Converting a manual RTG terminal to an AutoRTG terminal

Converting to AutoRTG – the next step towards improving performance

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Automation is the next step towards improving performance

This white paper describes the possibilities and processes of converting a rubber-tyred gantry crane (RTG) terminal to automated operation (Kalmar AutoRTG). Increasing the automation level of a terminal with products that automate a single part of the operation or the whole process is recognised as the next step towards improving performance at today's container terminals. The benefits of automation include lower operational costs as well as improved terminal productivity, capacity, safety and security.

Automating an existing RTG terminal is a complex project that requires deep expertise, careful planning, a capacity for wide-ranging systems integration and the ability to consider numerous factors beyond technical implementation. Besides the actual automated system, there is also extensive change management within the entire organisation of the terminal, as operating an automated terminal requires a thorough change of business processes as well as different skillsets for the people operating the terminal.

In this paper, we examine several of these areas, ranging from the financial impact of automation to terminal and infrastructure design as well as organisational considerations. Finally, we look at proven results from the advanced RTG installation at Norway's largest freight port in Oslo.

1. Why AutoRTG?

1.1 RTG BENEFITS

Rubber-tyred gantry cranes (RTGs) are the most popular equipment choice for container stacking at terminals around the world, especially where high-capacity stacking and good manoeuvrability are key requirements. With a global installation base of some 8,000 machines, approximately 60% of the world's container terminals use RTGs.

Automated RTGs are suitable for the same types of terminals as manually operated rubber-tyred gantry cranes. The main reasons to choose an RTG setup compared to other terminal concepts include simplicity as well as relatively low capital expenditures and infrastructure costs for deployment. RTGs are also highly flexible; by contrast with rail-mounted automatic stacking cranes (ASCs), the rubber-tyred cranes can be driven to a different area of the terminal if, for example, additional capacity is needed at another stack.

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RTGs also offer high stacking density and an easy automation upgrade path that is compatible with older equipment. As RTGs are able to interact with both road trucks and terminal tractors, the RTG concept is equally suited to both transshipment and import-export operations. When considering the choice of automation solution and terminal concept, it is important to remember that the question is not an either/or choice. Hybrid terminal layouts utilising multiple horizontal transportation and/or crane technologies are also possible.

1.2 BENEFITS OF AUTOMATED OPERATION

An automated RTG terminal offers several clear advantages over a traditional manually operated terminal. The most immediate and most easily quantified gain is significant savings in terminal operating expenses such as labour and maintenance costs. Other direct benefits include increased efficiency, more predictable operations, higher availability, significantly improved occupational safety, better site security and longer equipment life spans.

An automated RTG terminal can utilise various options for horizontal transportation equipment. These can range from traditional terminal tractors and manual shuttle carriers to automated guided vehicles and fully automated shuttle carriers. When automating an existing RTG terminal with an AutoRTG solution, a major benefit is that the full horizontal transportation system does not necessarily need to be revamped, but the existing terminal tractors can remain in operation.

Automation brings benefits to terminals of any size. In RTG terminals, the benefits typically become most apparent when operating half a dozen or more RTGs. However, even a very small terminal can realise performance gains from the first level of automation (remote-controlled operation). Automation can be implemented in steps; even a small investment will reap immediate benefits, and more can always be added later.

> Automated equipment conserves resources and contributes to the sustainability of operations.

RTG automation is relatively new in the industry; however, proven technologies from ASCs are increasingly being deployed in this field. An often-heard remark from people seeing an automated terminal for the first time is how smooth the operation seems. No aggressive driving is seen, no containers are banging on the ground, and everything proceeds in a steady, systematic fashion. In an automated terminal, equipment is always handled optimally. Collisions due to human error and unplanned repair tasks are eliminated.

Automated equipment also conserves resources and contributes to the sustainability of operations. Significant fuel and energy savings are realised through optimal driving patterns as well as the reduced need for air-conditioning and yard lighting. ▶

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2. Terminal implications

2.1 TIMEFRAMES FOR CONVERSION

The time required for the conversion of a manual RTG terminal to automatic operation depends greatly on the specific design, needs, operational environment and business goals of the terminal, in addition to target automation level, desired phasing of the project and the amount of equipment. However, a typical timeframe for an automation conversion project might be 12 to 30 months, though this is contingent on numerous factors including the need for possible terminal operating system (TOS) upgrades.

