AUTOMATION OPTIONS FOR RTG TERMINALS

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Rubber-tyred gantry (RTG) cranes are the most common container terminal operating mode in the world. However, the most common style for new terminals built in the last decade has been automated or semi-automated operations based on automated stacking cranes (ASCs). The world's busiest container port, the Port of Shanghai, built the Yangshan Island terminal originally as all RTG, but the newest expansion of this terminal now uses ASCs.

This paper explores the reasons, or lack thereof, for converting from an existing RTG terminal into an ASC terminal. In our example analysis we will consider a medium size, rectangular, three berth terminal with 1200m of quay face and 12 STS cranes. We will assume that the berth capacity of this facility is approximately 1.2 million container moves per year (100k per STS crane). At 1.75 TEU per container, this equates to a volume of 2.1M TEU per year. These are not absolute limits of course, but do describe a very busy terminal by North American standards, and are conveniently round numbers for illustrative purposes.

TERMINAL SPECIFICS

If we assume 50 slot turnovers per year (or a mean container dwell time of just under a week), this terminal will need to store approximately 42,000 TEU of container inventory during peak times. For 1 over-5 RTGs in an import/export operation, the maximum desired overall stacking height is perhaps 3.25, so 12,900 twenty-foot ground slots (TGS) will be required for peak storage. RTGs are most commonly arranged in rows parallel to the quay, and we will assume this arrangement in our example analysis. Each of these rows can store approximately 900 TGS for a 6-wide RTG configuration, meaning we will need 15 RTG rows in parallel in order to match the berth capacity of this example terminal. This will require approximately 450 metres of net container yard area perpendicular to the berth. This is coincidentally the approximate depth of the Yangshan RTG terminal layout.

One argument for converting to automation (i.e. ASCs) is an increase in capacity. Let's see how much area would be required to support the same 1,200m quay with an ASC operation. This width of terminal will likely allow for 31 ten-wide ASC blocks. Each block will need to store 1,355 TEU to meet the terminal wide target of 42,000 TEU. 1-over-5 ASCs can operate with slightly taller stacks than RTGs because they have more flexibility in rehandling containers so let's assume a target height of 3.5 for the ASC operation, meaning that each block will need to accommodate 387 TGS. At 10-wide, this means each block will be 39 TGS lengthwise. This is a net length of 300m for the high density storage, but each row has approximately 30m of storage buffer or truck parking at each end, and perhaps another 20m of vehicle maneuvering space, so the equivalent container yard (CY) space for an ASC row is approximately 400 meters.

This simple analysis shows that perhaps 10% of CY space can be saved by converting from RTGs to ASCs as a primary storage mode. This is effectively all due to the 10% taller stacking heights assumed in the calculations. In most real world scenarios, this 10% area difference is not a meaningful amount of space saving. This is especially true for existing terminals where there is no opportunity to monetize the surplus land by giving it back to a landlord port, or subleasing it for other purposes. For greenfield developments, especially those involving ocean fill, a 10% footprint reduction may be significant but it is largely irrelevant in a decision process for a potential retrofit project.

RTG TERMINALS VS ASC TERMINALS

Let's now turn our attention to the cost comparison of these two systems. The cost to build 31 ASC blocks, with 62 ASCs, a pool of perhaps 60 or more AGVs, plus all the related crane rails, pavement and drainage modifications, electric utility upgrades, software, sensors, and gate modifications will likely range from a third to a half of a billion US dollars. This will eliminate nearly all the stevedoring and gate service labour, but it will also take perhaps five years to accomplish, during which time the terminal will be operating while under construction which will almost certainly reduce STS productivity and increase operating costs during this phase of operation. This level of capital expenditure and risk is enough to dissuade all but the most enthusiastic ASC proponent from undertaking a conversion from a busy RTG terminal into an ASC terminal.

