SmartCrane™ Anti-Sway Crane Control

Installation and Maintenance Manual
The owner, authorized user, or dealer of a SmartCrane software or hardware product may reproduce this document for the purposes of installing, using, or maintaining the software or hardware.

No other reproduction or commercial uses are permitted.

We have made every effort to ensure this document is up to date and accurate. However, there are numerous SmartCrane products in production that have not been updated to the latest version. In those cases, previous manual versions will still apply. SmartCrane, LLC is not responsible for printing or clerical errors.

We encourage customers and users to provide comments and corrections to SmartCrane, LLC for the purpose of improving the accuracy and usefulness of this and related documents.

The SmartCrane logo and the name “SmartCrane” are trademarks of SmartCrane, LLC.
# Contents

## ABOUT THIS MANUAL

- In This Guide ........................................................................................................... 7
- PLC Interface Specifications ...................................................................................... 9
- Operator Guide ........................................................................................................... 9
- Operator Quick Guide ............................................................................................... 9

## HOW ANTI-SWAY WORKS

- What The Anti-Sway Needs From The Crane ............................................................ 10
- When A Sway Sensor Camera Is Installed ................................................................. 11
- Modes Of Operation .................................................................................................. 11

## INSTALLATION BASICS

- A Preview Of The Process ......................................................................................... 12

## PLANT SURVEY

- Plant Floor Or Yard Arrangements ............................................................................ 13
- Defining Destinations And Destination Objects ......................................................... 14
- Defining Destination Groups ..................................................................................... 14
- Defining Obstacles .................................................................................................... 15
- Defining Pillars .......................................................................................................... 15

## MOUNTING AND CABLEING HARDWARE

- Installing Controller CPU And Touch Screen ......................................................... 16
- Installing Ethernet Hub And Optional Gateway ....................................................... 17
- Installing Smartcamera™ And Reflector Target ....................................................... 18

## SWITCHES AND ALERTS

- Anti-Sway Control Switch ......................................................................................... 21
Anti-Sway Suspend Switch ........................................................................................................... 21
Anti-Sway Malfunction Alarm ....................................................................................................... 22
SmartHoist™ Alarm ..................................................................................................................... 23

PLC RESPONSE TO ANTI-SWAY 6 .......................................................... 24

Managing The Anti-Sway Control Code ....................................................................................... 24
Managing Brakes ........................................................................................................................ 24
Hoist Control .............................................................................................................................. 24
Maximum Speed and Ramp Times ............................................................................................... 25
Drive Response Requirements .................................................................................................... 25
Position Sensors .......................................................................................................................... 26

ABOUT INTERNET PROTOCOL (IP) ADDRESSES 7........................................ 27

Changing The IP Address Of The Smartercane Controller ......................................................... 28
Changing the IP Address of the Softing FG-100 Gateway ............................................................ 28
Changing The IP Address Of The ANYBUS Gateway ................................................................. 28
Remote Access For Software Maintenance ................................................................................. 29

SETTING UP A REPLACEMENT COMPUTER 8 ........................................ 30

Creating User Accounts ............................................................................................................ 30
Setting System Preferences ....................................................................................................... 31
Setting Up the Touch Screen ..................................................................................................... 32
Using SmartCrane Software During Commissioning ................................................................. 33
Installing Smartcrane Software ................................................................................................. 33
Required Directories and Files ................................................................................................. 33
Other Directories and Files ........................................................................................................ 34

TESTING BEFORE COMMISSIONING 9 ............................................. 36

Testing The PLC Interface ........................................................................................................ 36
Confirming Camera Operation .................................................................................................... 36
Adjusting Focus and Aperture .................................................................................................................. 37

AUTOMATIC COMMISSIONING  10 ......................................................................................... 38

A Preview of Automatic Commissioning ............................................................................................ 38
Step 1 - Check Communications With PLC ......................................................................................... 39
Step 2 - Check Inputs From PLC ........................................................................................................ 39
Step 3 - Check Crane Motion Without Anti-Sway ............................................................................. 40
Step 4 - Register Crane To Home Position ....................................................................................... 41
Step 5 - Operate In Auto Commissioning Mode ............................................................................. 41
Step 6 - Confirm Obstacle Safe Points ............................................................................................ 42
Step 7 - Enable Anti-Sway With Supervisor Code ......................................................................... 43
SmartHoist™ Calibration ....................................................................................................................... 43

OPERATIONAL TESTING  11 ........................................................................................................ 45

Important Precautions ......................................................................................................................... 45
Testing Manual Anti-Sway Moves ....................................................................................................... 46
Testing Automatic Anti-Sway Moves .................................................................................................. 47
Testing SmartHoist™ Feature .............................................................................................................. 48

EDITING REQUIRED FILES  12 ............................................................................................ 49

Controller Files You Can Update But Not Change ........................................................................ 49
Commissioning Log ............................................................................................................................. 49
Initialization File .................................................................................................................................. 50
Web-Based Editing ............................................................................................................................... 50
Categories in the Initialization File ....................................................................................................... 53

MAINTENANCE  13 ................................................................................................................................. 55

Routine Camera Maintenance .............................................................................................................. 55
Using Engineering Mode ..................................................................................................................... 55
Managing Obstacle Avoidance ........................................................................................................... 56

©Copyright 2009, 2010, 2011 by SmartCrane, LLC – All rights reserved
Administering the SmartCrane™ Controller CPU .................................................................................. 57
Shutting Down The Smartcrane Program Remotely .......................................................................... 58
Updating the SmartCrane Program .................................................................................................. 59
Managing the SmartCamera™ System .............................................................................................. 60
Updating Software on the SmartCamera™ ...................................................................................... 61
Updating Camera Software Using An FTP Client ............................................................................ 61
Updating Camera Software Using The Shell .................................................................................... 62
How To Tell If Your System Is Working Properly ............................................................................ 62
Routine Troubleshooting .................................................................................................................. 64
About This Manual

This manual describes the steps to install a SmartCrane system under various installation options. It also provides critical data for maintenance personnel to diagnose and correct problems, and how a customer can set up remote access to equipment and receive SmartCrane support.

SmartCrane™ Anti-sway is computer-controlled operation of the trolley speed, gantry speed, and hoist speed for the purpose of decreasing the time required to move a suspended load between destinations and improving the safety of operations. The SmartCrane™ software runs on any computer that shares or can exchange data with the customer’s crane drive in real time and responds, through the drive or directly, to operator’s commands. The patented SmartCrane™ Anti-sway Control uses an open-loop algorithm that eliminates load sway induced by trolley accelerations and decelerations. It operates in three modes: Manual Anti-sway, Automatic Move, and Suspend. In Manual mode, the control responds to the operator’s trolley stick demands and completely inhibits sway no matter what demands the operator gives.

In This Guide

This Installation and Maintenance manual includes the following information:

- Chapter 1, “How Anti-Sway Works” explains how the SmartCrane Anti-sway controls the motor speeds and what is required from the PLC.

- Chapter 2, “Installation” explains what needs to be done to install, wire, and test a SmartCrane™ system before commissioning.

- Chapter 3, “Plant Survey” explains how to obtain critical measurements required for the SmartCrane™ automatic move feature.

- Chapter 4, “Mounting and Cabling Hardware” explains how to best mount the SmartCrane™ equipment and provide cabling for power and communications.

- Chapter 5, “Switches and Alerts” explains the types of switches and alerting mechanisms are best for the proper and safe operation of SmartCrane™ Anti-Sway.

- Chapter 6, “PLC Response to Anti-Sway” explains what the PLC needs to do to control anti-sway and to respond correctly to anti-sway signals.
• Chapter 7, “About Internet Protocol (IP) Addresses” explains what needs to be done to ensure all components of the SmartCrane™ system can communicate using their Ethernet connections.

• Chapter 8, “Setting Up a Replacement Computer” explains how to install the SmartCrane software on a new computer not supplied by SmartCrane, LLC.

• Chapter 9, “Testing Before Commissioning” explains what needs to be done to test the components and cabling for proper operation, before commissioning.

• Chapter 10, “Automatic Commissioning” explains what needs to be done to commission a new SmartCrane™ system.

• Chapter 11, “Operational Testing” describes how to go about initial testing of anti-sway after the standard commissioning steps are complete.

• Chapter 12, “Editing Required Files” explains how to edit or update files that control the operation of the SmartCrane™ anti-sway system, including using a web interface to update the SmartCrane™ Initialization File. This file allows the same basic software product to be installed for different crane classes, crane types, lifting mechanisms, and crane response characteristics.

• Chapter 13, “Maintenance” explains what needs to be done to manage and maintain your SmartCrane™ system.
Other SmartCrane documents may be useful to operators, installers, PLC programmers, and maintenance personnel. These documents are in pdf format and are available for download free of charge from http://www.smartcrane.com/documents.

PLC Interface Specifications

This manual describes detailed data interfaces required to allow the anti-sway software to work with a crane’s PLC to control sway during both manual and automatic moves. Two configurations are addressed, where the primary operator interface is provided either by the PLC or by the SmartCrane™ touch screen.

Operator Guide

This document provides description and operator instructions the SmartCrane™ Anti-sway Control for overhead traveling cranes, rail mounted gantry cranes, and other cranes whose lift point height remains constant.

Operator Quick Guide

This two-page document contains short descriptions of operator use of the SmartCrane touch panel, using mostly picture rather than words.
How Anti-Sway Works

Read this chapter to understand how the SmartCrane Anti-sway controls the motor speeds and what is required from the PLC.

When an operator moves the control stick to a certain speed, the SmartCrane™ Anti-sway Control accelerates initially according to the operator's demand, inducing an initial load sway. When about half the reference velocity has been reached, the anti-sway "coasts", i.e., maintains constant velocity, for a short time. Then the trolley is accelerated again, this time to the full operator demand velocity. This second acceleration kills the sway induced by the first acceleration, so the trolley is now traveling at the operator reference velocity with the load hanging directly below the trolley. When the operator releases the stick demanding zero velocity, the same process is repeated in reverse to bring the load to a stop without sway. If the operator demands movement for a short time, the anti-sway will bring the motion to a stop and then perform a second movement to catch the sway.

The SmartCrane Anti-sway accounts for changes in hoist cable length, changes in operator demand, etc. The key feature is that the SmartCrane™ Anti-sway Control relies on precise timing of accelerations to control the sway. It does not require a camera or other sway-sensing device to control sway induced by moving the crane.

In order to remove sway introduced by other factors such as wind and non-vertical lift, the SmartCrane™ system offers an optional SmartCamera™ system that measures and corrects for actual sway in real time, usually at the end of a move once the trolley has come to a stop.

What The Anti-Sway Needs From The Crane

For manual anti-sway operation, the SmartCrane™ system only requires measurement of hang length and lift load. In order to perform automatic moves, the system also needs trolley and gantry positions.

