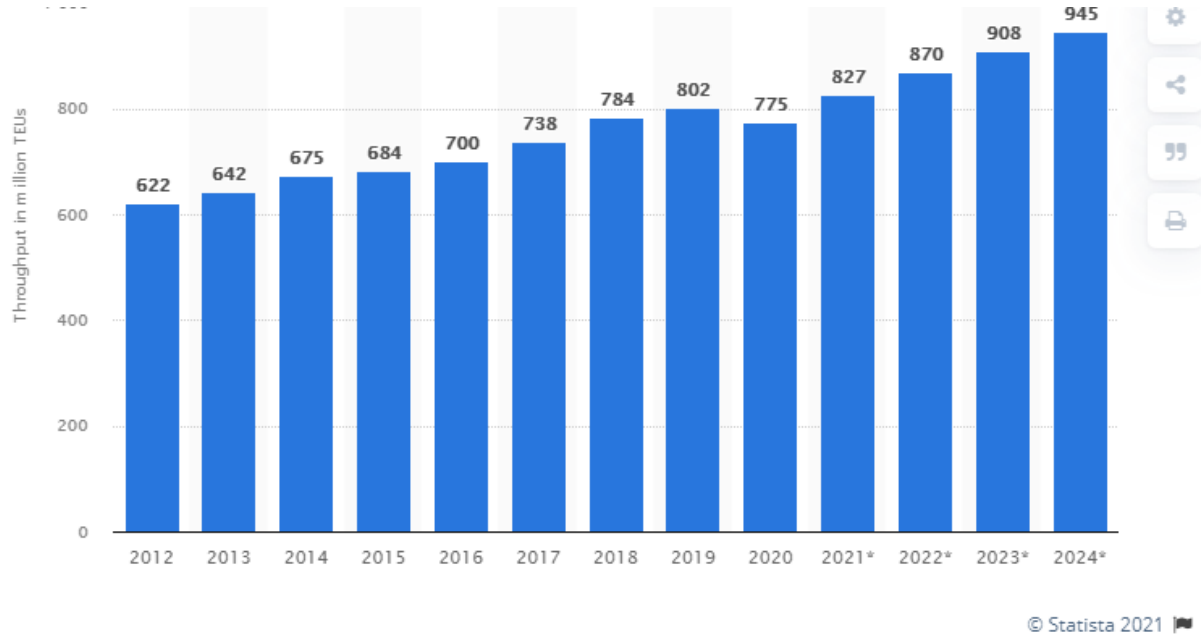
Container Terminal Automation for Next-Gen Ports with VAHLE

The container traffic has increased over the last years continuously with only the Pandemic given the Container throughput at ports worldwide a slight setback in 2020. However, the forecast showing for 2022 and the years beyond show increasing figures with an increase already of 3% from 2019 compared to 2021 forecast.



With the pandemic in mind and the possibility of even a port closing like in Yantian, China in 2020 it has made it mandatory to adjust the way of daily work in the container terminals accordingly.

Most of the container terminals have different characteristics like size, organization, and purpose of the container yard. When it comes to the used equipment, we are talking about Rubber Tired Gantry Cranes (RTGC), Automated Electrified Rubber Tired Gantry Cranes (AERTGC), Rail Mounted Gantry Cranes (RMGC), Automated Rail Mounted Gantry Cranes or Automated Stacking Cranes (ARMGC or ASC), Overhead Bridge Cranes (OHBC), Straddle Carriers (SC), Automated Lifting Vehicles (ALV), Reach Stackers (RS) and so on.

RTGs & RMGs are the most popular yard machines used still in container terminals. At this time many ports want to start automation of these machines or start looking at purchasing new equipment and what is needed to have these cranes most effective in operation.

Container terminals with parallel container blocks to the quay using RTGs for the container handling as the main stacking equipment. RMGs / ASCs will be used in a perpendicular yard layout.

The main advantage of the RTGC are the rubber tires: They allow the machine to move freely in the container on demand. However, the tires limit the size and lifting capacity.