When planning the conversion timeframe, a key consideration is whether to optimise for maximum testing of new systems or for the swift adoption of the new processes and organisational culture required by automated operations. A slower transition will enable more thorough technical testing and training of operational personnel, but a quicker transition may be preferable for organisational reasons.

2.2. MANAGING THE TRANSITION PERIOD

In any automation project, a key priority is carrying out the conversion with minimal disruption to the existing operations of the terminal. This requires careful advance planning.

> "Key priority is carrying out the conversion with minimal disruption to existing operations.

An RTG terminal can be automated in several steps, each implementing further levels of automation. Automating an RTG terminal does not necessarily require any changes to the terminal layout, but an automation-optimised layout may improve efficiency, especially if the horizontal transportation concept is re-organised.

If horizontal transport is also automated, the procedures for STS operation, landside interface and reefer operations will change completely. Alternative processes may need to be introduced also to handle non-standard cargo that cannot be taken into the automated area, as well as for empty container handling. However, it is also important to remember that RTG automation can be realised without changes to the terminal layout.

Change management of the workforce needs to be taken into account from the very beginning. The professional profile of the people operating and managing automated equipment will be markedly different from the staff running a manual terminal. Completely new skill sets are needed, and maintenance standards will need to be revised thoroughly. A well-planned automation project will also encompass training of the workforce as well as further development of the skills of equipment operators. ▶

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3. Infrastructure

3.1 THE BIG PICTURE

When automating rubber-tyred gantry cranes, the existing terminal infrastructure can in most cases be left as it is. However, to gain additional operational efficiencies at the more advanced levels of automation, layout changes can give a significant increase in the capacity of the terminal within the same land area.

An RTG automation conversion project can also be a natural point at which to carry out forward-looking upgrades on other terminal equipment. For example, diesel-electric RTGs can be upgraded to electric-powered RTGs which will be easier to automate in the future.

3.2 SEPARATING PEOPLE AND MACHINES

The number one priority in an automated terminal is maintaining strict separation between automated operations and areas in which people work, and designing safe yet practical interfaces between the two. In an AutoRTG terminal, particular attention needs to be devoted to truck lane operations in which road vehicles and their drivers are in the area.

For automated horizontal transport, processes must be developed for all activities that involve people moving in the same area as the transport equipment. These include, for example, the handling of exceptions. All non-standard cargo that requires manual handling also needs to be kept out of the automated operating area.

3.3 SOFTWARE INTEGRATION

Automated equipment is only as good as the software controlling it. To obtain the desired performance from automated container handling equipment, the terminal's ERP (enterprise resource planning), TOS and other systems must be up to the task, and designed to seamlessly fulfil the required business processes while providing efficient ways to handle exceptions.

An efficient automated terminal requires that business processes are mapped carefully, and the systems are designed to follow these processes seamlessly. Software integration needs to take place at all levels, from yard equipment to process automation. The complete system design, including all subsystems, has to be implemented according to a single set of business processes and exception scenarios, where the roles and interfaces between the subsystems and users are clearly specified. ▶