Anti-sway will not operate if the needed measurements are not present (and properly "homed" if necessary).
SmartCrane, LLC strongly advises the use of multi-turn absolute encoders for measuring trolley, hoist, and gantry position. While these instruments are more costly than ordinary incremental or absolute encoders, they will guarantee correct readings at all times, prevent possibly dangerous motions that anti-sway can generate using bad data.

When A Sway Sensor Camera Is Installed

With a SmartCamera™ installation, a camera and computer combination mounted in the trolley tracks the location of a special target on the top of the spreader. With these measurements, the Anti-sway Control can determine whether any excess sway has been induced by external factors. The feedback data is used at the end of manual and automatic moves. In an automatic move it also adjusts the position of the spreader to the exact destination position.

Modes Of Operation

In Automatic Move mode, the trolley is moved automatically to a predetermined position in response to a button press or command from a remote control. The operator can press a different button during the move, or he can interrupt the move by simply moving the joystick in the desired direction of travel. Transition from one mode to another, or from one destination to another, is seamless.

In Suspend mode, the control carries out no anti-sway operations, but waits for new commands from the drive control.

Typically, the operator has a switch that selects modes. In one position, anti-sway is OFF (suspend mode). In another position, both Manual Anti-sway and Automatic Move are available. In a third position, Automatic move is available but when an automatic move is not in progress, anti-sway is suspended.
Read this chapter to understand what needs to be done to install, wire, and test a SmartCrane™ system before commissioning.

It's important to ensure that the installers understand the requirements for installation and accomplish all the installation tasks before sending for the commissioning team. If one or more steps are missed or improperly taken, then the start of commissioning will be delayed until all steps are complete.

A Preview Of The Process

The basic steps of the installation are:

- Surveying the crane’s range of operation for precise location of destinations and obstacles.
- Locating and mounting the SmartCrane™ controller CPU with its companion touch screen (if supplied) in the operator’s position.
- Locating and mounting the optional SmartCamera™ on the crane trolley and its companion passive target on the spreader bar.
- Providing switches and alert signals in the operator cab.
- Locating and mounting the interface gateway to the crane’s PLC (if supplied).
- Assigning Internet Protocol (IP) addresses to SmartCrane™ controller CPU, gateway (if supplied), and SmartCamera™ (if supplied).
- Modifying PLC control logic to exchange data with SmartCrane.
- Installing the software.
- Conducting automatic commissioning tests.
- Certifying the software for operational use.
Plant Survey

Read this chapter to understand how to obtain critical measurements required for the SmartCrane automatic move feature.

The SmartCrane™ automatic move feature requires a complete description of the crane, fixed destinations, associated objects, and obstructions in order that each move can avoid dangerous contact.

All measurements are stored in a special file SmartCraneInit.txt. Chapter 12 describes all the elements of this data file and how to access it with either a web browser or a text editor.

This process may take some time, so customers are encouraged to prepare for this step well before the actual installation.

The use of CAD software is encouraged. If the plant is already defined accurately in one or more CAD drawings, that will assist in extraction of extent values for use by SmartCrane™.

Plant Floor Or Yard Arrangements

The plant floor can be surveyed using any coordinate system and measurement scale. For entry in the SmartCraneInit.txt file however, these measurements must be converted to SmartCrane's coordinate system, with X direction positive right parallel to the crane rails and Y direction positive toward the operator, and all measurements in meters.

To avoid confusion with negative numbers, the origin (0,0) of the plan should lie outside of the range of motion of the trolley center. The vertical reference should be the plant floor, although some areas may be below the floor (negative values).
If the PLC uses a different coordinate system, the conversion from PLC to SmartCrane must be defined in the SmartCraneInit.txt file (see Chapter 12). The SmartCrane software will convert all coordinate values to PLC coordinates for display to the operator.

Measure the height of the rails, the maximum hoist height of the spreader bottom, and the maximum allowed range of motion of the center of the trolley, in both X and Y.

**Defining Destinations And Destination Objects**

Destinations are XY locations that can be accessed by the operator via buttons on the touch screen. The number of these buttons displayed (10, 14, or 24) is an option that must be selected by the customer before delivery of the software.

The customer should request a number larger than what is expected for routine use, to allow operators set temporary locations in unused buttons.

The customer may set up permanent names and locations, up to the maximum number of screen buttons, and define these in the SmartCraneInit.txt file. Permanent here means that the operator may not change the name or location during routine use.

Basic destinations are defined by XY position and positioning tolerance.

Destination “objects” are defined by XY location, width, height, and shape (rectangle or ellipse). An object may be linked to a destination, in which case a move to that destination will adjust the destination height according to the object height (plus or minus). For instance, an arc furnace may be installed will below the plant floor, requiring the definition of an object with a negative height.

In any case, all destinations need to be measured precisely using CAD drawings, measuring instruments, or by moving the crane over each location.

**Defining Destination Groups**

Some destinations may actually consist of a group of related destinations, each with different positions and designations. Since the number of destination buttons is limited, the customer can put all the destinations in one group under a single button. Chapter 12 includes instructions for setting up destination groups.
Defining Obstacles

Obstacles are regions of the plant that must be avoided by automatic crane moves. Examples of obstacles might include buildings, other permanent structures, or sill beams of gantry cranes. An obstacle is defined in XY by a (non-convex) polygon and in Z by a single height value.

The SmartCrane™ software will calculate a combination of safe hoist heights and horizontal paths to avoid all obstacles.

Exception: If a permanent destination XY lies inside an obstacle, that obstacle will be ignored for moves to and from that destination.

One plant may have up to 60 obstacles and each obstacle may have up to 10 corners.

The survey should establish the actual boundaries of each obstacle and not a perceived safety zone, as the software creates its own safety zones (based on clearance values you define) and permits the customer to adjust these as needed.

Careful definition of obstacles can be used to control approaches to destinations. For instance, one could create artificial barriers using obstacles higher than the crane can hoist, forcing the optimal path into a specific approach direction.

Once obstacles are entered, it is important to review and adjust safe points before performing any automatic moves. For instructions, see Chapter 12 And 13.

Defining Pillars

The SmartCrane™ user display has three different real-time views in two dimensions: plan view, side view (showing the trolley motion) and front view (showing the bridge or gantry motion). Entering pillar positions will allow users to see the bridge motion in the front view.

If pillars are entered, only those under the rail at the top of the control view (away from the operator cab) need be used.
Mounting and Cabling Hardware

Read this chapter to understand how to best mount the SmartCrane™ equipment and provide cabling for power and communications.

The SmartCrane™ controller CPU is an Apple Mac Mini with Ethernet, VGA, USB, and Firewire ports and needs to be installed in the crane cab within cabling range of the touch screen. USB and VGA extension cables may be purchased locally and used if needed to extend this range. The Ethernet hub and (if supplied) PLC network gateway may be installed in any convenient location. The SmartCamera™ needs to be installed in the trolley, with full time view of its accompanying reflector target mounted on the spreader. All communications cabling should be well shielded, especially in proximity to large electrical motors.

Installing Controller CPU And Touch Screen

The controller CPU should be mounted securely in a dustproof enclosure, which may be shared with other electronic equipment. Temperature constraints are not critical but the enclosure should be large enough to dissipate heat without the need to circulate potentially contaminated air. The customer may wish to mount a spare CPU in the same enclosure. If so, the spare should be mounted under or separate from the main processor and not powered up except for emergencies. Do not mount anything directly on top of the CPU, to avoid interfering with wireless signals and buildup of operating temperature.

An external momentary power interrupt switch should be provided in case the system requires rebooting. The power switch should also interrupt the power supply for the SmartCamera, or a separate switch provided for that purpose.

The touch screen should be mounted in a position visible to the operator at all times but not interfering the visibility of the work area.

The best position is forward of the operator joystick on the operator’s console, and tilted away for best visibility and to provide an unobstructed view of the crane load and its path. A sunshade may be required for installations out of doors.
The touch screen may be installed on either the left or right side of the operator’s chair. SmartCrane, LLC will configure the buttons on the SmartCrane touch screen to be positioned on the screen based on the customer’s positioning design, so as to ensure the GO and STOP buttons are the easiest for the operator to reach.

Both USB and VGA cables must be installed connecting the controller CPU and the touch screen. The controller CPU must be cabled using CAT 5 wiring to the Ethernet hub or switch. Do not use “cross-over” cables.

Use wire ties to apply permanent pressure to all cable connections without screw fasteners. In particular, the power and USB connections on the touch screen can easily work loose because of cab vibration.

If the SmartCrane™ system is installed remotely (not on the crane), positioning may be selected to meet the customer’s operating requirements.

**Installing Ethernet Hub And Optional Gateway**

The Ethernet hub if needed may be installed in any location in the operator cab. Run the cable from the controller CPU to the hub.

The SmartCrane system may communicate with a PLC directly, using the PLC’s MODBUS TCP interface, using an Ethernet-PROFIBUS gateway FG100-PB from Softing, Inc., or an “ANYBUS” Gateway that converts MODBUS TCP to a number of proprietary networks. If supplied, mount it either near the hub and connect the proprietary cable (PROFIBUS or other) and power, or mount it near the PLC and connect it to Ethernet. Connect an Ethernet cable from the hub to the gateway or directly to the PLC, as appropriate, using a standard (not crossover) LAN cable. Extra sockets in the Ethernet hub can be used for commissioning, testing, or software updates.

The gateway will require DC power and must be set up as a slave node on the PLC’s network. When all connections are made, the PWR and LAN green lights on the unit should be on.
A GDB file is available from SmartCrane, LLC to support PLC programming for PROFIBUS communications. The configuration required is 84 bytes from PLC to SmartCrane and 28 bytes from SmartCrane to PLC. See the SmartCrane Interface Specifications document for formats.

**Installing Smartcamera™ And Reflector Target**

The optional SmartCamera™ must be mounted in its supplied enclosure securely on the trolley directly over the spreader bar. Any convenient mounting location is permissible, however the supplied reflector target must be installed directly under the camera on the spreader bar. The installer should select a position where both the target and camera can be aligned properly.

The camera must be installed parallel or perpendicular to the motion axis of the trolley. The reflector target must be aligned with the camera, not with trolley or crane axis. The black triangles of the target must align with left/right axis of the camera.

This photo shows an installation with the camera vertical view aligned with the crane (gantry) axis and the reflector target properly aligned with the camera.

To install a camera supplied with a shockproof enclosure, mount the supplied bracket to the trolley, using a level to insure vertical alignment in both directions. The bracket is steel and may be bolted or welded as appropriate. Be careful not to distort the bracket as the camera housing fits snugly through the two rings. Mount the bracket rigidly to the trolley to avoid unnecessary vibration.

Mount the camera in the bracket, with the rubber gasket between the supporting ring and the bracket, without tightening the clamps.
Turn the housing until the bottom of the camera housing is properly aligned, parallel or perpendicular to the trolley motion. The bottom of the housing is indicated by a mark on the outside of the canister.

Apply supplied self-amalgamating tape in at least 3 layers for a sufficient distance back from the connector so that rain flows away from the end of the wrap. Apply the tape as follows:

(1) Strip back the interleaving as required.

