GKD 3RCI Version 8 Series
User Instruction manual
### Change History

<table>
<thead>
<tr>
<th>Issue</th>
<th>Date/Change</th>
<th>Change Details</th>
</tr>
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<tbody>
<tr>
<td>1.0</td>
<td>23/10/2013</td>
<td>New issue for V8 3RCI</td>
</tr>
<tr>
<td>1.1</td>
<td>11/11/2013</td>
<td>Add swing / swivel boom information, plus “Limit Set” orange beacon (Spaceguard).</td>
</tr>
<tr>
<td>1.2</td>
<td>18/11/13</td>
<td>Add “Beyond Limit” feature / screen.</td>
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Introduction
The GKD rated capacity indicator is an integrated road-rail rated capacity indicator system. The system incorporates state of the art sensing and processing to provide audible and visual warning plus machine control signals. This manual applies to GKD 3RCi systems version 8 only. Information contained in this instruction guide may not apply to previous versions.

This manual covers both 3RCI and 3RCI Spaceguard variants of the system.

Warning
During normal operation the SWL (Rated Capacity) of a crane should not be exceeded. Therefore the warning of overload should not be used as a normal operating facility. It should be noted that certain statutory requirements do not permit the safe working load to be exceeded except for the purpose of testing.

THIS RCI IS NOT SUITABLE FOR USE IN EXPLOSIVE ATMOSPHERES. ADJUSTMENT BY UNAUTHORISED PERSONS WILL INVALIDATE ANY WARRANTY OR CERTIFICATION SUPPLIED. IF A PROBLEM ARISES WHICH CANNOT BE RECTIFIED USING THESE INSTRUCTIONS, AUTHORISED SERVICE SHOULD BE SOUGHT.

THIS DEVICE IS CERTIFIED TO MEET CURRENT UK & EC SAFETY REGULATIONS FOR EXCAVATORS USED AS CRANES, AND IS COMPLIANT WITH RSSB STANDARD RIS-1530-PLT Issue 4.
3RCI SPACEGUARD IS CERTIFIED TO MEET THE CONDITIONS OF NETWORK RAIL REMIT MLD-R003 FOR MOVEMENT LIMITING DEVICES WORKING ADJACENT LINE OPEN AND UNDER LIVE OVERHEAD CABLES, PROVIDED IT HAS BEEN INSTALLED AND CONFIGURED IN ACCORDANCE WITH GKD INSTALLATION AND CALIBRATION INSTRUCTIONS, IS USED IN ACCORDANCE WITH THE GKD OPERATING INSTRUCTIONS, AND IS SUBJECT TO REGULAR TESTS TO ENSURE CORRECT OPERATION.

Backwards Stability
The working conditions of these machines mean it is possible under extreme situations of cant and gradient to tip the machine over backwards. In particular this may occur with high boom angles when working up the gradient or with the counterweight down the cant. The GKD indicator automatically monitors for backward stability when working on rails. The system has two levels of protection, 50 mm and 150 mm cant. In the event of a backward stability warning being shown, do not remove any load from the machine until it has been returned to a safe position.

In-gauge indicator
The indicator includes an aid to drivers with an in-gauge warning. This is designed as a guide only and will not take into account any attachments or modifications made to the machine. The operator must check the machine suitability to travel particularly for height. No liability is accepted for any damage or consequential loss caused by travelling this machine with or without the in-gauge indicator.

Spaceguard
3RCI Spaceguard systems can be certified to work under OLE and system 1,2 and 3 ALO conditions.

It is the responsibility of the operator to ensure that the system is fully operational and that the dimensions of any load or attachment is taken into account when setting limits.

In operation, the slew speed of the machine should never exceed 2 meters per second measured at the bucket pin when a slew limit or virtual wall is set.

