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Future-Proof Your Crane

Presented at TOC Americas, Miami
October 2001

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THE FUTURE

For a dockside container crane, the future starts tomorrow and will last until 2025 or 2030. This is the reasonable life of a container crane.

The crane may be operational for 40 years, but the useful life will not be more than 25 or 30 years, and even then the crane will need occasional upgrades to perform to modern standards.

We are now in a state of rapid change. Ships are larger and will continue to grow. Concomitantly, production must increase to maintain reasonable turnaround times. Laser and optical technologies also continue to develop, making current systems obsolete.

Cranes ordered today must be capable of growing as new ships grow and technology evolves. The cranes must be future-proof. But if today's crane is built large enough to serve tomorrow's ships using future technology, the crane will not perform well on today's ship with today's technology.

This paper presents our expectations of the future and some ideas on how to cope with them without paying now.

THE FUTURE-PROOF CRANE

The future-proof crane shown below illustrates some of the issues that need to be considered. The keynote numbers identify the issues. Of course, none of the suggestions are correct for all conditions. The purpose is to present some ideas that need consideration.

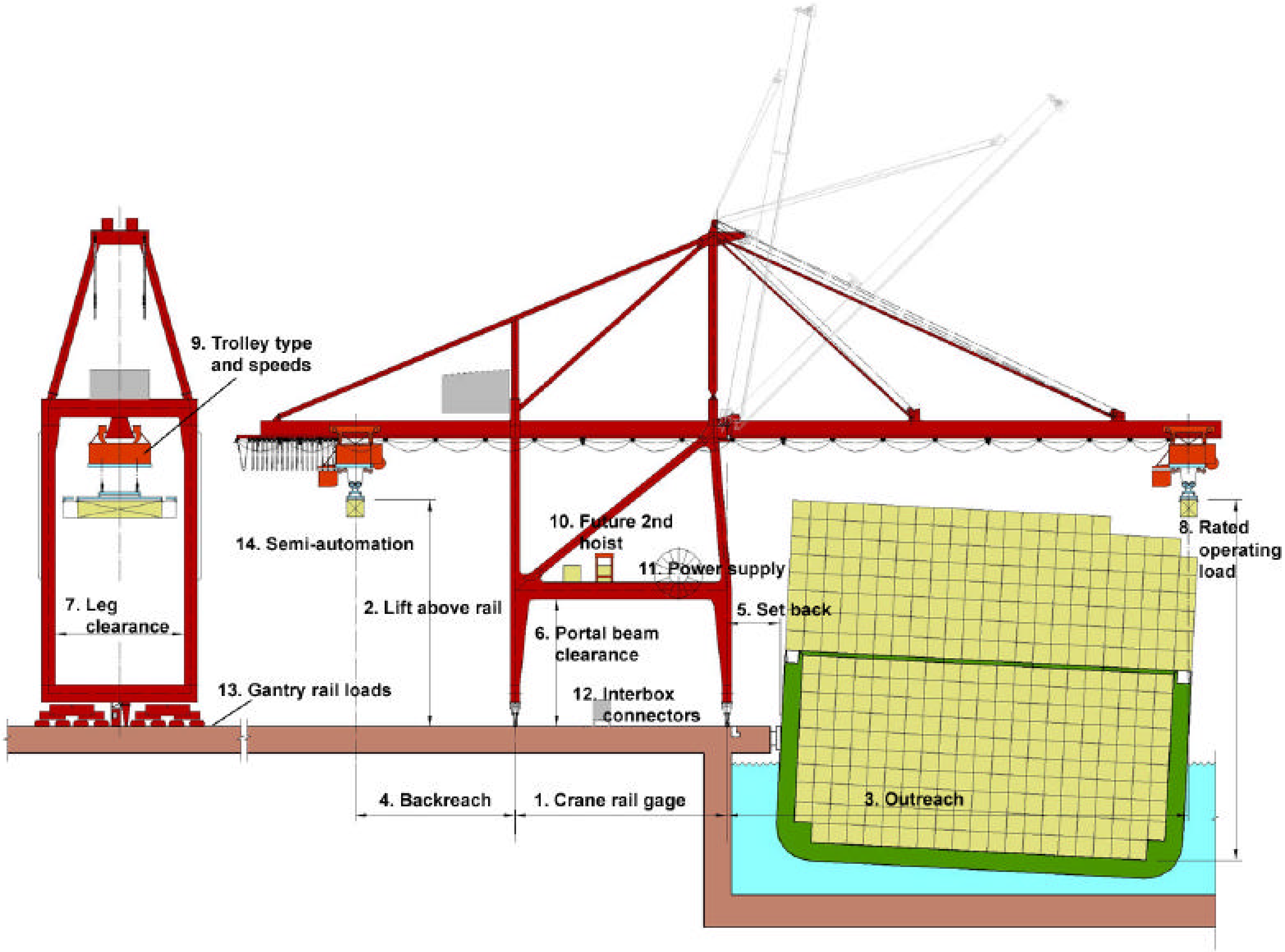

Figure 1: Future-Proof Crane

Dimensions

1. Crane rail gage: 100 feet

Although there are some good arguments for increasing the gage to as much as 150 feet, the cost of shipping the erected crane will be much greater, since the larger gage cranes cannot be shipped athwart ships. So instead of four or six cranes being shipped on one vessel, only two cranes can be shipped on one vessel.

2. Lift above rail: 131 feet now, 156 feet future. Total lift: 183 feet now 207 feet future

The higher the trolley is above the wharf, the more difficult it is to control the load. Therefore, the current height should be kept to a minimum. The 131 feet will suit current needs for vessels with 7 containers on deck. If the crane is designed now so the height may be increased to 156 feet later, the crane will then be able to handle the 22 wide ships when they arrive. Providing for the future raise now increases the cost now, but only nominally. The cost is offset by future savings in time and cost when the future raise is made by simply adding segments to the legs and making the concomitant changes.

3. Outreach: 210 feet

The question is: How wide will the future ship be?

