Conveying a message about container terminals*

All container terminals have two operating modes: ship-to-shore (STS) and shore-to-yard (STY). In a perfect world both modes would function in perfect harmony to achieve a satisfactory throughput with capital, operating, and maintenance costs all optimised for both modes. Terminal industrial engineers can achieve these goals on paper, but that never works out because the human element is unpredictable.

A terminal could be equipped with a fleet of STS cranes built to achieve a peak throughput of 50 containers per crane hour and the yard could be equipped with STY transporters and stacking cranes to match that peak productivity. Yet the odds are that the STS cranes will average less than 30 boxes per hour because the human factors for STS or STY modes are not as expected. Longshore workers are not programmable robots.

In most container terminals the yard operation does not "feed the hook" fast enough. The reason could be labour factors or inadequate yard capacity or both. Yard productivity usually governs terminal productivity because STS productivity is overemphasised when new cranes are purchased.

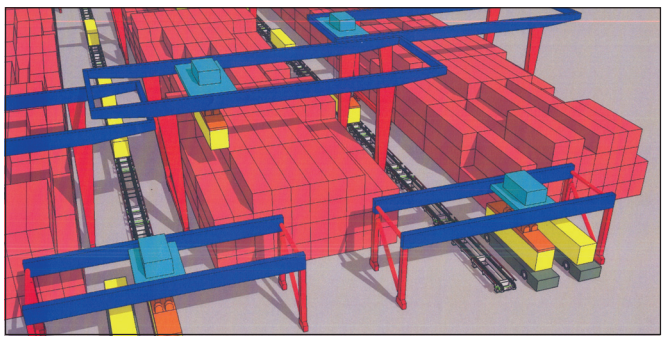
Minimal labour expense has not proven to be a sufficient justification for automated container terminals. Instead, valid justification must come from achieving highly reliable throughput goals and also minimising capital, operating, and maintenance costs by avoiding mismatches between STS and STY modes.

Warehouse lessons

Similar economic factors apply to automated warehouses, which is why automated container terminals should steal as much technology as possible from proven automated warehouse technology.

This leads to us to some basic planning concepts such as:

- Transporters that must return empty are at a disadvantage compared to a concept that avoids returning empty. Such transporters must travel each way in roughly half the time or twice as many transporters are needed.
- In order for STS cranes to average 30 boxes/hour they must have a peak capacity much higher than that - say, about 40 per hour.
- STY peak capacity should match or exceed the STS peak capacity.
- Cheap labour does not eliminate the primary advantage of automation. Shippers seek fast and reliable turn time for their ships. Furthermore, low labour rates can lead to high labour expense if it takes more workers to do a particular task. For example, when APL first started calling Mumbai, its labour cost per container was higher than at any other port even though hourly rates were the lowest of any port it called.



Impression of ASC stacks with CP&A conveyor system (AGV variant). See WorldCargo News, December 2010, p3 for explanation of fixed, buffer cranes

Conveyors are the transport mode in most automated warehouses and are used in many other industries. One reason why they have never been practical for container transport is the large physical size of shipping containers, which makes supporting the weight on a typical conveyor challenging. Again, a complete stop is required during STS transfer to conveyor so a fleet of STS cranes must work "in sync" or each one must have its own dedicated conveyor line, and corners and curves are not easily negotiated.

Stationary model

But look again at automated warehouses and note that some have a stationary modular conveyor system. Each stationary module stops, starts, and runs in sync with adjacent modules, but is independent of all other modules. Modules on the same line can even move in opposite directions. Like a relay race, a module down track can be instructed by the operating system to start and get up to synchronous speed just in time to receive oncoming conveyor traffic.

A stationary modular conveyor mode is what we favour for automated container terminals. Our modular system is assembled using only four different modules:

- A powered transport module that is about 50ft long.
- A side shift module that consists of a standard transport module supported on transverse bogies.
- A turntable module that consists of a standard transport module supported on bogies that travel on a rail circle.
- A short non-powered idler module that has a site-specific length, so a train of modules precisely aligns with the backland aisles.