The reliability and performance of the Spaceguard system is dependant on the GKD performance and inspection regime being adhered to.
<table>
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<th>Definitions</th>
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<tbody>
<tr>
<td><strong>Radius</strong></td>
</tr>
<tr>
<td>Radius is defined as the horizontal distance between the slew centre line and the selected lift point. This is the slew centre line measured at the joint between the upper and lower machine structure.</td>
</tr>
<tr>
<td><strong>Height</strong></td>
</tr>
<tr>
<td>Height of selected lift point measured from the virtual plane created by the supporting wheels. This height may not correspond to the measured height between the ground and the selected lift point when operating on canted and gradient rail.</td>
</tr>
<tr>
<td><strong>Rated capacity</strong></td>
</tr>
<tr>
<td>Is the maximum load that may be lifted at the current radius and height. The weight is shown in tonnes. This is usually determined as a percentage of the load that will tip the machine.</td>
</tr>
<tr>
<td><strong>Slew</strong></td>
</tr>
<tr>
<td>Slew is the measure of rotation of the machine. Measured in degrees and relative to the straight ahead position of the machine. Measured in a clockwise direction when viewed from above.</td>
</tr>
<tr>
<td><strong>Load</strong></td>
</tr>
<tr>
<td>Load on hook indication.</td>
</tr>
<tr>
<td><strong>SWL</strong></td>
</tr>
<tr>
<td>Safe Working Load. Term now replaced by Rated Capacity.</td>
</tr>
<tr>
<td><strong>Articulated Boom</strong></td>
</tr>
<tr>
<td>An articulating boom is a boom comprised of two pieces with a hydraulically adjustable centre section.</td>
</tr>
<tr>
<td><strong>Planning chart</strong></td>
</tr>
<tr>
<td>A planning chart comprises of a series of charts giving rated load capacity of the excavator at different radius and heights. This information is used to determine that the machine is capable of performing the lifting operation.</td>
</tr>
<tr>
<td><strong>UCM</strong></td>
</tr>
<tr>
<td>Under-Carriage Module. The signal processing system on the lower half of the machine. Located adjacent to the slew ring. See components for more details.</td>
</tr>
<tr>
<td><strong>Module</strong></td>
</tr>
<tr>
<td>External module providing inputs, outputs or additional processing. Typical installations may use four or five modules in total.</td>
</tr>
<tr>
<td><strong>Unloaded Wheel</strong></td>
</tr>
<tr>
<td>A wheel upon which the load is reduced from the normal balanced status of the machine.</td>
</tr>
<tr>
<td><strong>Tandem Lifting</strong></td>
</tr>
<tr>
<td>A lifting operation where two machines are used to lift a heavy or large load. The lifting capacity of the machines is reduced to increase the safety margin.</td>
</tr>
<tr>
<td><strong>Rail gear Interlock</strong></td>
</tr>
<tr>
<td>During the on-tracking or off-tracking operation it is possible to have a situation where there is no rail wheel braking and a potential uncontrolled runaway may occur. To avoid this dangerous situation the 3RCi can be configured to control the rail gear deployment. (optional feature dependant on manufacturer).</td>
</tr>
<tr>
<td><strong>Trailer Breakaway</strong></td>
</tr>
<tr>
<td>When towing with the RRV any loss of hydraulic brake pressure will be detected by the 3RCi and an alarm and error message will occur.</td>
</tr>
</tbody>
</table>
System Layout

1. **Machine Controllers Switch (Foreman's key switch)**
   Allows or denies access to the user settings and service menus. Used when there are slew and height limits in use to avoid accidental changes by the operator.

2. **Display**
   Touch-screen colour display which provides user information and control of the system.

3. **Overload Warning LED**
   Red LED illuminates to show when the machine is in an overload condition.

4. **Rated Capacity Warning LED**
   Orange LED illuminates to show when the machine is in approaching the rated capacity and overload condition.

5. **System power / comms OK**
   Green LED flashes continuously to indicate power and system operations.
The display shows the following information.

[1] Radius
Radius of lift point relative to slew centre. (see definitions)

[2] Height
Height of lift point. (see definitions)

[3] Rated Capacity
Maximum permitted load

NOTE. When a * appears against the rated capacity it will indicate that either the machine is in Hydraulic Limit or the rating displayed is the maximum based on the hydraulic limitations of the machine.

[4] Slew
Slew angle

This display bar moves from bottom to top on the display to indicate the relationship between the applied load and the rated capacity. A warning will occur at between 92.5% and 97.5% of the rated capacity. This warning is an amber LED and intermittent siren. If the lifted load should exceed 104% of the rated capacity then the Red LED is lit and a continuous siren is sounded. The machine will then inhibit further unsafe movements of the crane.

[6] Status
Machine configuration data.

Access to user and service functions can be gained by operating this button. Note if the machine controller’s key is activated then the system will not allow access to service menus or limit settings.

[8] Load
Displays load on hook information

[9] In-gauge
Shows green when the machine is within gauge to travel. Will also show red when a slew limit is exceeded or a height limit is exceeded. See warning at beginning of manual.

[10] Dig Mode
If the system is in dig mode this icon shows green and the motion cuts and alarms on overload are disabled, the blue beacon is not illuminated.

3RCI Spaceguard Systems that achieve a high safety performance level and are capable of being certified to work Adjacent Line Open will show the symbol “ALO √”, 3RCI systems that are not capable of being certified to work Adjacent Line Open, or approved systems without operational slew limits or virtual walls, will show “ALO X”

[12] Logging

This icon shows the status of the onboard logging system. There are four states for the icon. 1. Not shown - logging is disabled. 2. Logging icon - no events recorded logging on. 3. Exclamation mark - Logging is on and an overload or other event has been recorded. 4. Logging symbol with red cross - Log is inoperative or full.

[13] Active Lift Point

The current active lift point is shown here. Possible options are BP (Bucket Pin), ALP (Auxiliary Lift Point), QH (Quick hitch), or TLJ (demountable Telejib).

[14] Duty indicator

This symbol will indicate whether the RCI is switched to Rail duties, Road duties, or LUL (London Underground) duties.

[15] Cant / Gradient

Shows the current cant and gradient being registered (rail duties only). Cant will show as positive (right hand rail high at 0° of slew) or negative (right hand rail low at 0 degrees of slew), and gradient will show as positive (facing up gradient) or negative (facing down gradient).

