



SmartCrane™ Anti-Sway Crane Control

Product Descriptions



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About Anti-sway and SmartCrane, LLC

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Since 2001, SmartCrane, LLC has been delivering sway control solutions for all types of cranes and situations. Our technology is based on precise mathematical solutions to the sway control problem, which permits our systems to provide effective sway control, every time. We have implemented solutions on every type of crane, including container cranes, grab cranes, overhead trolley cranes, and mobile harbor cranes.

The SmartCrane™ software runs on a 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.

The SmartCrane™ system operates in three modes: *Manual Anti-sway*, *Automatic Move*, and *Trap*. 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 Automatic Move mode, the system controls crane drives to move the load efficiently and safely from one location to another, lifting over and even going around obstacles. In Trap mode, the system uses a SmartCamera™ to take a snapshot of the load and position the suspension point directly above that position, without sway.

About This Document

This the remaining chapters of this products document provides the following information:

- Chapter 2, "How Anti-Sway Works" explains how the SmartCrane Anti-sway controls the motor speeds and what is required from the PLC.
- Chapter 3, "SmartCrane™ Product Family " explains the components of the SmartCrane Product family and how they are used together to solve special problems in crane control.
- Chapter 4, "SmartCrane™ Software Features " explains features of the SmartCrane™ software and how they can be utilized to maximize your crane control efficiency and safety.
- Chapter 5, "Benefits " explains the many benefits of installing Anti-Sway Control by SmartCrane, LLC.

- Chapter 6, “SmartCrane™ Product Line “ explains how to put together elements of the SmartCrane™ product line to solve your crane control problems.
- Chapter 7, “SmartCrane™ Sample Screen“ shows sample of the SmartCrane™ graphic user interface.

Other SmartCrane documents may be useful to potential customers and OEMs in deciding how to outfit a crane for anti-sway. These documents are in pdf format and are available for download free of charge from <http://www.smartcrane.com/Documents.html>.

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.

Initialization Manual

This manual describes the details of 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.

Installation and Maintenance Manual

This document 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.

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.

How Anti-Sway Works **2**

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

The SmartCrane™ anti-sway control translates operator commands into carefully timed acceleration patterns that are transmitted in real time to a crane's PLC. These patterns vary only slightly from the operator's stick control or from a simple speed ramp, but the difference is just enough to cancel out any sway resulting from the motion of the trolley.

For instance, if an operator moves the control stick to full 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 removes 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.

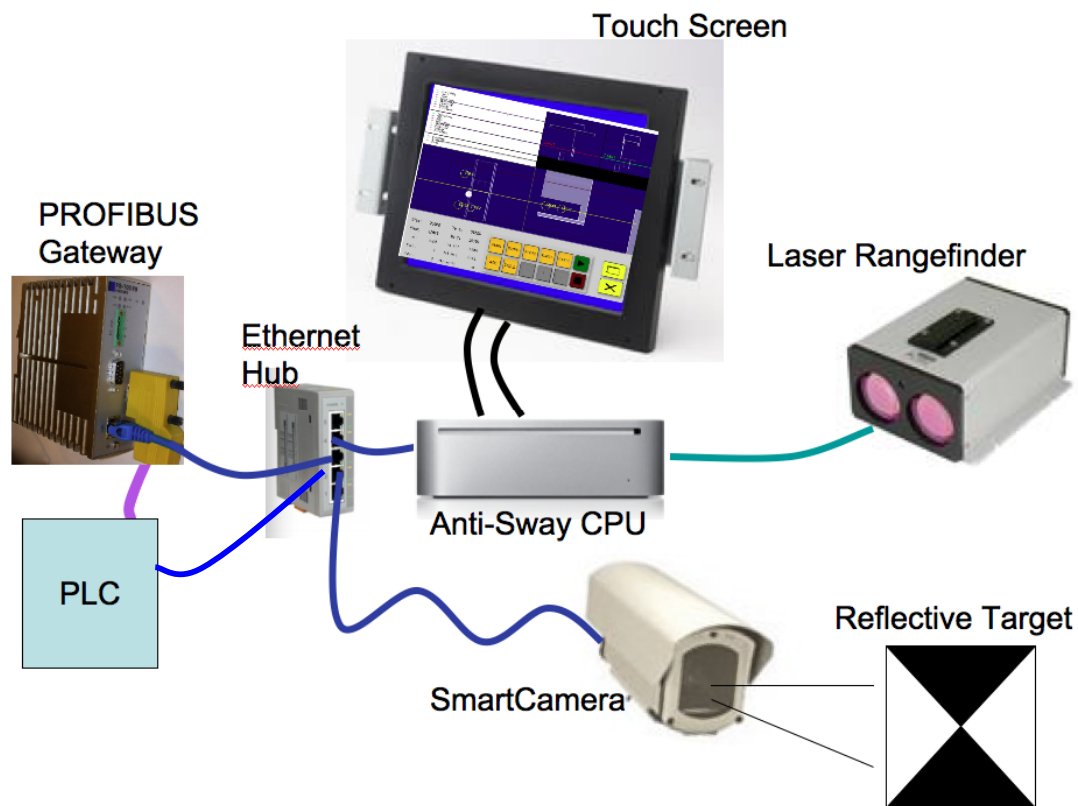
All this requires precise timing, which in turn depends on the natural frequency of the pendulum motion. The SmartCrane Anti-sway carefully accounts for changes in hoist cable length, changes in operator demand, etc., in real time. The key feature is that the SmartCrane™ Anti-sway Control uses precise timing of accelerations to control the sway, rather than real-time sway measurement and control feedback. It does not require a camera or other sway-sensing device to control sway induced by moving the crane.

