symbols makes many functions independent of language.

The editor uses the touchscreen for navigation and data entry.



#### 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

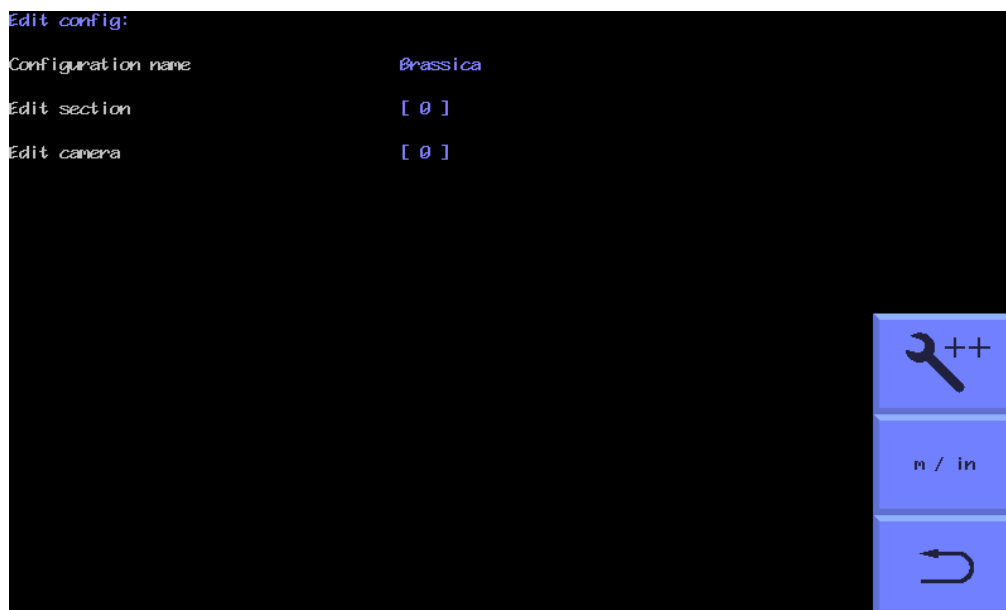
available for editing. Touching on one of the list either pops up an appropriate keyboard (Letters for editing name, numeric for entering numbers) or presents another lower level list of parameters to select from. To remove the keyboard from the screen, press it's return key.

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 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



*Configuration file editor screen with standard settings selected*

### **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 subcomponents. It is possible to have more than one of these subcomponents 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

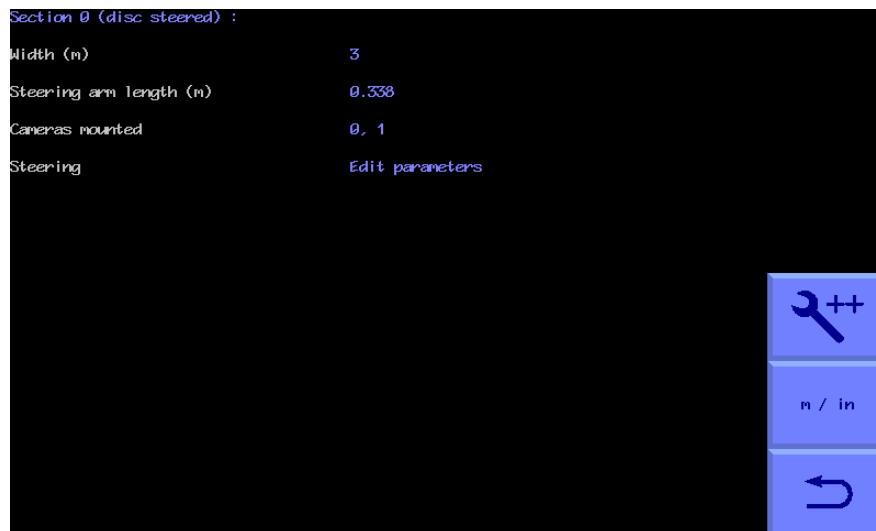
conventions numbering of these subcomponents always starts at zero, e.g. the first camera has index number 0 and the second 1.

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

### Section settings

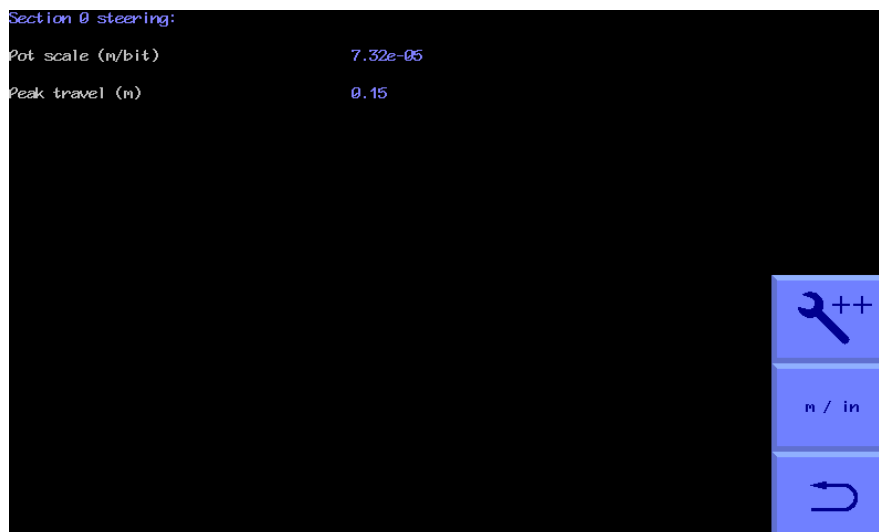
A section is defined as a frame that has independent steering. Most implements will have only one section. However, it is possible to have an implement with up to three independently steered sections. This is useful when it is required to span multiple drill/transplanter bouts.

The settings are "Width" is the width of that section and is only used to calculate area worked, "Steering arm length" (for disc steered machines only) and "Cameras mounted" which allocates which cameras are fitted to that section, e.g. 0 for one camera, 0,1 if two are fitted.



*Configuration file "Section" standard editor screen*

It is also possible to edit further steering mechanism parameters.



*Configuration file "Steering parameters" standard editor screen*

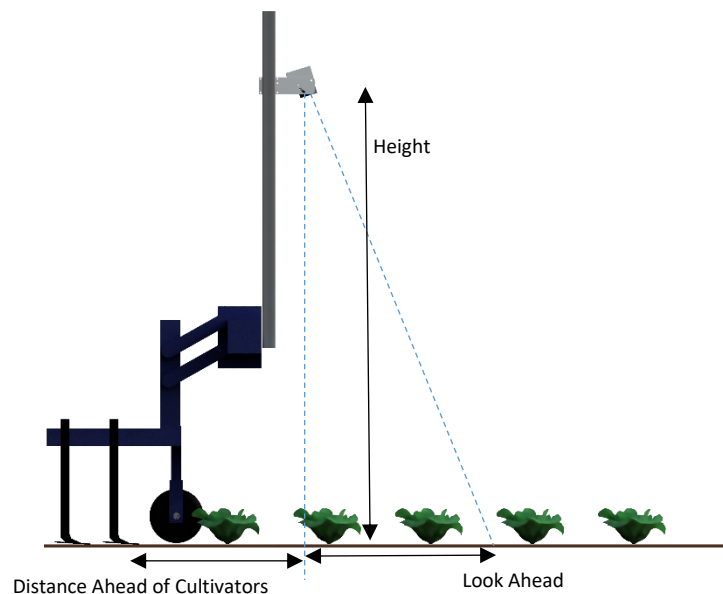


For side shift machines these are the linear position sensor scale and the peak travel from the central position, usually set to be just under half the total stroke of the sensor.

For disc steer machines these become maximum angular deflection from the central position and calibration of the rotary potentiometer that measures steer angle.