(2) Stretch tape to reduce its width by about a third and wrap under tension with 50% overlap.

(3) To finish, hold tape under thumb and snap by stretching.

Leave slack cable at the camera to facilitate camera mounting and removal. Route all wires to the SmartCrane cabinet and connect as described below. The power cable may be cut as required.

Mount the rain shield if provided. Trim the top portion of the shield to prevent excessive cable pressure. Open the shield and place over the cable. Remove the covering from the tape strip and overlap the two sides of the shield and seal using the tape strip. Use more of the self-amalgamating tape to seal the top of the rain shield.

To install a camera supplied with a standard enclosure, mount a vertical plate in an appropriate position and drill matching holes. Bolt the enclosure to the plate and then mount the camera inside the enclosure.

In a standard enclosure the camera will be delivered with a 24VDC power supply (120V-24VAC) and an Ethernet (LAN) cable connected to an Ethernet hub inside the enclosure (NOTE: older installations may have the Ethernet cable and power cable extending directly from the camera to an electrical cabinet. In these cases, that cable may require extra shielding or conduit to prevent electrical interference).

The defogging system in the enclosure requires 120/240VAC cable.
The following table gives the wiring connections if needed.

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>24VDC +</td>
<td>Red/blue</td>
</tr>
<tr>
<td>Camera</td>
<td>GND</td>
<td>Black</td>
</tr>
<tr>
<td>Heater/blower</td>
<td>120/240VDC (2 cables)</td>
<td></td>
</tr>
<tr>
<td>Camera</td>
<td>Ethernet RJ45 1</td>
<td>White/pink</td>
</tr>
<tr>
<td>Camera</td>
<td>Ethernet RJ45 2</td>
<td>Pink</td>
</tr>
<tr>
<td>Camera</td>
<td>Ethernet RJ45 3</td>
<td>White/Green</td>
</tr>
<tr>
<td>Camera</td>
<td>Ethernet RJ45 6</td>
<td>Green</td>
</tr>
</tbody>
</table>

The camera should be mounted securely in the enclosure and the enclosure itself mounted in a position where it will not be damaged. Connect the camera cables and the power cable to the defogging system. The power cable may be cut as required. With the standard enclosure, the installer must supply a shielded industrial Ethernet cable, properly terminated, to connect to the Ethernet hub inside the enclosure.

For outside systems, install a protective cover over the entire assembly to protect the unit from direct sunlight and precipitation if necessary.

Run the cables from the camera location to the cab (if cab and trolley are connected) or to a cabinet inside the trolley enclosure, securing them every 2-3 feet. Allow drip loops at both the camera end and the cab end. Be sure the cable is protected from weather and from mechanical damage.

The camera lens focus and aperture will be set at the SmartCrane factory and secured with setscrews and electrical tape. Do not remove the tape but remove the lens cap before closing the enclosure.
Switches and Alerts

Read this chapter to understand the types of switches and alerting mechanisms are best for the proper and safe operation of SmartCrane™ Anti-Sway.

The SmartCrane™ controller gets its direction from two sources: (1) the PLC and (2) the operator via the touch screen (if supplied). Best practice requires relying on the PLC for basic operating mode and for alerting the operator to problems.

**Anti-Sway Control Switch**

The SmartCrane system requires a signal from the PLC for the operating mode. The available modes are:

1. Antisway off (suspend);
2. Antisway available for pushbutton automatic moves only; and
3. Antisway full-time, where anti-sway is in effect for automatic moves and all moves by the operator stick.

The customer may install a switch in the cab or operator console to allow all three of these modes, or only those it selects. The PLC should process this switch and pass the code to the SmartCrane processor.

**Anti-Sway Suspend Switch**

It is useful for the operator to momentarily suspend the anti-sway feature for certain operations. For instance, in a situation where non-vertical lift has caused initial sway, the operator may wish to remove it using the joystick. However, with anti-sway on, the SmartCrane system will prevent this from happening (remember anti-sway without camera feedback can only preserve the starting sway, not remove it).
Therefore a momentary switch installed on the joystick will give the operator the flexibility to control the crane in the appropriate way. Some cranes have a slow-down button on the joystick and this can be a handy signal to use for this purpose. The PLC should switch its anti-sway control code to SUSPEND while this button is depressed.

Without this momentary button, the operator could switch anti-sway off and on using the anti-sway control switch and achieve the same result.

If desired, SmartCrane LLC can provide a SUSPEND footswitch that connects directly to the Anti-sway controller, using USB cable.

**Anti-Sway Malfunction Alarm**

The anti-sway feature of the SmartCrane system allows an operator to demand full speed in trolley or crane direction using the joystick, without any risk of sway. If for some reason the operator thinks anti-sway is working but it is not, moving the crane in this manner can be very dangerous.

Therefore the customer should install a warning light and audible alarm in the cab in order to alert the operator when the switch is in full-time anti-sway but when the SmartCrane computer does not respond affirmatively to the PLC.

There are two ways that the Anti-sway controller CPU will not provide anti-sway controls to the PLC:

1. The controller CPU sends a continuously changing number to the PLC called a “heartbeat.” If this value stops changing, then some fault has occurred in the controller CPU and alert the operator.

2. The controller responds to the PLC with the requested Anti-sway control code. If the controller CPU detects some fault in the data (such as disagreements among velocity and position data from the PLC, or a sudden shift in position encoder readings), it may respond to anti-sway ON request from the PLC with anti-sway SUSPEND. In this case the PLC should alert the operator. In these cases, the SmartCrane touch screen will also display an alert, and in some cases instructions for correcting the problem.
SmartHoist™ Alarm

The SmartCrane system monitors hoisting of loads when it is made aware of the weight of a load being picked up. It also can make automatic moves to pick up or deliver loads registered in the customer’s data file. This feature is only available in cranes with an accurate load-measuring device.

During these hoist operations, the SmartHoist™ feature compares load readings and hoist length readings to the expected load and hoist profile of the crane. A deviation from that profile means that either:

1. The weight of the load being hoisted is incorrectly recorded OR
2. The hoisting mechanism is not properly engaged.

With a container spreader, it may mean that one or more twist locks are not engaged. With hooks or tongs, it will mean that one hook or one pair of tongs is not properly engaged. Also, with slab cranes and an accurate slab inventory, the system will detect when the slab is lifted off balance.

When any of these things happen, if the SmartCrane software is lifting for an automatic move, it will immediately stop the hoist and raise an alarm. If the operator is controlling the hoist using the stick, the system will also raise an alert on the touch screen and send a hoisting alarm to the PLC. The customer may decide to have the PLC interrupt hoisting when this alarm is set (hoist demand from the Anti-sway controller will be set to zero for this purpose).

In any case, a separate audible and visible alarm should be installed. For extremely heavy loads or those with dangerous material, there should be a loud alarm or siren outside the cab to alert workers in the area to the potential danger.
PLC Response to Anti-Sway

Read this chapter to understand what the PLC needs to do to control anti-sway and to respond correctly to anti-sway signals.

Using the SmartCrane Anti-sway control software requires close cooperation by the PLC. Besides exchanging data in accordance with the SmartCrane Interface Specifications, a number of changes to the logic in the PLC will be required.

Managing The Anti-Sway Control Code

The PLC decides when and how to set the Anti-sway control codes for the Anti-sway computer. The codes are explained in the SmartCrane™ Interface Specifications.

One condition controlling the code is the position of a selector switch in the operator cab. A second condition is the position of any “suspend” button or other signal that the operator does not want anti-sway adjustments to stick demands. Also, the PLC should set the anti-sway control code to SUSPEND should it detect any condition that renders the anti-sway not useful, or evidence that anti-sway is not functioning, such as a frozen heartbeat signal.

Managing Brakes

The PLC will need to control the setting and release of trolley and crane brakes. If these decisions are currently made within the drives themselves, then a new signal is required for each set of brakes to correspond with the signals from the anti-sway computer.

Automatic setting of hoist brakes will not interfere with anti-sway performance.

Hoist Control

The PLC should always respond to the operator’s main hoist stick signal, when it is not zero, or when anti-sway is in SUSPEND mode. When the operator’s main hoist stick is in the zero position and anti-sway is not in SUSPEND mode, the PLC should take its velocity demands from the anti-sway computer.
When the SmartHoist™ feature is enabled, the PLC should always take its hoist demand from the SmartCrane controller, even when anti-sway is in SUSPEND mode. When the crane is in position to begin hoisting, the SmartHoist™ algorithm limits the upward hoisting speed sent to the PLC, to increase the number of data points for analysis at the very beginning of the lift.

If SmartHoist™ detects an abnormal lift profile, it will set the STOP HOIST flag AND will limit upward hoisting speed to zero, until the hooks are lowered and disengaged. When the SmartHoist™ feature is enabled, the PLC should always respond to a STOP LIFT signal by not allowing any hoisting UP until the signal is canceled. This feature operates in all anti-sway modes including SUSPEND. The PLC should also energize any warning signals while this signal is on. The customer may have a switch to turn off or suspend this feature.

We recommend an external alarm (siren and/or flashing light) be installed and controlled by the PLC according to the STOP HOIST bit.

The SmartHoist™ feature depends on a statistical process and is very sensitive to abnormal conditions. Occasionally, it may provide a false positive warning. The PLC should be supplied with an external CANCEL switch or button (any existing button may be used). When this is pressed, the PLC should turn off the SmartHoist code and allow the lift to continue.

Also, if the SmartCrane system has a touch screen, the operator may cancel a warning simply by touching the screen.

**Maximum Speed and Ramp Times**

The PLC should be modified to use the same trolley and crane ramp times for deceleration as for acceleration. The anti-sway computer will calculate maximum acceleration and deceleration rates from the ramp times and maximum speeds, and the velocity demands from the anti-sway computer will always respect those limits. If available real-time, the PLC should supply ramp times and maximum speeds in the data interface.

**Drive Response Requirements**

The PLC should be programmed to supply velocity references to the crane and trolley drives exactly as they are received from the SmartCrane™ Antisway. The crane and trolley drives should respond linearly, without imposing any smoothing or S-Curve filtering. If the customer desires smoothing in trolley or crane motion, there are settings in the SmartCrane™ Antisway to provide smoothing. All demands are smoothed by the SmartCrane processor, whether Antisway is ON or OFF.
Position Sensors

It is critically important that the absolute position sensors for all three dimensions: crane, trolley, and hoist, be perfectly reliable at all times. As previously noted in Chapter 2, SmartCrane, LLC strongly advises the use of multi-turn, absolute encoders for measuring trolley, hoist, and gantry position. While these instruments are more costly than ordinary incremental or absolute encoders, they will guarantee correct readings at all times, prevent possibly dangerous motions that anti-sway can generate using bad data.

If multi-turn absolute encoders are not installed, then there must be homing switches installed for all three dimensions in positions such that they regularly calibrate the positions supplied by the sensors.