[16] Axle Lock

Shows the current state of the axle lock input. A locked padlock indicates that the axle lock state is detected as Locked, an unlocked padlock indicates that the axle lock state is detected as Unlocked, and an unlocked padlock with a cross through it indicates that the axle is locked and that an unlock request has been received, but that the 3RCI is not allowing the axle to unlock as doing so would put the machine into overload and it is therefore not safe to unlock.
Operation

Auto-diagnostics
During the start up procedure and during normal operation the system performs constant checks on all inputs and systems to ensure that the data is within prescribed limits. If an input data is in error then the system will issue a warning. Depending on the severity of the data error the system may continue to operate at a de-rated performance or forbid further operation.

The system may request the operator to slew through the zero reset. (Over the front of the machine). The operator will be required to acknowledge the message to remove the warning.

Daily Checks
Before operating this system the operator should check the following on a daily basis.

- Visually inspect the angle sensors and pressure sensors for damage or misalignment.
- Visually inspect angle sensor and pressure sensor cables for damage and proper connection.
- Visually inspect the rail gear detection switches and cabling (if fitted).
- Start the machine allow RCI to complete start-up procedure. Note any errors and call service if required.
- Raise boom and then slew through 360 degrees to ensure the slew counts correctly and allow a reset of slew to be carried out. (Important if machine has been idle for a long period of time). Ensure the slew counts in both directions.
- Operate the booms and verify that the height and radius displayed on the screen correspond with the actual height and radius to the selected lift point, and that the displayed height and radius change as appropriate when the booms are moved.
- Select the MENU screen and press the TEST tab, and then press the alarm test button. The external indicator lamps and alarms should be activated one by one in sequence as reported on the 3RCI screen. Verify that they all work as expected.

For Spaceguard systems the following checks should be carried out, in addition to those listed above, prior to commencing works in a restricted area. These checks should form part of a pre-use work procedure which should be signed by the operator and witnessed by a competent person.

- Set a height limit. Operate the machine at full speed to attempt to exceed the height limit.
- Set slew limits. Operate the machine at full speed to attempt to exceed the slew limit.
- Set virtual wall limits. Operate the machine at full speed to attempt to exceed the wall limits.

Upon successful completion of tests sign the test form.

Touchscreen
The 3RCI system uses a colour touchscreen for control of the indicator functions. The touchscreen is designed for use by finger or gloved hand or with an approved stylus.

DO NOT attempt to use any sharp or heavy items to operate the indicator. Use of unauthorised objects may scratch the overlay or damage the screen glass. Damage caused by operation of the touchscreen using inappropriate objects will not be covered by warranty.
Switching On
The RCI automatically engages when the machine is switched on and started. The system automatically detects the machine status. During the start up sequence the internal alarm will sound until the system is fully operational. The operator will then be prompted to stop the alarm sounding.

At start up the system requires an eight digit driver identification code to be entered before the machine is made active. The operator should enter his / her PTS number.

External Indicator Beacons

**Blue Beacon** - The system is fitted with at least one blue beacon on the outside of the cab. This may take the form of a lamp or LED strip. The beacon is illuminated when the machine is configured in a lifting duty. The beacon will be turned off when the machine is in digging mode. When lifting in Tandem Lift mode, the blue beacon will cycle on and off at 2 second intervals.

**Balfour Beatty Indicators** - Optionally the 3RCi system may be fitted with an additional two indicator lamps on the side of the cab. These are coloured red and white. The white indicator lamp mimics the blue beacon as described above while the red indicator will illuminate when the system is not in a lifting configuration.

**Orange Beacon** - Optionally, 3RCI Spaceguard systems may have an orange beacon installed on the roof of the cab. This beacon illuminates when an angular slew limit or a virtual wall has been set AND the foreman key switch on the display is in the locked position.
ON/OFF Tracking and rail gear interlocks (optional)
The 3RCI may control the deployment of the rail-gear to ensure that a dangerous situation cannot occur where the braked road wheels are not in contact with either the ground or the rail wheels.

When in road mode (both bogies fully up) the operator will be restricted to operating only one bogie. This is usually the fixed, non floating, bogie. The operator should align the bogie to the rails and lower fully. Once the bogie is fully lowered the RCi system will allow the second bogie to be engaged and lowered.

At anytime during the lowering or lifting of either bogie it is possible to move the gear either up or down. i.e. The operator has full control to abort the operation and return to the starting position.

The rail lifting mode, which has the lower lift rating, will be automatically selected when a bogie is determined not to be fully lifted.

In the event of a non permissible condition occurring the indicator will show a ‘bad rail gear’ message or ‘no brakes’ message.

If a ‘no brakes’ message occurs a rail gear override button will become active in the menu screen allowing manual intervention to recover the situation. The release has a timed action to allow recovery and is only activated when an error occurs. This button is labelled as “Gear Release”.

Use of the Gear Release mode will allow recovery to a safe situation in an emergency. This message may also occur if a machine has been parked in road mode for a long period during which the rail-gear may have ‘dropped’ due to hydraulic oil leakage past the gear rams.