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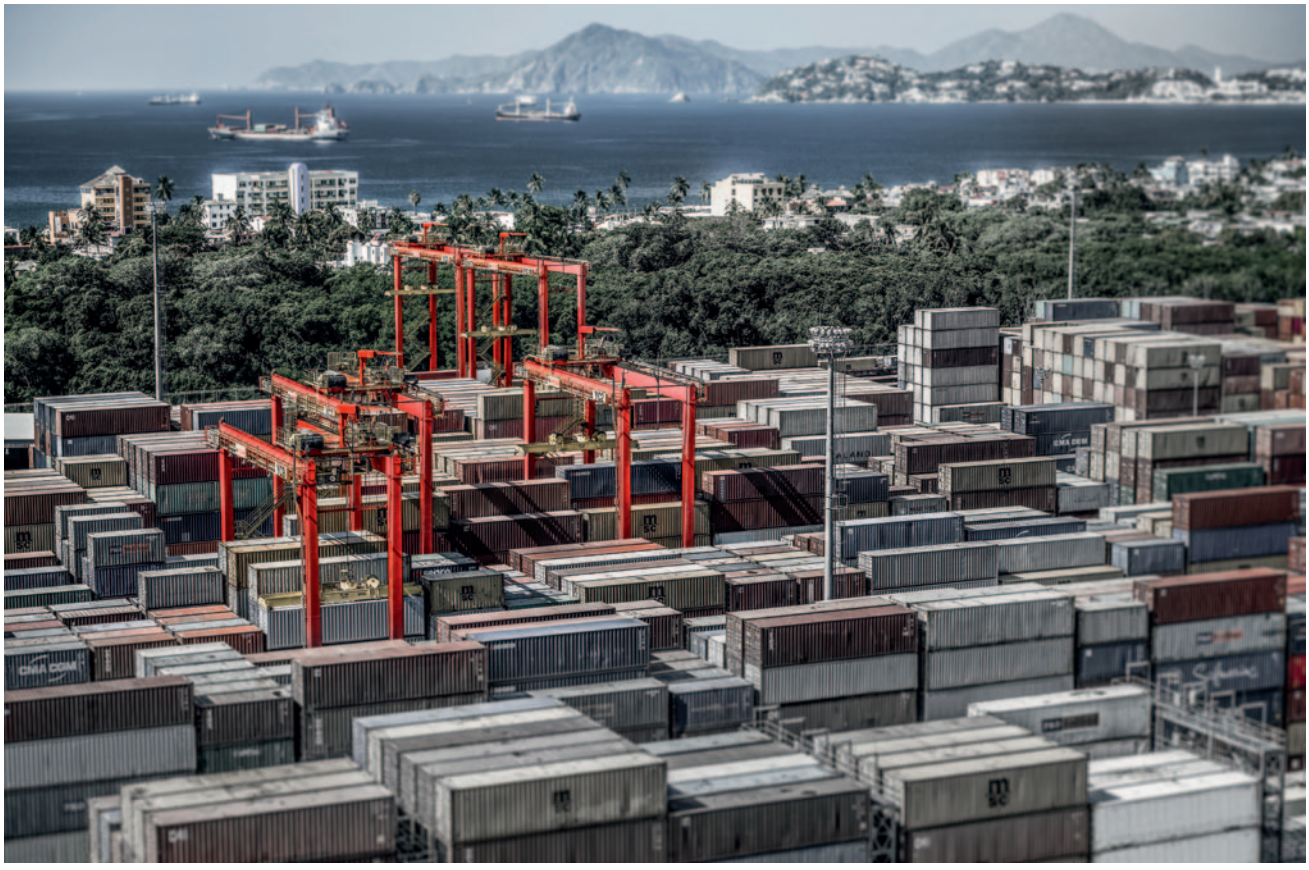
Smooth and efficient deployment of new technology in an automation project requires thorough testing to ensure that all subsystems form a solution that complies with planned business processes. The execution of all business processes has to be confirmed first in a lab environment where all subsystems are present and end-to-end scenarios have to be verified with simulation and emulation before starting the testing in a live environment.

Kalmar can offer a comprehensive emulation environment that runs an authentic terminal logistic system with simulated vehicles and cranes. Complex deployments can include a number of different software versions and releases from multiple vendors, which can all be tested beforehand with actual terminal data.

3.4 INTEGRATION SERVICES

Integrating an automated container terminal is a significant task that demands seamless interfaces between numerous systems and subsystems. The task can be simplified greatly by professional services delivered by a trusted systems provider. In addition to testing, such services can include, for example, integration management that involves coordinating multiple sub-projects to deliver a single solution to the customer; or operational consulting that identifies ways the terminal can improve its operational processes. ▶



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4. Automation conversion

4.1 DEGREES OF AUTOMATION IN AN AUTORTG TERMINAL

RTG terminals can be set up with several levels of automation, from basic crane remote control all the way to fully automated operation. The desired automation level can be selected based on the existing systems, operating environment and business goals of the terminal. Typically, process automation is deployed prior to – and alongside – automated equipment as the first step in gaining the benefits of terminal automation.

4.1.1 REMOTE CONTROL

The most basic level of terminal equipment automation is remote control, which already enables a single operator to control multiple cranes. For manual RTGs, crane idle time is usually approximately 50%. In a typical situation, a terminal might need to manage 10 RTGs at night with only a few road trucks arriving, because the required containers are located around the yard.