IMPORTANT: When the crane or PLC is started from a cold start, the PLC must restrict certain uses of anti-sway until all sensors have received a homing event:

1. No anti-sway moves should be permitted until the PLC detects the first hoist position home. The PLC should keep the Anti-sway control code at SUSPEND and trigger the anti-sway alarm if the operator switches the anti-sway to another position other than OFF.

2. No Anti-sway automatic moves should be permitted before the PLC has detected at least one homing event in each of the three directions. Allowing Anti-sway automatic move to begin before both crane and trolley first homing events could cause anti-sway to begin a move with a bad starting position and could cause the anti-sway to ignore position limits, with disastrous results.

3. From a cold start, if the hoist homing event has occurred, but one or both crane and trolley homing events have not, the Anti-sway control codes should be restricted to either SUSPEND (code 0) or MANUAL ASSIST ONLY (code 3).

4. When first starting, the Anti-sway controller compares the position readings from the PLC with position readings stored when Anti-sway was last run. If these readings disagree, anti-sway will respond to the PLC with SUSPEND and the touch screen alerts will provide instructions for the operator.
About Internet Protocol (IP) Addresses

Read this chapter to understand what needs to be done to ensure all components of the SmartCrane system can communicate using their Ethernet connections.

The SmartCrane™ system communicates with the PLC and its SmartCamera using Ethernet (TCP/IP). The customer is responsible for assigning unique IP addresses compatible with its own network for the controller CPU, SmartCamera, and PLC or PLC gateway. The customer should supply those addresses to SmartCrane, LLC before the system is delivered.

It is important that all of the IP addresses in the local area network have the same numbers in the first three positions, indicating that all are in the same “subnetwork.” So, all must be a.b.c.n, where a, b, and c are the same for every address and all the n are different. The maximum value for n is 254 and the minimum value is usually 2 (1 is normally reserved for network routers).

If the customer does not provide any instructions, then SmartCrane LLC will assign default IP Addresses according to the following table. If the system(s) are later connected to a customer LAN/WAN, then IP addresses may have to be changed.

<table>
<thead>
<tr>
<th>Device</th>
<th>IP Address</th>
<th>Port #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
<td>10.0.1.21,22,23...</td>
<td>8901</td>
</tr>
<tr>
<td>Gateway</td>
<td>10.0.1.31,32,33...</td>
<td>2357</td>
</tr>
<tr>
<td>Camera</td>
<td>10.0.1.71,72,73...</td>
<td>7771</td>
</tr>
<tr>
<td>Wireless AP</td>
<td>10.0.1.11,12,13...</td>
<td></td>
</tr>
</tbody>
</table>
Changing The IP Address Of The Smartcrane Controller

To change the controller IP Address, connect a keyboard and mouse and log in as a user authorized to administer the computer (usernames and passwords are supplied separately for each customer).

Under the Apple menu, select “Location…Network Preferences…” In the left column, select Ethernet and on the right side select “Using DHCP with manual address” and enter the new IP address in the space provided. Then select AirPort and make sure AirPort is OFF, by pressing “Turn AirPort Off.”

Click “Apply” then close the System Preferences window using the red button.

Changing the IP Address of the Softing FG-100 Gateway

Some installations use a gateway to connect the SmartCrane controller to the PLC’s PROFIBUS™ network. To change the Softing FG-100 IP Address, connect a computer with an IP Address currently in the same sub-network as the FG-100. Launch a browser window to connect to http://x.x.x.x, where x.x.x.x is the FG-100 current IP Address. On the left, click on “Network Configuration” and then enter the password and the new IP Address.

Make sure the address is entered correctly (have a second person observe) and write it down. Changing the IP Address and then forgetting it may require returning the unit for factory repair.

Changing The IP Address Of The ANYBUS Gateway

<To be developed.> Refer to ANYBUS documentation.
Remote Access For Software Maintenance

If SmartCrane laboratory computers can access these devices remotely before commissioning, SmartCrane engineers can assist in pre-commissioning tests. For continuing support, that remote access can be made permanent or, if security restrictions require, at least available for temporary activation to diagnose questions or update software to newer versions. A representative of the customer’s IT department should contact SmartCrane, LLC to arrange this access.

The SmartCrane™ controller CPU comes pre-configured to support access by virtual private network (VPN) clients. Customer representatives may have any number of user accounts on the SmartCrane™ host. These accounts and access passwords may be arranged directly with SmartCrane, LLC.

A SmartCrane Monitor system, if purchased separately, can be installed on the customer’s network. It can access the SmartCrane™ host securely on a private access port, as long as the host is reachable. For maintenance and troubleshooting, SmartCrane, LLC can also gain secure access via the same private port. In order to ensure real-time performance of the antisway system, a maximum of three monitor systems may be connected at any one time.

1 The “super” user is always “smartcrane” and that password is available to SmartCrane employees only.
Setting Up a Replacement Computer

Read this chapter to understand how to install the SmartCrane software on a new computer not supplied by SmartCrane, LLC.

SmartCrane software will normally be installed on the computers when shipped. When first started, the anti-sway controller will automatically log in to an administrative account and the SmartCrane software will not start automatically.

Creating User Accounts

When building a new system for backup or operation, it is usually convenient to create two classes of user, one for routine operation and others for administration. SmartCrane will create three users, operator, administrator, and smartcrane. The smartcrane user has special privileges but the administrator account can perform any and all required system changes.

Create an account “operator” by selecting <Apple Menu> System Preferences...Accounts. Add an account “operator.” Set password to empty (no password). Un-check “Allow user to administer this computer.”

IMPORTANT: Do not do the following until you will actually place the computer in service. Unless the PLC Gateway is present, you do not want to run SmartCrane in live mode. To switch from live mode, edit SmartCraneInitx.txt and comment (#<space>) DEFINE_PLC.

To auto-start SmartCrane, login as operator and select <apple menu> System Preferences, Accounts. With “Operator” selected, click the Login Items tab. Click the + button to add one Login Item. Navigate to /Applications and select SmartCrane.app. From now on, when operator logs in, SmartCrane will start automatically.

Create another administrator account and supply the name and password to SmartCrane, LLC by email.
Setting System Preferences

At startup, the Mac Mini will try to find a mouse. When there is none connected by Universal Serial Bus (USB), it will search for a Bluetooth (wireless) mouse. This feature must be turned off. Select <Apple Menu> System Preferences…Bluetooth. Click Advanced and turn off all checkboxes.

The crane may power off completely during maintenance, or just routine down times. To make sure the SmartCrane computer operates when the power is turned on again, Select <Apple Menu> System Preferences…Energy Saver. Set the Sleep Option sliders to “Never” but turn on “Put the hard disk(s) to sleep when possible.” This will make sure the system is always alive but reduce long-term wear on the hard drive mechanisms.

Click Show All and select Desktop & Screen Saver. Click the Desktop tab and select your company’s logo from the Pictures Folder. Select Tile display.

Click the Screen Saver tab and move the Screen Saver slider to Never. The SmartCrane application has its own built-in screen saver feature that does not interfere with operations.

Click “Show All” and select Sharing. Enter a short name for this computer that starts with the company or installation name. Check only the following: Screen Sharing, File Sharing, Web Sharing, and Remote Login.

If this computer is on a Virtual Private Network, highlight Screen Sharing, click Computer Settings, Click VNC Viewers… and enter the VNC password.

Highlight File Sharing and click Options. Check ONLY Share Files and folders using AFP and SMB.

The dock will show at the bottom of the screen. Remove items by dragging them up into the desktop. Remove everything except Finder. Open a Finder window and navigate to /Applications. Select the SmartCrane application and drag it down to the dock. Its icon should now be visible. Repeat this procedure for the TextEdit application, which will be useful for editing the initialization file(s) in certain circumstances.

Navigate to /Applications/Utilities and find Terminal<.app> and drag its icon to the dock. It is useful for testing connectivity using the ping and Telnet functions.
Select <Apple menu> Dock and make the following selections. Turn Hiding Off, turn Magnification On, and Position on Bottom. Now the dock will always be visible and starting the SmartCrane application will be easy, with a single click.

In order to use the SmartCrane Web Interface, two files in the system will need to be changed. You can either change them using the Terminal and “vi” editor, or get new versions via email directly from SmartCrane LLC. Contact SmartCrane for instructions.

**Setting Up the Touch Screen**

The touch screen requires installation of a driver and calibration utilities. These are contained in an archive ELOSetup.zip or macxELO.sit. Open the archive (double-click to expand) and find three files: setup, UPDD Calibrate, and UPDD Console.

Attach the touch screen (both VGA and USB cables) and run (double-click) setup. You will need to enter the administrator password. The starting screen is shown below. You do not need to make any selection, as the program will detect the USB connection.

![UPDD Install](image)

Click “Install.” You will need to re-enter the password. You may have to restart the computer before and after the install process.

Run UPDD Console and select “Properties.” Using the down arrow, set “Liftoff time” to 0.

Then select “Calibration” and check the box “Confirm after calibration.” Make sure the number of points is set to 4. At the bottom left of the UPDD Console window, find a button marked “Calibrate.” Click this. You will see a white screen with a cross. As each cross appears in a different corner of the window, touch it with your finger (not the mouse). After four touches
Using SmartCrane Software During Commissioning

During commissioning it is more convenient to have access to the Operating System without SmartCrane running. In the touch panel screen, find the SmartCrane logo in the dock at the bottom of the screen. Touch the logo briefly and it will begin to bounce up and down; shortly, the SmartCrane screen will appear.

At the conclusion of the commissioning, Use Apple…System Preferences…Accounts to set up “operator” as the default account at startup. Do this by first “unlocking” the preferences using the padlock symbol in the lower left. An administrator password will be required. Then click Login Options and then set the “Automatic Login” pull-down menu to the “operator” account. This account will have no password set when the system is shipped, however the customer may assign a password. You will need to supply this password when setting Automatic Login.

Finally, Login as “operator” and choose Login Items. Make sure that only “SmartCrane” is in the list and it is not checked as “Hidden.”

Installing Smartcrane Software

To install software on a replacement computer, Login as an administrator then either copy a disk image from a DVD or portable hard drive (the easiest way) or manually copy files to their correct locations, then set up user accounts and preferences.

The following files are required:

/Applications/SmartCrane.app – this is the application program.

Required Directories and Files

To copy files to the correct directories, you will need to log out of operator and login as a user with Administrative privileges. Certain directories and files are needed for regular operation. Although SmartCrane installs these before shipment, the customer may wish to purchase a backup computer and prepare it for operation. The following directories and files are required:
license.txt - This file contains the coded license for use on one processor only. It must be present and it must not be changed. SmartCrane, LLC will supply a new file if the processor is replaced.

