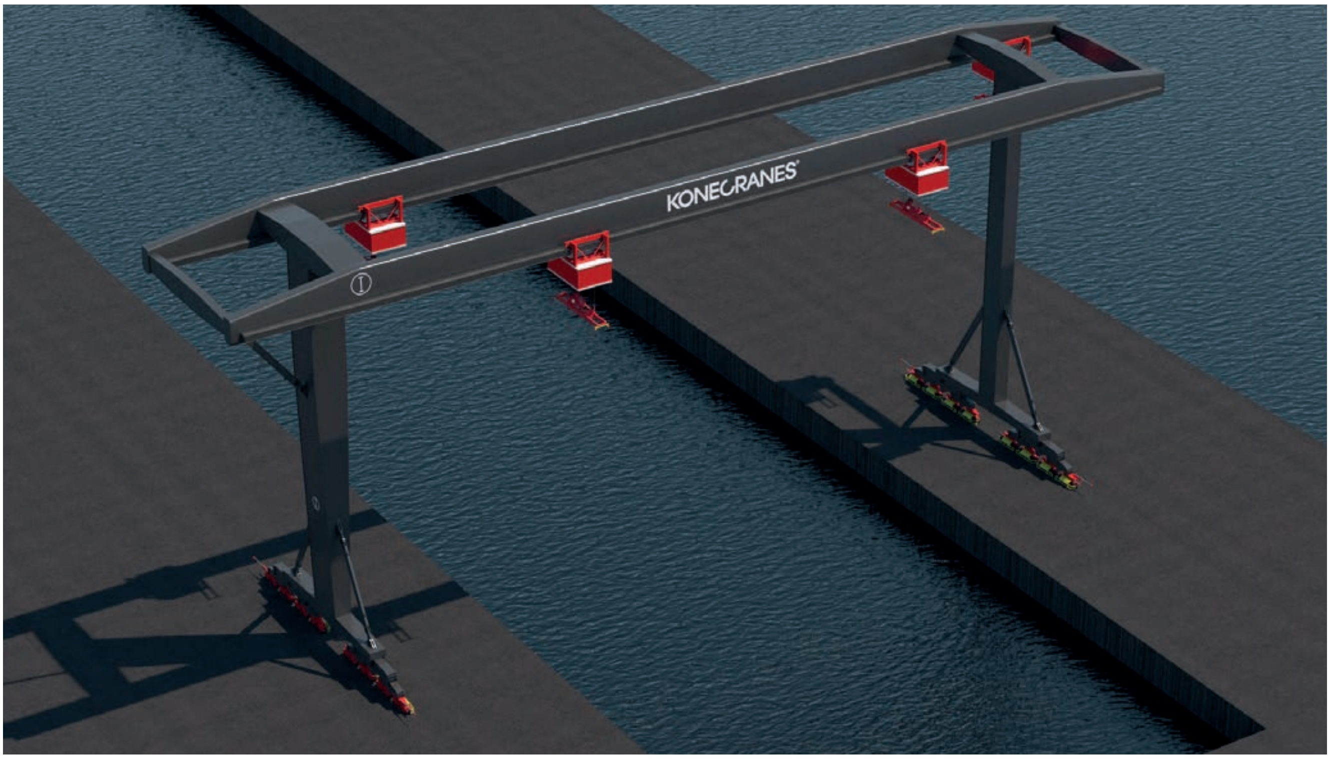

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NEXT-GEN STS CRANES

A MODEL FOR THE FUTURE

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When the container transportation system was developed in the last century, it was built on linear ship berthing and a crane loading and unloading the ship on one side only. The crane was equipped with a boom that could reach across the entire width of the ship. Container pick-up, transfer and drop-down was done by a trolley that travelled along the boom and a fixed bridge girder, usually equipped with a backreach. Space was needed on the ground for vehicles to receive and transport containers to the container stacking yard, and vice versa.

