Alternative RMG applications in container ports

Dan Johnson, Senior Project Manager, JWD Group, a division of DMJM Harris, Oakland, CA, USA

Rail-mounted gantry cranes (RMGs) are a hot discussion topic at container ports these days. Many port authorities, terminal operators, and shipping lines are taking a keen interest in how facilities with RMGs perform, and how their own facilities might some day use the technology. This article discusses RMG options that were studied at Jebel Ali in Dubai and at the New York Container Terminal (NYCT). The results at these very different facilities were illuminating.

The JWD division of DMJM Harris, acting as a subconsultant to Halcrow HPA, prepared conceptual plans for Jebel Ali Terminal 2. We prepared simulation analyses that studied options for end-loaded and side-loaded RMGs, comparing them to other, more conventional yard-handling options. The end-loaded option included pairs of end-loaded, portal-frame RMGs perpendicular to the wharf (see Figure 1). When automation is included, this arrangement is called an automatic stacking crane (ASC) system. Facilities currently using this technology, albeit with differing layouts, include CTA in Hamburg (with nested pairs of RMGs per run that can pass each other), and ECT in the Netherlands (with a single RMG per run). For our study, the Dubai Ports Authority (DPA) selected the comparison option of matched-gage RMGs in pairs. For waterside transport, options included automated and manual shuttle carriers, automatic guided vehicles (AGVs), and conventional yard-tractor/trailer combinations.

The side-loaded RMG option included double-cantilever RMGs parallel to the wharf with wharf-to-yard transport provided by either shuttle carriers or yard-tractor/trailer combinations (see Figure 2). DMJM Harris had previously prepared similar conceptual plans for terminals that are now operating at Pusan Newport, South Korea, and Haifa, Israel. Other installations include HIT in Hong Kong and T-5 in Kaohsiung, Taiwan. Side-loaded, cantilever RMGs are also commonly used in intermodal rail yards.

Detailed terminal simulations were prepared to show overall on-terminal traffic movement with each transport option. The cantilever RMG layout had higher expected productivity (35.5 lifts per hour) than the ASC (33.6) and RTG (29.0) options. The cantilever RMG layout also had a relatively low variable cost per lift (US$15.60) compared to the ASC (US$18.70) and RTG (US$14.90) options.

Ultimately, DPA decided to use double-cantilever RMGs served by tractor-trailers in the first phase of the multiphase development. Tractors won out over shuttle carriers partly because tractors parked close together under the quay cranes were expected to support

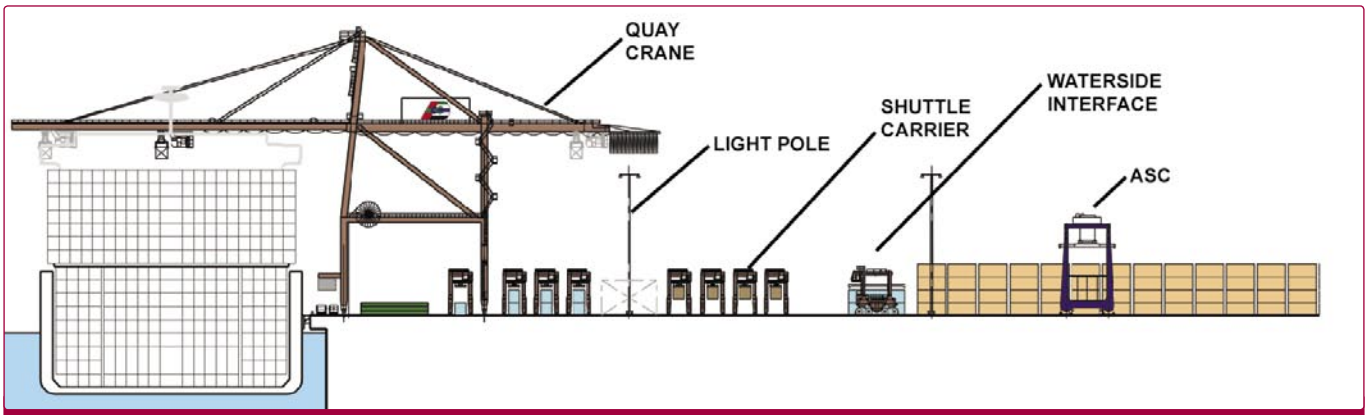

Figure 1. Cross-section of End-loaded RMG option.