SmartCraneInit.txt - This file contains all the initialization data for this particular crane, as well as a statement of licensed use, which is displayed at the bottom of the screen. Details of the data in this file are given in Chapter 12.

safepoints.txt - This file contains the critical position data that defines the safe routes available for automatic moves. If you are installing a replacement processor, then you should copy this file from backup. If the file does not exist, the SmartCrane application will create one.

swingcorr-<n>.txt - In older systems, this file contains the swing period corrections for crane <n>. If you are installing a replacement processor, then you should copy this file from backup. If the file does not exist at startup, the SmartCrane program will prompt the user to begin the built-in automatic commissioning process. The systems are shipped with a null file with the same name for pre-commissioning purposes: this file has only three lines, each with a single “0.”

commissioningLog.txt – this file is created during the SmartCrane Automatic Commissioning process. See .

SmartHoistData<n>.txt – This file contains the tuning parameters for the SmartHoist™ feature, for crane <n>. This file is created by SmartCrane at installation (after data collection). There are no user adjustable data items in this file. If the file is not present, the SmartHoist™ feature is disabled.

IMPORTANT: If major changes are made to hoisting equipment such as re-cabling, the SmartHoist™ data collection process must be repeated and a new file created. Contact SmartCrane, LLC for assistance.

Other Directories and Files

The SmartCrane software also requires other directories to be in existence and you will need to create them. If they are not found on startup, the SmartCrane program will try to create them. This will only be possible if you are logged in as a user with administrative privileges (usually any account other than “operator”).

©Copyright 2009, 2010, 2011 by SmartCrane, LLC – All rights reserved
These are:

/Library/Application Support/SmartCrane/archive – this directory is where the system will store data needed for retrieval after a power cycle.

/Library/Logs/- This is a standard system directory, in which the program will create the following subdirectories.

CraneConfiguration/ - Includes the file SmartCraneInit.log, which records changes made to the SmartCraneInit.txt using the SmartCrane Web Interface (see Chapter 12). It will also contain the file CommissioningLog.txt, which contains critical data collected during the automatic commissioning process.

CraneOperation/ - For daily operational logs, organized in yearly directories and named by date.

CraneRecordings/ - By pressing and holding in the upper left display area, the operator can start and stop detailed recordings. Each recording interval is saved as a separate file in this directory.

DataCommunications/ - Contains daily logs of data communications events.

OperatorTouch/ - Contains daily logs of crane operator touch screen commands, as well as a record of steps accomplished by the program during startup.

These daily logs are recorded in .csv format (comma-separated values) and then compressed as zip files. These files can be easily uncompressed and loaded into a spreadsheet program for review, in case they are needed. These files cannot be changed or deleted from the system except by an administrator.

The SmartCrane control processor does not ship with a spreadsheet application, so one should copy the files to another computer capable of recognizing and opening files with the .csv suffix.
Testing Before Commissioning

Read this chapter to understand what needs to be done to test the components and cabling for proper operation, before commissioning.

It is important to ensure that the installers understand the requirements for installation and accomplish all the installation tasks before sending for the commissioning team. If one or more steps are missed or improperly taken, then the start of commissioning will be delayed until all steps are complete.

Testing The PLC Interface

Once the Ethernet connection (either directly or using FG100-PB gateway) is working properly from the PLC side, the SmartCrane controller should be powered up. When delivered, the SmartCrane controller will automatically start up logged into the user “operator” but the SmartCrane program will not start automatically.

Attach a keyboard to a USB port on the SmartCrane controller for initial testing. If the keyboard is for use in other than U.S. systems, there will be a delay before the keyboard is recognized. The system will ask for pressing certain keys to recognize the keyboard version.

Once the keyboard is recognized, click on “Terminal” in the dock of the SmartCrane screen. Type ping x.x.x.x where x.x.x.x is the IP Address of the FG100-PB or the PLC if connected directly. If there is no response, check all cabling and power until the ping is successful. Do not try any other testing until ping is successful.

Confirming Camera Operation

To confirm camera TCP/IP connection, connect any computer to the network, making sure its IP address is compatible with the SmartCrane subnetwork. In a command (terminal) window use the ping command to determine if the camera is alive and communicating.

The camera image can be viewed on any MS-Windows operating system platform connected to the same sub-network as the camera. Open a telnet session with the camera,
telnet <camera IP address><return>

When asked for password, just

<return>  Then,

vd -l<return>  ("l" is the lowercase L: this sets the video to live mode)

Img2bnew &<return>  (starts the image server).

Now run the program axclient on the Windows machine, enter the camera’s IP address, set the dimensions to 640 and 480, check the **Live Mode** button, and press **Get Image**. The camera image will appear on the Windows screen and update automatically. Adjust the shutter speed in the telnet session,

sh 2000<return>  (use a larger number to increase the exposure).

If the image is always black, check the installation to make sure the lens cap is off and that nothing is blocking the camera lens.

**Adjusting Focus and Aperture**

The camera is set to the correct focus and aperture at the factory. However, if the tape has been removed or the screw settings loosened, the adjustment will need to be repeated, as follows.

An assistant should manually adjust the aperture and focus until a sharp picture appears. For focusing, the aperture (iris) should be opened until the target is very clear and the focus adjusted for sharpness. Once a good focus is achieved, the focus set screw should be tightened.

Once the focus is set, then the aperture should be reduced until the contrast for most objects in the image is reduced but the SmartCrane black-and-white target is clearly visible. Tighten the aperture setscrew and put a small amount of epoxy adhesive at the base of each setscrew to prevent loosening. Wrap the entire circumference of the lens and lens mount with electrical tape, taking care not to block or smudge the lens.
Automatic Commissioning

Read this chapter to understand what needs to be done to commission a new SmartCrane™ system.

It is important to ensure that the installers understand the requirements for installation and accomplish all the installation tasks before sending for the commissioning team. If one or more steps are missed or improperly taken, then the start of commissioning will be delayed until all steps are complete.

A Preview of Automatic Commissioning

The basic steps of the automatic commissioning process are as follows.

Step 1: Check Communications With PLC.

Step 2: Check Input Values From PLC.

Step 3: Check Crane Motion Without Anti-Sway

Step 4: Register Crane To Home Position

Step 5: Operate Crane Without Anti-Sway In Auto Commissioning Mode.

Step 6: Confirm Obstacle Safe Points

Step 7: Enable Anti-Sway With Supervisor Code.

Antisway will not function until all steps are complete. However, in steps 3, 4, 5, and 6 below, anti-sway will apply S-curve smoothing to trolley (and crane) motion. Make sure S-curve in trolley (and crane) drive(s) is permanently disabled.

During every step of the Automatic Commissioning, the user has the option to restart that step by pressing the red “STOP” button once, or starting the entire process over at step 1 by pressing and holding the STOP button until it turns bright red.
Step 1 - Check Communications With PLC

The purpose of this step is to confirm the basic communications between PLC and anti-sway. Do this with PLC disconnected or crane stopped. Assign arbitrary values to PLC memory that can easily be checked byte by byte on the SmartCrane screen. In this mode, Smartcrane output bytes will correspond to 01, 02, 03, etc., in byte order, obviously having no relationship to real demand values. The SmartCrane touch screen Plan View panel will be replaced with the following screen to enable the byte-by-byte checking:

When the check is complete, confirm by pressing and holding the green “GO” button until it turns bright green, then release it. Step one is now recorded and the instructions screen will appear, showing your progress:

Step 2 - Check Inputs From Plc

In this step, now that step 1 has confirmed that byte values are passed correctly, the program helps to check the real value of inputs from plc (still with crane stopped). Examine each item in PLC data panel to ensure all data are correctly received. With direct access to the PLC, set each value, including stop bits and ready bits, to known values, one at a time. Examine the values in the blue panel in the center of the screen:
At the bottom of the screen, the program keeps track of the number of times each of the important PLC input data elements have changed.

When all of the elements have changed at least once, the display will indicate that the operator can confirm this step by pressing and holding the green GO button. The instruction screen will again appear.

**Step 3 - Check Crane Motion Without Anti-Sway**

In this step, the PLC must be connected to the crane and the crane running. The operator must make small movements in trolley (and crane) directions, just to ensure crane responds in the correct directions (no sign errors).
The yellow panel at the bottom indicates when each direction has been tested. As the crane moves, the direction requested by the anti-sway and the direction the crane moved, will be shown by arrows adjacent to the trolley symbol in the Plan View.

As before, once the crane has actually moved in each direction, the operator will be allowed to confirm by pressing and holding the green GO button.

**Step 4 - Register Crane To Home Position**

In this step, the encoder position values received from the PLC must be registered to a known physical location for the crane. When prompted, the operator should move the crane to the predetermined home position. This is usually with the crane/bridge at its end of rail or beam, or aligned to a fixed platform, with trolley at an end position closest to the operator cab, and with hoist at highest position. The XYZ values of this home position are set in SmartCrane coordinates, in the initialization file (see Chapter 12).

When the trolley is in this position, all of the stop limit switch values should be zero and the crane should not move any farther in any direction. The Automatic Commissioning software will detect this condition and, when there, the operator should press and hold the go button as prompted.

**Step 5 - Operate In Auto Commissioning Mode**

In this step, the operator will move the crane, without anti-sway, in auto commissioning mode. In this mode, the anti-sway program will collect the data it needs to fine tune its parameters to this particular crane. It will look for maximum and minimum speeds, accelerations, and travel in all dimensions. It will also use the camera to measure swing timing at all hoist heights and all load conditions.

It is important to operate at all extremes of the crane’s capabilities, even doing so artificially, until the data collection requirements are satisfied. The Auto Commissioning data panel will indicate what crane motions have been recorded, and will show the original values, the number of observations, and the current estimated value. This panel overlays the Plan View window and may be closed by pressing the red box with “X.” It can be reopened using the PAGE button.
The data collection tracking panel shows which data items are monitored and the number of additional observations needed. When an item no longer needs to be observed, it will not appear in this panel. When no more items appear, the operator will be prompted to confirm by pressing and holding the green GO button.

### Step 6 - Confirm Obstacle Safe Points

If there are obstacles in the initialization file, the associated “safe points” will be used to develop optimal paths of the crane around the obstacles. Before commissioning, the anti-sway program uses the safe distance values supplied by the user. During this commissioning step, the operator has an opportunity to adjust those safe points to supply the needed safety distances for the real crane.

The danger zones around them will now turn red and the corners of the zones will become available for editing.
Follow the instructions on the screen to make and save changes.

**STEP 6: CONFIRM OBSTACLE SAFE POINTS**

During this step, you may adjust any or all of the safe points displayed for automatic routing around obstacles. Each safe point is a candidate for being part of an automatic route to a new destination, so be sure there is sufficient safety margin, accounting for the size of the spreader and largest load.

Select a safe point to edit by pressing the page button. When a point is highlighted by a circle you can move it in either of two ways:

1. Drag it on the screen or touch the direction arrows at the edge of the view, or
2. Move the crane to the desired safe location then the press and hold the page button. Press the page button again to select a different safe point at any time.

---

**Step 7 - Enable Anti-Sway With Supervisor Code**

After all steps are complete, a supervisor will enable anti-sway with a special code, entered using the numbered buttons at the bottom of the screen. SmartCrane LLC will supply this code to a responsible person. Once this code is entered, anti-sway will be activated.