The crane could travel along the quay on rails to position itself as needed with each line of containers on the ship deck or below, and/or to move from one ship to another. While travelling, if the crane encountered obstacles in the ship superstructure, the boom could be raised to a semi-vertical position.

The trolley itself could be equipped with an onboard hoisting and travelling mechanism (machinery trolley). Alternatively, the hoisting mechanism could be located in a stationary machinery house on the bridge girder and the travelling mechanism onboard (semi-rope trolley), or both the hoisting and travelling mechanism could be located in a stationary machinery house (rope-driven trolley).

Evidently, each of these systems has advantages and drawbacks. The first system is autonomous, but the heavy trolley is a drawback for the crane structure and for the travelling mechanism itself, particularly when vessel size increases, leading to a need for faster trolley travel. An advantage was found in the relative simplicity of the design – with short hoist ropes and fast trolley positioning aiding load control.

The second system, a compromise, makes it possible to have a light trolley, giving good control over trolley traversing. But it has acceleration limitations caused by wheel/rail friction. The third system became the most common, since it enabled faster trolley acceleration and speed. This system has a light and fast trolley with a minimum of inertia forces during travel. Its drawback is a long and complex rope system requiring regular maintenance, with rope elasticity affecting load control.

This model remained in place for decades until the economies of scale in container transport began to drive up the size of containerships. Inevitably, ship-to-shore (STS) crane development had to follow and so began the evolution of Panamax, post-Panamax, super-post-Panamax and finally ultra-large container vessel Malaccamax STS cranes. The cranes grew higher, with longer outreach, faster trolley travel and greater load capacity. First came single lift, then twin lift, then dual tandem (quadric) lift, while one trolley became two trolleys,