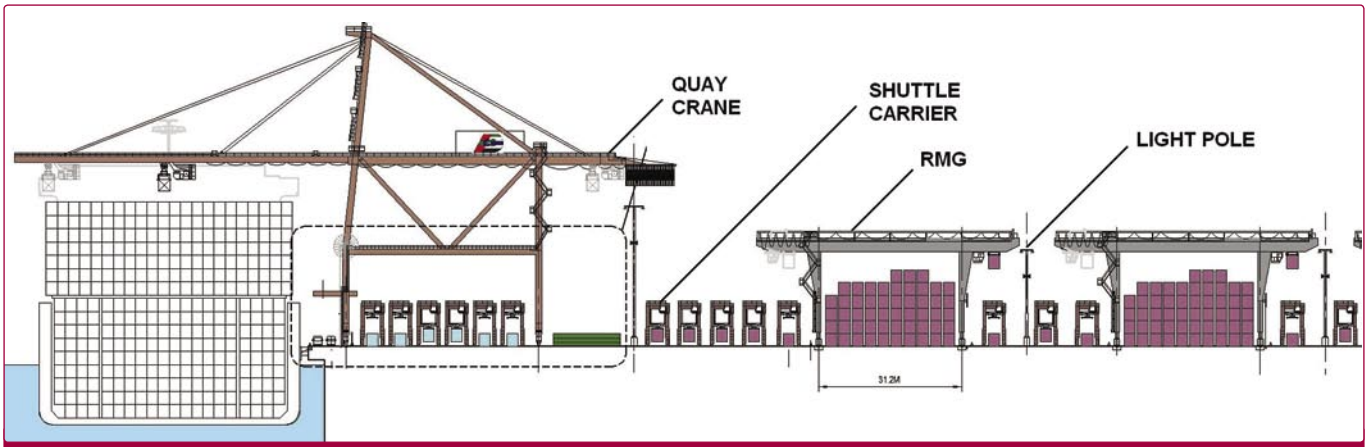

Figure 2. Double-cantilever RMG option with shuttle-carriers.