However, when required 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, to within user-selected tolerances.

SmartCrane™ Product Family 3

Read this chapter to understand the components of the SmartCrane™ Product family and how they are used together to solve special problems in crane control.

SmartCrane anti-sway control can be supplied as software-only or add-on hardware. The components of a typical complete system are shown in the following diagram.



Anti-sway Computer

Three products, SC-01, SC-2, and SC-03 provide anti-sway control using an external computer (Apple Mac Mini running UNIX-based Mac OS 10.6). The anti-sway software is a common module to all applications and controls sway for any number of dimensions of any one crane. The CPU is small,

easy to install, and requires no special cooling. It maintains complete logs of all operation, whether anti-sway is enabled or not, and can easily be updated by on-line connection.

One processor (without a user interface) can effectively control sway on almost any number of cranes at the same time.

Touch screen

The operator interfaces with the SmartCrane™ CPU using a graphical touch screen. SmartCrane offers a number of these devices in different sizes depending on the crane and cab configuration.

SmartCamera™ Sway Measurement

If required for the application, SmartCrane offers a standard smart camera for trolley mounting and accompanying black-and-white target for installation on the spreader. The target is completely passive, requiring no power or communications, and only requires regular cleaning. With the SmartCamera™, a SmartCrane™ system can stop all spreader motion to within arbitrary limits.

Depending on the data rate, a separate processor may be required to process and analyze the range data in real time.

Laser Range Measurement

Integrated laser systems can be used to measure operational ranges in real time, and integrate those measurements into the anti-sway control system. The lasers can be mounted to measure, for instance, the heights of container stacks on a ship, heights of product stacks under a traveling crane, distance to other cranes or obstacles for collision avoidance, and accurate trolley and crane position when other position sensors are impractical or insufficiently accurate.

Ethernet Communications

The software communicates with the installed PLC to exchange data at 5-20 Hz, using a single interface data block for each transmission direction. The SmartCrane™ computer can use Ethernet or serial for communication. If the customer PLC does not have Ethernet capability, then a gateway must be added to perform conversion to a proprietary bus protocol such as PROFIBUS. Depending on distances, one or more Ethernet hubs may be required to provide reliable data transfer.

SmartCrane™ Software Features 4

Read this chapter to learn the features of the SmartCrane™ software and to understand how they can be utilized to optimize the efficiency and safety of your crane control.

The software, whether running in a separate processor or in an existing PLC provides many useful features that may be used for an application as necessary:

Manual Assistance For Operator Sway Control

This feature calculates any real-time speed adjustments to the operator's demands and sends revised speed demands to the PLC. This feature does not require a user interface.

With this feature, an operator can use zero to full speed and back to zero, without inducing any sway in the load. Also, the operator can make small adjustments to load position by moving the trolley half the desired distance: the anti-sway will time the second half of the move automatically, to correct the swing and bring the load to a stop.

Controlled Move In One Or Two Dimensions

This feature creates a path along a straight line to a destination in one or two dimensions, and guides the trolley (and crane) by sending anti-sway velocities to the PLC. The operator can hoist or lower as needed during the move without affecting the sway.

Controlled Move With Automatic Hoist

This feature uses vertical profile data about the crane, its load, its lifting mechanism, and the vertical position of the destination. The software will compute a minimum starting hoist that the operator may adjust. Crane and trolley motion will start only after the hoist has reached the starting value.

Near the end of the move, the software will begin hoisting down to reach "arrival" height. Once the load is table at this "arrival" height, then the system will lower to the final height, which will bring the load to rest and ready for disengaging.

Controlled Move Around Obstacles

This feature uses pre-stored locations of obstacles in the field of motion of an overhead crane. Each object is defined as a polygon in horizontal plane with “safe” zones. During commissioning, the customer engineer uses the display touch screen to adjust the corners of the “safe” zones to allow safe passage of the trolley and its load. Once commissioned, the corners of the “safe” zones become eligible as waypoints for a non-straight path.

When the operator selects a new destination for the crane, the software computes the shortest path through these waypoints and displays the path for the operator.

Each obstacle also has a pre-stored height value. When computing the path, the SmartCrane™ software will adjust the hoist profile to lift over an obstacle if possible. Thus, it will create a path that may lift over some obstacles and move around others.

When the move is initiated, the software sets the target speeds on each turn in the path to avoid contact with obstacles and sends the turn coordinates and target speeds to the anti-sway module to control the real-time motion. The path is executed smoothly and moves through each turn point without stopping.

This feature requires a Touch screen (any product TC-x) and display software (any product DP-x).