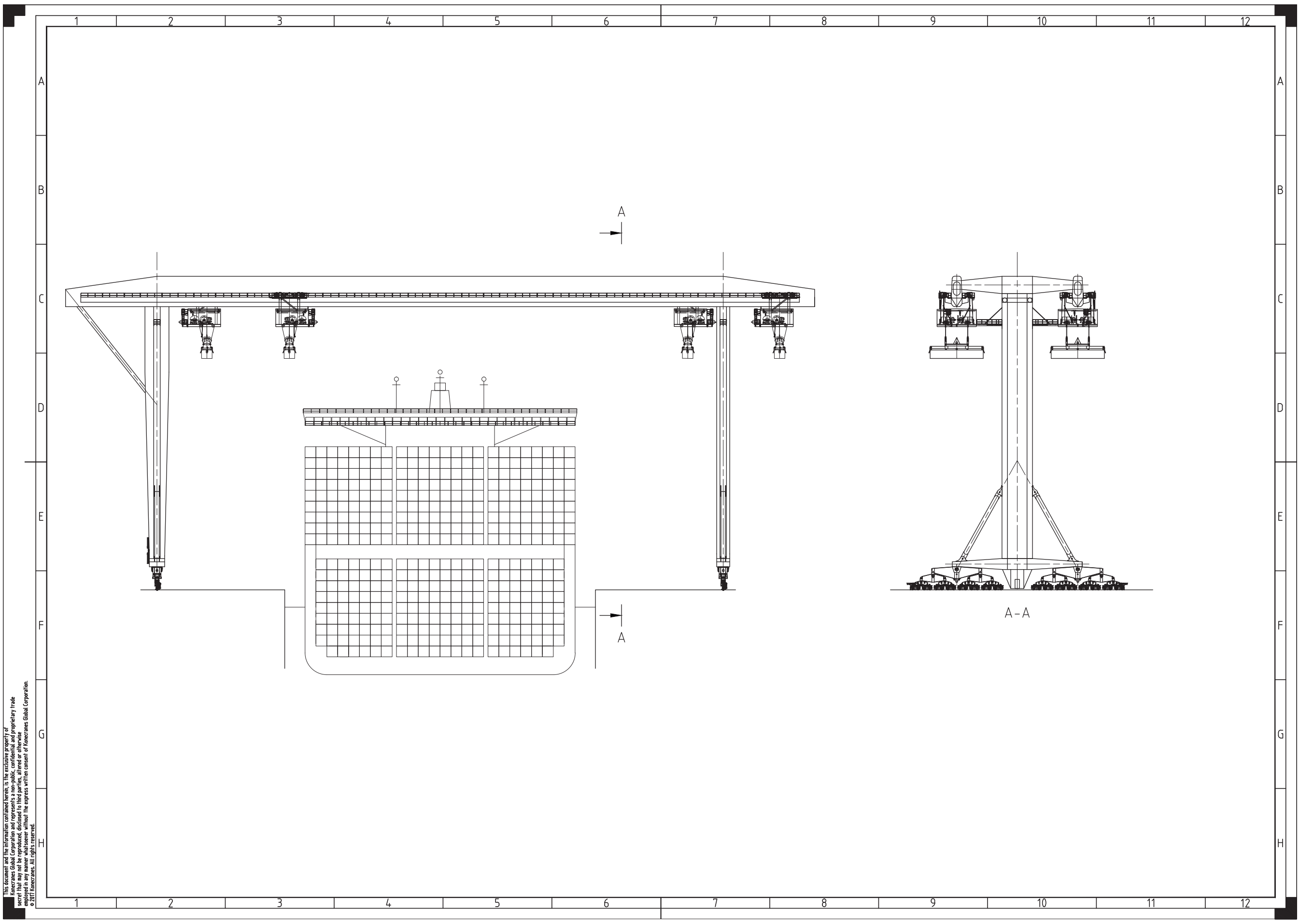

Figure 1. New quayside berth and STS crane concept

making the cranes ever heavier and more expensive.

A direct consequence of the growth in crane size and weight is the increase in the cost of crane runway foundations, particularly at the quayside. The cantilever effect of boom extension also calls for a heavier counterweight to keep the crane stable. Therefore, corner loads and support requirements on the crane foundation have multiplied during the last decade.

It is quite clear that we are reaching the end of our ability to evolve and improve STS crane performance by scaling up.

FROM EVOLUTION TO REVOLUTION

The end of STS crane evolution is confirmed when we look at the obstacles inherent in containership design. Economies of scale require more and more containers to be placed onboard. To date, naval architects have lengthened the vessel up to 400 metres (m) while restricting the increase in the width of the beam. They point out that going beyond this length in the standard design of a container ship is not advisable because it would lead to insufficient torsional stiffness, leaving aside the question of maneuverability.

Taking another path by increasing the width of the beam runs directly into another limitation of ship-to-shore crane design. It is simply against the laws of physics to extend the crane boom forever. Moreover, the speeds of rope-driven trolleys today (250m/min and more) are such that their travel mechanisms could more aptly be called “rope destruction” mechanisms.

As the number of containers carried by container ships increases, the size of the average port call is increasing up to 10,000 TEU per call and more. The pressure to unload/ load these huge vessels as quickly as possible is greater than ever – but there is a limit to how many adjacent cranes can service the vessel. Quay productivity has not increased significantly despite all attempts to develop faster trolleys that can carry more than one container per move.

In the big picture, the ever-growing quantity of containers to be transported requires that container terminals grow in size, with longer quays to receive ships, taking more of the available coastline. This poses a significant environmental problem that, accompanied by other nuisance factors such as increased air and noise pollution and traffic jams, inevitably has to be dealt with in parallel.

THE MULTI-TROLLEY STS CRANE CONCEPT

Theoretical STS productivity can be calculated according to the basic parameters of distance, speed and acceleration. Today’s STS specifications call for 90/180m/min hoist speeds, acceleration of 2/4 seconds, and trolley speed of 250m/min accelerated in 5 seconds. Over the vessel through one bay (on deck: 23x1+25x10+ and in cells: 21x10+19x1=502 moves), we can calculate the productivity of a current STS for an ULCV with a cycle time of approximately 120 seconds, giving a net production of 30 moves per hour, or 4,320 moves in 24 hours per berth with 6 cranes (or 5,760 with 8 cranes).