### 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)



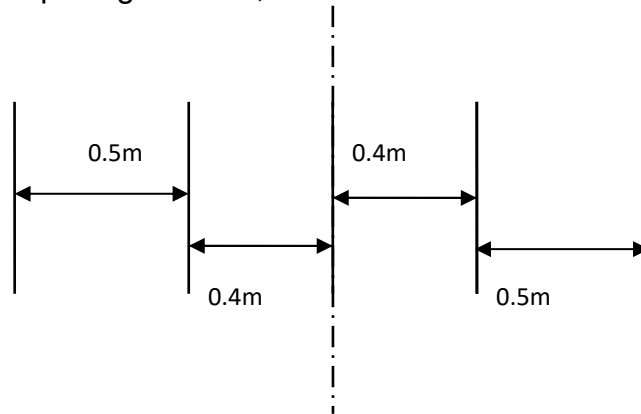
The next settings relate to what is seen in the image. The number of rows and their spacing.

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

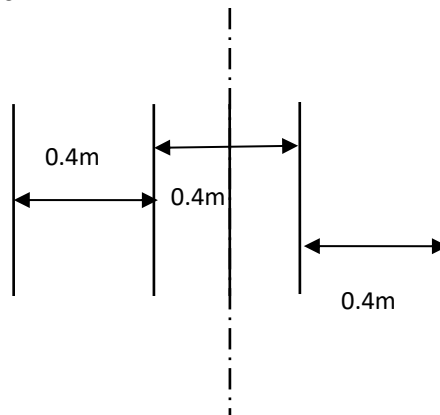
Spacing between rows is normally uniform across the field of view and is therefore a single figure. However, some crop geometries with a number of different row spacings in the same scene require a more complex arrangement. Syntax for this is based on the assumption that the pattern is symmetrical about 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*

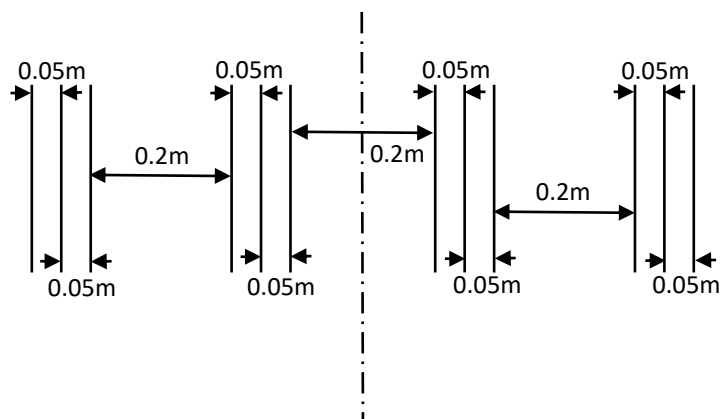
Rows 5 Spacing 0.4,0.5

*Even no of rows regular spacing example*

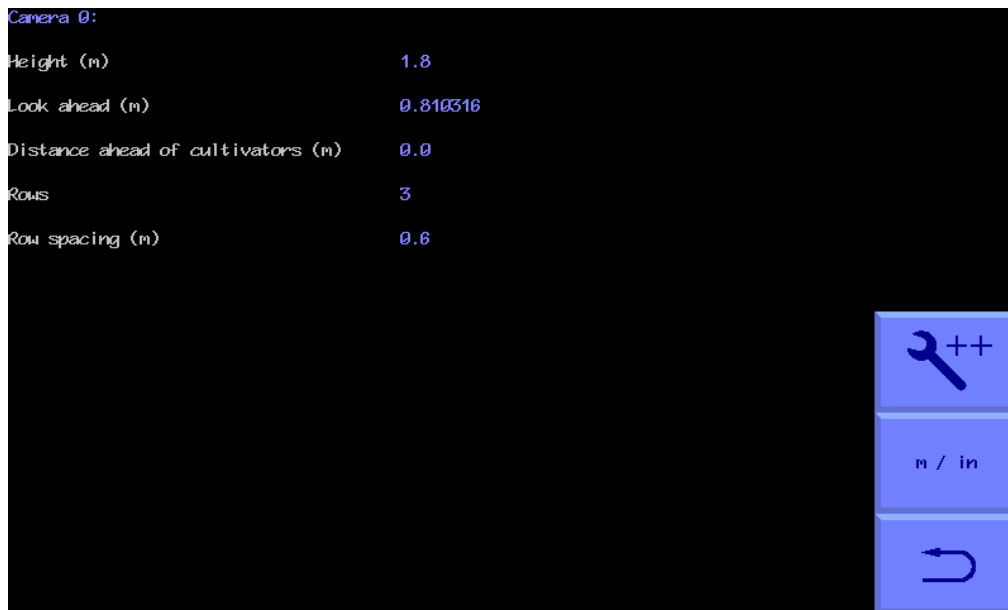
Rows 4 Spacing 0.4

*Grouped sets of rows example*

Rows 12 Spacing 0.2,0.05,0.05,0.2,0.05,0.05



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 red "?" touchscreen keyboard key.

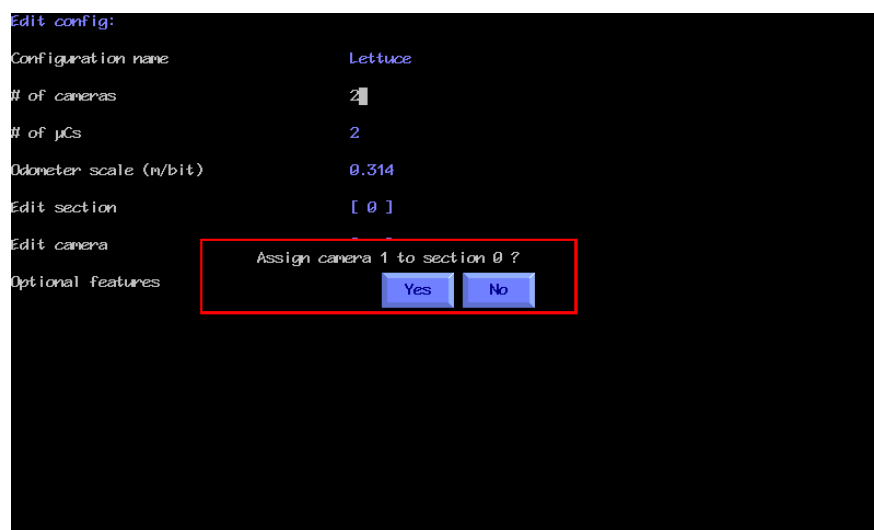
### **Additional settings available from the advanced editor**

Under normal circumstances it should not be necessary to alter any of the additional parameters listed in the advanced editor.

#### **Additional general settings**

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

For example, adding an additional camera can be achieved by increasing the number of cameras fitted by one. You will then be asked if you wish to assign this camera to a section for guidance purposes. Normally you would reply "Yes". If you also wish to copy the setup settings from the previous camera setup you can reply "Yes" to the next question asked.



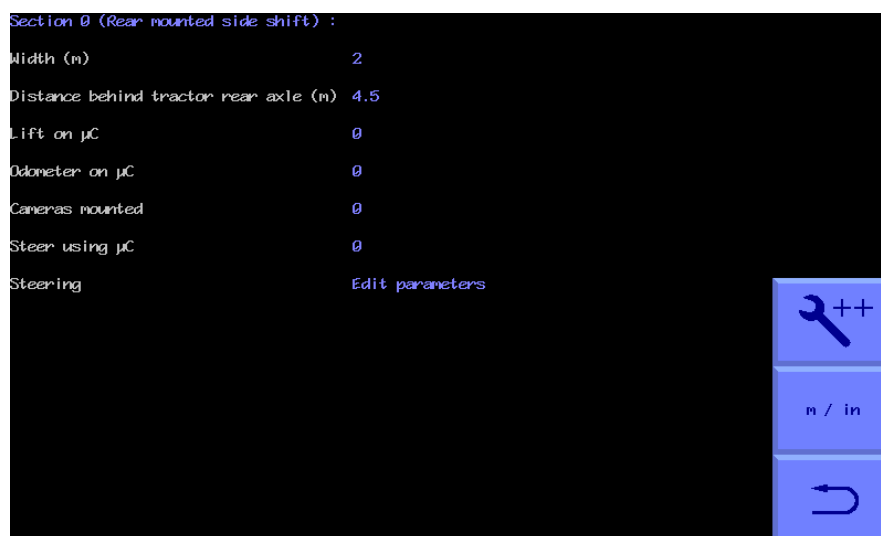
*Configuration file editor screen with advanced settings selected*

However, it is also possible to add additional cameras that are not used for guidance, but instead provide a CCTV function. To add a camera for this purpose do not allocate that camera to a section. 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) from the ground engaging wheel diameter according to the formula:  $\pi \times \text{Wheel diameter} / \text{PPR}$ . Typically there will be approximately 12 teeth or studs on a wheel making  $\text{PPR} = 12$ .

