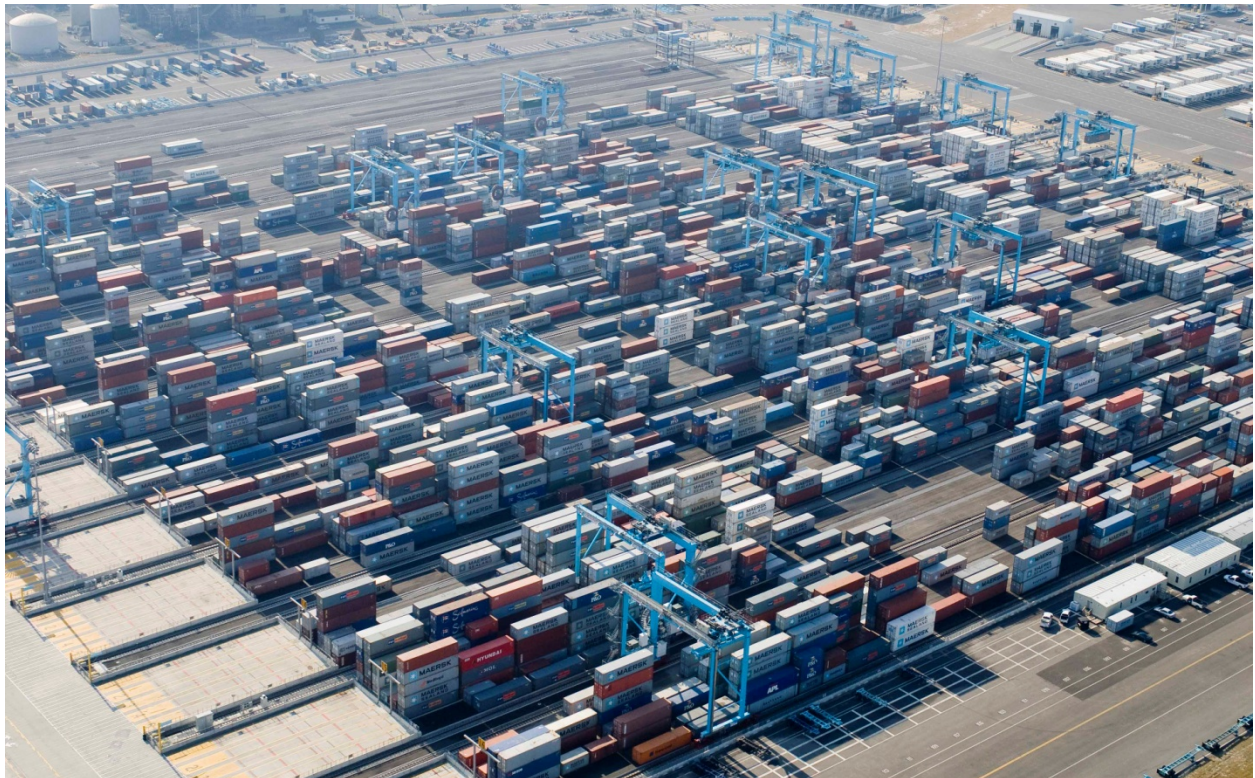


## Automated Container Handling in Port Terminals

**Overview.** Shipping containers revolutionized the movement of goods, driving change and efficiency throughout the global supply chain. The next revolution in container handling is the application of automation to operating the container terminal. At this time there are multiple automated container terminals in operation and more in development globally.

The automation challenge has been in the part of the terminal where the containers are stacked, called the block. One end of the block services the ships being loaded and unloaded, and the other end services trucks and trains being loaded and unloaded. A typical layout is shown in Figure 1. Stacks are usually five containers high with a narrow space between the rows, and there are typically eight rows of containers per section, stretching for up to a quarter mile (400 meters). The sections are duplicated providing parallel sections.



*Figure 1. Dockside Container Terminal Stacking Area*

Rail mounted gantry cranes are not new to the industry, however they are now gaining traction in the marine terminal world. The large cranes, called automatic stacking cranes (ASC), are typically 80 feet high and 110 feet wide and have been developed to handle up to 10 rows of containers. Two ASCs share a pair of rails, moving up and down the rails carrying containers, continually stacking, and unstacking them. Innovative crane

engineering allows the cranes to perform their work without any operators. This significant advancement has been brought about by sophisticated optical systems on the cranes which recognize the containers, and new scheduling software in the port management supervisory computer. The complete system provides a huge improvement in terminal productivity, and also in the reliability of the container handling.