So what are the options and the payback for operators of manual RTG terminals? There are two primary strategies: automating the RTGs alone, and automating both the RTGs and the terminal tractors. Let's now examine operating costs for a manual terminal. The simplest way to do this is to consider a single STS crane doing 100,000 moves per year. If this crane works at 25 moves per hour, it will operate for 4,000 hours per year. A typical stevedoring gang may consist of two RTGs in the yard to support each STS crane. On the gate side there are likely at least two RTGs also utilized to serve street trucks moving the 100,000 containers to or from the hinterland. Overall, our terminal will need approximately 50 RTGs to support 12 STS cranes and gate operations simultaneously.

For this generic example let's assume 1.5 drivers per RTG for relief (on the US West Coast, up to 4 people including two drivers + clerks and spotters may be used for each RTG). So in the manual operation, six RTG drivers are employed to support each STS crane with four RTGs. If these RTGs are automated and the drivers control them remotely as needed, the terminal can be staffed with perhaps one driver per three RTGs. For our single STS crane example, automating the RTGs would save 4.67 drivers, or 18,700 driver hours per year. With an example labour cost of US$75/hr (this is also much higher on the US West Coast), automating the RTGs can be expected to save approximately $1.4M in labour, or $350,000 in labor per RTG automated.

A Feb 14, 2018 article in the Journal of Commerce cited a cost of approximately $600,000 per RTG for conversion to automated operations at CT9 in Hong Kong. This implies a payback period of approximately two years for RTG automation projects. If our example terminal has 50 RTGs in total, the entire capital outlay for RTG automation is approximately $30M, which is less than 10% of the capital cost of an ASC conversion, and has the additional benefit of very little disruption to the ongoing operation.

RTG automation also promises to increase driver safety and comfort by moving them into an office setting. A testimonial to this can be found in a YouTube video produced by ABB. In it, Eric Gonzales, a remote ASC crane operator working in an office at LBCT who formerly worked on RTGs states, "I really like working in the control room environment. I get to drink a lot of water, which is a lot healthier. When you are up in the crane you don't get to drink a lot of water because you don't get to come up and down". Using remote RTG operators also saves a great deal of time and hassle to physically shuttle drivers to and from their machines. This combination of attributes makes automation of existing RTGs a very appealing proposition, especially for terminals in high labour cost areas. Automated RTGs also can potentially be combined with appointment systems to facilitate clever strategies for low cost pre-sorting of containers for the next day's pickup at the gate.

CONCLUSION

Of course, this is not yet an 'apples to apples' comparison with an ASC+AGV terminal in terms of labour savings. Each STS crane is supported by a fleet of perhaps seven yard tractors and eight drivers, including some relief. So 12 STS Cranes will require 96 tractor drivers to support the stevedoring operation. All of these can be eliminated with a conversion to AGVs (or autostrads). 100 tractors at 4,000 operating hours per year at $75/hr is a labour saving of $30M per year. Added to terminal-wide RTG labour savings, a fully automated terminal in this example may save nearly $50M in annual labour. This is considerable but not an obviously appealing return on investment compared with a total up front conversion cost that may be as high as $500M.

The conventional wisdom in terminal planning was that robotic vehicles needed to be physically separated from manual vehicles, including street trucks, for safety reasons. This paradigm resulted in the end-loaded ASC operation which allows for fully separate zones of work with robotic stevedoring transport vehicles on the waterside of the ASC stacks, and manual street trucks on the landside of the stacks. This requirement for strict segregation is now being challenged in a variety of areas from pallet sized robots in warehouses, to automated cars and trucks operating on public streets.

A number of companies are working on automated tractors or retrofit systems to automate existing manual terminal tractors. The Port of Tianjin is one recent example of a location that is currently testing automated tractors. The cost premium for a new tractor or retrofit kit for existing tractors is not well known but likely to be in the range of $100-200k per tractor. If these prove viable, the 100 tractors in our example terminal could be automated for a cost of only $10-20M in additional capital and generate a savings of $30M per year, for a payback time of only a few months.

These simple calculations strongly suggest that for operators of existing, heavily utilized RTG terminals, the best course of action in terms of automation is not to proceed with wholesale conversion to ASC+AGV systems, but to focus on automation of the existing RTGs and probably also the tractors as this technology matures and local regulations allow it.

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