STS cranes cannot achieve maximum productivity if the crane driver has to adjust the gantry location to land or pick a container. With our modular conveyor system, there is no need to adjust the gantry to match a transporter's position. The individual module or modules located in the landing zone are stopped. The landing zone can include a transporter-idler-transporter. It does not matter, since all modules are stopped unless moving a container.

Pin piles

There are several good reasons for using small diameter steel "pin" piles to elevate all modules about 1.5m to a common elevation throughout the entire terminal.

Modern yard chassis have a pair of beams that support the container's floor framing rather than the traditional corner casting supports on older chassis and bombcarts. Side guides assure longwise alignment.

For our system each transport and idler module is equipped with a chain and sprocket system that resembles a pair of bicycle chains. The pair of chains supports the container weight similar to the twin support beams on a modern yard chassis. We also have side guides for lengthwise alignment.

When designing an automated or semi-automated terminal the planners and engineers have unlimited freedom to arrange the modules to best suit specific site and operating conditions. In this context semi-automation refers to combining automated yard transport with manually driven RMGs.

Terminal productivity of 30 containers per hour per dockside crane is a common requirement based on the usual expectation that STS cranes should average at least 30 per hour. But if STS cranes are to compensate for slowdowns and waiting spells, the backland operation, be it manual or automated, must have the capacity to feed the STS cranes at a rate considerably higher than 30 per hour.

50 per crane hour

Our conveyor modules are designed to provide 50 per hour per STS crane. This is based on STY feeding peak STS productivity. It is governed by the sideshift and turntable productivity if they are preceded by a few modules that serve as buffers.

During terminal planning, as the industrial engineering and simulations evolve, one will find that the minimum backland stack spacing and RMG spans are governed by the buffer requirements. We estimate that our system can feed semi-automated STS cranes so as to average 40 containers per hour.

Getting the best

Again, how planners achieve optimum terminal performance and cost is largely determined by the skill and innovative ability of the planners and industrial engineers to make best use of our four conveyor system modules.

The same can be said about the TOS. Here are some possibilities:

- Individual modules can be shut down when not needed. They only need to start and be running in sync with arriving containers, which can come from either direction.
- Power generated during stopping one module can help start another module.
- The idler modules are an ideal location to measure speed and send advance notice to down track transport modules.

In many ways our conveyor system can be visualised as being similar to automobile travel with main multi-lane highways, exit lanes, turns onto urban streets, and more turns onto local streets; even a beltway surrounding the city.

As with autos, one can picture alternate routes to avoid congestion and detours to avoid a street that is closed. The terminal and TOS can be designed to be "smart," to manage traffic in real-time based on present and pending near term traffic conditions.

Elevated view

Here are some more advantages of an elevated conveyor system:

- Elevated conveyors have been used in manually operated ports for decades with little or no issues about restricting human access. We believe the prevailing mandate that no people are allowed inside an automated terminal is not applicable to our conveyors, just as it is not applicable to the bulk conveyors presently in service at numerous ports worldwide.
- Dock worker access to reefer stacks can be unrestricted and the reefer stacks can be fed by a branch of the conveyor system.
- Sheet rainwater drainage over sloping pavement to catch basins is unobstructed.
- For a "green" terminal, paving is unnecessary except for vehicle travel. Otherwise, gravel or even turf could be the surface treatment.
- Electrical power is provided by conventional conduit and wiring attached to the underside of the conveyor structure.
- Snow and ice are a common problem at many ports. The space under an elevated conveyor can be enclosed and heated. A snow blower or plough can be transported on the conveyors to self clear the conveyor system.
- Modules can be lubricated and maintained in situ or replaced with a sister module and transported to the maintenance shop when that is necessary. ❑

**This article has been written by Bill Casper, president of US-based crane design and engineering firm Casper, Phillips & Associates. The system described has patents pending. See also WorldCargo News, December 2010, p3. email: casperph@cranedesign.com*