At first, all container ships could pass the Panama Canal; these ships were known as Panamax. In the late 1980s, American President Lines introduced the C10 vessel with 16 containers on deck. The C10 vessel is too large for the Panama Canal, and is referred to as post-Panamax. The Regina Maersk has 17 containers on deck. Current Maersk crane orders provide for vessels with 22 containers on deck. We have developed wharf loads for ships with 23 containers on deck; these ships are referred to as Suezmax. In 1999, Delft University Press published a book[1] describing the "Ultimate Container Carrier" with 24 containers across: the Malacca-max. Where will this end?

We think the future beam will end at 22 across and for many ports, perhaps 17 across. It's well known that all organisms grow until they become too large to compete. Then the extra large die and a smaller, more fit species evolves. This happened with super tankers and will also happen with container ships. So, although the Malacca-max ship may have a niche someday somewhere, they will be so rare that they do not need to be considered for American ports. We suggest planning for the 17 wide vessels today and the 22 wide vessels in the future.

Generally, it's much more economic to design for 22 wide now than to increase outreach later. The outreach was calculated using the following:

> *Outreach beyond waterside rail = 8.05 x (containers on deck - 0.5) + setback + increase due to 1° list + overrun*

The overrun was assumed to be 3 feet. This overrun is reasonable for current controls that automatically reduce trolley speed as the trolley approaches the end of the runway.

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[1] Niko Wijnolst, Marco Scholtens, and Frans Waals. Malacca-Max: The Ultimate Container Carrier. Delft University Press, The Netherlands, 1999.

Of course, larger ships require more crane lifting height. Current cranes can be designed for future increase in height as shown below.

In many cases, channel depth will limit the practical vessel size. If this is your case, don't plan for a ship you will never service.

4. Backreach: 75 feet

This allows for handling hatch covers and container landside of the landside rail. Less backreach may be reasonable, but the cost reduction is low.

5. Set back of the landside rail from the face of the fender: 25 feet

This provides a traffic lane for vehicles servicing the cranes and the ship. Eventually, automated guided vehicles will handle the containers. Automated vehicles and manual vehicles, e.g., tractors, should not be operated in a common area – a barrier is required between the automated zones and the manual zones. The natural location of the barrier is at the waterside of the waterside rail. If the barrier is between the crane legs, the space between the crane legs will be reduced, causing even more congestion on the wharf.