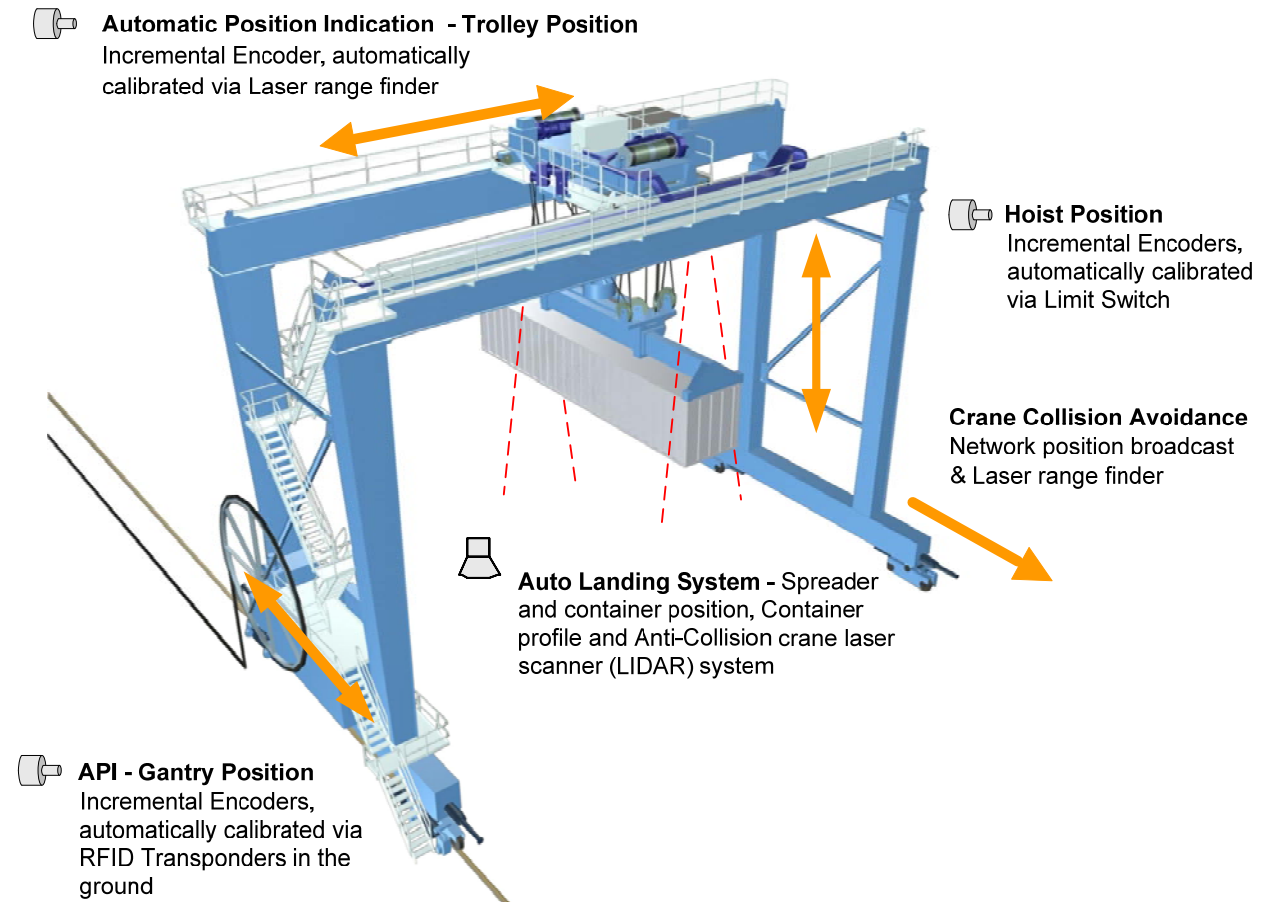
**Motion Control.** The unmanned gantry cranes can position containers to within +/- 50mm using laser based guidance systems. This doesn't sound difficult until you consider the 40 foot container may weigh 40 tons and be moving at speeds of 5 meters per second in gantry travel mode. The cranes handle all ISO standard 20, 40 and 45 foot containers.