**SmartHoist™ Calibration**

The SmartHoist™ feature compares readings from the PLC to data profiles created from actual lift data, in order to alert or stop hoisting when lift conditions are abnormal. Because it is a statistical feature, multiple lift events must be recorded.

The procedure for collecting data for the SmartHoist™ feature is as follows.

1. Begin a data recording by switching to the plot window then touch and hold until the recording alert appears. Then switch to the PLC input screen where load values appear.

2. Lower an empty lifting device to the floor or ground, taking care not to topple pulleys or unrevee cables. Slowly lift the device until it is off the ground, and lower again. Do this 4-5 times.

3. Lift a light load then lower it to the ground or floor carefully as before. Slowly lift until the load begins to move, and lower again. Do this 4-5 times.

4. Repeat step 3 with a heavy load.

5. Attach any load using only one hook, one set of tongs, or fewer than 3 twistlocks (foul lift). Heavy or light loads will do, because you will not move the load in this step. Hoist up very slowly until the load value begins to change in the SmartCrane PLC.
output screen. DO NOT MOVE THE LOAD. Hoist down again until the tension is released and then hoist up slowly again. Repeat this 4-5 times.

(6) Tong cranes only: attach a long slab near its end, so it is off balance. Lift until one end comes off the floor or ground. Set the load down again. Repeat 4-5 times.

(7) Turn off the recording using the plot window. Copy the recording zip file and email to support@smartcrane.com.

SmartCrane will send a new profile file SmartHoistData<n>.txt that must be copied into /Library/Application Support/SmartCrane/. Once this file is present, the SmartHoist™ feature will be automatically enabled.
Operational Testing

Read this chapter to understand how to perform tests on a newly-commissioned SmartCrane™ system.

Once the commissioning phase is complete and Anti-sway is operational, it is important to make a few tests to ensure that all parts of the Anti-sway system are working correctly.

Important Precautions

During these initial tests, it is important to recognize that, if some important step has been omitted or conducted badly, or if some data in the initialization file or commissioning log are not correct, the crane could respond poorly or even dangerously. Take the following precautions:

- Move all people away from the operating area of the crane.
- Hoist the crane hook or spreader to a height above any surrounding objects.
- Have a safety observer in the crane who is familiar with Anti-sway and who has access to emergency stop controls.
- Ensure all persons in the cab have seat belts or secure handholds.
- Always begin a new crane recording before each step and stop the recording at the end of the step. Recordings are controlled by pressing and holding in the upper left window. Write down the recording number for each step.
Testing Manual Anti-Sway Moves

These procedures can also be used to demonstrate the anti-sway capabilities to the customer.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Short Manual Move</td>
<td>Turn on anti-sway. Move the trolley stick a very short distance (~1 meter) and release the stick. The trolley should respond to the first motion and then move a second time to catch sway. Do this separately for trolley and crane directions.</td>
</tr>
<tr>
<td>Suspend</td>
<td>Repeat the short manual move but immediately after releasing the stick, press the Suspend button or foot pedal. The second motion should not happen and there will be sway. Do this separately for trolley and crane directions.</td>
</tr>
<tr>
<td>Slow Manual Move</td>
<td>Move the trolley slowly 5-10 meters and release the stick at the end. The anti-sway should continue the move a small distance to catch the sway. Do this separately for trolley and crane directions.</td>
</tr>
<tr>
<td>Fast Manual Move</td>
<td>Repeat the 5-10-meter move at full stick. The anti-sway should continue the move a longer distance to catch the sway.</td>
</tr>
<tr>
<td>Trap Stationary (Quay Cranes only)</td>
<td>While depressing the suspend switch, move the trolley to induce sway of ± 1/2 meter. Release the suspend switch and press the Trap switch to capture spreader position by the camera. The anti-sway will move the trolley once or twice both to catch the sway and trolley the trolley directly over the captured spreader position.</td>
</tr>
<tr>
<td>Trap Moving (Quay Cranes only)</td>
<td>Start a manual move with Anti-sway on. Release the trolley stick and press the Trap switch before the Anti-sway has finished its move. The trolley should reverse direction and return to the position at which the Trap switch was pressed, without significant sway.</td>
</tr>
<tr>
<td>Slow-down Zone</td>
<td>There are limitations placed on operations near the ends of the motion in both directions. Move the trolley close to the stops (&lt;2 meters) and repeat Short Manual Move.</td>
</tr>
</tbody>
</table>
Testing Automatic Anti-Sway Moves

This series of tests validates the automatic move features.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Move to Shore (Quay Cranes Only)</td>
<td>Turn Anti-sway to AUTOMATIC. Hoist up to ship stack level and move the trolley outside the sill beam. Press the appropriate button to select one of the shore lanes. Press and hold the GO button. The trolley should return to the shore location and adjust the position to remove the sway. (With automatic hoist cranes, the hoist will automatically commence lowering upon crossing the sill beam and stop at a safe height above the pier.)</td>
</tr>
<tr>
<td>Automatic Move to Ship (Quay Cranes Only)</td>
<td>Press one of the ship stack buttons. Begin hoisting, if that is required at this installation. The automatic hoist should begin at slow speed and then accelerate. When the Anti-sway predicts that the spreader will be at the designated safe height for clearing the ship, the trolley will begin moving to full speed with ramps.</td>
</tr>
<tr>
<td>Simple Automatic Moves (Other than Quay Crane)</td>
<td>Select a destination that does not require obstacle avoidance, a short distance from the current crane position. Start an automatic move. If automatic hoist is enabled, check that the spreader is hoisted to the correct START height. Check that the center of the trolley symbol on the screen follows the straight-line path to the destination.</td>
</tr>
<tr>
<td>Obstacle Avoidance</td>
<td>Select a destination on the touch screen that requires maneuver around one obstacle. Check the path to ensure the obstacle is avoided. Begin the automatic move and monitor the trolley symbol to see that it follows the intended path.</td>
</tr>
<tr>
<td>Stick Interrupts Automatic Move</td>
<td>Repeat any Automatic Move, but once the crane reaches full speed, take control by moving the trolley stick. The trolley should begin to respond to operator actions and when the stick is finally released, the trolley should come to a stop without sway.</td>
</tr>
<tr>
<td>Suspend Automatic Move</td>
<td>Repeat any Automatic Move, but as soon as the trolley begins to move, press the Suspend switch. The trolley should immediately stop but there will be sway. In a Quay Crane, use the Trap switch to cancel this sway.</td>
</tr>
<tr>
<td>Suspend Hoist Control</td>
<td>Repeat any Automatic Move but during the hoist phase, move the operator hoist control. Once moved, no further automatic hoist should occur.</td>
</tr>
<tr>
<td>Change Destinations</td>
<td>Repeat any Automatic Move. While the move is still underway, select a new destination by touching the Plan View or a destination button. Press and hold the green GO button. The crane should smoothly change to a new velocity and proceed, without sway, to the new destination.</td>
</tr>
</tbody>
</table>
Testing SmartHoist™ Feature

This series of tests validates the ability of the SmartHoist™ feature of the SmartCrane software to detect a foul lift and prevent hoisting almost instantly.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Procedure</th>
</tr>
</thead>
</table>
| Testing with Ladle Crane        | Load a ladle furnace with cold material. Deliberately connect only one hook to the ladle and take a strain by hoisting, using full hoist up demand.  
                                | The actual hoisting should be very slow and should stop before the ladle moves. Any connected alarms should activate.                         |
| Testing with Slab Crane         | Deliberately connect only one set of tongs to a slab and take a strain by hoisting, using full hoist up demand.                             
                                | The hoisting should be very slow and should stop before the slab moves. Any connected alarms should activate.                               |
| Testing with Slab Crane         | Deliberately connect the tongs off balance to one end of a slab and take a strain by hoisting, using full hoist up demand.               
                                | The hoisting should be very slow and should stop before the off balance end of the slab leaves the floor or ground. Any connected alarms should activate. |
| Testing with Coil Crane         | Deliberately connect only one of the tongs to a coil and take a strain by hoisting, using full hoist up demand.                          
                                | The hoisting should be very slow and should stop before the coil moves. Any connected alarms should activate.                          |
| Testing with Container Crane    | Deliberately connect to a loaded container with only two twistlocks at one end. Take a strain with full hoist up command.            
                                | The hoisting should be very slow and should stop before the container leaves its starting position. Any connected alarms should activate. |
Editing Required Files

Read this chapter to understand how to edit or update files that control the operation of the SmartCrane™ anti-sway system.

The SmartCrane software executes on a Macintosh “Mini” computer, with Ethernet connections to PLC and SmartCamera if needed. The files required for proper operation are as follows. Standard UNIX directory structure applies: paths beginning with “/” begin at the root directory.

Controller Files You Can Update But Not Change

These files are required for SmartCrane proper operation but you should not attempt to modify them in any way.

SmartCrane.app – This is the main application program residing in /Applications/. Download revisions, when available, from http://www.smartcrane.com/downloads/. You will need a password.

license.txt – This is a text file residing in /Library/Application Support/SmartCrane/. A different file is required for each license purchased. It will work only with the computer for which it was created. Do not make any changes in this file.

Safepointsx.txt (where x is a number containing one or more digits) is a text file residing in /Library/Application Support/SmartCrane/. This file is created automatically during the safe point process described in Chapter 10. If this file is renamed or moved, the SmartCrane program will create a new version when next run. Do not try to make changes in this file.

Commissioning Log

CommissioningLog.txt – This is a text file residing in /Library/Logs/CraneConfiguration/. If this file is not present the program will always start in automatic commissioning mode, step 1. Only make changes to this file if advised by SmartCrane personnel.
Initialization File

SmartCraneInit.txt is a text file residing in /Library/Application Support/SmartCrane/. This file contains all the important configuration values for the customer site and the crane(s) to be controlled. Data sections begin with special keywords in capital letters with underscores, followed by data elements separated by spaces. Data elements may follow in succeeding new lines if desired.

Web-Based Editing

Data in this file can be managed using a web browser on any computer connected to the same network as the SmartCrane host. Simply enter the IP address of the SmartCrane machine in the browser URL window, e.g., http://10.0.1.10. The page below will appear.

Web-Based Configuration Manager

Instructions

Use your browser to make configuration changes to SmartCrane™ anti-sway crane controller on this host.

The Categories page allows you to choose from among the categories of data that can be modified using this web interface. At the bottom of this page, you will see a list of pending changes you have created during this session.

When you select a category, the Category Data page appears showing all the data elements in that category along with their original values. Consult the Categories page if you are unsure of what you may have changed.

To change an item in the list you must enter the new value and press Change.

Start the process by pressing Make Backup. This will make a backup will allow you to discard all changes and repair to the backup, at any time during the process, until you finally press Save Changes.

The first step is to click the Make Backup button. This creates a backup copy of SmartCraneInit.txt that you can use at any time to recover from mistakes in entry.
Once the backup has been completed, the following message will appear. There may also be warning messages about SmartCraneInit.changes file: you may ignore these warnings.