Remote control provides the possibility of adjusting the manning level of the terminal based on the true amount of moves needed instead of the number of cranes, as the operators are located in an office environment at remote control desks, able to take over control of any crane in the terminal. Typically, a single operator can manage up to three RTGs remotely.

4.1.2 REMOTE CONTROL WITH DRIVER ASSISTANCE

At the next level of automation, the crane makes automatic gantry and trolley moves under the operator's supervision. This mode of operation streamlines operations and saves valuable seconds on each move, providing significant incremental gains over time. Automatic gantry steering is already the norm in new RTG installations. Other automated solutions that are rapidly gaining ground include container location systems and stack profiling which increases safety through improved collision avoidance.

4.1.3 SEMI-AUTOMATED OPERATIONS

More advanced automation features can be added for even higher efficiency and performance. In semi-automated RTG operations, the crane gantry and trolley are under fully automatic control. This is a major step in the overall safety approach, as the equipment functions without an operator. Container handling operations in the stack and truck lane are still controlled remotely by an operator.

4.1.4 FULLY AUTOMATED OPERATIONS

Finally, in a fully automated RTG setup, all crane functions including hoist operation, container picking and placing, and stack housekeeping are automated. If needed, an operator can still step in to manage exceptions remotely. Only the servicing of trucks in the truck lane happens under remote control.

> Process automation is an easy way to begin automating a terminal and will continue to deliver increased value as more of the equipment is automated.

4.2 STEP-BY-STEP AUTOMATION APPROACH

In any terminal automation project, the key consideration is maintaining maximum throughput during the conversion. Many terminals have containers moving 24/7 at the quay and roadside, so operations cannot be shut down for automation deployment.

Often, the most practical way to automate an RTG terminal is an incremental conversion following the automation levels outlined above. However, this is not the only option, as areas of the terminal can also be automated in one go, for example on a block-by-block basis. The optimum choice will always depend on the business needs of the terminal.

Whether automating the terminal with a step-by-step or block-by-block approach, the cost savings can immediately be measured and evaluated as the conversion progresses. A well-planned automation project will also involve adding readiness for future automation levels that may be needed at a later date.

4.3 PROCESS AUTOMATION

Irrespective of the automation level and conversion type chosen for the RTGs and other terminal equipment, an additional way to realise significant performance gains in any terminal is through software-based process automation. Small incremental productivity gains from keeping track of containers, eliminating manual input of information and optimising crane, container and equipment moves add up to significant savings per year. Process automation is an easy way to begin automating a terminal and will continue to deliver increased value as more of the equipment is automated. ▶

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> The most crucial safety element in any automated terminal is maintaining strict separation between automated areas and those with people working in them.

5. Safety and security

Safety is always paramount in any terminal operation. Automated terminals provide significant improvements in occupational safety by keeping people out of the operating area of moving heavy machinery. As an example from automated straddle carrier terminals, the Patrick container terminal in Brisbane has become one of the safest in the world since the adoption of the Kalmar AutoStrad™ system. To date, the terminal has operated for nine years with zero accidents.

The most crucial safety element in any automated terminal is maintaining strict separation between automated areas and those with people working in them. In an RTG terminal, the key area to consider is the truck lane, which must be engineered to provide a safe yet practical interface for loading and unloading outside road trucks. Particular attention must be paid to the driver interface and the driver waiting areas. To maintain adequate throughput with roadside operations, road trucks must also be able to drive safely in and out of the truck lane at designated places along the length of the truck lane.

For RTG operations, another key safety consideration is container handling, both in the stack and during loading/unloading. Safety can be further improved with automated gantry steering, anti-truck lifting which prevents a locked chassis from being accidentally lifted, and stack profiling which eliminates the risk of containers being accidentally knocked off the stack.

Automated RTGs can accommodate any type of automated or manual horizontal transport equipment depending on the needs and existing infrastructure of the terminal. The required safety solutions will need to be adapted depending on the type of horizontal transportation solution chosen.

In addition to infrastructure and terminal layout considerations, a different kind of safety mindset will need to be instilled throughout the workforce. Adoption of safe working procedures for accessing the automated area is required. Employees will also need to be trained locally – a safety handbook in English is not enough.