Automatic Engaging and Disengaging

This feature uses the position and height information to select a final destination depending on the type of load and type of lifting mechanism. Moving empty to a destination presumes a load exists there. For example, moving a ladle crane (with two lifting hooks) to a ladle places the hooks offset from the center of the ladle and at a height low enough to engage. Then the system moves the trolley horizontally to the engagement position and executes a very small hoist just until the load sensor registers a strain.

When beginning an automatic move lift, the software checks the load strain versus the lifting height to ensure the lifting mechanism is fully engaged. If the load pattern is not within tolerance for the situation, the hoisting is stopped and the automatic move canceled, and the operator alerted. The software can be modified to effect a proper pattern for any lifting scenario.

SmartHoist™ Hoist Safety

With this extra feature, all hoists are monitored by the hoist pattern, whether anti-sway is on or off, and whether the move is manual automatic. When beginning a lift, SmartHoist™ limits lifting to a safe slow speed. Once the connection is sensed by the load signal from the PLC, SmartHoist™ compares the real-time data to the statistical pattern for that crane. If the lift is unsafe, lifting stops and an alert is signaled. The operator may override the alert and continue lifting if a good condition is confirmed. This feature requires data collection during actual lifts on each crane.

Automatic Inventory

This feature uses the descriptions of loads as pre-stored in the computer by the end user. If a load remains in its pre-stored location, or if the SmartCrane-equipped crane moves it to another location, that location is retained in memory and on disk for future use. The operator can select a load as a destination by touching its symbol on the screen, and the system will compute a path to that location.

If the load is not in its original location (if another equipment has moved it), the operator can still move and manually lift the load. The system will prompt the operator to select the ID of the load, or just keep it in inventory as unidentified load. The system can be configured to ignore ID values if large numbers of identical loads are managed without ID tags.

Sensor-based Collision Avoidance

The customer may wish to install distance-measuring devices on the bridge to measure the positions of other cranes on the same rails. If the customer provides these measurements to the PLC, then those positions can be provided to the SmartCrane anti-sway computer in the normal data message.

The SmartCrane anti-sway control software will prohibit automatic moves that interfere and will stop anti-sway motion in time to prevent close approach. The product SC-09 may be used for the same purpose, except that it connects directly to the SmartCrane anti-sway processor by serial cable.

Network-based Data Sharing

If two or more cranes share the same rails, SmartCrane™ processors on all cranes can communicate with one another and share data. If one crane deposits a load, that load's location will automatically appear in each crane's database and display.

If one crane initiates an automatic move, then its neighbor cranes will display the path of that move on their touch screens and will prohibit any automatic move that would interfere.

This feature requires the addition of a wireless access point on each crane, if one is not already installed. SmartCrane™ can adjust Internet Protocol (IP) addresses of all components to be compatible with a customer local area network.

Network-based Monitoring

SmartCrane™ offers a separate product, based on its standard software, which can monitor any number of cranes over a local or wide area network. This software can display the real-time positions of multiple cranes and show the current activity of each. This software will automatically update its inventory of loads based on the inputs from each crane.

Network-based Work Order Management

The customer may wish to develop work orders and communicate those orders to the cranes electronically. SmartCrane, LLC will gladly provide a quotation to customize its monitor product to exchange data with a customer system to accomplish this task. Alternatively, we can add features and database elements to the monitor product to support the direct manual or automatic generation of work orders in that software, to be transmitted to the cranes as needed.

Network-based Support

SmartCrane, LLC will provide free customer support for a limited time after installation. This support requires a remote connection to a customer wide-area network, on either a permanent or as-needed basis. SmartCrane, LLC will arrange convenient times with the customer to install software updates as they become available.

If the customer arranges such a remote connection in advance, SmartCrane LLC will use the connection for remote pre-commissioning testing and tuning, and will discount the final purchase price.

Benefits 5

Read this chapter to learn the many benefits of installing Anti-Sway Control by SmartCrane, LLC.

SmartCrane anti-sway control provides benefits for efficiency, safety, and operator comfort.

Crane Productivity

Crane moves controlled by the SmartCrane™ anti-sway control always produce time savings when compared to manual movement. Even the very best operator cannot move the crane any faster than the anti-sway, and usually do so at a slower pace. Add to this fact that not all operators are experts and not every manual move achieves an operator's best results, and you can see that the *average* move time in manual mode will always be slower than one done automatically. Of course the automatic move never varies from its minimum time, so the *average* move time with SmartCrane™ is always the *minimum* move time.

SmartCrane™ saves time in many ways:

- When in manual anti-sway control, the SmartCrane™ software allows an operator to use full speed commands for all movements, resulting in faster transit times. Upon arrival, the sway of the load is minimized, allowing shorter lowering and engaging/disengaging.
- Control of sway during load movement is effective no matter what the hang length of the load. Thus, hoisting to full hoist height to suppress sway is no longer required. This allows crane and trolley motion to begin more quickly, again saving transit time.
- When in automatic control, the SmartCrane™ software accelerates to maximum speed using maximum acceleration at all times. Maximum speeds for each direction of travel (crane and trolley) are automatically calculated to produce a minimum time transit. It is impossible for the crane to move from one point to another in a shorter time than that produced by the SmartCrane™ control.
- Furthermore, when in the presence of obstacles, the automatic control calculates the absolute shortest path between origin and destination. It guides the crane and trolley

along that path with only the least slowing at turn points, still controlling sway through the turns, for the entire distance.