RMGs are limited to travelling on rails but can lift more weight than RTGs. RMGs with steel wheels can span approx. 90 m stretching across many rail tracks, container stacking area and even truck lanes.

However, the trend is very clear since 2019 with increased numbers of supplied RTGC and strong decrease of delivered RMGC, which confirms the demand of flexibility in the container terminal yard.

How to consider automation in brownfield terminals?

What is the best practice approach for electrifying and automating existing equipment of a brownfield terminal? There are a lot of different solutions available to upgrade the equipment for an automated system.

However, automation could be considered from the beginning on or be integrated later step by step based on the local requirements, but it makes sense to prepare the IT or yard infrastructure if possible.

Everything starts with Electrification

The main driver is the electrification of container terminals by converting diesel powered RTGs into E-RTGs powered by conductor rail systems or cable reels. This process allows terminal operators to significantly reduce fuel and maintenance costs (up to 90%). This brings a return of the CAPEX in a low amount of time. Most important is in these days the reduction of CO^2 and NOX emissions as well as noise pollution for ports close to dense urban environments and helps further to transform the port to carbon emission free environment without the need to buy CO^2 certificates in addition.

Additional equipment like lasers and sensors for auto-steering and off-track protection helps the crane operator in their daily work to focus on the main target to handle containers as efficient as possible. In a block change moment, a battery or small diesel gen-set takes over after and before an automated seamless switching process between the different power supply sources.

With the add-on of the data communication the then fully automated version of RTGs allows the operator even to leave the driver cabin and to operate the RTG by remote control from an ergonomic office environment which results in improved safety and working conditions. Secondly one operator can handle more than one crane at the same time in one block or even could switch between different container yard blocks easily.

What are the main challenges to implement automation in a brownfield terminal?

As usual the change management process is the most difficult part to implement something new in an existing organization which is focused to achieve their corporate goal.

When it comes to brownfield container terminals, we face the ongoing operation which is the core business. That means the container yard is usually occupied with containers. Furthermore, the existing container layout can be a challenge when the available space for a required infrastructure is less. The equipment is only effective when it works and therefore not available for retrofit or conversion. Often the existing equipment is in the middle of the lifetime which results in bigger tolerances, not supported IT or PLC components. It needs to be checked how the upcoming automation can work in the existing IT environment and terminal operating system.

However, all these challenges can be handled by an experienced partner which can act as a general contractor to fulfil the required task in a turnkey project with optional first level support and preventive maintenance of the whole system.

Guideline to automate container terminals in 4 steps (Exemplary at RTGCs)

Process automation step by step can be the best and safest way for the terminals to improve the efficiency during daily operation. Conventional RTGs consume approx. 35-liter diesel fuel per hour. The diesel generator is working 24 hours per day during container handling and even during idle time.

Therefore, the first step is to electrify the existing yard cranes like RTGs, terminal tractors etc. by insulated bars with 1000 A with aluminium/stainless steel conductors suitable for maritime environment or motor cable reels. This results immediately to savings of fuel and maintenance costs. This very first step supports to finance the further automation steps because every converted RTG saves a lot of money. The return of investment is depending on the yard layout (quantity of container blocks, length of container blocks), quantity of yard machines and the speed of conversion but can achieved within one year.

The electrification consists of a high voltage ring within the terminal with substations at the container blocks to transform the high voltage into low voltage for example 415 V, 50 Hz on the stationary side. The substation could feed up to 4 container blocks depending on the number of RTG cranes operating in the block. The RTG cranes will be equipped with an automated connection system consisting of an automated telescopic arm to enter and leave the infrastructure automatically, synchronization unit for seamless switching of the power supply between still needed genset and grid. However, a fully electrified solution with batteries could be retrofitted as well getting the genset obsolete.

The second step brings the absolute positioning of the RTG cranes in the container block. For maritime environment a favored solution shall ensure a high durability and lifetime. This can be achieved by use of durable data matrix code combined with an optical reading head. By a precise position feedback for process automation, the automated movement within the container block to the exact container position by one tick in the box will helps to optimize the efficiency.