An automated terminal will bring about a major change in the overall working conditions of operating staff. By transitioning to indoor desk work, employees will no longer need to work outdoors exposed to noise and other emissions, cold and heat, bad ergonomics or vibrations.

Automated terminals improve the security of both cargo and personnel thanks to automated container handling and location tracking of all containers. Containers are not accessible in the automated zone and cannot be set down in unauthorised areas. Increased security contributes to customer trust and terminal competitiveness while reducing financial losses.

> With automatic operations, the emphasis shifts to more frequent preventive maintenance.

6. Maintenance

Manual crane systems will work even the equipment is not in perfect condition, since human operators can usually compensate for the quirks and deficiencies of each individual piece of equipment. By contrast, automated equipment always needs to be in 100% working condition to deliver its full potential.

This requires a major change in practices and attitudes for maintenance operations. With automatic operations, the emphasis shifts to more frequent preventive maintenance. However, as this maintenance is usually done at planned intervals, the caused impact to the operation is minimal. As collisions and other accidents due to human error are eliminated, the need for ad hoc repairs is also reduced dramatically, bringing cost savings in the long term. Automated equipment can also provide continuous updates on its status and can send alerts when any faults are detected.

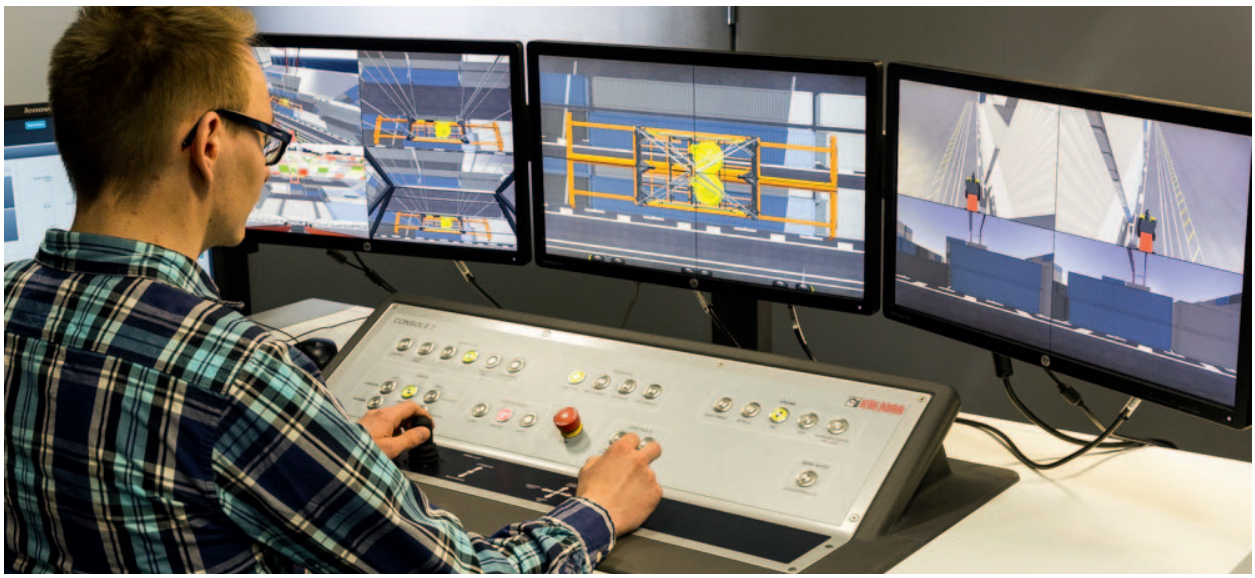
7. Automating existing equipment

The actual automation of most RTGs of recent model years is relatively straightforward. Steering and driving is controlled by onboard automation systems instead of from the cabin, while sensors and data links are added for control, monitoring and system diagnostics.

Electric RTGs are the easiest to automate, as pre-existing cabling runs can be used for remote control signals and zero-latency video feed. Diesel-electric RTGs can also be converted to fully electric operation, which will reduce emissions and can cut fuel costs by as much as 95%. The return on investment can be less than two years. A turnkey project includes the design and supply of power grid connections, substations, conductor-bar system or cable-reel integration, taking into account the full chain of interacting components

Kalmar's automation solution is suitable for use with any brand of RTG together with Kalmar equipment. However, there are limits due to the age and type of cranes that may not be practical and/or economical to automate, potentially leading to less than optimal performance. In older models, sensor installation may not be feasible, but they can still be remote controlled. A terminal can also successfully run different models and generations of RTGs.