- When planning an automatic move the SmartCrane™ control software calculates the safe vertical profile to clear any obstacles and all ladles in the computer's inventory. This may allow a move to commence before the maximum hoist height is reached, again reducing the time for the move.
- When automatic engaging is activated, the SmartCrane™ control guides the hook quickly to a safe and steady position alongside the ladle and in the correct hoist position to engage the handles. The control system moves the hooks smoothly to the engage position and begins hoisting at slow speed until engagement is detected using the load cell.
- When automatic disengaging is activated, the SmartCrane™ control sets the ladle down gently at the precise destination position and continues to lower until the measured hang length is sufficient to move away from the handles. The control then moves the trolley smoothly away from the ladle, ready for hoisting.

Crane Safety

The SmartCrane™ control offers a number of features that enhance safety of crane and personnel.

- Sending work orders digitally over the network will reduce the use of radios, resulting in more efficient and accurate communications, with no errors.
- The monitor computer manages conflicts between crane moves by preventing work orders from crossing each other or by delaying sending a work order until execution is safe.
- The monitor computer will track the movements of both cranes at all times, and will bring cranes to a safe and swing-free stop any time there is risk of collision.
- The crane operator can cancel an automatic move any time by touching any place on the screen, or by touching the crane or trolley stick control. The crane operator may interrupt the automatic hoist part of the move by touching the hoist stick, but the crane and trolley motion will continue. The control room operator can safely cancel any automatic move using the STOP button provided.

- Automatic hooking and unhooking are designed for maximum safety. The trolley stops clear of the ladle and the hooks are lowered to a fully clear height, based on encoder readings from the hoist and the recorded height of the ladle. Then the trolley moves slowly until it is directly over the ladle, before hoisting begins. While hoisting, the computer monitors the load readings from the PLC and stops as soon as a proper strain is detected. If the height readings from the encoder exceed the normal contact height without a sensed load, even by a small margin, hoisting will stop and the operator alerted.
- Every time a ladle lift begins, whether automatic or manual, the anti-sway computer on the crane will compare the load profile to the standard profile for that crane. If the profile does not match, that indicates that the lift is bad and hoisting will stop immediately, and anti-sway will send a signal to the PLC. We suggest that the PLC be fitted with a bright light and siren to alert workers when this happens.
- Whenever a crane is in motion, its range of motion will show a different color on the control room display. If there is an automatic move in progress, the range of motion will be the entire move. If the operator is moving the crane manually, the range of motion will be just that sufficient to bring the crane to a safe stop, without any sway.
- Each crane's anti-sway will monitor operator manual moves to prevent contact with obstacles and the other crane. If the anti-sway calculates a possible contact, it will bring crane and trolley motion to a safe and swing-free stop.

Operator Comfort

When antisway control is engaged in manual moves, operator stress is reduced, from not needing to watch and control load sway.

During automatic moves, operators may relax completely until the very end of the move. This reduces operator fatigue and improves operator response to unsafe conditions, even after a long shift.

SmartCrane™ Product Line 6

Consult this chapter to put together elements of the SmartCrane™ product line to solve your crane control problems.