### Additional section settings

Distance behind rear axle is the measurement between the cultivators and the tractors rear axle. It is 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 microcontroller number for the odometer is left blank, odometric speed will be calculated from the flow of features through successive images. Finally, the cameras mounted on that section are allocated by listing them 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 side shift implement*

The advanced version of the steering parameters allows users to alter the value of position sensor reading that is defined as central (normally 2048).

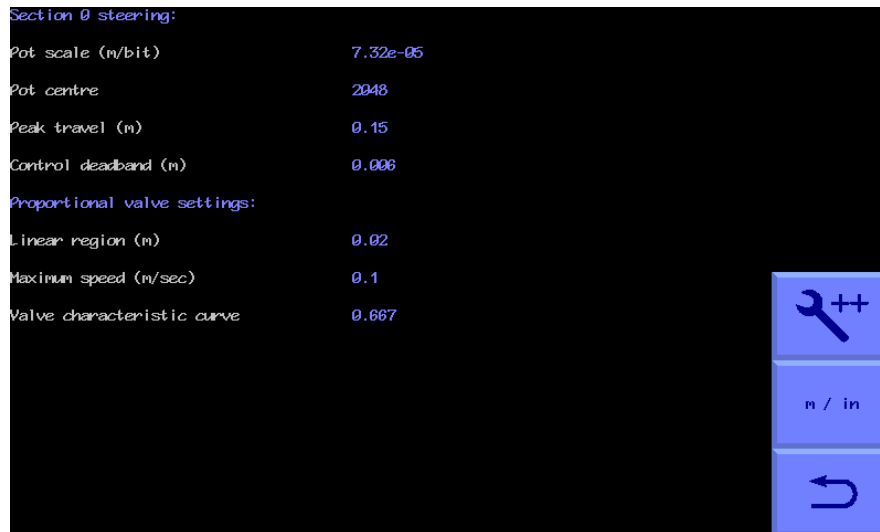
There are also a number of parameters that relate to steering control. Deadband (the minimum steering error that results in a corrective action) can be set. Smaller values increase accuracy but can cause rapid steering oscillations if the steering rate (oil flow) is set too high. As standard this is set to 0.006m.

Linear region, maximum speed and valve characteristic curve all relate to the control of proportional hydraulic valves. And may need adjustment to suit some proportional valve setups, default values are good base to start from. Their function is explained by a diagram/graph in the help (?) facility.

Disc steered machines (not shown in example) can be fitted with an additional potentiometer to display linear free shifting slide position on the working screen light

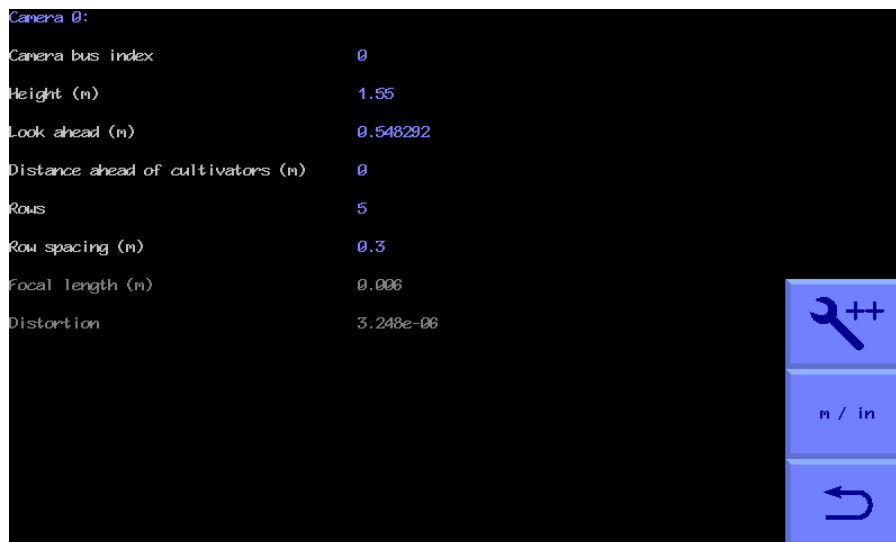
bar. The parameters for this additional lightbar potentiometer are derived in the same way as you would for a side shifted machine. If the lightbar peak travel is set to zero, the system assumes there is no separate lightbar position sensor, and the working screen light bar will display steering disc angle instead.

The damping term relates to disc steering.



### Additional camera settings

Additional camera parameters are lens focal length and a figure relating to correcting for lens distortion. However, cameras from serial No 717 onwards have this lens data stored internally, which takes precedence over configuration file data, making these figures irrelevant, except where older cameras are fitted. It is also possible to change camera bus index, though this should not be changed from the camera number in blue above without taking expert advice.



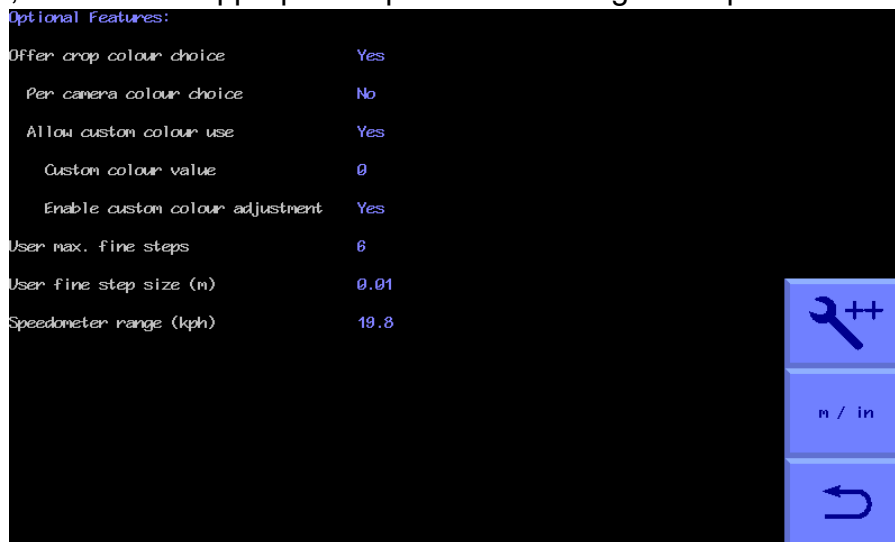
*Configuration file "Camera" advanced editor screen*

## 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 leaved 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 working or advanced settings screen.

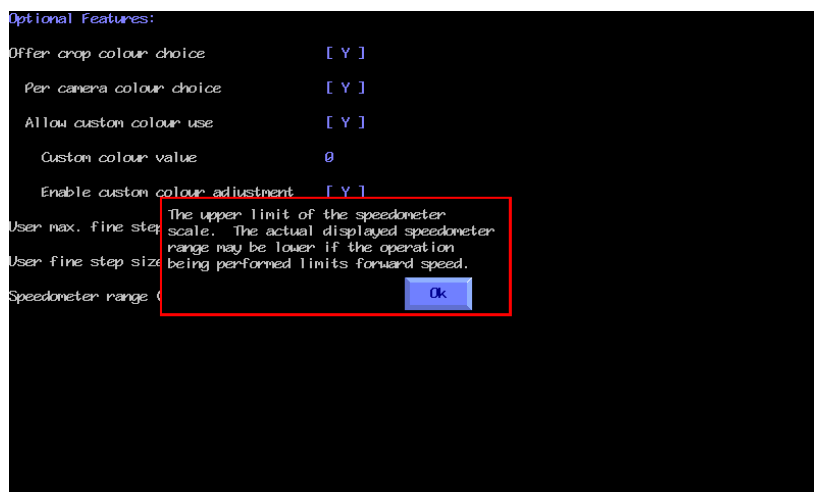
There are two options relate to customising fine offset which can be useful if extra stroke is required working across steep slopes for example. One allows the maximum number of fine offset steps to be changed (default is 6) and the other allows the size of those steps (default 10mm) to be modified.