The best automation solution will always be based on the needs of the customer. Working with a fully integrated system from a single vendor – and upgrading equipment when necessary – is often the lowest risk and most cost-effective solution for the terminal in the long run, when considering the longer term maintenance of the solution in the rapidly changing world of new technology.



The most significant cost savings from automation are due to the drastically smaller number of operators required. Typically, a single operator can handle two to three AutoRTGs remotely, and in quiet periods even up to six machines.

8. Human resources

The most significant and immediate cost savings from automation are due to the drastically smaller number of (but more highly skilled) operators required. Typically, a single operator can handle two to three AutoRTGs remotely, and in quiet periods even up to six machines.

8.1 CHANGING SKILL SETS

Automation is where IT meets engineering. In a traditional manual terminal, these are typically two separate teams that have little contact with each other. With an automation rollout, they need to start co-operating and form a joint team in which the skills and responsibilities of the people match each other and mutual responsibilities are clearly defined.

> An automated terminal requires a significantly different profile of employee.

An automated terminal requires a significantly different profile of employee. A different level of maintenance engineer skills is also required for the stricter maintenance standards of automated equipment. In addition, automated operations will require new, different skill sets in several other areas, including:

- Data and fact-based usage and analysis compared to operators reporting faults in equipment
- Understanding the operating principles of automated equipment and systems
- Systematic planning of operation and maintenance work

New tasks that will need to be handled include automation system specialists; system optimisation engineers; IT system service and maintenance professionals; and instructors for internal staff and external parties.These competences can be built in-house or sourced from a trusted external provider.

Successful and sustainable automation also requires new key performance indicators (KPIs) for operation planning. These can include system and subsystem-level performance measurement, tracking of deviations from the normal level of performance, and operation accuracy measuring. KPI measurement is usually part of the automated system software and is monitored and reported automatically.

8.2 NEED FOR OPEN DIALOGUE

In many geographies, limited availability of personnel, even at competitive salaries, is a challenge. Automation can help mitigate this issue, but also changes the profile and structure of the terminal workforce. In general, an automated terminal will require a smaller but more highly trained staff. Automation provides new job opportunities, but also places additional demands on the workforce.

Successful change management requires an open dialogue with all relevant parties. Human resources need to be taken into account from the beginning. The significant workforce impact of automation needs to be considered and planned carefully, working in cooperation with local labour organisations and other stakeholders. Conditions, legislation and industry labour norms will differ greatly from geography to geography, so these questions can only be fully answered by the terminals themselves.

9. Change management

> "An often overlooked or underestimated fact is that automation is foremost a major culture change in how a terminal operates.

An often overlooked or underestimated fact is that automation is foremost a major culture change in how a terminal operates. For an automation deployment to be successful, managing this culture change is more crucial than the technical implementation.

The job profile of the workforce will be transformed, a new maintenance approach is required, IT and engineering operations will need to converge, and business processes will need to be mapped and planned more carefully than before.

Whether creating a new automated terminal or converting a manual terminal to automated operation, change management is crucial. Equipment is easily replaced, but human behaviour takes more time to adapt. Change is inevitable, so the question is how to manage it. ▶

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10. Financial impact

10.1 METRICS

Kalmar can work together with the customer to calculate the financial impact of automation in different operational scenarios and with various levels of automation. The exact numbers (OPEX, CAPEX, payback time, ROI) will vary depending on the automation approach taken. Savings in salary costs are the simple and immediately obvious benefit that is easy to calculate together with the automation vendor. For more detailed long-term projections, the terminal is the best expert in forecasting their own future volumes and operations.

Automation projects always revolve around a basic wish list – an idealised implementation that encompasses the swiftest possible deployment, maximum performance improvement, and a totally integrated turnkey solution. Success in practice will depend on skilful optimisation of these and numerous other factors.

10.2 INTEGRATED SOLUTION

A key consideration in an automation project is implementation time. On one hand, terminals seek to minimise the cost of conversion, often by combining components from multiple vendors. On the other hand, every interface between two systems needs to be not only integrated, but also maintained through the lifetime of the solution. The simpler the overall system and the fewer interfaces that need to be integrated and tested, the faster the implementation.