SmartCrane offers this software in separately priced products, and when hosted on a separate machine the software is configured before delivery.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
Basic anti-sway control		Controls sway for one move at a time, either following operator speed or directed destinations. Without a sway sensor, these products do not remove sway caused by external forces or non-vertical lift.
SC-01	Simple Anti-sway, one dimension	Controls sway for trolley motion. Includes one external computer, software license and two days installation support. Travel from the U.S. East Coast if needed, is extra. (Business class for flights over 8 hours)
SC-02	Simple Anti-sway, two or three dimensions	Controls sway for crane, trolley, and hoist. Includes one external computer, software license and two days installation support. Travel from the U.S. East Coast if needed, is extra. (Business class for flights over 8 hours)
SC-03	Automatic Anti-sway, two or three dimensions	Controls sway for multiple cranes at a time, for crane/trolley and hoist. Includes one external computer, software license and two days installation support. Travel from the U.S. East Coast if needed, is extra. (Business class for flights over 8 hours)
SC-13	SmartHoist™ software upgrade	Only cranes with load cells installed. Monitors all lifts, whether anti-sway is on or off. Requires SC-01, SC-02, or SC-03.
SC-07	Integrated Anti-sway	Simple anti-sway similar to SC-01 or SC-02 but integrated into PLC or drive. One-time engineering fee and special assistance may be required depending on PLC or drive specifications and capabilities. Does not require separate computer or communications.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
Sway Measurement Products		<p>Three products, SC-04, SC-05, and SC-06 provide sway measurement and minimal sway control using a SmartCamera™, a self-contained machine vision system. This device must be mounted to provide continuous view of the top of the spreader or hook assembly. Normally this means mounting in a vertical position on the trolley; however, in special circumstances, it may need to be mounted horizontally at the end of the trolley, using a mirror positioned to provide the correct view.</p> <p>The SmartCamera™ requires the use of a special high-contrast target supplied by SmartCrane. Under difficult lighting conditions, supplementary lighting to illuminate the target may be needed to assure continuous tracking. Under sunlit conditions, this illumination source may need to be very bright. The illumination beam should be as narrow as possible, both to focus the light on the target where needed and to conserve energy.</p>
SC-04	SmartCamera™	Feedback sway measurement. Can be used with SC-01, SC-02, or SC-03. Ethernet hub included. This product supplies only sway measurement and communicates with SmartCrane processor to deliver sway measurements. During periods of no trolley motion, the SmartCrane processor uses special algorithms to compute the precise parameters of the current sway. It will remove any residual sway in a series of small adjustments. When driving to a destination, the adjustments will usually be in pairs, to achieve the dual objective of removing sway and finishing precisely at the destination.
SC-05	All-in-One Anti-sway	<p>Includes SmartCamera™ with all features of SC-04 plus manual-assist anti-sway software. Does not require separate computer. Ethernet only.</p> <p>Does not support automatic move to a destination. The PLC must supply speed demand, maximum speed, ramp time for one direction, as well as load and hoist length. The SC responds with adjusted velocity reference and brake on/off signal</p>
SC-06	All-in-One 2D Anti-sway	<p>Includes SmartCamera™ with all features of SC-04 plus manual-assist anti-sway software with two dimensions of sway control. Does not require separate computer. Ethernet only.</p> <p>Does not support automatic move to a destination. The PLC must supply speed demand, maximum speed, ramp time for both directions, as well as load and hoist length. The SC responds with adjusted velocity references and brake on/off signals.</p>
SC-14	SmartCamera™ Standard enclosure	Can be used with SC-04, SC-05, SC-06, SC-08, or SC-09. Interior or sheltered exterior installation. Simple mounting and easy access to camera or laser.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
SC-15	SmartCamera™ Exterior enclosure	Can be used with SC-04, SC-05, SC-06, SC-08, or SC-09. Steel moistureproof enclosure for exposed exterior installations. Shock mounting included.
SC-16	SmartCamera™ Upgrade enclosure	Can be used with SC-04, SC-05, SC-06, SC-08, or SC-09. Stainless steel, moistureproof enclosure for severe exterior installations. Shock mounting included.
Special Sensor Applications		
SC-08	Truck Tracking SmartCamera Truck Position Measurement.	This product uses the same SmartCamera™ and similar targets as the SC-04. It searches for the special target, applied to the cab of a truck, in special designated lanes under a quay crane. When a target is located, it begins tracking and then begins searching for the chassis and/or container in the same lane at a pre-defined distance behind the truck. It reports these positions in real time to the SC-10 processor via Ethernet cable or wireless connection. Requires Tracking Processor SC-10. Sufficient for one direction of traffic under quay crane.
SC-09	Profiling SmartLaser	Profiles heights of objects and tracks motion of ship between crane moves. Profiles area and measures object heights and lateral positions. Requires Tracking Processor SC-10. Includes serial cable. This product uses a ranging laser device to measure vertical distances below the cab or trolley of any crane. The device measures and relays these distances to the SC-10 processor. The device can also be used to measure horizontal distance to a companion crane in a bridge crane application. In this case the signals can be supplied by serial cable to the SmartCrane processor. The SmartCrane anti-sway will protect against collisions when automatic or operator-assisted anti-sway are in use.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
SC-10	Pier and Ship Tracking Processor	<p>Collects data from SC-08 Truck tracking SmartCamera and/or SC-09 Pier and Ship Profiling SmartLaser. Calculates truck lateral positions, stack heights, and ship position. Exchanges data with Anti-sway processor. Can control truck driver signal lights. Ethernet hub included. This product may be configured to many applications. For a quay crane, it uses the vertical distances to profile one hatch of a ship.</p> <p>Once a first profile is taken, it receives data from the SmartCrane processor when a container is loaded or unloaded. It compares the profile on each new movement of the crane to determine any motion of the ship from changing loads or tidal effects and it supplies a ship position reference to the SmartCrane anti-sway processor.</p> <p>It communicates with one or more SC-08 SmartCameras and one or more SC-09 Profiling Lasers and coordinates measurements of truck position for ship loading operations over a pier. For factory stacking applications, this product can develop a vertical profile of products on the factory floor and to supply that profile to define destinations for automatic moves.</p>
SC-17	Pier and Ship Tracking Processor upgrade for Smart Hoist and Smart trolley advice	Software upgrade to SC-10. Supplies PLC with hoist and trolley speed reference to slow lowering to landing and avoid collision with measured vertical profile. Will slow hoist when close to target and stop or slow trolley based on hoist rates and vertical profile. Requires SC-10 and additional interface data to and from PLC.
SC-18	Boom Crane Camera enclosure	Weatherproof stainless enclosure for suspension from crane boom or other movable structures. Contains one 6-degree of freedom inertial measurement unit (IMU, for moving crane) OR one pivot encoder (for stable crane), one Ethernet hub, and one power supply. Requires one of the following: 120VAC, 240VAC, or 24VDC. Communicates via Ethernet. Accepts one or two SmartCameras, selected from SC-19 or SC-20. Includes mounting bracket. Choice of IMU or encoder is based on the stability of the crane platform.
SC-19	Boom Crane SmartCamera with fixed lens.	SmartCamera with fixed-focal length, manual iris, manual focus lens. Customer must supply focal length (12.5, 16, 25, 35, 50, or 75mm) when ordering. Camera interprets IMU or encoder data and can send stabilized or unstabilized images from all or part of camera image, with 1X, 2X, or 4X compression. Images contain vertical reference point for safe lift. Supplied with Windows or Mac software to control image transmission and display image on computer screen. Requires SC-18 enclosure.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
SC-20	Boom Crane SmartCamera with remote control telephoto lens.	SmartCamera with variable-focus (telephoto), variable-iris, and variable-zoom lens. Customer must supply preferred focal length range when ordering (only certain ranges are available). Camera controls IMU operation and can send stabilized or unstabilized images from all or part of camera image, with 1X, 2X, or 4X compression. Images contain vertical reference point for safe lift. Supplied with Windows or Mac software to control zoom, focus, iris, and image transmission and display image on computer screen. Requires SC-18 enclosure.
Remote and Stand-Alone Applications		
SC-11	Remote Monitoring Computer	<p>Collects data from SC-01, SC-02, SC-03, SC-05, or SC-06 and displays data from multiple cranes in graphical and digital form. Saves data to disk. Can be configured to transmit data to any internet host. Includes computer and software only. Display, keyboard, and mouse not included. This product allows supervisors and managers to display the activities of one or more cranes in real time. It can be configured to adapt to a touch screen TC-15 and above, or to the user's own display (minimum 1024 x 768 resolution) and mouse. Third party touch screens may not be supported.</p> <p>The display is different from the other displays in that the entire motion range of the cranes is displayed in a smaller scale and the data displays include pages representing 3D view, strip chart view, and raw data view. Every crane being monitored has its symbol on the screen and the crane whose data are displayed is shown in a different color.</p> <p>The operator may switch from one crane to the other for detailed data by clicking or touching the screen. The user buttons for the selected crane are displayed exactly as they appear on the operator's screen. If one crane is being displayed but is not being operated and another crane begins some activity, the monitor software will automatically switch to that crane. Any alerts shown on a crane's display are also shown on the monitor screen. The monitor software does not allow the remote station to control a crane. The product SC-03 is designed for that purpose. If a customer wishes to have parallel remote access to control a crane at the same time as an operator, for training purposes, the SmartCrane™ software can be temporarily configured to allow that by use of LAN screen sharing, at no extra charge.</p>