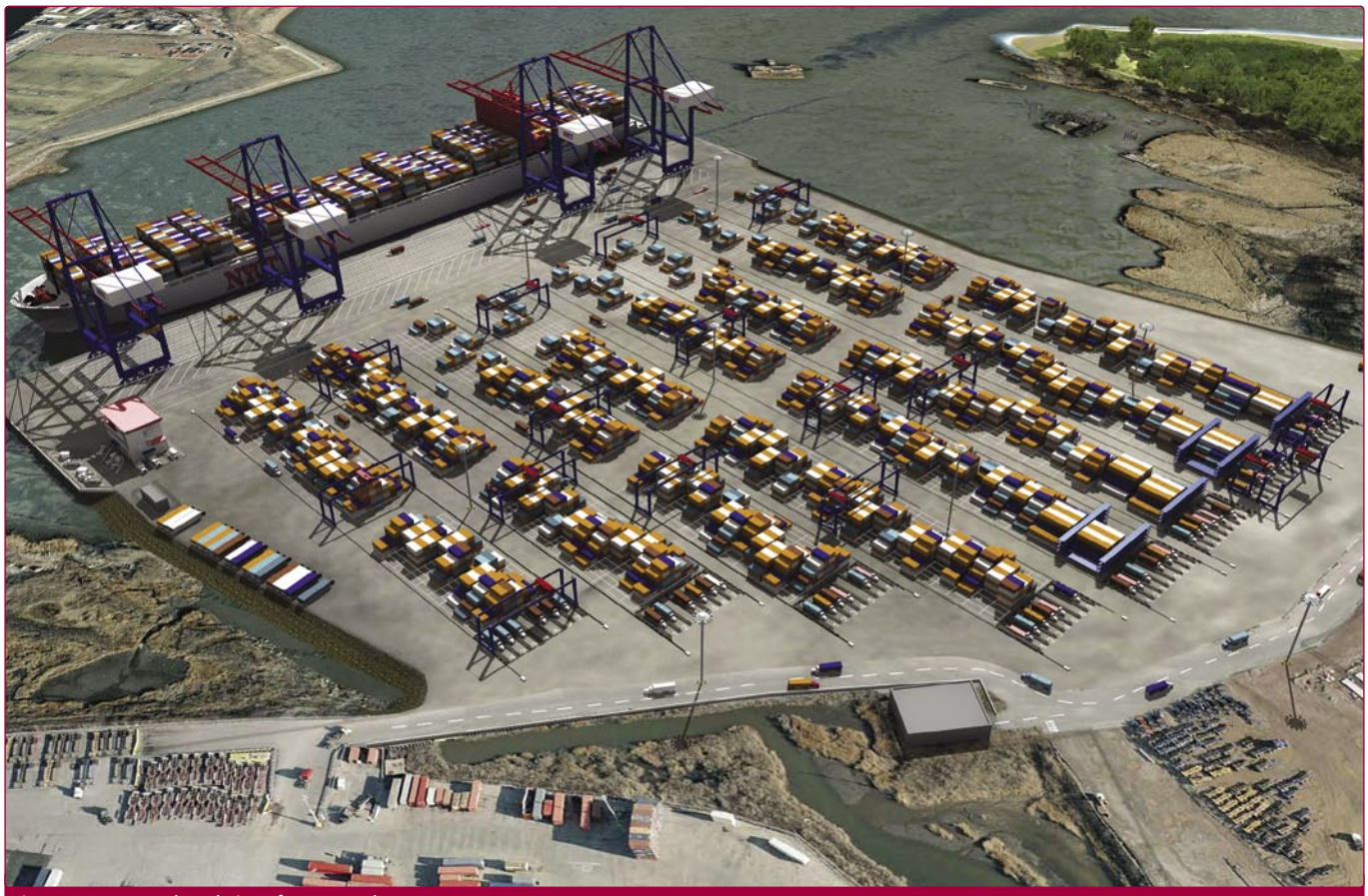

Figure 3. Conceptual rendering of NYCT, Berth 4.

tandem-lift operations better than shuttle carriers. The terminal will be configured with storage areas for loaded containers stacked 6 high by 10 wide in grounded stacks, serviced by 31.2 m gage, eight-wheel, electric-powered, double-cantilever RMGs capable of lifting one container over a 6-high stack. The RMGs will run parallel to the wharf.

One element driving that decision was that labour costs in the area are very low. Therefore, any potential automation could not be expected to generate a large reduction in labor costs. A second element driving the decision was the perceived lower risk of delay to start-up for the selected operation. DPA's critical requirement was its extremely aggressive schedule.

New York Container Terminal

DMJM Harris studied similar operating options for RMGs at NYCT (see Figure 3). The U.S. operating environment is very different from that of the Middle East. Currently, the only automated facility in the United States is the APM Portsmouth, Virginia terminal that opened in August, 2007.

NYCT asked us to refine a novel RMG layout they had devised. The refined layout (Figure 4) includes portal-frame RMGs perpendicular to the wharf. The RMG infrastructure can readily be used in an ASC layout, but initially it will be adapted for nonautomated use. This is accomplished by splitting the storage yard down the middle, halfway back from the wharf. NYCT's idea uses the waterside of the yard as a side-loaded RMG yard, as one would operate a rubber-tired gantry crane (RTG) facility where RTGs are run perpendicular to the wharf.