Backup of /Library/Application Support/SmartCrane/SmartCraneInit.txt was successful.
Any previous changes not saved are now discarded.
You can restore the previous values whenever you see the Discard Changes button.

Press the Categories button to continue.

Pressing Categories will bring up the Categories page where you can select the kind of data you wish to view or edit.

<table>
<thead>
<tr>
<th>Records</th>
<th>Category</th>
<th>Update/Add New</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DEFINE_YARD</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NEW_CRANE_TYPE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>COORDINATE_TRANSFORM</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NEW_CRANE</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CRANE</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DEFINE_CONTAINER</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CONTAINER_SHIPPING</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CONTAINER_UPDATE</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>SAVED_DESTINATION</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>DEFINE_OBJECT</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>DEFINE_OBSTACLE</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>PILLAR</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DEFINE_CAMERA</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>DEFINE_FG100</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DEFINE_MODBUS</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>DEFINE_REMOTE_CRANE</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>DEFINE_FOOTSWITCH</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DISPLAY_STACK</td>
<td></td>
</tr>
</tbody>
</table>
Descriptions of these categories are given in the table at the end of this chapter. If there are no records in a given category you will have the option to “Add New.” Otherwise, to make changes, click “Update.”

The following is an example page for editing the New Crane category. The first column defines each item in this category, the current values are in boxes, and more explanations are shown to the right.

Suppose we want to change the name of this crane. Type SD16NEW in the name field and press Edit. A confirmation screen will appear as follows:

If this is correct, then simply touch the BACK button on your browser and the category page will appear again, with the new (temporary) values. However, if you press Categories again, and click Update New Crane, the original values will still appear (but your changes are still saved). Now press Apply Changes and the following confirmation will appear:
This shows all the changes that have been made to the SmartCraneInit.txt file during this browser session. You may continue to make changes by pressing Categories again, you may review the changes made so far by pressing Review Log, or you may cancel all changes made during this session by pressing Restore Backup.

CAUTION: Some data elements in the initialization file are replaced by new values during the Automatic Commissioning process. You can update these values in the initialization file later, but the Anti-sway program will always use the values in the CommissioningLog.txt file. You may edit the CommissioningLog.txt values but you should get assistance from SmartCrane LLC to do so.

Categories in the Initialization File

The following table explains the categories of data in the initialization file.

<table>
<thead>
<tr>
<th>Category</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFINE YARD</td>
<td>Defines the general layout of the work space under and around the crane.</td>
</tr>
<tr>
<td>NEW CRANE TYPE</td>
<td>Defines the general capabilities and behavior of a specific type of crane.</td>
</tr>
<tr>
<td>COORDINATE TRANSFORM</td>
<td>Defines conversion parameters between user/PLC measurement system and SmartCrane standard measurement system.</td>
</tr>
<tr>
<td>NEW CRANE</td>
<td>Defines a new instance of a crane type as previously defined. All cranes created here will appear on the SmartCrane display.</td>
</tr>
<tr>
<td>CRANE</td>
<td>Gives the current status of one individual crane, including a number of tuning parameters.</td>
</tr>
<tr>
<td>DEFINE CONTAINER</td>
<td>Defines one load, such as a shipping container, ladle, slab, or coil, including shape and size.</td>
</tr>
<tr>
<td>CONTAINER SHIPPING</td>
<td>For shipping containers, defines location and position aboard one or more container ships.</td>
</tr>
<tr>
<td><strong>CONTAINER UPDATE</strong></td>
<td>Gives the latest position and status of one container.</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td><strong>SAVED DESTINATION</strong></td>
<td>Provides position and title for one saved destination. These cannot be changed by the operator.</td>
</tr>
<tr>
<td><strong>DEFINE OBJECT</strong></td>
<td>Defines position and size of an object, associated with a saved destination, to be displayed on the screen. This can also define a height to be used for an automatic move to the destination.</td>
</tr>
<tr>
<td><strong>DEFINE OBSTACLE</strong></td>
<td>Defines position, shape and size of an obstacle that must either be moved over or around when executing automatic moves.</td>
</tr>
<tr>
<td><strong>PILLAR</strong></td>
<td>Defines a pillar-shaped object for display with overhead cranes.</td>
</tr>
<tr>
<td><strong>DEFINE CAMERA</strong></td>
<td>Defines network access and configuration parameters for a SmartCamera for measuring residual sway.</td>
</tr>
<tr>
<td><strong>DEFINE FG100</strong></td>
<td>Defines network access and parameters for a PROFIBUS to Ethernet Gateway.</td>
</tr>
<tr>
<td><strong>DEFINE MODBUS</strong></td>
<td>Defines network access and parameters for a Gateway that converts any PLC data bus to Ethernet MODBUS TCP.</td>
</tr>
<tr>
<td><strong>DEFINE REMOTE CRANE</strong></td>
<td>Defines the Ethernet access for monitoring other cranes in the system.</td>
</tr>
<tr>
<td><strong>DEFINE FOOTSWITCH</strong></td>
<td>Defines the uses of signals from a USB footswitch connected directly to the SmartCrane Anti-sway controller.</td>
</tr>
<tr>
<td><strong>DISPLAY STACK</strong></td>
<td>Defines an XY coordinate system used by the customer to arrange containers (loads) in rows and columns under the crane.</td>
</tr>
</tbody>
</table>
Read this chapter to understand what needs to be done to manage and maintain your SmartCrane™ system.

Once the system is installed and tested, there should be little that needs to be done to keep it going.

**Routine Camera Maintenance**

If a camera is installed, it will be necessary to inspect and clean the “reflector” target on the spreader regularly. A visual inspection from above will suffice: if the white part of the target still looks white everywhere, then no action is required. If has large grease spots or appears grey, then cleaning is required. At the same time you should clean off the outside glass of the camera enclosure.

Once a year you should open the camera enclosure and inspect it for signs of damage and check the inside of the glass for buildup of dirt. Clean the glass gently, being careful not to disturb the lens of the camera. If needed, you can remove the camera from the enclosure by loosening the screws holding the metal sled to which the camera is attached. Once the sled is loose, remove the two cable connections by pulling gently on the connector sleeves. The sled and camera together can then be removed for cleaning.

Should a camera need replacement, remove the two screws from the bottom of the sled and remove the camera.

**Using Engineering Mode**

An administrator may perform certain functions by entering “Engineering Mode.” Enter the administrator’s code (supplied separately) by pressing the saved destination buttons on the screen in a certain order.
When the SmartCrane computer is turned on, it will automatically login as operator and the SmartCrane anti-sway crane control program will begin automatically. In order to perform other computer function, the administrator must press and hold the LOGOUT button, shown here. If not already in Engineering Mode, the user must enter the administrator’s code.

Identifying Cargo Numbers. In Engineering Mode, a supervisor can remove all cargo symbols from the screen by entering a special code and then pressing and holding the PAGE button.

Extra Display Pages. In Engineering Mode, pressing the PAGE button will provide access to a number of pages not normally available to an operator.

To exit Engineering Mode, press and release the LOGOUT button.

Managing Obstacle Avoidance

In case there are obstacles that the crane/trolley needs to avoid, an administrator has the option to include the dimensions of these obstacles in the input data file along with safe clearance distance (see Chapter 12). The SmartCrane™ system avoids obstacles by creating safety zones around the obstacles and then steering the spreader in a path that may include one or more safety zone corners.

When an administrator first enters Engineering Mode, the SmartCrane software presents a special view of these safety zones, as shown below.
The SmartCrane program will create these zones automatically at the first startup, and during commissioning provides an opportunity to adjust these safe zones (see Chapter 10). While these zones are showing, you can change them by selecting corners and moving them on the screen.

To select a different corner, press the PAGE button. A new corner will be highlighted and its number will also appear.

The program enforces certain restrictions on moving these corners. First, moving a corner cannot expose any part of the original obstacle outside of the safety zone. Second, the operator cannot move a corner of one safety zone into another safety zone.

However, the system will allow a corner to be move such that two safety zones overlap. This is permitted, however it may prevent certain moves from being executed, as there is no path from origin to destination. If this occurs, the system will give the operator another opportunity to correct the layout by adjusting corners again.

When all adjustments are complete or none are needed, the operator presses the GO button and the system removes the safety zones from the display and saves the current results to disk. If you want to cancel all adjustments, press the STOP button and start over.

**Administering the SmartCrane™ Controller CPU**

User Accounts. The SmartCrane computer system uses Apple MAC OS, which is based on UNIX. When delivered, the system will have several accounts established, including at least “SmartCrane” and “Operator.” The SmartCrane account is not available to customers and the operator account (which has no password) will not have administrator privileges. Besides these accounts the system will have one or more other users with administrator privileges, required for making changes and copying or moving files.
To change to another user, the SmartCrane software must be stopped, using the logout button as above. The user may wish to gain keyboard and mouse access to the computer by attaching a USB keyboard and USB mouse to the USB ports on the computer.

Alternatively, if you have another computer you may gain remote access by connecting an Ethernet cable to the Ethernet hub (or from any computer on the customer network, if the crane is connected) and then using the Screen Sharing option. You must first set the remote computer’s IP Address to match the subnet.

Under normal conditions, a remote user cannot operate the SmartCrane screen. In order to gain access and make system changes, the SmartCrane program will need to be shut down either directly from the user screen, or remotely using either of these methods.

**Shutting Down The Smartcrane Program Remotely**

There are two methods for shutting down the SmartCrane program from a remote location. The first is screen sharing, if you have access to another Apple Macintosh computer. The second uses a command-line program to perform a remote login.

From another Mac computer on the network, start screen sharing with the SmartCrane computer. When the window appears, hold the command key and press TAB one or more times until “Finder” is selected in the SmartCrane window.

Now you can use the Apple Menu to Log Out Operator, or Quit the application identified by the SmartCrane logo. You can also press and hold the SmartCrane icon in the Dock and the bottom of the screen and select “Quit” (if the program is running normally) or “Force Quit” if it has locked up for some reason.

From any computer on the network, access a command line window (in Windows, use Command Prompt, in Macintosh use Terminal). Make sure the SmartCrane computer is reachable by typing ping x.x.x.x (where x are the numbers in the assigned IP address).
If the computer responds, then type `ssh -l <username> x.x.x.x`. The system will prompt for a password and may ask for a confirmation. Enter the password and/or respond by typing yes. This will log you into the SmartCrane computer as `<username>.

Find the process ID of the SmartCrane program by typing `ps -elf`. In the response, look for a process named `Leroy Somer` or `SmartCrane`. The process ID is the second number in that line.

Stop the program by typing `sudo kill -9 <process ID>`. The system will prompt for a password. Once the password is entered, the SmartCrane program will stop and the screen will be available for remote access.

Now under the Apple Menu, select Log Out `<operator>...` and a new login screen will appear. Select an administrative user account and enter the password. Now you may edit, move, copy, or delete files as needed.

You may copy files to a blank CD or DVD by inserting the media into the disk slot and then copy/paste the files. Then select “Burn” and eject the disk. After checking that the disk has the data using a separate computer, you may delete files on the SmartCrane computer.