The 3rd step and one of the most important is to integrate a reliable, interference-free, and safe transmission of safety data, steering data, and video signals. The data communication system allows to connect all yard cranes with the IT infrastructure and the terminal operating system.

The availability of high data rates for machine-to-machine communication and human-machine-interfaces is one crucial aspect.

One possibility is to use a slotted microwave guide extreme SMGX. The system works with its multi node infrastructure in a frequency range of 5 Ghz, so VAHLE can upgrade bandwidth step by step as required by the customer. RF emissions are well within EMC regulations so that more than 1 Gbit/s can be available.

All components are designed to allow more bandwidth in the future. This allows the customer to upgrade the transceivers to new software/hardware in the future, but everything else can be still used, so upgrade costs are minimized.

VAHLE is building on considerable experience with its former SMGT system on STS cranes and E-RTGs. For example, a semi-automated E-RTG set-up has been installed in cooperation with Kalmar at the Yilport Oslo container terminal, where eight Kalmar E-RTGs have been equipped until 2019 with conductor rail power supply, absolute positioning, and data communication system SMGX. The terminal operator has added in 2021 another 3 Kalmar E-One² into operation bringing the total amount to 11 cranes.

Getting all element together

The fourth step means to combine all elements like electrification, positioning and data communication to automate processes or even full automation which leads to significant reduction of container handling time.

A positioning system connected to the crane PLC and TOS allows the crane to get a permanent feedback in real-time of its actual position. In combination with a data communication system and the TOS link, it is possible to drive the crane to a certain row in the container block. This can be done in semi- or full-automatic mode.

Future developments include the VAHLE TRIMOTION System which provides electrification, positioning and data communication allowing remote operation of the RTGs from an ergonomically and safe office environment. The operator will be de-coupled from the RTG and idle time (approx. 20%) can be eliminated to increase efficiency. However, data communication is only one step to take. The main goal, using the valuable source of an efficient operator, is still valid. Therefore, more steps have to be taken. With an electrified system, e. g. an E-RTG, the carbon footprint as well as operational costs will be reduced significantly.

The first fully automated rubber-tired gantry cranes are operated in Laem Chabang, Thailand

The first phases consisting of total 20 container blocks á 250 m and 20 brand-new automatic RTGs are in operation since 2019.

The second phase of this new terminal extension project will start shortly with an expected SOP middle of 2022. For this the terminal operator has considered longer container blocks to increase volumes without the need to leave the stack.

The connection of all RTGs to the IT infrastructure will make the following data available.

- Crane positioning
- Crane power consumption
- Video data
- Automation control data
- CMS remote maintenance
- Weight of the container
- Consumption of the grid power in the block
- Function and errors of the crane
- Function and errors of the substation
- Measurement of the substation
- Emergency stop signals

This allows to update and maintain the RTG software and ensures first level support by remote connection. Even VAHLE support with remote maintenance equipment is possible. Very helpful during the pandemic, VAHLE has supported their customers from the distance during travel bans and flight restrictions.

The system of electrification, positioning and data communication will also be made available for STS cranes. At present STS trolley speed is limited by the need to take the crane operator into account. For new automated/semi-automated STS cranes, however, this limitation is removed, and the USMGX system will ensure high productivity as the trolley speed can be increased and downtime due to environmental conditions such as heavy rain or high wind speeds, shift changes or time-consuming maintenance of festoon system will be minimized.

VAHLE is building on its experience of STS crane projects where the customer used its USMG (Unipole conductor rail + Slotted Microwave Guide) instead of festoons or energy chains. The USMGX system consists of four or more conductor rails up to 1000Aand SMGX data communication waveguide. The trolley could be operated more than 300m/min travel speed, which still no spreader trolley currently works at. In addition, the positioning system will help automate the trolley sequence. This will be required as soon as more ultra large container vessel will approach the container terminals during the daily business.

Further information about Paul Vahle GmbH & Co. KG at: https://vahle.de/