On the landside, the layout is a typical ASC yard. Trucks arrive at an RMG interface at the landside ends of the storage blocks, where they are loaded and unloaded by manned RMGs. Containers are marshaled for receipt and delivery to and from street trucks in an adjacent storage yard, and are shifted between the landside and waterside storage blocks as time and operations

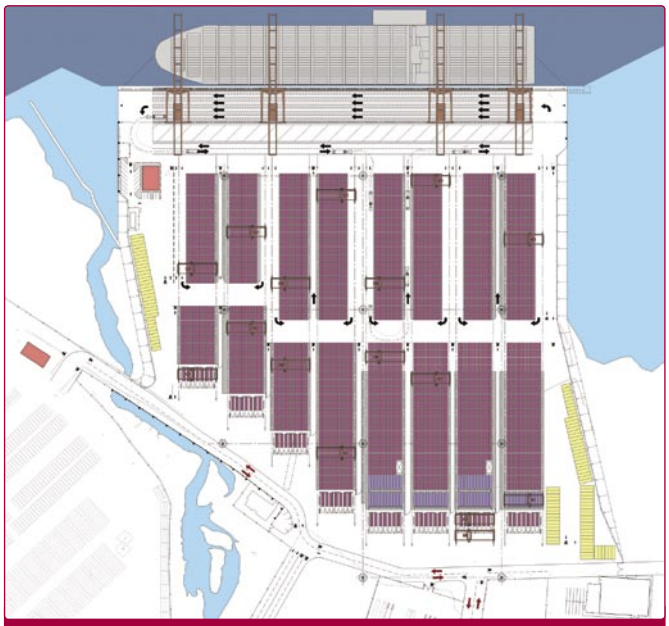

Figure 4. Refined NYCT Cconceptual plan.

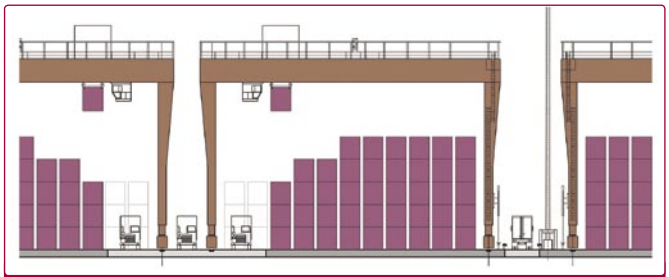

Figure 5. Hybrid RMG cross-section.

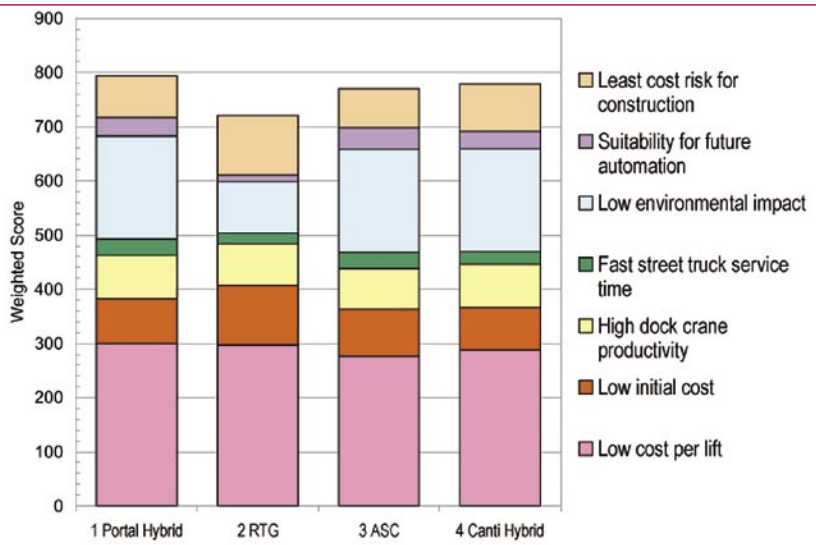

Figure 6. Scoring of final options.

permit. During stevedoring operations, yard tractors circle back toward the wharf and cross a single rail of the RMG that is serving them. Safety is maintained at the RMG truck crossing through a variety of measures that include locking out RMGs to keep them from traversing the center cross aisle when that row is being used for stevedoring.