If you connect using another Macintosh computer, you may copy and move files using the file sharing option. If you have a Windows computer you can use your Network Neighborhood to view the shared folders.

**Updating the SmartCrane Program**

First exit the SmartCrane program as detailed above. Then make a duplicate (just in case) of the existing copy of SmartCrane.app, using the File…Duplicate menu. Then copy the new version of SmartCrane.app to the folder `/Applications/` and (if supplied) the new version of SmartCraneInit.txt to the folder `/Library/Application Support/SmartCrane/`.

If you can connect remotely using file sharing that is the easiest way. Otherwise, copy the new files to a USB thumb drive and connect it to one of the USB ports. You can perform all the copying tasks without a mouse or keyboard, just by using the touch screen. Or, if you prefer, you can connect any USB mouse and use it to drag and drop the files.
Managing the SmartCamera™ System

You can access the SmartCamera™ system from any computer on the local area network. First, ping x.x.x.x to make sure it is powered up and responding. If it does not respond, ping another node on the network such as the SmartCrane™ controller to make sure your connection is good. If other nodes respond but the camera does not, switch the camera on then off. If it still does not respond, check the cable connections. As a last resort, open the enclosure and check the wiring connections there. If the hub is operating, plug in a separate Ethernet cable there. If you still cannot access the camera, it will need to be replaced.

Once the camera responds, connect using Telnet from the command line, or by using any suitable terminal program like ProComm, HyperTerminal or TeraTerm.

Cameras also support FTP standard commands SYSTEM, PWD, CWD, LIST, DEL) and direct access to the MMC / SD via FTP (from VCRT 5.18.). File up- and download is possible using a standard FTP client. From a Windows command line:

telnet x.x.x.x <return>

The camera will respond by asking for a password. There is none, so just hit <return>. Now you should see data appearing on the telnet window. To interrupt the program, type “q”.

Now you will have access to the camera’s shell, in which you may enter commands. Descriptions of all the shell commands may be obtained by typing “help <return> “ in the shell. The following table gives some important shell commands. Each must be followed by <return>.

<table>
<thead>
<tr>
<th>Function</th>
<th>Keyboard Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uploading of programs from PC to camera flash memory</td>
<td>$lo (and then activating the upload function of the terminal program).</td>
</tr>
<tr>
<td>Program execution (SmartCamera™). You will need to do this if you’ve stopped the tracking program.</td>
<td>$new</td>
</tr>
<tr>
<td>Display the File Directory on fd (md)</td>
<td>$dir  ($dir md:/)</td>
</tr>
<tr>
<td>Delete Files (from directory content)</td>
<td>$del myfile</td>
</tr>
<tr>
<td>Packing the EPROM (freeing memory of deleted files: you should do this after every</td>
<td>$pk</td>
</tr>
<tr>
<td>software update)</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Turn video output to live (or still) mode. Do this when you want to use the image server</td>
<td>$vd -l (vd –d)</td>
</tr>
<tr>
<td>Check Camera OS version</td>
<td>$ver</td>
</tr>
<tr>
<td>Change the shutter interval</td>
<td>$sh &lt;number between 100 and 100000&gt;</td>
</tr>
<tr>
<td>Start the image server as background task</td>
<td>$img2bnew &amp;</td>
</tr>
</tbody>
</table>

To start the tracking program again, type “new <return>.” This time, the program will generate a network error and will reset itself, after which the program will be running from AUTOEXEC, but the Telnet connection will terminate.

To exit the Telnet connection, use command-] (this may not be the same key on a non-U.S. keyboard: try the second key from the right in the row above the return key). At the “Telnet->” prompt, type quit. Or you can just close the command line window.

### Updating Software on the SmartCamera™

SmartCrane LLC will supply two versions of a software update compressed as smartcamera.zip. Double-click to access the two versions, new.out and new.msf. The version you need to use depends on whether you use the camera shell (new.msf) or an FTP client (new.out). A second program kron.out also needs to be uploaded if a new version is supplied or if installing camera software for the first time.

After each update, it is a good idea to pack the flash memory, using the shell command “pk <return>”.

### Updating Camera Software Using An FTP Client

File upload is possible using a standard FTP client. Cameras support FTP standard commands SYSTEM, PWD, CWD, LIST, DEL. An inexpensive FTP client is “Total Commander” which can be downloaded at [http://www.ghisler.com](http://www.ghisler.com).

Make the connection to the IP address using the FTP client and change to directory fd.

Using Total Commander or another visual FTP program, open the directory containing new.out and drag it to the camera fd directory window.
From a UNIX or Mac OS Terminal window using the standard command-line FTP client, first navigate to the directory on your PC containing your new software. Then type ftp x.x.x.x to start an ftp session and type bin <return> to set binary mode. Change camera directory to fp then upload new.out ("put new.out <return>"). Exit ftp by typing "bye".

**Updating Camera Software Using The Shell**

The shell command “lo” is used for uploading “*.msf” files to the camera. Msf files, or Motorola S-Record files are a file format chosen for safer serial and Telnet file transmission, including checksums. Note that ONLY *.msf files can be uploaded via RS232 or Telnet.

This description uses TeraTerm as an example program. Other programs have similar if not exact duplicate functions.

1. At TeraTerm start up select “TCP/IP” and “Telnet” and specify the camera IP address (shown at startup video output). The default IP address is 192.168.0.65 as shown.

2. Confirm your input selecting “OK”

3. The TeraTerm window asks for a password (Telnet feature). Password input is not required – confirm with <return>.

4. The camera welcome prompt is displayed including the OS version number and the $ prompt. The camera shell is now accessible.

5. Type “$lo” followed by <return>. Calling the shell command “lo” without parameter activates the file upload. The camera sends “start address for file: xxxxxxx” and waits for activation of the terminal upload function (program specific).

6. In TeraTerm, select “Send File” under the “File” menu and browse for the new.msf file to upload.

7. When you are done uploading, type “pk” to pack the flash memory.

**How To Tell If Your System Is Working Properly**

In all cases, either with or without load sway feedback, the SmartCrane™ Anti-sway will prevent induced sway caused by trolley motion. It does so by modulating both stick demands from an operator and goal-seeking velocity demands from its automatic move algorithm. The modulations are based solely on the input demands themselves, the output demands (limited by maximum acceleration and other parameters), and hoist length.

In the no-feedback (or open loop) mode, the SmartCrane™ Anti-sway only operates one move at a time. Once the operator has set the trolley stick to zero and the Anti-sway finally sends
a “move complete” indication, the system assumes that residual sway is zero and will remain at zero until the next move. If there is any sway at the beginning of a move, the SmartCrane™ Anti-sway will preserve that sway at the move’s end, in the absence of any external measurement.

In open loop, the accuracies of the input data and the fidelity with which the crane drives respond to speed demands both limit the performance of the SmartCrane™ Anti-sway. Any difference between the speed demands sent by the Anti-sway and the speeds actually achieved by the trolley will be reflected directly in residual sway at the end of the move. Similarly, any bias or error in input of hoist length will also have a direct impact on the residual sway.

With perfect crane response and hoist length measurement, the SmartCrane™ Anti-sway with open loop should be expected to limit the sway to less than +/- 10 cm over a 10- to 20-meter move at the same hoist length.

The open loop performance is limited only by the crane drive’s ability to maintain absolute speed control in response to the anti-sway’s demands. If there is any lag in trolley speed response or a small bias in hoist measurement, that terminal sway may be greater. With large biases or errors in hoist length, the anti-sway modulations based on those measurements may actually increase the residual sway.

The open loop performance also relies on the ability to predict swing period based on hoist length. In multiple-rope suspension, that is best accomplished when all ropes are vertical. If the suspension ropes are installed at angles (for mechanical sway damping), then the swing period estimates will be inaccurate and anti-sway performance will suffer. On-site measurement of swing periods at different hoist lengths is always required.

The closed-loop (feedback) mode using the optional SmartCamera™ is a supplement to, and not a replacement for, the open loop sway control. Open loop works as always, but using the camera measurements the SmartCrane™ Anti-Sway can adjust to adjust the trolley position to remove small residual sway. This correction process works best at the end of a move and will continue until the customer specifications for sway reduction are met, or until a certain time limit has expired. Depending on trolley response to small adjustments, maximum sway specifications can be set as small as +/- 1 cm.

The SmartCrane™ automatic move accuracy is limited only by (1) the sensors used to determine trolley position and (2) response of trolley motors to very small speed demands.
Tuning For Best Operational Results

In addition to the maximum sway specification, the Anti-Sway software maintains a target destination dead band that can be set to customer requirements.

It is operationally important to set the desired sway reduction no smaller than the smallest practical error in trolley positioning, to allow the operator an opportunity to "hit the target" by eye every time, using only the hoist control.

The diagram to the right illustrates this. If the trolley stops anywhere in the dead band, even at its boundaries “A” or “B,” it is important that there be enough residual sway to allow the operator to set the container exactly at the target, “C,” by timing the final lowering.

For best performance we recommend customers set both the dead band error and maximum sway to the same value, usually +/- 10 cm.

For fully automatic operation (where there is no operator), the anti-sway software will determine the stopping dead band.

For best performance, the anti-sway software must either control hoist or have a message from the PLC that tells the target hoist length and the distance from the target at which the lowering will begin.

Routine Troubleshooting

While the SmartCrane™ controller CPU and SmartCamera™ should work continuously, they are electronic devices and have random-access memory that is subject to temporary corruption from electrical interference and other effects.

Should the SmartCrane™ program on the controller CPU exit for any reason, the background screen and “Dock” at the bottom of the screen will be showing. In this case, simply pressing the SmartCrane™ icon in the Dock will restart the program.

Should the SmartCrane™ program “lock up” for any reason, the screen will stop updating. There are two things on the screen that should constantly change. First, in the CPU input screen, the “HEARTBEAT” value should change continuously. Second, there is a small dot in the upper left hand corner of the screen that should blink on and off. If these indications show that the
system is frozen, simply find the power interrupt button on the cabinet (it might be marked
RESET) and press and hold for five seconds. If there is no RESET button, then find the circuit
breaker in the electric cabinet and turn it off for five seconds then back on again.

Check the operation of the SmartCamera™ by examining the PLC data window or the
camera window. If the SmartCamera™ stops responding, the anti-sway program will display:

<table>
<thead>
<tr>
<th>Camera Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Not Responding</td>
</tr>
<tr>
<td>Will Try to Reconnect...</td>
</tr>
</tbody>
</table>

After a period of time, the anti-sway will try to reconnect with the camera. If it fails, the PLC
green) page will say, “TURN ANTI-SWAY OFF TO RECONNECT CAMERA.” This means that
the camera communications did not successfully reconnect. First check the camera Ethernet
cable connections, then reset the camera using its on/off switch. Once it is reset and 10 minutes
have expired since failure, turn the anti-sway switch to the OFF position. Then check the anti-
sway PLC screen for camera operation. It should change to “CAMERA ON.”