‘Bad rail gear’ indicates that non permissible logic for the rail gear has occurred such as the indicator sensors suggesting that a bogie is both up and down at the same time. This is an error condition and must be rectified before the use of the machine.
Motion Cuts
When a lifting duty is engaged, the RCI system will protect the machine from moving into unsafe conditions when unstable. The overload alarm will sound at this time. To aid the driver to recover to a safe position the system graphics provide a visual indicator of the allowable motions through use of coloured arrows associated with each hydraulic function. The cut motions are shown in red and the allowable in green, as shown in the screenshot below.

The RCI uses intelligent algorithms to determine which motions are allowable and will only release valves to reduce the overturning moments.

All motion valves are de-activated when the RRV engine is switched off. This is a battery saving feature and will show all the arrows as red accompanied by an ‘engine off’ message on the front screen.

Axle Lock
The axle unlock is controlled by the RCI system. When the machine is in an axle locked configuration the system will calculate if it is safe to unlock the axle on the operator command. If it is unsafe then the axle will remain locked until the load is reduced. The axle lock icon will be greyed out and a red cross is shown through it.

Drive Cut
When the machine has the axles locked then drive is cut and the machine will not be allowed to travel. The 3RCI will also cut drive in an overload state, or when the brake air pressure is detected as low.

Speedometer (optional)
The speed of the machine is indicated on the operators screen. If the machine exceeds the maximum allowable speed then this is logged by the data logger.
User settings

User settings are reached by pressing the MENU button on the front screen. Some features are only available when the machine controller’s key is in the unlocked position.

The RESTRICTIONS screen is shown to the right. There are four tabs which switch between restriction selections and a status screens showing the current configuration of the machine.

To return to the main screen press the EXIT button.

Restrictions  Operator options for setting limits, operating modes, lift point selection and recovery conditions.

Status  Shows system status for diagnostics.

More  Screen which shows all error conditions (front screen only shows highest relevant error condition).

RGIS  Rail Gear status screen (option, only when rail gear interlocks are configured).

Test  Accesses the test screens, including the alarm test button used as part of the daily system check.

The TEST button (inside the TEST tab) and SERVICE button are password protected and allow access to maintenance and diagnostic modes. System operation is not possible when inside the test screens, service mode access is data logged with time and date.

For user settings select the ‘Restrictions’ tab.
Height restriction

Height restriction is defined as the maximum height that the excavator can work at. This allows the machine to be used in restricted areas such as tunnels, stations and under overhead wires.

**WARNING.**
The height restriction function is designed to be used at slow lift speeds only. Use at speed may result in an overshoot into a potentially dangerous position.

The height restriction functions in the GKD 3RCI continually monitor the highest part of the machine. If the highest part of the machine should exceed the pre programmed height restriction then the appropriate motion cut signals will be activated.

The buttons in the RESTRICTIONS menu indicate the current status of the restriction. The two screens below show the height limit switch legend when the restriction is off and on. When set, the height limit is shown on the front screen as a red line above the machine graphic. The text in blue shows the current height of the highest part of the machine, the red height figure under the red line indicates the current active height limit.

### Setting a height limit

There are two methods of setting the restriction value, either by entering a height on the keyboard or by moving the machine to the required limit and capturing a position.

**To enter a height** press the ‘Height Limit is OFF’ button to begin the height limit set procedure.

The system will now ask you to confirm that you wish to enter the height via the keyboard.

Select ‘YES’ to enter the height in meters via the keyboard.

Otherwise select ‘NO’ to capture the machine position.

If “NO” is selected, the system will prompt you to move the machine to the maximum height. Move the machine booms to the maximum height that is allowed.

Select ‘YES’ to set the restriction. The height limit will be set based on the highest point of the machine equipment.

You may exit from this screen without setting a height restriction by selecting the ‘NO’ button.
Once a height limit has been set, when the machine reaches the set limit the hydraulic lift circuits will automatically be restricted.

The main display will show the active height limit in red below the current machine height display, which is shown in blue. When the programmed maximum height is reached then machine movement will be restricted. Any motion cuts that are inhibited will be shown in red on the depiction of the machine on the screen.

**NOTE:** the height restriction is measured from the highest point of the machine which in many cases will be higher than the bucket pin height. The RCI monitors the top of the fore boom, the top of the dipper boom, and the end of the dipper boom. On mono boom machines, the RCI will also monitor the top of the “bend” along the main boom.

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**Turning the height limit off**

To remove the height restriction press the MENU button and select the “Height Limit is ON’ button. The limit will be reset and the button status will show “Height Limit is OFF” The main operator screen will show no height limit set, as indicated by the examples below.

**Example - height limit set at 5.0m, actual machine height at 4.03m.** The machine movements will be restricted as appropriate to keep the machine components below the set height limit.

**Example - no height limit set.** No restriction on boom movement related to height limits.
Slew Restriction
There are two modes of slew restriction, angular limits, and virtual wall.
Angular restricts the slewing of the machine between two user determined angles.
Virtual wall restriction allows the machine to operate to a limit determined by a virtual wall placed parallel to the rails.