The RMG rails are arranged in the same way as an 11-container-wide ASC layout. The overall layout can later be converted to an ASC terminal with automated, end-loaded stevedoring equipment (if desired).

The simulation model calculated that there was adequate time available to shift containers between the landside and the waterside storage blocks during slack times. DMJM Harris performed a simulation analysis of several operating options using similar assumptions. NYCT's so-called hybrid RMG layout (Figure 5) had higher expected productivity (33.1 lifts per hour) than the ASC (31.1) and RTG (31.7) options. The hybrid RMG layout also had the lowest variable cost per lift (US$66.70) compared to the ASC (US$72.20) and RTG (US$68.90) options. The comparison metrics are shown in Figure 6. The hybrid RMG option scored best – by a narrow margin – and was therefore selected for implementation.

The hybrid RMG option offers the following benefits:

- Relatively high expected vessel productivity
- Ability to develop the system without technology introducing potential delays
- Ability to station a person with each piece of equipment (per NYCT's explicit goal)
- Ability to convert later to a fully automated ASC system
- Critical environmental advantages in a difficult permitting environment (the proposed yard cranes are electrically powered)

Decision criteria

DMJM Harris used a variety of tools to help the decision makers evaluate their options. These tools included simulation modeling, capital and operating cost estimates, and a decision matrix that combines these factors with qualitative issues (such as relative environmental impacts and expected start-up delay risks). Each operator used a completely different set of decision criteria, and weighted the relative factors very differently.

Conclusions

The two described projects illustrate some interesting points about RMG options:

1. Location may dictate design conclusions. The 'best' option for one country, region, or port may not be the best for another.
2. The decision may be swayed by issues other than productivity and cost per lift.
3. Operators who are not yet ready to implement completely automated operations have options; they can create a flexible manual system that may be automated in the future.
4. Simulation modeling is an excellent way to economically compare proposed operating alternatives.

In years past, the maritime industry often fell back on RTG layouts when leading-edge options were being compared. This was particularly true when issues such as start-up schedules and risk were the major concerns. It appears that the industry has evolved to a point where manually operated RMGs are the fallback option, and partially or fully automated cranes are now considered viable. The RMG alternative is certainly a major step forward for an industry that is moving toward higher volumes, increased density, and the use of sophisticated technologies in the terminal environment.

ABOUT THE AUTHOR

Daniel J. Johnson, has planned and designed marine terminal and intermodal rail facilities in 14 countries, and he has managed container terminal operations in Seattle and Los Angeles. Dan holds a bachelor's degree in industrial engineering and operations research, and professional licenses in both civil and industrial engineering.

ABOUT THE COMPANY

DMJM Harris has provided port planning, design, and construction management services since 1927, and recently enhanced its marine terminal planning and simulation capabilities by acquiring JWD Group. With its staff of over 2,000 professionals, DMJM Harris is the flagship transportation component of AECOM, a global professional services corporation. AECOM has recently been ranked as the United States #1 transportation and #2 marine facilities engineering design consultant by Engineering News-Record.

ENQUIRIES

Dan Johnson, P.E. – Senior Project Manager
DMJM Harris
300 Lakeside Dr. Suite 750
Oakland, CA. 94612
USA

Tel: +1 (510) 844 0554 (direct)
Fax: +1 (510) 835 3464
Email: dan.johnson@dmjmharris.com
Website: www.dmjmharris.com