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
SC-12	Training Computer	Configurable to replicate any SmartCrane SC-01, SC-02, or SC-03 system. Runs authentic sway simulation and shows crane moves identical to real crane. Includes computer and software only. Display, keyboard, and mouse not included. This product is supported on any Apple Macintosh computer. A software-only version is available.
SC-21	Add wireless access	Adds wireless access point with external antenna to any product. Customer must supply wireless router IP Address, MAC Address, and access code, or specify product configuration as router.
SC-22	Collision Avoidance and Inventory Sharing	<p>Software upgrade to SmartCrane SC-02. Communicates with other SmartCrane SC-02 on same network and same crane rails. Prevents automatic moves that cross other crane positions. Displays other crane positions on each operator screen. Can be set to move other cranes out of the way for automatic or manual move. Updates load position database from other cranes' activities.</p> <p>This product is a software upgrade to the SC-02 anti-sway system that adds the inter-processor communications to allow companion SmartCrane anti-sway systems on different cranes, and remote monitoring computers, to share information. Position information is used to prevent moves that risk collision. Furthermore, when any crane in the group places a load in a known position, that new position is shared among all the processors. Then at some future time, a different crane may be tasked to retrieve that load, and its position will be known precisely. Requires Ethernet connection.</p>
SC-23	Upgrade SC-11 to allow remote work orders	Adds function to SC-11 to allow remote operator or supervisor to develop work orders for one or more cranes on the network. Performs movement coordination, anti-collision, and many other features. Requires SC-11 plus for each crane to be controlled, SC-22 and Ethernet connections.
Gateway Devices		
CO-01	PROFIBUS Ethernet Gateway.	Can serve multiple cranes that share the same PROFIBUS network. Required for any SC-01 through SC-06 where PROFIBUS is required by PLC. This product comes with a description file that is entered on the PLC, allowing the device to act as a PROFIBUS slave. The device must be configured with an IP address on the same sub-network as the SmartCrane anti-sway processor and SmartCamera™.