With the current STS concept, the

largest productivity constraint is operation on only one side of the ship, with all of the consequences described earlier.

The new, multi-trolley STS crane concept that we propose can work on both sides of the ship. It was initiated by the desire to create an ideal quayside crane match for the new ultra-large container vessels. The design goals are:

- To significantly increase berth moves in comparison with the best STS technology available today
- To substantially reduce the number of cranes servicing the ship without detriment to productivity (operational flexibility, maximum utilization rate of equipment, reduced cost of initial investment, reduced energy consumption and reduced maintenance cost)
- To improve crane stability and substantially reduce quay loads and foundation requirements (especially on the waterside), bringing a significant cost reduction to the crane runway

The new crane concept eliminates the current unloading/loading process bottleneck with a double beam portal crane design (Figure 1) that is capable of servicing the ship from both sides and that, for the first time ever, can work simultaneously on two bays of containers. The concept enables installation of two trolleys per beam, which not only greatly increases productivity but also shortens trolley travel, thus reducing the current need for high trolley speed.

The concept calls for a ship berth in the shape of an indented berth. This enables the crane to be supported symmetrically along the longitudinal centerline of the ship, thus reducing the load on the crane foundations.

In comparison with a traditional STS crane, the new crane has similar hoist speeds and a reduced trolley speed of 125m/min accelerating in 4 seconds, resulting in approximately 135 seconds per move – for one trolley. This is multiplied by four trolleys on the crane, giving a production of 106 moves per hour.

The crane concept with two parallel beams is able to match vessel bay spacing, overcoming the constraint of crane width. The output of three cranes will be 7,600+ moves per berth in 24 hours, this without considering the impact of multiple lifts already utilized with current STS cranes.

The new crane concept provides many advantages over traditional STS design:

- Reduced trolley travel speed without a loss of output (reduced energy consumption, less maintenance downtime and cost, less noise)
- No restrictions on combined trolley loads, exceptional performance in heavy-lift situations
- There are no trolley rail joints (less maintenance, less noise) so the steel structure suffers less fatigue (longer crane life, less downtime, reduced maintenance cost)
- There are dampening measures, giving a longer lifetime to the crane and crane runway
- Better aerodynamic performance thanks to the shape and shielding of the parallel beams and the absence of stays suspending the boom and upper structure (reduced foundation cost, reduced corrosion)
- Use of new materials to reduce crane mass and corrosion
- Use of remote operation and automation technology, good load control and positioning

CONCLUSION

The new crane concept is not meant to replace current STS cranes, but to complement them in a symbiosis of scale. Attempting to further evolve current ship-to-shore crane design is unlikely to solve the handling problems that the industry faces (this is also the assessment of Drewry, Ref. 1). A completely new integrated approach is needed that covers the crane, the terminal, and ideally even the ship. Together with our partners we are making progress in all three areas.

The new concept also provides a platform for further STS evolution. This point can be illustrated by the crane design. A variant of the present concept was created by slightly increasing the distance between the two beams, and creating space for a third beam running in the mid–plane of both legs. Such a crane would operate over 3 adjacent bays.

Introducing such a third beam would give an increase in output of 50% on top of the output of the two-beam crane concept. In practical terms, this means that just two cranes, instead of the presently envisaged three, could service a ship with identical output.

This could significantly decrease the initial purchase price, without mentioning other cost reductions that could be enjoyed thanks to the triple-beam crane concept.

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ABOUT THE AUTHOR

Vladimir Nevsimal-Weidenhoffer holds an M.Sc. (Hons.) degree in Civil Engineering. He has a long track record extending back to the late 1960s in crane engineering, refurbishing and project management, focusing on Goliath cranes for shipyards and grab unloaders. He holds several patents and is the inventor of the "Cofastrans" quayside crane concept described in this article.

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