The range of the speed bar displayed on the working screen can be changed from the default 20kph, this is useful for situations where lower working speeds are anticipated, and a more appropriate speedometer range is required.



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

**Tip** Context sensitive help is available within the configuration editor by pressing the red **?** touchscreen keyboard key.



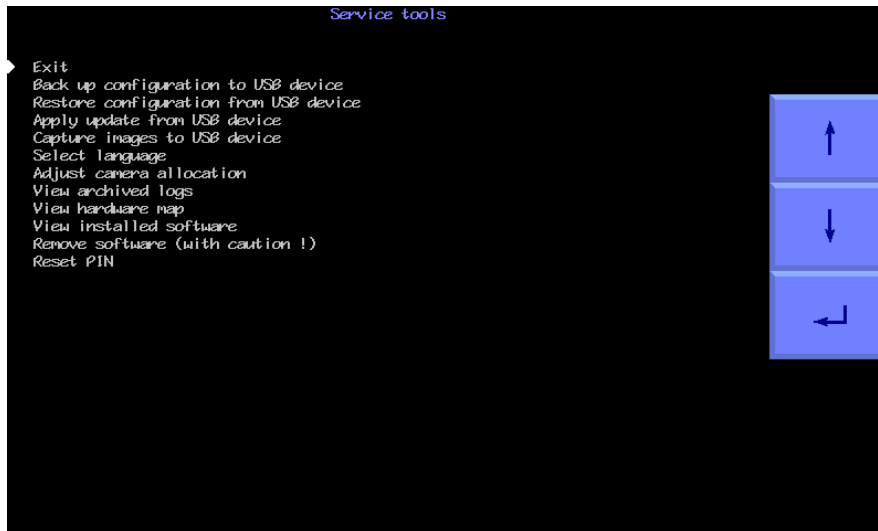
Example of context sensitive help obtained by touching the red **?** touch screen key.

## 10. 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. Always ensure power is supplied from a supply that is appropriately fused (10 - 20 amp).
4. Always ensure the correct supply polarity is adhered to.  
**BLUE** = - negative, **BROWN** (fused side) = + positive.

## 11. Service menu tools (including USB Update and backup procedure)



From the start-up screen users can enter a service menu by touching the tools symbol. The service menu, illustrated above, offers a number of tools that can be useful in maintaining or fault finding a system.

### Backup configuration to USB

To backup to a USB device the memory stick must be inserted into the USB port of the console prior to entering the service menu. If this is not the case, or if the USB device is not formatted in the correct form, you will see a black screen with the message “No USB storage device found”. Similar messages will be received for other operations requiring a USB memory stick.

If the console has a valid USB device connected it will then save a backup of the configuration data to the first directory of the device. The file name being in the format “backup\_0.tgz”. If there are already backup files stored on the device the backup will be named numerically one higher than the last backup. Backup files can be copied onto another computer and renamed but names must be in the format backup\*.tgz where \* can be a string of alphanumeric characters excluding spaces. Ensure that your laptop or computer does not attempt to open/unpack the file as that can corrupt the file into an unreadable format.

### Restore configuration from USB

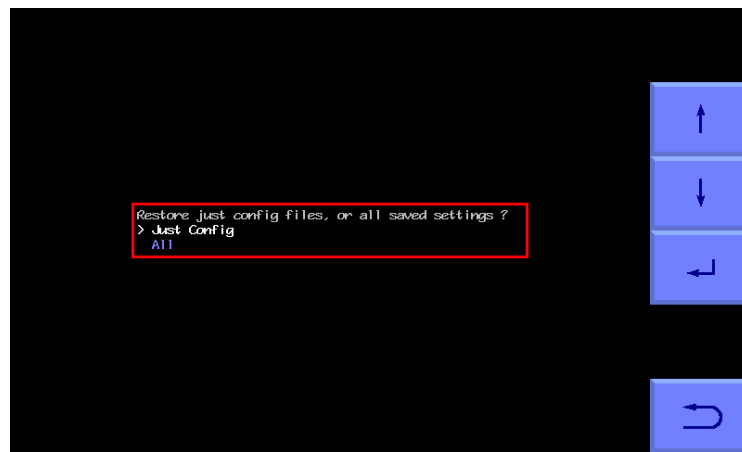
To restore data from a USB device the memory stick must be inserted into the USB port of the console prior to entering the service menu.

If no backup files can be found on the USB device or backup files have been corrupted, you will see a black screen with the message “Can’t open backup file”.

If more than one backup is found on a USB device a choice of which backup to restore from is given.

When restoring from a specific backup you are able to choose whether to apply the restoration to only configuration data or to all settings such as area meter, hours run, camera skews etc. In most situations only configuration data will need to be restored from.

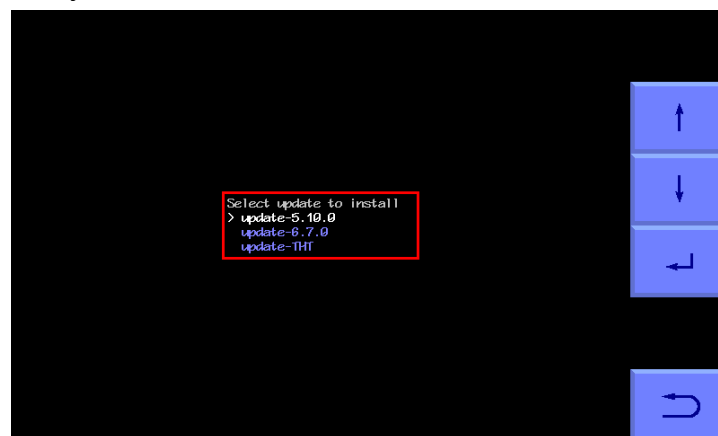




### Apply update from USB Device

It is important that when you are sent an update file of the format update\*.tgz you ensure that your laptop/computer does not attempt to open or unpack it as this may cause corruption. When wishing to apply an update to a console it is recommended to copy and paste this file into the top directory of your USB device.

If multiple updates are stored on your USB device, you will be given a menu to decide which update you would like to select and install onto the console.



Once your update has been successfully installed you will see a black screen with the message:

“Installing update, Done”

### Capture images to USB device

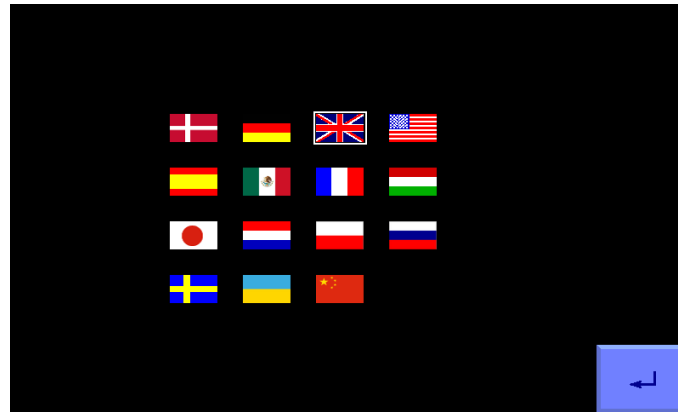
This function saves a still image and can be useful for remote fault diagnosis as images can be e-mailed to an expert for analysis.

Ensure that a USB stick is inserted and select the capture function. You will see a screen with a small live video image and touch buttons down the right hand side. To capture an image touch on the button with the camera logo. You will hear a buzzer sound and a directory “images\_0” will be created on the USB stick and an image “cam0\_0.tiff” placed in that directory. You can capture more images with the same camera, and they will be numbered sequentially in the same directory.

If multiple cameras are fitted these can be selected using the left and right arrow buttons and images captured from them in the same way and named according to the camera index.

## Select Language

Selecting this function brings up a screen with an array of national flags. Touching on a flag highlights it with a white border and will change the language used to that corresponding to the flag. Where translations are missing, or incomplete, language revert to English. In practice translations are mostly complete for users screens, but there are significant gaps in most languages for the configuration file editor. If you would like to contribute to translations, we would be very pleased to provide you with a translations table.