6. Clearance under portal beam: 50 feet

The clear height is recommended to provide for future straddle carriers or other second hoist equivalents on the wharf. Someday, the landside operation may be fully automated. Then, a second hoist equivalent may be justified, since an extra operator would not be required.

The higher portal requires increased structure to maintain a reasonably stiff crane in the trolley travel direction. This is necessary to prevent sympathetic response of the frame to the trolley accelerations. The increased cost is nominal.

The sway problem is discussed in "Megacranes: Holding Sway[2]."

7. Clearance between the legs: 60 feet

Container lengths will increase to 53 feet. The current maximum of 48 feet provides 6 feet of clearance on each side, which provides for flipper clearance. By the time the container length increases to 53 feet, the landside operations will be automated and the crane controls will automatically verify that the flippers are either up or down as the container passes through the legs.

Capacity

8. Rated operating load: Twin twenties at 30 long tons each; single forty at 50 long tons; cargo beam to suit strength determined by the normal operating load

Container loads may increase beyond the recommended values. But the heavier containers will not suit most highway limits, so higher loads will only occur for containers that are not taken over the highway.

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[2] Michael Jordan. "Megacranes: Holding Sway," *Port Development International*, May 1998, pp. CC10-11.

Another limitation is the capability of the container ship. The ship can carry TEUs with a maximum average weight about 12 long tons. Since FEUs are used for bulkier cargo, the average FEU weighs less than 24 long tons. The duty cycle effective fatigue load will be less than 60 long tons. The design should include a rational development of the fatigue load spectrum. Typically, the effective fatigue load is about 37.5 long tons.

In some cases, a much heavier cargo beam load is justified. For some ports, a 100-long ton cargo beam capacity is economic. The extra revenue from an occasional heavy lift may more than pay for the added capacity cost. This is true at some berths in the Port of Oakland.

Trolley

9. Trolley type and speeds: Machinery on Trolley; Hoist at 300 fpm loaded and 600 fpm unloaded; Travel at 800 to 1000 fpm

The trolley type will either be a "machinery on trolley" or a "rope trolley." The pros and cons have been discussed in "Rope-Towed or Machinery Trolley, Which is Better?[3]." We recommend the MOT. If a rope trolley is used, the ropes should be continuously supported by the boom and girder so the load can be properly controlled when the landside operation is fully automated.

The speeds and accelerations, along with dwell times, limit the production of the crane. The effects of varying these can be examined using Liftech Consultants Inc. program, "CraneSim."

The following sketch shows an efficient machinery trolley.

[3] Available for download on the Liftech website: http://www.liftech.net/LiftechPublications/machtrly.pdf