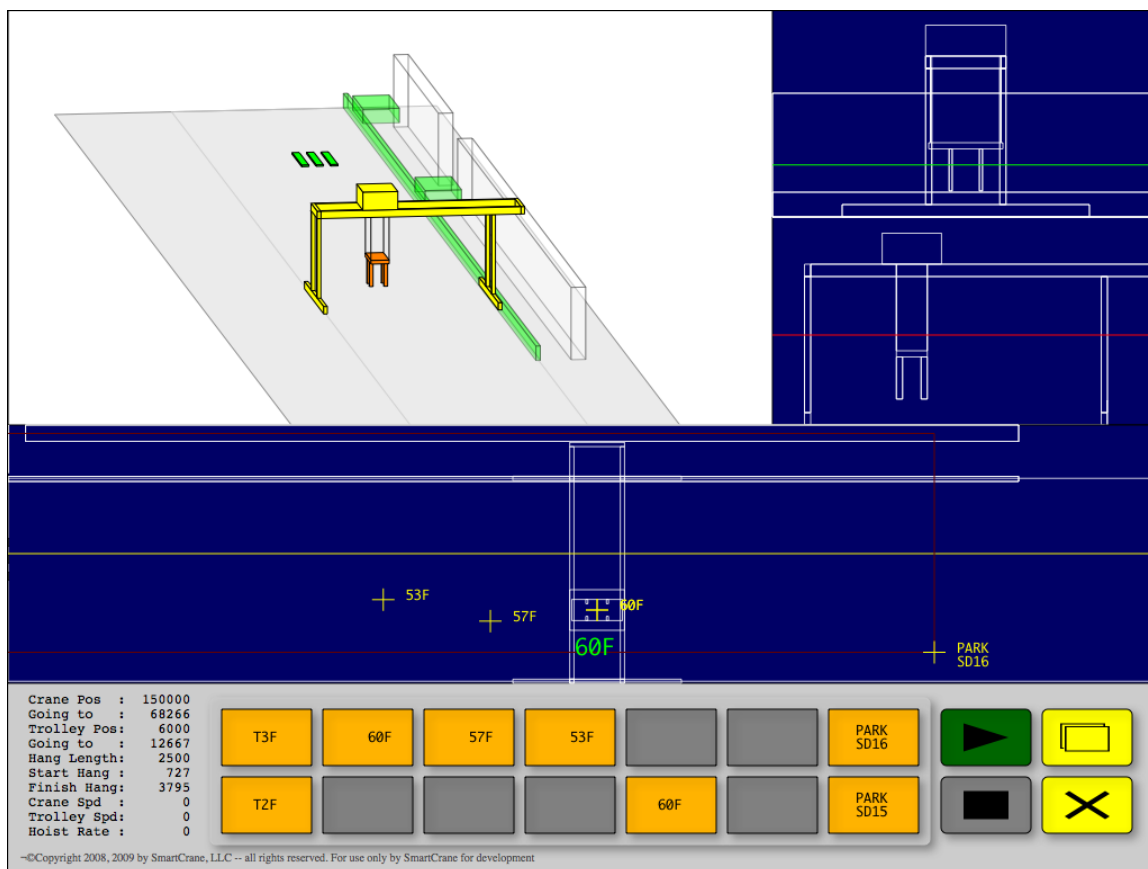
PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
Touch Screen Displays		The selection of the touch screen device depends on the space available at the operator's station. Any of the software control display options can be used with any size screen, except that the 12-inch screen only supports 800x600 resolution and thus cannot display the 3D version. The customer should specify whether the screen needs to be a standalone device or inside a cabinet or control box, as these are different products. The selection will depend on the room available to mount the device where it is immediately accessible to and visible by the operator. It is poor practice to mount the device where the operator must reach a long distance or turn away from the work area of the crane. The software will occasionally display warning messages and alerts, and the operator should be aware of those without delay.
TC-12	Small Touch Screen 12-inch, Rear or Desk Mount	Can be added to SC-01, SC-02, or SC-12. Touch screen connects to anti-sway computer. Supports buttons or 2D display only.
TC-15	Medium Graphic Touch Screen 15-inch, Rear or Desk Mount	Can be added to SC-0, SC-02, SC-11, or SC-12. Touch screen connects to anti-sway computer.
TC-17	Medium Graphic Touch Screen 17-inch, Rear or Desk Mount	Can be added to SC-0, SC-02, SC-11, or SC-12. Touch screen connects to anti-sway computer. Operator can save and later select these or pre-loaded destinations. Shows loads previously set.
TC-20	Large Graphic Touch Screen 19-inch, Rear or Desk Mount	Can be added to SC-01 or SC-02. Touch screen connects to anti-sway computer. Operator can save and later select these or pre-loaded destinations. Shows loads previously set.