## Adjust camera allocation

To ensure camera thumbnail location on screen and camera physical location match the order in which cameras appear can be adjusted using this tool. Alternatively, cameras can also be swapped mechanically to match that of on screen, but this is not always convenient.

The camera allocation tool is shown below.



Camera order from top to bottom relates to the order in which cameras will be displayed screen from left to right. Along with their associated bus index, camera serial number and lens type and a live image thumbnail to aid with identification of the selected camera.

To adjust the order of cameras the use of the thick and thin arrows is employed. Thin arrows help select the camera that you wish to rearrange, with the thick arrows allowing for adjustment of order in the list of connected cameras.

The bin symbol allows for the selected camera to be deleted from the list.

Once correct camera order has been established the return arrow can be pressed to return to the service menu.

### View archived logs

This is a list of one line error messages that have been deleted or overflowed from the error log.

### View Hardware map

This tool is useful for determining if connection to all required microcontroller boards and accessory devices is being made when the system is turned on. The address IDs for each connected component can also be viewed to ensure that the address you have intended for each component is correct. This is only necessary when dealing with multi-section machines or machines with multiple CAN devices added.



### View installed software

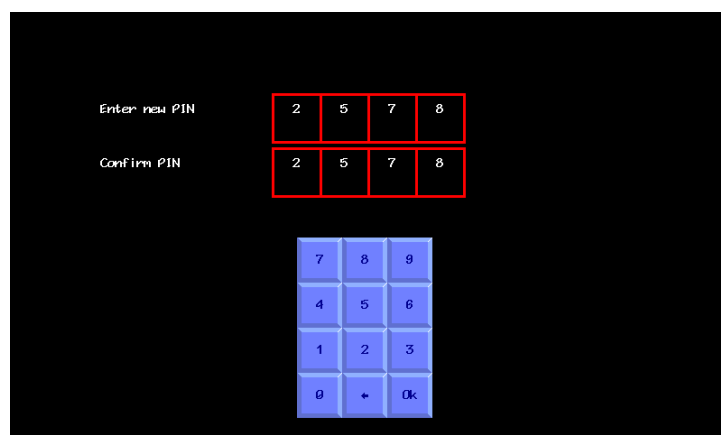
Lists software loaded e.g. inter-row guidance along with version number.

### Remove software

This is a function for removing unwanted modes of operation e.g. after selling a demonstration system you may wish to remove demo mode. However, it is very rarely required and should never be selected unless you are absolutely sure you want to delete software permanently.

### Reset PIN

To reset the PIN the old access code must be entered (factory default = 1,2,3,4). If the old code has been lost contact us to for reset instructions.



## 12. 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 near the power lead entry gland. 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.
- Four 0.2 s blinks followed by 1 s off indicates the valve over current trip is active, possibly due to steer valve output short circuit
- Five 0.2 s blinks followed by 1 s off indicates open circuit on a steer valve output

#### Manual and Feeler modules

Both these modules contain a microcontroller board that has one green LED and four red LEDs 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 (as displayed in error messages and the error log)

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

**ctnnn** **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  
 209xx Excessive number of CAN bus errors  
 210xx More than one device set to same ID  
 211xx Unrecognised CAN device  
 212xx Valve output overload

### **4xxxx** hardware error codes

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

### **5xxxx** Operator errors

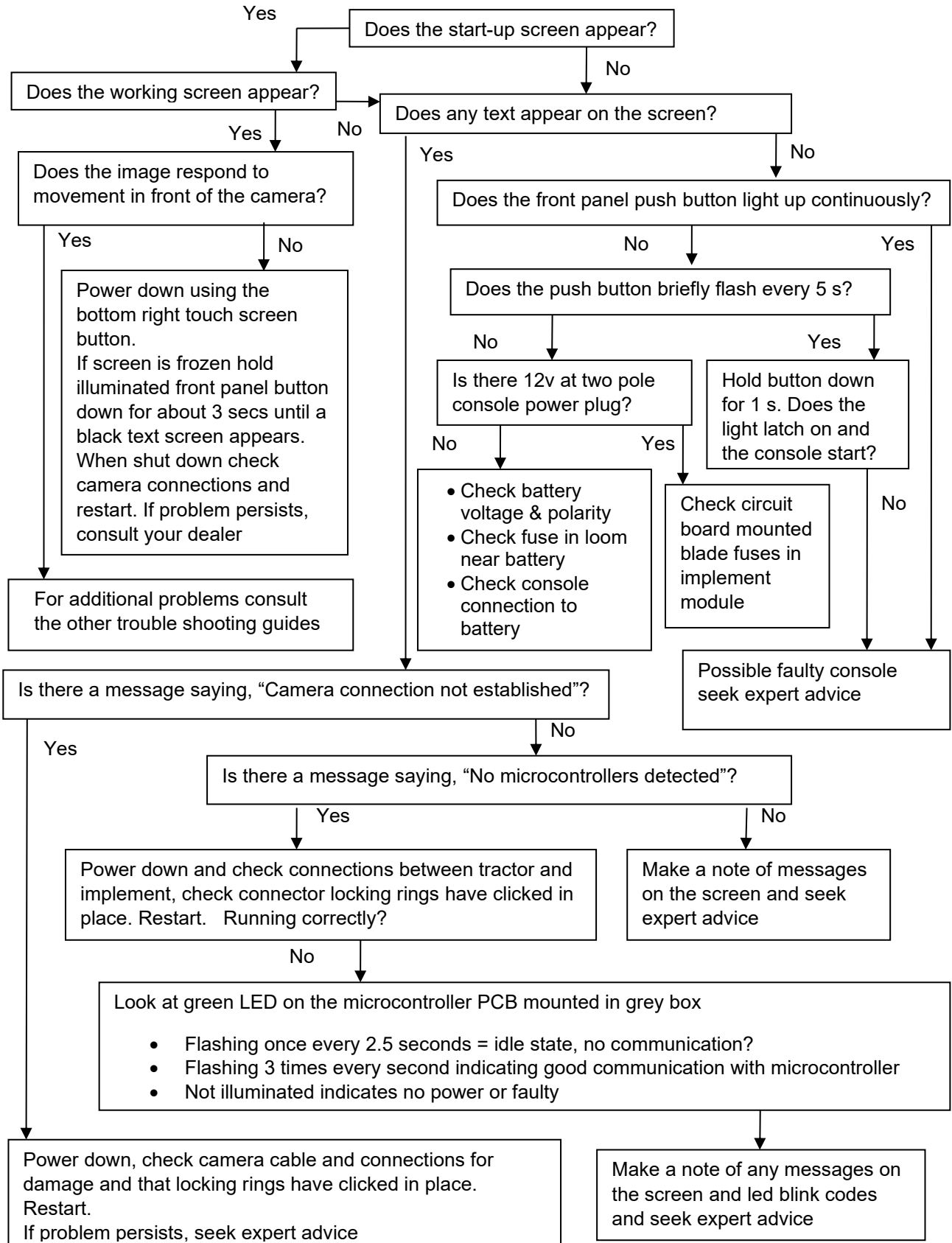
50100 Going too fast!