Simply optimising for the cost of individual subsystem components is a shortsighted approach. A delay of just a few weeks on a major automation project can cost of millions of euros in terminal downtime as time to value is extended. If automation is built with a ”bits and pieces” approach, the terminal may save in the very short run, but these savings can be lost already at the deployment stage due to the added complexity of integration and slower ramp-up of productivity. By contrast, a vendor that can offer a completely integrated turnkey solution will be able to provide a system that is not only deployed faster, but is also more cost-effective as a whole, while providing lower lifetime maintenance and support costs. ▶

> Benefits will be reaped by forward-looking operators seeking to stay ahead in today's intensely competitive global container shipping industry.

10.3 ADDITIONAL SAVINGS

In addition to the direct benefits of lower operating expenses and improved terminal performance, automation offers indirect cost savings in numerous other areas as well. Automatic driving eliminates collisions and accidents in the container yard, which will decrease the insurance premiums of the terminal.

For an RTG terminal, automation can also safely enable somewhat higher stacking density, as many manual terminals currently leave the stack partially lower due to safety reasons.

10.4 COMPETITIVE ADVANTAGE

Compared with numerous other fields, automation is still a new development for the terminal industry. Automation adoption rates vary greatly from geography to geography, and terminals will look to the automation level of other terminals on the same trade routes and/or in the same region.

Terminal demand for AutoRTG solutions has been growing markedly in the last few years. At the time of writing, in early 2015, competitive advantage was still available for first movers that adopt automation sooner than their competitors. Conversely, without automation, terminals will inevitably fall behind in competition against automated terminals in the same region. In the worst case, this may even mean the end of business for the terminal.

For greenfield terminals, automation is already the norm rather than the exception. It is highly unlikely that any major new terminals will be built for traditional fully manual operation, at least without very careful consideration of all available automation options. For existing terminals, the benefits of automation are equally clear, and over the next few years these benefits will be reaped by forward-looking operators seeking to stay ahead in today's intensely competitive global container shipping industry.

11. Case study: Port of Oslo

Over 125,000 containers are unloaded each year at the Port of Oslo in Norway. Together with a yearly throughput of one million tonnes of dry cargo, including grain, sand, cement and salt, the Sjursøya Container Terminal in the port's South Harbour is aiming to increase container throughput from 210,000 to 450,000 TEU annually. The Port of Oslo is located in a densely populated urban area, which posed the challenge of doubling the capacity of the port by the year 2030 without increasing noise, pollution and energy consumption. ▶

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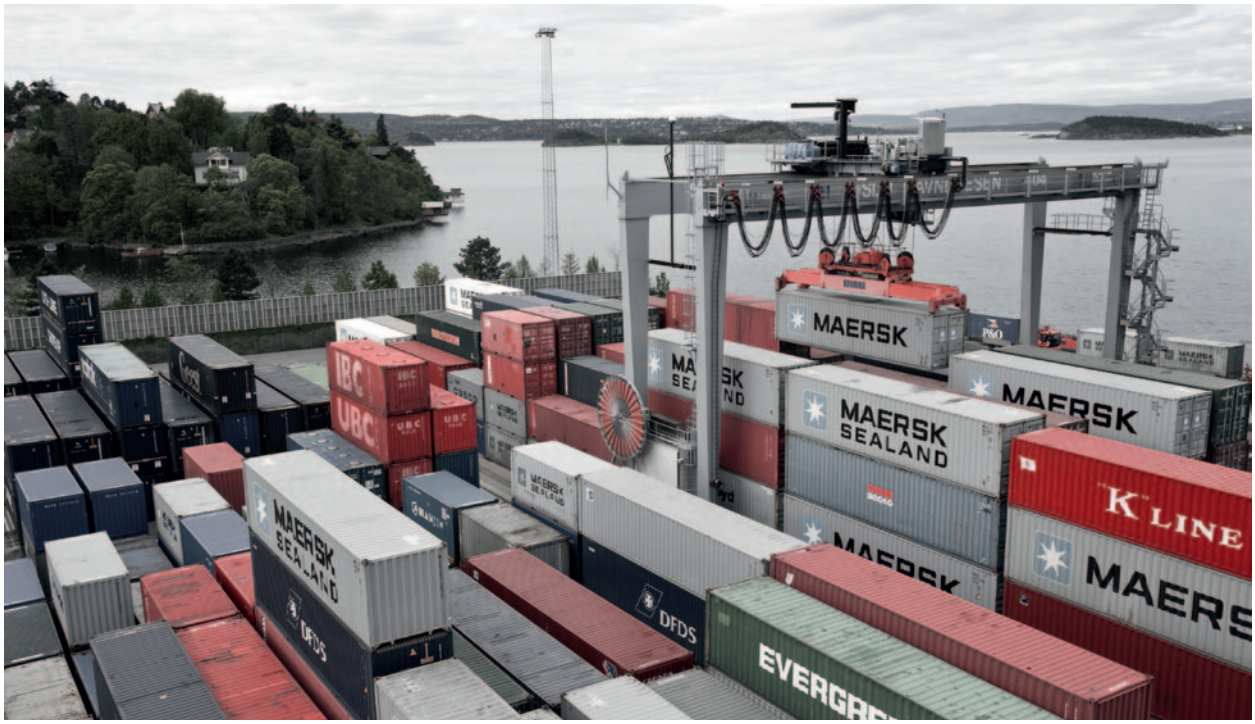