**WARNING.**
The slew restriction functions are designed to be used at **slow slew speeds only**. Use at speed may result in an overshoot into a potentially dangerous position.

The buttons in the user settings menu indicate the current function of the button. Therefore, when the system is active then the button will say “Slew Angle is ON” and requires a button press to switch it off. In addition the slew restriction status is shown on the front screen as part of the slew position graphic, as depicted in the graphic on the right.

**Entering of slew limits**
Set the slew limits as follows.
Press Menu and select ‘Slew Restriction”. when asked if you wish to enter slew restriction parameters, select “YES”.
Using the keypad enter the clockwise maximum angle.
press the OK button.
Enter the least clockwise angle.

The display will change to indicate angular slew limit set. The limits are shown below the slew angle.

**Capture of Slew Limits**
When asked if you wish to enter slew restriction parameters, select “NO”. You will then be asked to slew to the desired clockwise slew limit and enter, and then to the desired counter clockwise slew limit and enter.

If the preset angles are exceeded then the appropriate slew motion cut is applied, and the slew motion cut icons on the operator display change colour to RED to show the slew service is cut.

**Turning the slew restriction off**
To turn off the slew restriction select MENU and press the “Slew angle is ON” button.
The system will ask for confirmation that slew limits are to be turned off, confirm by pressing “YES” and the slew limits will be turned off. The slew Limits button will now show “Slew angle is OFF” and no slew limits will be active.
Virtual Walls
It is possible to set a left wall, a right wall or both walls.

Setting a wall
Select MENU and press the “Virtual Wall Off” button. The screen shown to the right appears. To set a wall to the left of the machine (slew angles 180º->360º) Press the ‘LEFT’ button. The system will ask if you wish to ENTER a wall distance, if “YES” is pressed a keypad will appear, enter the distance desired to the virtual wall in meters from the machine centre. If you prefer to set the virtual wall distance by capturing it from the boom position, when asked to ENTER the wall distance press “NO”. The system will now ask you to move the boom end to the desired virtual wall position. Move the machine so that the bucket pin is at the maximum allowable distance from the machine and press ‘YES’

Repeat the procedure for a right wall (0->180 slew angles) using the right button.

NOTE: LEFT wall and RIGHT wall are to the left or right of the machine when the machine is at 0º of slew. When the machine is slewed to 180º of slew, the left wall will be on the left of the undercarriage, but on the right of the cab as the cab position is reversed.

Enabling the walls
To enable the wall select the radio button corresponding to the walls required. Select cancel to switch off the walls.

Once the limit is set the slew indicator on the front screen changes to show two red lines either side of the machine. The perpendicular (at 90 degrees) wall limit distance is displayed below the wall in red. The actual machine position is shown in blue below the wall.

The points monitored on the machine against the wall are the bucket pin, the counterweight corners and rear, and the cab front corners.

When the limit is reached the machine will be restricted. The motions that are restricted are shown in red. Typically, the slew motion will be cut along with any boom function that will cause an increase in boom radius. All hydraulic functions that reduce the boom radius, and slew away from the wall, will be available.

WARNING.
It is the responsibility of the driver to make sure that any limit set is outside any wheels, stabilisers or attachment that may be fitted to the machine which could cause it to be in a dangerous position. The size of the load suspended from the bucket pin or lifting point should also be considered when setting a wall.
Exceeding Set Limits

Should any set limit be exceeded, the 3RCI system will notify of the limit being exceeded. This includes setting a new limit when the machine is already outside the set limit.

The 3RCI system will cut any hydraulic function that will allow travel further outside the set limit being exceeded, and will allow all hydraulic functions that will cause the machine to move back into a “safe” position within the set limits.
**Calculator**

The 3RCi has a calculator function built in which allows the operator or crane planner to determine the lift capacity of the machine in the event of an unforeseen (unplanned) lift. By pressing the calculator button on the MENU screen, the lift conditions may be typed in to check the lift capacity of the machine.

Note; the calculator will be configured with the current position and status of the machine when the calculator button is first pressed. If the lift point is positioned directly over the load to be lifted before the calculator button is pressed, the capacity up and down cant for the current boom position, duty selection, radius and height can be read directly off the screen.

The system will ask for a range of heights (start and stop height of lift) and calculate the minimum capacity of the machine for both up and down cant conditions of track.

Once a calculation has occurred the result may be saved to the data log as a record of the planning operation by pressing the “LOG” button.

![Calculator Screen](image)

**Stub release**

It is possible to get the machine into a situation where the indicator will lock motions such that the machine cannot be moved. Specifically this can occur when the stub-boom is lifted until the end of the lift ram travel occurs. At this point a pressure can be induced into the ram that exceeds the pressure that would be induced by a rated capacity. In this case lowering the boom may increase the radius of the load (even if there is no load - the indicator is unaware of the difference) and the indicator will shut off this circuit. To allow recovery there is a timed override facility. Select MENU->Stub release. Lower the boom slightly to release the trapped pressure and the machine will be operable again.