## Flow Charts

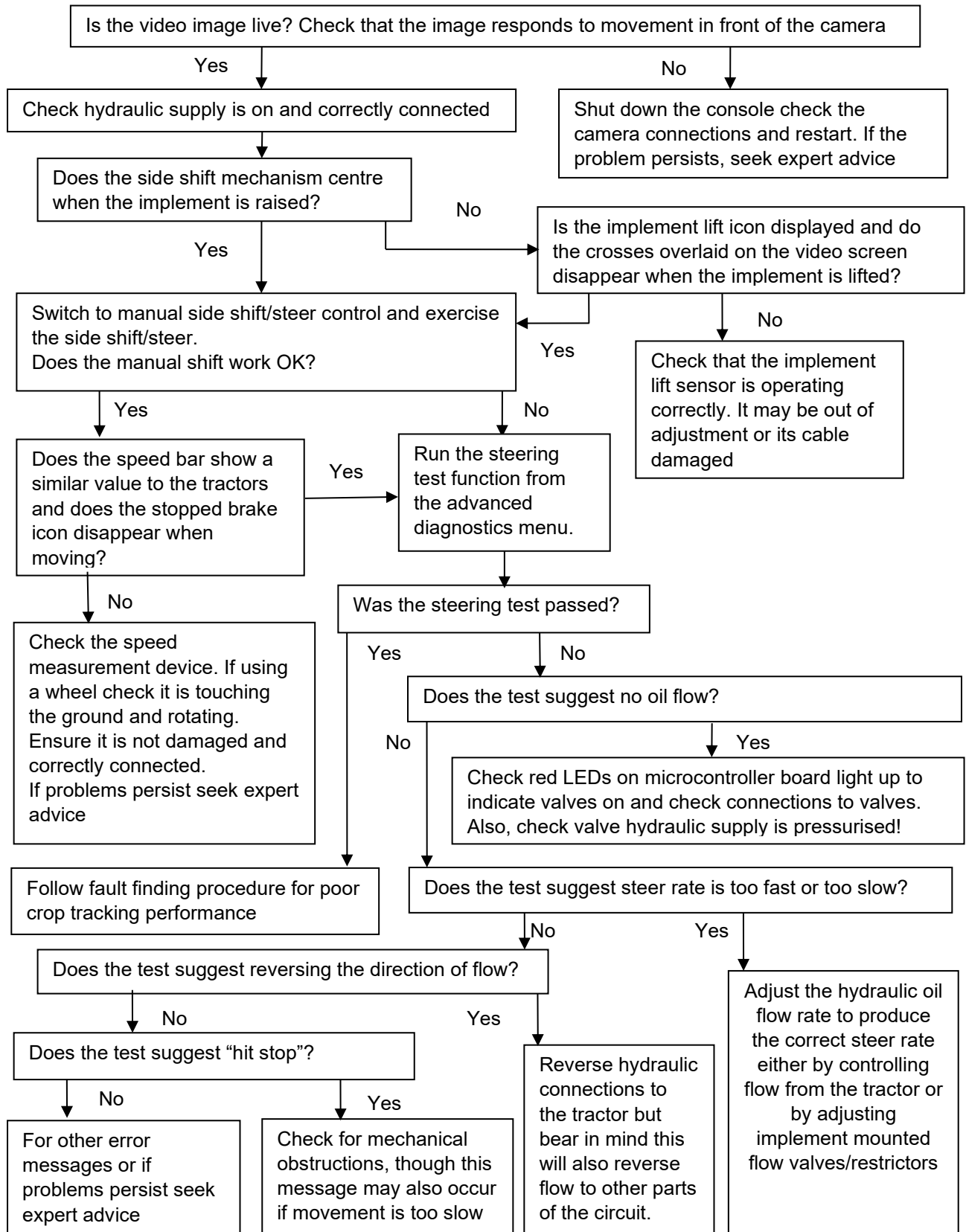
Problems have been divided into three categories listed below:

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

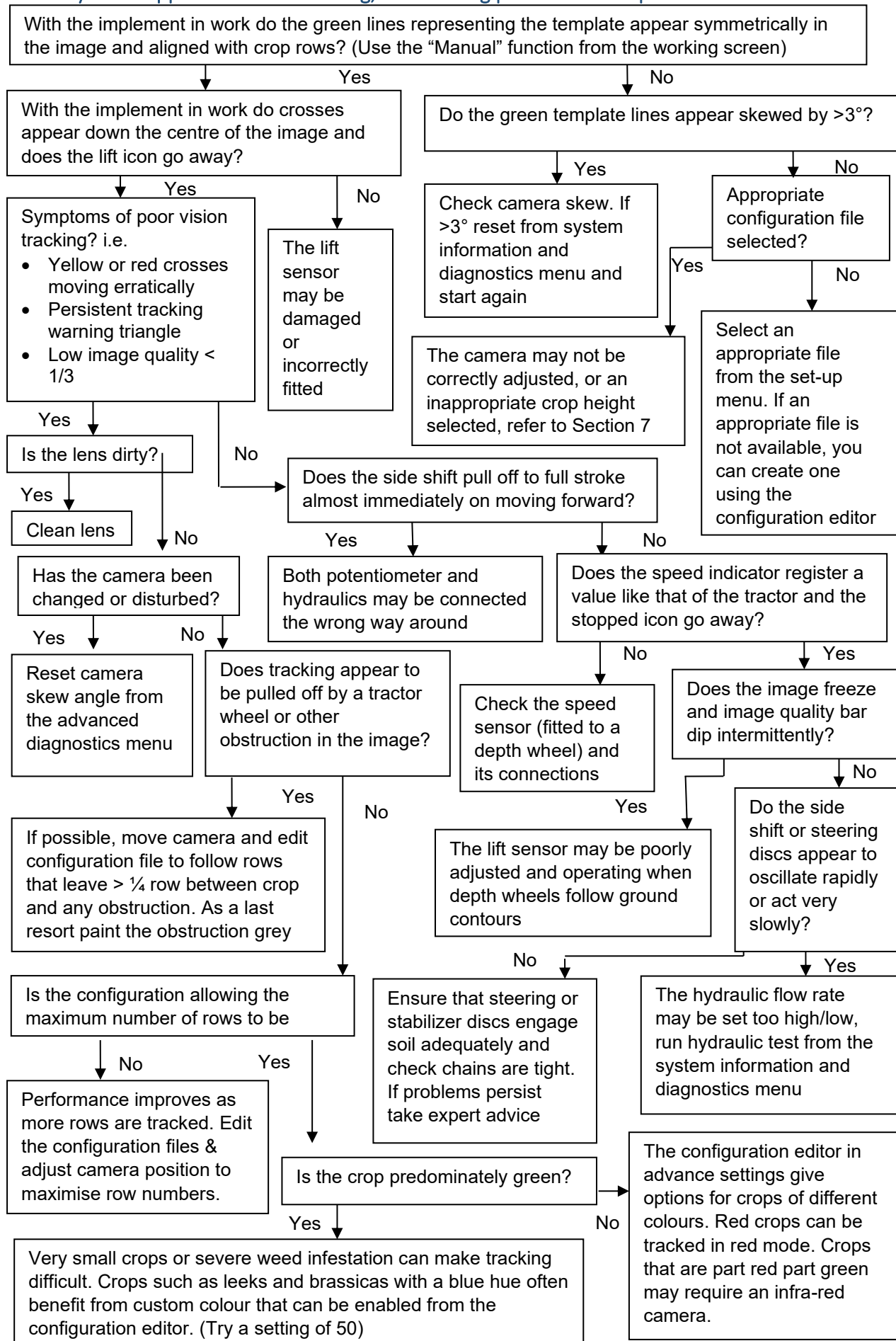
### 1. Console fails to start up correctly



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



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





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## Annex – Hydraulic systems

The hydraulic system required to operate a side shift or disc steer system is conceptually a simple one involving a single directional control valve to meter hydraulic oil into either side of a hydraulic cylinder. However, there is often a need for additional components to control the rate of oil flow such as variable restrictors and pressure regulators.

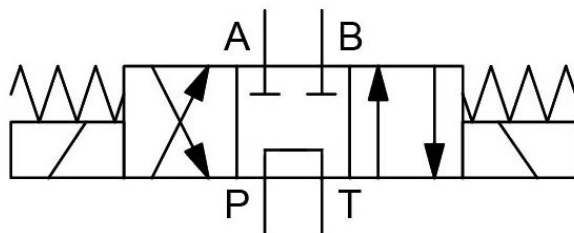
A diverse range of tractor hydraulic power systems introduces further considerations when designing implement hydraulics.

This note is not intended as a comprehensive design tutorial, rather it is a guide to the more common arrangements and a discussion of some of the issues.

It is usually cost effective for implement manufacturers to provide their own hydraulic systems suited to their own requirements. However, if required Tillet and Hague technology can supply basic hydraulic systems as part of a complete guidance and control package.

We will start by considering tractor hydraulic PTO systems. These can broadly be categorised as “open centre” or “closed centre/load sensing”. Open centre systems are generally found on older, or budget tractors, where the oil is supplied from a gear pump at a rate that is proportional only to engine RPM. For these systems an “open centre” directional control valve is preferred in which its centre position provides an unobstructed return path for the oil back to the tank.