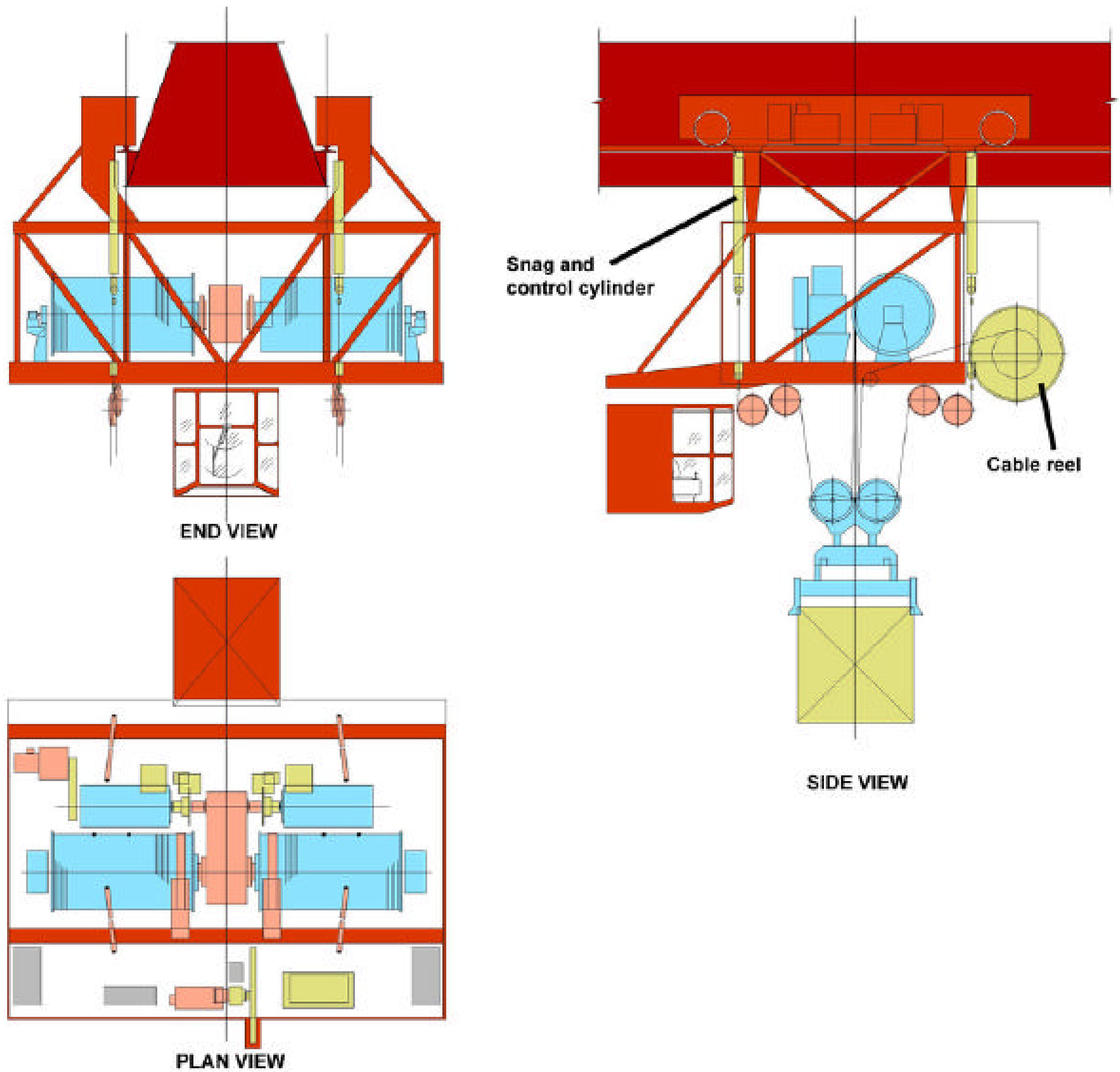

Figure 2: Machinery Trolley

10. Future second hoist on the portal: Not recommended

Typically, crane production is limited by the shore operation, so the second hoist does not have as great of an effect as analysis of the crane might indicate. Unless the shore operation is fully automated, a second hoist requires a second operator. Usually, the cost of the operator overrides the potential benefit. In the future, the effect of a buffer and second hoist on the crane can be achieved using a equivalent second hoist on the wharf.

In some special cases, it may be worthwhile to include provisions for a future second hoist on the crane. Liftech has designed a number of cranes with provisions for future second hoists. Some of the cranes are now over 20 years old. None have been converted to dual hoist cranes and we don't expect them to be. Generally, dual hoist cranes have not been economic in the Americas.

11. Power supply: Design to suit facility

Power is supplied either through a cable reel of a collector trench. The cable reel has an advantage in that it can include a fiber optic cable for communications. Cable reels have been built to hold 2500 feet of cable, e.g., Port Everglades low profile cranes.

Supply voltage ranges from 4160 V to 12 kV. The higher voltage will become more common as the power demands of the crane increases. The total operating power in current cranes is about 1500 to 2000 hp. More is required during some operations when motors reach current limit. The power requirements will vary according each facility.

If a collector trench is used, it needs to be rather large because of the high voltage, like the ones on berths 55 through 60 in Oakland. The trench can also include a communications wave guide.

The better choice is not clear.