Each crane typically has more than 20 three-phase, 460 V motors, each with its own variable frequency drive to vary the speed in both directions. The table shows the main crane functions:

Crane Function	Quantity of Motors
Main Hoist	2
Trolley for across the stack motion	4
Gantry motion along the rails	12
Spreader Skew/Sway control	4

*Table. Crane Functions and Motors*

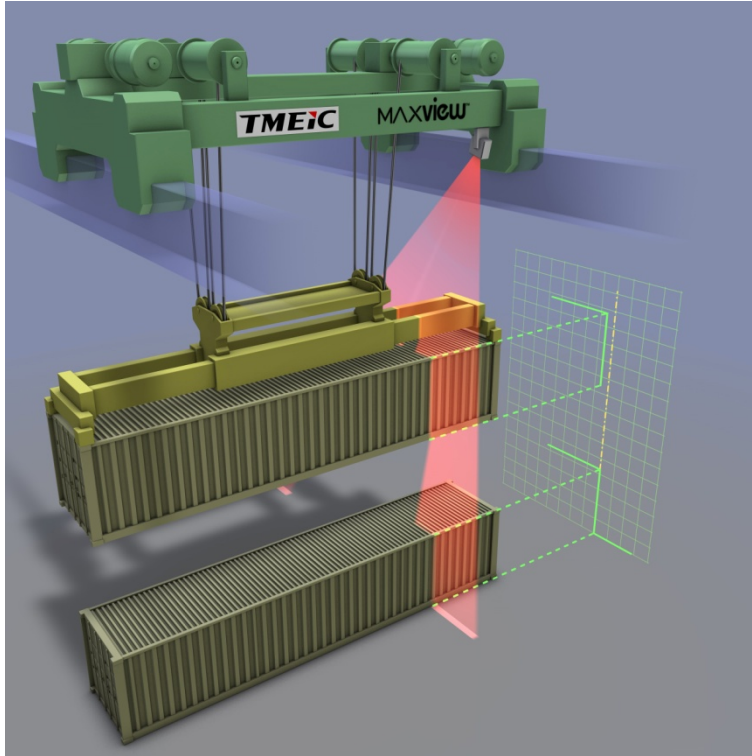
**Advanced Automation Systems.** Sophisticated sensors are mounted on the crane to detect the position of the moving parts, the load, and target destination. These sensing systems include encoders and scanning laser rangefinders as shown in the diagram below.



*Figure 2. Rail Mounted Gantry Crane for Automatic Container Stacking*

The automatic position indication system makes direct measurements of the gantry, trolley, and hoist position via laser rangefinders, unaffected by factors such as rope stretch and wheel slippage. The automatic landing system uses laser scanners on the trolley to measure the position of the spreader (the container pickup assembly) relative to the container below.

Gantry position along the rails is determined using an antenna which picks up signals from transponders embedded in the surface.



*Figure 3. Laser Range Finder based Scanning System, one of Two Axes*

The optical positioning system uses laser scanners which measure the distance and angle to any surfaces, such as the container, the lifting spreader, and target container, as shown in Figure 3. A second axis scanner picks up the ends of the containers. With these measurements the crane control can automatically pick and land containers in the stacks, based on instructions issued by the yard management computer system.

There is a remote control room in the operations building with operator stations and video screens to allow the crane to be switched to manual control if unexpected conditions occur. Currently, human control is used when the automated crane interfaces with a manned over-the-road truck at the delivery gate. Safety is paramount for automated ASCs and as such a wide variety of systems and controls are in place to assure that automated ASCs and people never have an unfortunate moment.

**Programmable Logic Controller.** Variable frequency drives power the motors providing the hoist, trolley, and gantry functions. The drives run off DC power supplied by a common regenerative central converter, and independent inverters provide three-phase AC, pulse width modulated power to the motors.

A PLC controls the drives' speed over a local area network. The PLC takes all the position data, compares it with the desired position supplied by the yard computer, and directs the variable frequency drives. The main functions of the PLC are:

- Sequence control for unmanned container handling
- Absolute measurement of gantry, trolley and hoist position
- Spreader sway control in the gantry and trolley directions
- Collision avoidance with the other crane in the same block
- Interface to the terminal operating system and remote operator station over fiber optic Ethernet

In addition a PC is dedicated to the laser scanners and to four video cameras, which supply video to the remote operator stations,. The only manned cranes in the terminal are those loading and unloading the ships, and small shuttle cranes which move containers from the dock to the container stacking area.

Crane automation allows unmanned, 24/7 operation of all the stacking cranes, providing the terminal with significant cost savings. In addition, less mechanical damage caused by operator skill or diligence is experienced, and container tracking is improved with reduced losses through miscommunication and human errors during container handling.

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