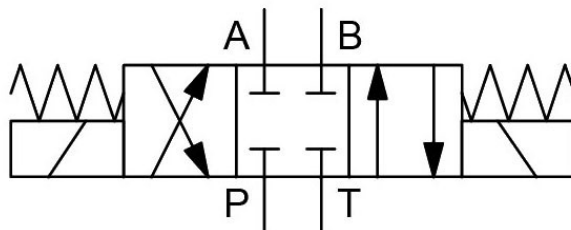
Open centre valve



If a “closed centre valve is used in which the ports are closed in the central position, then oil will be forced to return to the tank via a pressure relieve valve (the tractors own valve is normally set just above 200 bar). This is inefficient and can create large amounts of heat which may damage both tractor and implement.

Tractors with some type of load sensing system maintain a low pressure on standby and only develop full system pressure when flow is detected. These systems can use “closed centre valves”, where the pressure line is blocked in the valves centre position.

Closed centre valve



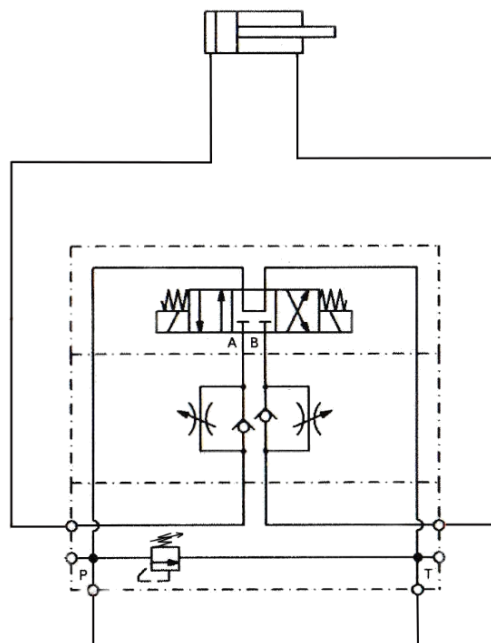
One advantage of closed centre valves is that it is possible to put additional valves in parallel on the same hydraulic circuit. This can be useful when the implement also features automatic levelling, or tine raising, but it is inconvenient, to supply each of these services from its own independent tractor spool.

It is also possible to operate multiple closed centre valves with a tractor equipped only with a gear pump and no load sensing, but it requires an additional dump valve. That valve is arranged to be normally open so that tractor oil is returned to tank with little pressure drop when none of the valves are operated. The dump valve must be wired in such a way that it closes when any of the other control valve operates, leaving them with full system pressure and flow. Tillet and Hague can provide a circuit board with multiple optically isolated inputs which are logically “OR”ed to a dump valve output for this purpose.

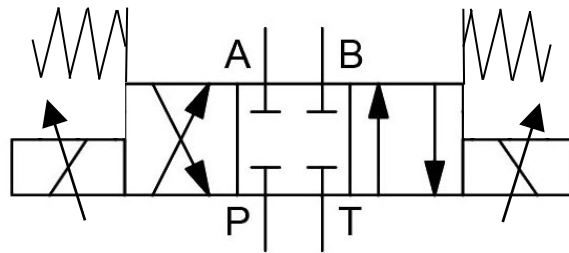
In some tractors it is possible to regulate the maximum flow on each spool independently. Exceptionally this may be sufficient to control the rate at which the steering cylinder moves to the desired target of approximately 0.1m/s. However, because the steering cylinders are normally small in diameter, the required volumetric rate is lower than the minimum offered by the tractor. Furthermore, the two sides of the steering cylinder often have different areas requiring different flow rates in each direction to achieve the same linear speed. To regulate steering rate, it is normal to fit variable restrictors on the output to each side of the cylinder.

It is not uncommon for variable restrictors to be almost fully closed to achieve the required steering rate. This makes setting very sensitive to small adjustments and to oil temperature. It can be advantageous to reduce the pressure across the restrictors with a pressure regulator, enabling them to operate with larger orifices thus reducing their sensitivity. This also has the effect of reducing the force generated by the steering cylinder, which is not normally a problem as steering forces need not be high.

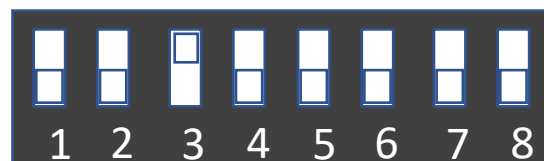
A typical circuit, as provided in the Tillet and Hague standard directional valve block assembly, is given below showing how all these components might be used in a hydraulic circuit.



Proportional closed centre valve

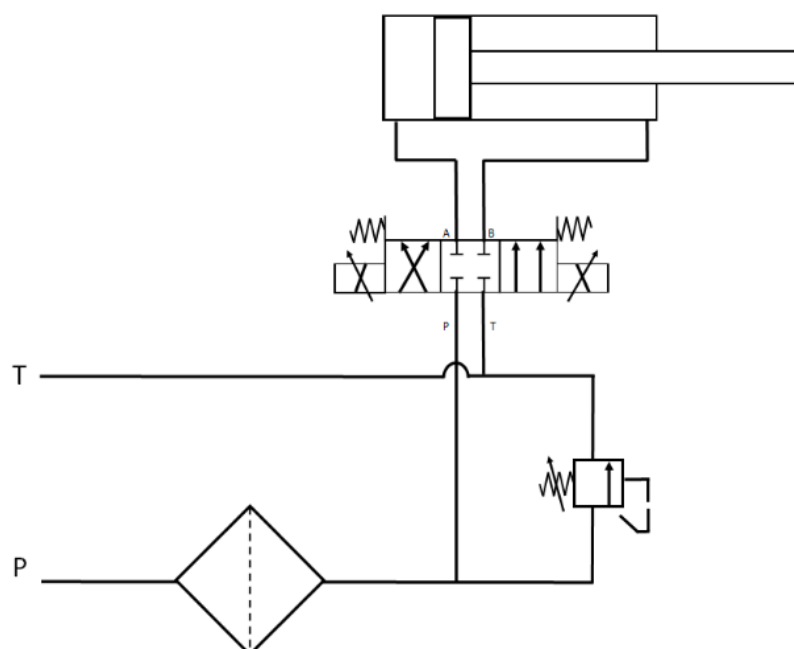


For proportional steering control to be utilized a closed centre circuit design must be used, due to fine internal tolerances of proportional control valves, a filter may need to be integrated to avoid valve damage. To activate proportional control option of a proportional control capable implement module DIP switch number 3 must be switched UP to the ON position, as shown below:



Control system parameters relating to proportional control can be found in the configuration editor in Section 9.3. Valve characteristic curve parameter may need to be adjusted to suit chosen valve.

The typical circuit for the Tillet and Hague proportional directional valve block assembly shown below.



### Hydraulic system set up:

Make hydraulic hose connections taking care to ensure that pressure and tank hoses are the right way round when the tractor spool is operated in its preferred direction.