12. Interbox connectors: If possible remove them “off hook”

Unfortunately, IBCs are here to stay. Only a few hatch-less ships will be used. We expect that installing and removing IBCs will continue to slow production.

The IBCs can either be removed while the container attached the spreader or after the spreader releases the container at the wharf.

If the crane sets the container on bomb carts, “cornerless bomb carts” may be used. The cornerless bomb cart has longitudinal beams that support the container so the corners are free. This allows the trolley to set the container and not wait for the IBCs to be removed.

If the IBCs need to be removed before the crane releases the container, consider providing for a IBC platform on the crane. This way, when shore operation becomes automated, the workers will not be in the way of the automated vehicles.

Rail Loads

13. Gantry rail loads: Using ACI 318-99 criteria for the factored loads: Landside rail 60 kips/foot; Waterside rail 70 kips/foot

The criteria for the determination of the design wheel loads are often confused. One difficulty is that a civil engineer designs the wharf, and a mechanical engineer designs the wheels. The mechanical criteria used by the mechanical engineer are concerned with both strength and durability. Usually durability is dominant. The structural criteria used by the civil engineer are concerned with collapse.

Frequently, the mechanical engineer reports wheel loads based on combinations, which are not related to the ACI load combinations. Often, the structural engineer is unaware of how the mechanical engineer determined the loads. To add to the confusion, different manufacturers use different criteria. The result is often extravagant conservatism. The owner’s specification should include a load combination table showing each load and the required load factor.

The recommended rail loads are based on operating conditions and the ACI criteria. A small contingency has been added. Out-of-operation conditions have not been included.

The following table shows some salient data for some classic cranes:

CRANE TYPE	ROPE TROLLEY						MACHINERY TROLLEY		
Typical values	Panamax APL C9	Post Panamax C10	Regina Maersk	New Maersk Standard	Suez-max	Malacca-max	New Maersk Standard	Suez-max	Malacca - max
Containers across deck	13	16	17	22	23	24	22	23	24
Ship Draft, ft	38	41	45	50	56	69	50	56	69
Ship Beam, ft	105	129	137	178	165	180	178	165	180
Outreach, ft	117	150	212	210	220	227	210	220	227
Setback, ft	14	14	25	25	25	25	25	25	25
Gage, ft	50	100	100	100	100	100	100	100	100
Backreach, ft	30	50	30	50	50	50	50	50	50
Wheels per Corner/ spacing	6/5’	8/4.9’	8/4.9’	8/4.9’	8/4.9’	8/4.9’	8/4.9’	8/4.9’	8/4.9’
Out-to-Out distance between bumpers, ft	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5
Capacity, LT	30	40	50	60	65	60	60	65	60
OPERATING LOADS APPLIED TO CRANE RAILS									
Service Operating Loads, k/ft									
Landside	15	22	20	25	25	25	36	36	36
Waterside	18	22	26	39	40	41	41	42	43
Factored Operating Loads, k/ft									
Landside	21	33	30	36	38	40	46	50	56
Waterside	26	33	39	57	58	60	58	59	60

The values in this table are approximate and will vary depending on the manufacturer and special conditions at each site.

Table 1: Data for Classic Cranes

14. Automation: Provide some now and plan for more later

Lasers and optical devices are being used now to make the landside operation semi-automatic. The position of the chassis on the wharf is sensed and signals direct the driver to adjust the load. The spreader is brought to near the pick and set positions automatically. The load is controlled using hardware and software.

In the near future, improved technologies will allow automation of all loading operations, except the fine positioning over the ship. Later, the entire operation will be automatic.

When the crane is automated, the operator's cab will not need to move with the trolley. We expect the cab will either be fixed to the crane or be on a separate independent trolley, which will probably be outboard of the main trolley.

MEGA-SYSTEMS

This paper has not addressed the many mega-systems, e.g. the Fantuzzi Octopus. These systems will have their own niche. They are beyond the scope of this paper.

SUMMARY

The above discussion is based on Liftech Consultants Inc.'s experience and opinions. Certainly, different opinions may be just as valid. Opinions will change as the container handling industry evolves.

The issues are, however, universal.