**Dig Mode**

The system has a function to allow the machine to be used for digging. The actual operation of the digging mode is slightly different between on-rail and road.

**Rail**

When digging on the rail it is preferable not to lift the rail wheels from the rail as the impact of the wheel returning to the track after a breakout operation may result in damage to the track. Dig mode will disable the motion cut on overload functions, the external alarm on overload will be disabled and the beacons will indicate non lift duties. The display will still show the loading and overload status of the machine but will not intervene on overload. aUse of dig mode is recorded in the system data log. Site personnel will be warned that the RCI is not operating and is in Dig mode by the lack of illuminated beacons.
Road
The system is inoperative as an RCI and external alarms and beacons are disabled. There is no protection against overloading or tipping.

Backward Stability
This machine is fitted with a backwards stability monitoring function to avoid the machine tipping backwards when high boom angles are achieved with no load applied. The 3rci system monitors the position of the front end equipment and will override backwards stability when the bucket pin is below a preset height or when the load on the hook is sufficient to maintain stability. When the backwards stability is overridden by the load on hook the backwards stability icon will show on the screen to warn the driver that the load should not be released in this position.

Lift Point Selection
3RCI supports multiple lift points.

If multiple lift points have been set up, from the “Restrictions” page, press the bottom left button to cycle through the available lift points.

Available options may include Bucket Pin, ALP (Auxiliary Lift Point), Quickhitch (assumes the Quickhitch is Horizontal for purpose of Height and Radius display) and Telejib.

The lift point in use is indicated on the RCI screen next to the Height display.

BP = Bucket Pin
ALP = Auxiliary Lift point
QH = Quick hitch
TLJB = Demountable Jib
Solenoid override switch

The indicator is fitted with motion cut control circuits to control service solenoids on the machine to stop the machine operating into dangerous zones. In the event of a rated capacity system failure it is possible to over-ride the circuit for recovery purposes.

The over-ride key-switch is fitted within a remote housing and protected by an anti-tamper seal. The key-switch will electrically open all the service solenoids to allow unrestricted use of the machine.

When overridden by the external key switch, the 3RCI screen at the operator station will show a warning message as indicated here. The external alarm will sound continuously when the override key switch is used to override the machine hydraulics.

With the Override key switch engaged, all hydraulic functions are enabled regardless of load status or limits set. All RCI functions are disabled and there will be no protection against overload, or exceeding any height or slew limits or virtual walls.

WARNING - when operating the machine without the rated capacity indicator and the solenoid override engaged, do not lift loads. Operate only to recover the machine.

During the recovery operation the system will continuously log the status. Once the seal is broken the machine requires inspection and the seal replacing before being allowed to work on track.

Offset Boom / Swing Boom machines

It should not be possible to perform lift operations with an offset boom or swing boom machine unless the boom is in the “straight” position.

This position is detected generally by a sensor, and when the boom is detected as “straight”, normal lift duties are allowed.

When the boom is not detected as “straight”, the 3RCI will impose a capacity restriction of typically 700kg, to prevent potential overturns caused by forces imposed when lifting with the boom in an offset position.
**Error Messages**
The system diagnostics continually monitor all of the system components for correct operation. The system will flash a warning to the operator and if appropriate sound the alarm. Below is a list of the error messages and a short explanation of the meaning. Where multiple errors occur they are displayed in the following order of decreasing priority:

<table>
<thead>
<tr>
<th>Error Message</th>
<th>Definition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No serial comms!</td>
<td>Display unit is unable to communicate with other system components.</td>
<td>Total CAN bus comms failure, usually caused by the CAN bus messages being swamped by errors. Slipring is the usual cause, water ingress or wear. Could also be a faulty sensor, identify by unplugging angle sensors / modules / encoder one by one until error disappears.</td>
</tr>
<tr>
<td>Under Carriage Comms!</td>
<td>System unable to communicate with under-carriage module</td>
<td>Usually a slip ring fault, could also be a damaged CAN lead to the under-carriage module, possible undercarriage module fault.</td>
</tr>
<tr>
<td>Angle Sensor 1 Comms!</td>
<td>System unable to communicate with stub-boom angle sensor (may include loss of pressure information too).</td>
<td>Check cable to angle sensors, check green LED on stub boom sensor (should be flashing green). If no LED the sensor not powered, if red then sensor faulty. If fore boom and dipper sensors functioning then likely faulty stub boom sensor.</td>
</tr>
<tr>
<td>Angle Sensor 2 Comms!</td>
<td>System unable to communicate with fore-boom angle sensor</td>
<td>Check cable to angle sensors, check green LED on foreboom sensor (should be flashing green). If no LED the sensor not powered, if red then sensor faulty. If dipper sensor functioning then likely faulty stub boom sensor.</td>
</tr>
<tr>
<td>Angle Sensor 3 Comms!</td>
<td>System unable to communicate with dipper angle sensor</td>
<td>Check cable to angle sensors, check green LED on dipper sensor (should be flashing green). If no LED the sensor not powered, if red then sensor faulty.</td>
</tr>
<tr>
<td>Angle sensor 4 Comms!</td>
<td>System unable to communicate with alternate dipper angle sensor</td>
<td>Check cable to angle sensors, check green LED on dipper sensor (should be flashing green). If no LED the sensor not powered, if red then sensor faulty.</td>
</tr>
<tr>
<td>Angle sensor 5 - 8 comms!</td>
<td>System unable to communicate with safety angle sensor</td>
<td>Spaceguard systems with DIRECT2 angle sensors, 5 = stub boom, 6 = foreboom, 7 = dipper, 8 = alt dipper.</td>
</tr>
<tr>
<td>Error Message</td>
<td>Definition</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Angle Sensor Error</td>
<td>System is communicating with indicated angle sensor but angle sensor is reporting an error state.</td>
<td>Check indicated angle sensor, possible that two halves of sensor have separated slightly (press back together), possible that sensor has been pulled out of shape on mount.</td>
</tr>
<tr>
<td>Stub Ang out of range!</td>
<td>Stub boom angle reading indicates that machine has achieved a mechanically impossible position.</td>
<td>Probably stub angle sensor fault. Check angle sensor for correct operation, replace if faulty.</td>
</tr>
<tr>
<td>Dip Ang out of range!</td>
<td>Dipper angle reading indicates that machine has achieved a mechanically impossible position.</td>
<td>Probably dipper angle sensor fault. Check angle sensor for correct operation, replace if faulty.</td>
</tr>
<tr>
<td>Boom Ang out of range!</td>
<td>Fore boom angle reading indicates that machine has achieved a mechanically impossible position.</td>
<td>Probably foreboom angle sensor fault. Check angle sensor for correct operation, replace if faulty.</td>
</tr>
<tr>
<td>Over pressure!</td>
<td>Pressure sensor is reporting a pressure in excess of the main relief valve</td>
<td>Possible pressure transducer fault, or faulty connection to the pressure transducer.</td>
</tr>
<tr>
<td>Low pressure!</td>
<td>Pressure sensor is reporting a pressure that is below 5 bar in main lift ram.</td>
<td>If the main equipment is not resting on the ground then is a fault. If equipment is powered into ground then lift equipment to check again. Possible pressure transducer fault, or faulty connection to the pressure transducer.</td>
</tr>
<tr>
<td>Press sensor 0!</td>
<td>Indicates that pressure sensor output is zero. Cable fault or sensor failure</td>
<td>Check cable or replace sensor as appropriate.</td>
</tr>
<tr>
<td>Press sensor 1023!</td>
<td>Indicates that pressure sensor output is full scale. Cable fault or sensor failure</td>
<td>Check cable or replace sensor as appropriate.</td>
</tr>
<tr>
<td>PLC comms error x 5</td>
<td>Loss of connection to remote unit (Railsafe). Reboot all systems.</td>
<td>CAN bus comms failure between GKD system and GOS Railsafe PLC.</td>
</tr>
<tr>
<td>Trailer breakaway!</td>
<td>Indicates that the trailer breakaway flow switch has activated and the trailer brake coupling is disconnected. This is not technically a fault with the indicator unless there are no trailer brakes attached when this indicates a flow switch or wiring problem.</td>
<td>Check trailer breakaway detect switch on undercarriage for correct operation.</td>
</tr>
<tr>
<td>No Brakes!</td>
<td>Error message indicating that the rail-gear sensor show that neither bogie is engaged with a braked wheel and that the braked road wheels may not be in contact with the ground.</td>
<td>If rail gear is fully deployed, check rail gear detect switches for correct operation.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Error Message</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bad Rail Gear!</td>
<td>Bad rail gear’ indicates that non permissible logic for the rail gear has occurred such as the indicator sensors suggesting that a bogie is both up and down at the same time. This is an error condition and must be rectified prior to the use of the machine.</td>
<td>If rail gear is fully deployed, check rail gear detect switches for correct operation.</td>
</tr>
<tr>
<td>Safety Mis-match</td>
<td>Sensor inputs or calculated spatial information is outside the preset maximum limits. Do not operate the machine until this error has been cleared.</td>
<td>Use TEST function to determine nature of mismatch and inspect the appropriate angle sensors and cabling for damage and correct operation. Slew mismatch often cured by slewing over slew reset switch to reset the tooth counting sensor count.</td>
</tr>
<tr>
<td>Backwards stabili-ty!</td>
<td>Warning of potential for machine instability due to operating “up” cant without a load applied.</td>
<td></td>
</tr>
<tr>
<td>Mod 1 Comms!</td>
<td>System unable to communicate with Output Module</td>
<td>Check CAN cables to module, check module is operational (green LEDs visible through case), possible module fault.</td>
</tr>
<tr>
<td>Mod 2 Comms!</td>
<td>System unable to communicate with Spaceguard module</td>
<td>Check CAN cables to module, check module is operational (green LEDs visible through case), possible module fault.</td>
</tr>
<tr>
<td>Mod 5 Comms!</td>
<td>System unable to communicate with Input (I/O) module</td>
<td>Check CAN cables to module, check module is operational (green LEDs visible through case), possible module fault.</td>
</tr>
<tr>
<td>Mod 9 Comms!</td>
<td>System unable to communicate with Slew module</td>
<td>Check CAN cables to module, check module is operational (green LEDs visible through case), possible module fault.</td>
</tr>
<tr>
<td>Mod 11 Comms!</td>
<td>System unable to communicate with under-carriage module</td>
<td>Check CAN cables to module, check module is operational (green LEDs visible through case), possible module fault.</td>
</tr>
</tbody>
</table>
Addendum

SpaceGuard System

Introduction
The 3rci SpaceGuard system adds dual sensing and processing of machine component position to the standard system. This allows the system to provide improved electronic stops for the height and slew limits and for virtual walls.