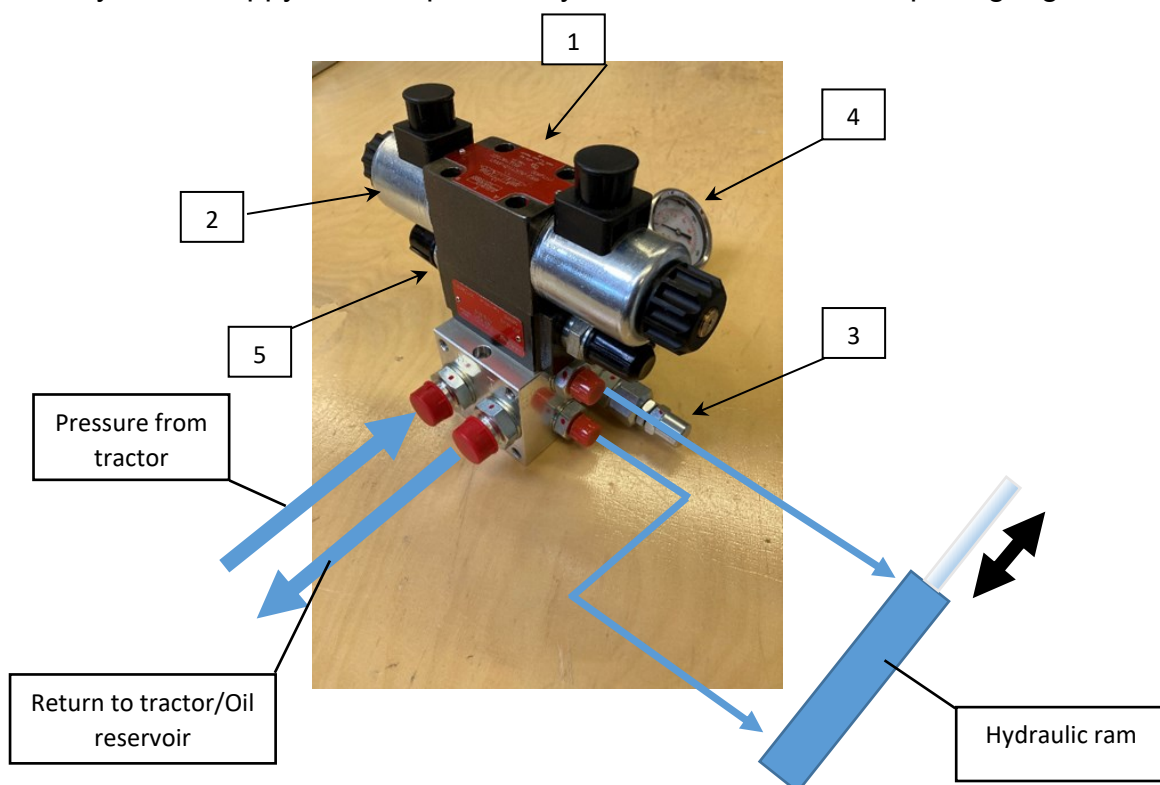
If the tractor hydraulic system allows, reduce the oil flow from the tractor to an appropriate level. 10% of maximum flow is usually sufficient.

### Standard directional control valve setup:

Connect the test point pressure gauge and, after checking that the hydraulic cylinder is safe to operate, turn on the tractor oil supply. The pressure gauge should read zero as the oil is passing unrestricted through the open centre directional valve. Arrange for the directional valve to operate so that the cylinder moves fully to one end of its stroke. The pressure should increase to the value set by the pressure reducer, normally 20 to 40 bar is sufficient. If required, this can be adjusted by loosening the 17mm locking nut and making the adjustment with a 4mm Allen key. If you are using the control system to operate the valve it will switch off once the desired position has been reached, so you may need an assistant to view the pressure gauge whilst the valve is operated, and the cylinder is moving.

If you reverse the direction of operation of the directional valve the cylinder will move to the other end of its stroke. Use the corresponding flow control (needle) valve knob to control the rate of movement. A speed of 0.1m/s is normally a satisfactory starting point but can be adjusted later. Keep reversing the direction of flow and adjusting the two flow control knobs until speed is satisfactory in both directions. If you find that the flow control adjustment is too sensitive, you can try further reducing operating pressure using the pressure reducing valve.

Once you are happy with the pressure you can remove the test point gauge.



	Part Name	Part Function
1	Directional control valve	Open centre directional control valve used for diverting flow of oil
2	12V solenoid coil	Activates valve to direct oil flow
3	Pressure Reducer adjuster and locking nut	Used to set operating pressure
4	Test point gauge	Used to measure operating pressure, (only required for setup and not routine running)
5	Flow control valve	Used for setting flow rate to left and right steering functions independently



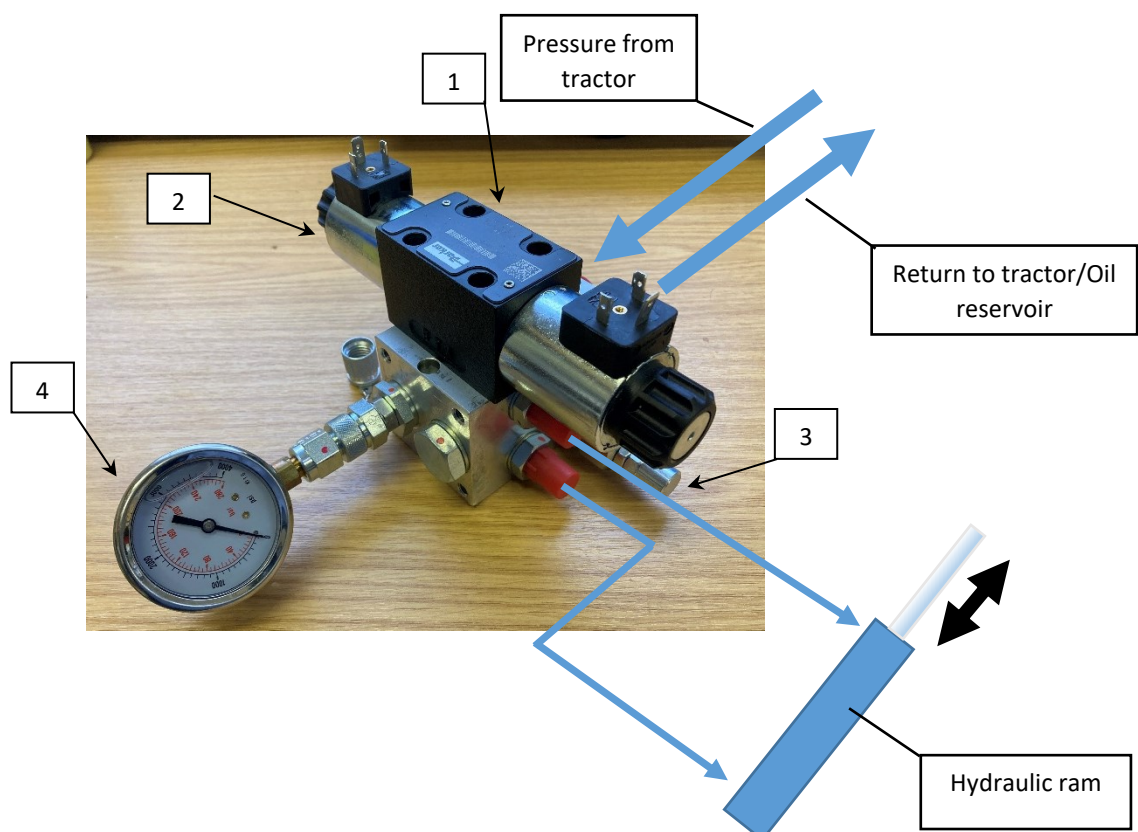
## Proportional hydraulic system setup:

Connect the test point pressure gauge and, after checking that the hydraulic cylinder is safe to operate, turn on the tractor oil supply. The pressure gauge will read currently set circuit pressure. Adjust pressure reducer to required circuit pressure, between 20 to 40 bar should be sufficient. If required, this can be adjusted by loosening the 17mm locking nut and making the adjustment with a 4mm Allen key

The test steering application located in the advanced settings and diagnostics page can be used to test and calibrate the proportional control circuit.

Circuit pressure may need to be increased if implement movement cannot be achieved by the hydraulic cylinder.

Peak cylinder speed can be increased or decreased in the configuration editor, as standard this is set to 0.1m/s



	Part Name	Part Function
1	Proportional control valve	Proportional directional control
2	Proportional solenoid coil	Activates valve to direct oil flow
3	Pressure Reducer adjuster and locking nut	Used to set operating pressure
4	Test point gauge	Used to measure operating pressure, (only required for setup and not routine running)

**Hydraulic fault finding:**

The advanced settings and diagnostics page include a steering test which can be helpful in diagnosing hydraulic problems. If in doubt, run this simple test. It will interactively ask you which direction is left, and which is right, show if the hydraulic supply is connected the wrong way around or is believed to be inversed, if the flow rate is too high, or too low. The test also attempts to diagnose faulty position sensors by detecting irregular output signals, or a mechanical jam for which you get the message "Hit stop". The "Hit stop" message can also be triggered by hydraulic issues such as entrapped air, or low flow rates.