In a turnkey project, Kalmar is delivering eight revolutionary all-electric, 50-tonne RTGs, providing the Port of Oslo with the world's most sophisticated RTG installation that combines automated positioning technology and process automation. Semi-automation offers flexibility for the future, allowing the terminal to take automation to the next level when needed.

The RTG cranes installed at the port will be the most advanced in the world and the first to benefit from the automated positioning functionality realised within the Kalmar Terminal Logistic System software platform and already used in Kalmar ASCs, AutoStrads™ and AutoShuttles™. This will be supported by a number of Kalmar SmartPort process automation solutions.

To eliminate the risk of knocking down containers from the stack into the truck lane, the cranes will be provided with a container stack profiling system. The RTGs will also feature a complete data transmission system between the control room and the cranes, allowing the terminal to provide an optimum maintenance regime for the equipment, and enabling the transfer of operational data for future purposes. Productivity and efficiency are further improved through Kalmar SmartStack, which reports container moves to the TOS without any actions from the driver, automatically keeping track of the inventory.

As the first terminal to deploy this revolutionary technology in RTGs, the Port of Oslo is able to make its operations more sustainable, safer and quieter. Choosing Kalmar Zero Emission RTGs over diesel-electric RTGs, CO^2 emissions are reduced by over one million kilograms per year for the fleet of eight RTGs. The port is also ranked as the world's most space-efficient terminal. ▶

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Director, Terminal Automation, Kalmar, is a container terminal automation professional with more than 15 years of experience in research and development, product management and sales in international business environment. His background is in Kalmar straddle carrier and shuttle carrier automation development. He lead the project of the onboard automation control system design for automated straddle carriers including software architecture design, software development, testing, commissioning and support in Patrick's AutoStrad terminal project in Brisbane during 2000–2007. Timo Alho is currently responsible for automation sales at Kalmar.

TOMMI PETTERSSON
Vice President, Automation, Kalmar, has strong experience in software and hardware development, automation project management and project sales as well as related business model development. Before joining Kalmar in May 2014, he worked as CEO in a Finnish industrial investment and development company focusing on demanding automation solutions, and, prior to that, in management positions at Elqotec, a consumer electronics contract manufacturer.

MIKA VIRTANEN
Vice President, RTG and STS, Kalmar, has more than 20 years of industry experience and started his career at Kalmar in 2002 as development engineer for terminal tractors. He moved on to Cargotec daughter company Bromma and was most recently Managing Director of Bromma Malaysia responsible for Bromma Supply, including engineering, sourcing and total deliveries. Since early 2014, he is heading Kalmar's RTG and STS business lines which are closely working together with the joint venture Rainbow-Cargotec Industries in China.

ABOUT THE COMPANY

Kalmar, part of Cargotec, offers the widest range of cargo handling solutions and services to ports, terminals, distribution centres and to heavy industry. Kalmar is the industry forerunner in terminal automation and in energy efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. Through its extensive product portfolio, global service network and ability to enable a seamless integration of different terminal processes, Kalmar improves the efficiency of every move.

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