There are two independent angle sensors fitted to each of the stub boom, fore boom and dipper. In addition, a second means of measuring the machine slew position is fitted. These angle and slew sensors are compared continuously against each other and if a calculated error between the safety and standard computers occurs a Safety Mismatch message is shown on the screen and the machine will stop motion.

The SpaceGuard also incorporates slow zones to allow the system to stop the machine movement within the set limits even if it is being operated at speed. Spaceguard evaluates the speed of operation and uses pre-emptive stopping to stop motion before the limit is reached.

Operation.
Please read the section in the main manual on the setting of virtual walls and slew/height limits. The manner of setting these limits has not changed in the SpaceGuard system. However, the operation of the machine is now affected when using limits.

Default height limit
On system start up, a default height limit will be imposed automatically. This height limit is set at 3.500 meters. Should a height limit not be required, the height limit will need to be disabled after start up every time the system is turned off. If a different height limit is required, the height limit will need first to be turned off, and then an alternative height limit will need to be set (see the section on setting a height limit in the main section of the user manual).

Slow zones.
In accordance with the Network Rail remits for working under with an adjacent line open, whenever an angular slew limit or virtual wall is set and active, the slew speed of the machine will be reduced to a maximum of 2 meters per second measured at the bucket pin with the boom at full reach.

When the machine is in proximity to a slew limit or virtual wall the system will automatically select a further slow mode, where the slew speed of the machine will be further reduced to 1 meter per second.

When working with height limits, full machine boom speed will be available when working away from a set height limit, but as the boom approaches an active height limit boom speed will be reduced.

Pre-emptive stopping
The ‘SpaceGuard system implements a pre-emptive stop software to allow the system to predict the stop position of the machine when running quickly. This means that the machine may stop early when approaching a limit quickly. It will then release the motion cuts and allow slow movement towards the limit. The use of pre-emptive stops take into account inefficiencies in braking and reaction times for stop valves.

Margins
The “SpaceGuard” applies a dead band margin to the limits set by the user to ensure that should a pre-emptive stop occur very close to a limit the system will not allow an overshoot.
Safety System and mis-matches
The “SpaceGuard” continuously monitors the inputs from the angle and slew sensors to check that they agree. If there is a mismatch then “Safety Mismatch” will be displayed and all motions are disabled. Should this occur an override button appears on the screen to allow movement to a safe position. Only use the override button for recovery purposes. If the mismatch is cured then the Override button will disappear and normal operation recommences. The external “tipping” alarm will sound constantly under a mismatch condition, and will continue to sound once the override button is pressed. The alarm will stop only once the mismatch is cured.

Should a safety mismatch warning occur, use the override button provided to re-enable motion, and slew the machine over 0º of slew to reset the slew sensor. Should this fail to correct the mismatch, further investigation will be required by a technician to determine the cause of the mismatch and to correct the fault.

**WARNING.**
WHEN THE “OVERRIDE” BUTTON IS USED TO RE-ENABLE MOTION, NO PROTECTION IS IN PLACE WITH REGARD TO SLEW OR HEIGHT LIMITS OR VIRTUAL WALLS. IT WILL BE POSSIBLE TO EXCEED ANY SET LIMITS.

Safety Mismatch at start up
There may be occasions when the safety mis-match occurs at start up due to slew angle differences accumulated during shut down. Use the override button to slew round past the reset sensor on the floating end (0 degrees) of the machine. Once the slew is synchronised the machine may be operated normally.

Offset Boom or Swing Boom machines
Where a GKD 3RCI Spaceguard system is installed onto a machine with a swing boom or swivel boom, additional protection is provided to ensure that the boom is in the “straight ahead” position when working with positional limits.

Sensors automatically detect when the offset or swing boom is in the “straight ahead” position.

When the boom is NOT detected as being straight, access to setting of positional limits (height, slew and virtual wall limits) is disabled. The machine lift capacity is also reduced, typically to 700kg.

It will only be possible to set a limit when the boom is in the straight ahead position. Once a limit is set, the hydraulic controls to the boom swing or offset will be motion cut, and it will not be possible to swing or offset the boom whilst a limit is active.

Orange beacon
Some 3RCI Spaceguard installations incorporate an additional beacon on the outside of the cab, usually orange in colour.

This beacon is designated as “Limit Set” and will be activated when either a slew limit or a virtual wall is set and active AND the foreman’s key switch on the display is turned to the “Locked” position.