PRODUCT NUMBER	PRODUCT NAME	DESCRIPTION
Software for Touch Screen Control		
DP-01	Touch Screen Interface Software	Buttons to control movement of crane. Operator can save and later select saved or pre-loaded destinations. This product only shows pre-determined locations, without any graphical display. This is appropriate in a situation where there are a large number of stored destinations, such that showing one button for each can fill an entire screen. It is also appropriate for a crane with a very small range, no obstacles, any number of pre-stored destinations, no requirement to remember load locations, and no need to automatically move the crane to an arbitrary location on the plant floor.
DP-02	Touch Screen 2D Interface Software	View and Control Crane motion in two-dimensions. Can control more than one crane when used with SC-03. Operator can save and later select saved or pre-loaded destinations. Shows loads previously set. Shows and avoids obstacles when used with SC-02 or SC-03. It shows a plan view of the crane under control and any other cranes whose positions are known. It shows the position of each remembered load, each pre-stored destination, and each obstacle outline. It also shows the projected path of an automatic move from the present crane position to any selected position on the screen. The operator selects the destination by (1) moving a cursor, (2) selecting a destination by button press, or (3) selecting a known load by touching it on the screen. When the crane moves, its outline also moves on the screen, in real time. The product also has a side view and front view, which each show motion in that direction. These views also control the start height and finish height of an automatic move, each of which can be adjusted by the operator by a simple pointing motion. A changeable panel is also provided, which supplies data on PLC input and output data.
DP-03	Touch Screen 3D Interface Software	View and Control Crane motion in two- or three-dimensions. Can control more than one crane when used with SC-03. Operator can save and later select saved or pre-loaded destinations. Shows loads previously set. Shows and avoids obstacles when used with SC-02 or SC-03. This product is identical to DP-02 except that it adds the choices of 3D display and strip plot display to the operator's page selection. This product requires a screen with 1024x768 resolution (TC-15 or above).

SmartCrane™ Sample Screens 7

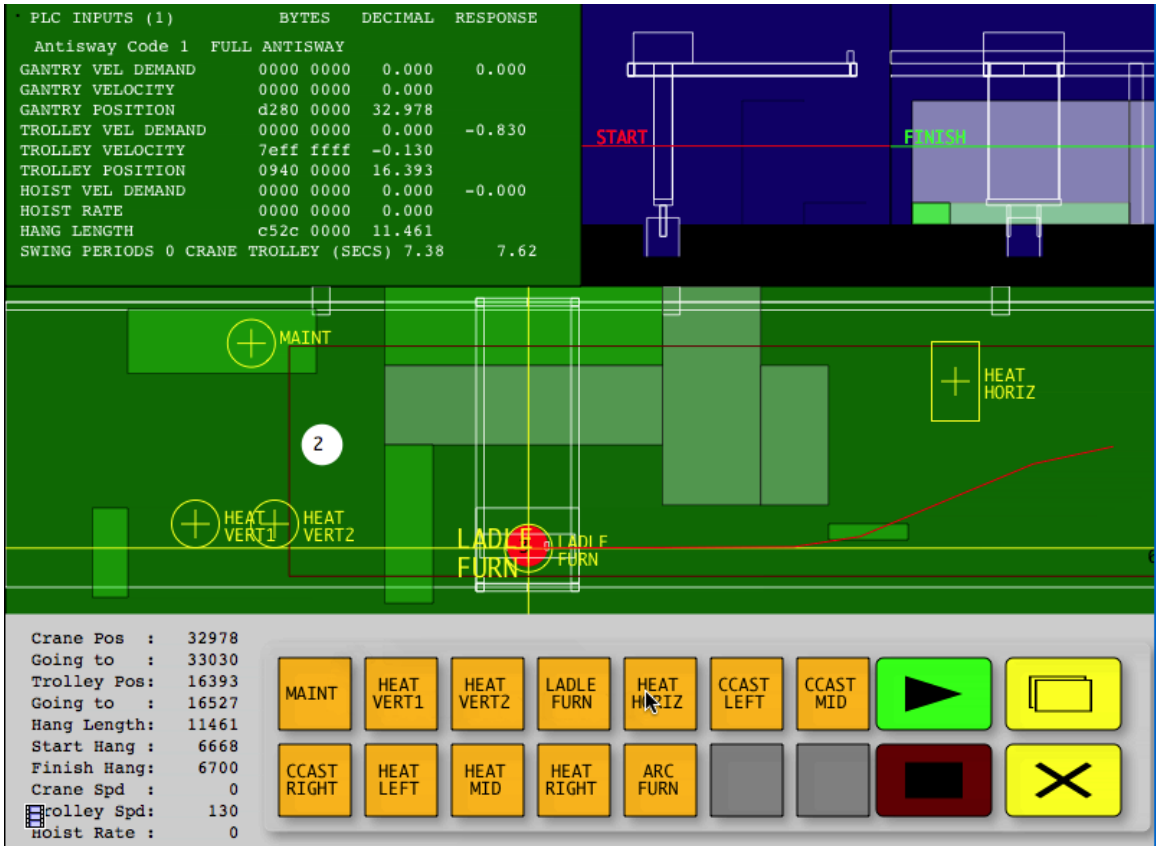
This chapter shows samples of the SmartCrane™ graphic user interface.

This image shows an actual screen capture, using the 3D display version, where the application is a surface rail gantry crane.



In the upper left are the selectable windows, here showing the 3D display. The operator can change the viewing angle and zoom in or out in this window. To the right are two vertical views, showing front and side of the crane. Below is the control view (plan view here) and below that are the control buttons and a real-time data display window.

The second image shows a screen capture of the 2D version, with application to ladle crane, with overhead rails.



In the upper left as before are selectable windows, here showing inputs from the PLC. An automatic move is just finishing, moving ladle #3 to a destination labeled LADLE FURN. The red line shows the optimal path taken to avoid obstacles in grey-green color.

In this version, the system controls hoisting and the upper right diagrams show the minimum height at the start and finish of the travel.