AUTOMATIC TRANSHIPMENT SYSTEMS FOR CONTAINER TRANSPORT IN TERMINALS

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Summary: In automated container terminals, containers are transported from the marshalling yard to a ship and vice versa by Automated Guided Vehicles (AGV). In the blocks operate the Automatic Stacking Cranes (ASC). Delivery operations by automated guided vehicles (AGVs) play an important role for synchronizing operations of container cranes with yard cranes in port. These cranes provide transport for the container terminal inside most of the waterfront, which is mainly for loading and unloading containers on a container ship into the predetermined storage terminal sector.

Key words: container, Automated Guided Vehicles, Automatic Stacking Cranes

INTRODUCTION

Worldwide container traffic is growing: tonnage, vessels and cargo-handling volumes are increasing. This means that terminal operators face major logistical challenges: boosting the productivity of their terminals while expanding existing terminal infrastructures and building new ones. Environmental issues are also gaining in importance. Not only should the equipment achieve a high level of performance, it must also be environmentally friendly – a requirement, for example, when terminal concessions are awarded.

The transhipment container terminal in place in several stages, which are implemented in different service areas. The individual parts are used in various types of automatic transhipment system:

- transhipment of containers from sea-going vessels - gantry cranes,
- transfer of transhipment containers to blocks - Automated Guided Vehicles (AGV),
- transhipment of containers in each block - Automated Stacking Crane (ASC),
- transhipment of containers in the rail terminal - semi-automated cranes.

Rapid growth in container traffic and the associated threat of cargo handling gridlock are driving the development of automated solutions for terminal logistics. Their key benefits are these (1):

- improved productivity,
- reduced wage and operating costs,
- increased safety ,
- predictable, continuous operation almost completely independent of the weather,
- maximum use of space,
- resource-saving operation.

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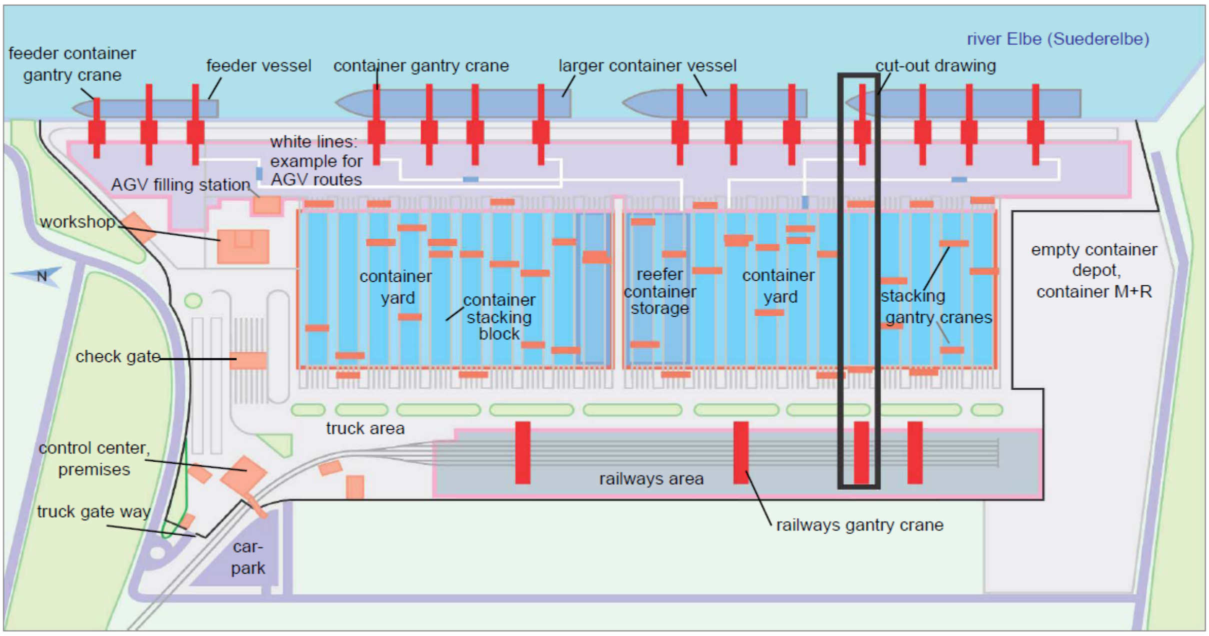

Source: (4)

Fig. 1 - Basic structure of handling procedures for container flows in terminal CTA (Hamburg)

1. AUTOMATED GUIDED VEHICLES

Automated, high-speed container transport between quay and stackyard – as the only global supplier of Automated Guided Vehicles (AGV) for use in container terminals, including the management and navigation software to control the AGV fleet.

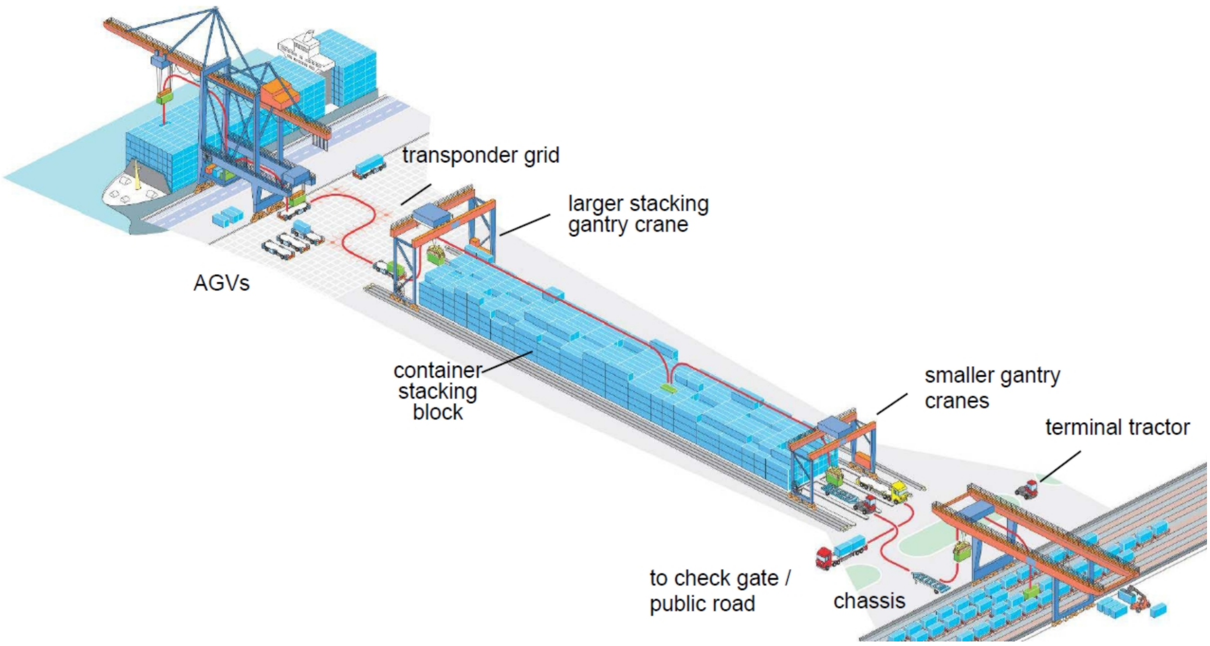

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Fig. 2 – Container Terminal Altenwerder workflow

Delivery operations by automated guided vehicles (AGVs) play an important role for synchronizing operations of container cranes with yard cranes in port. AGV vehicles have all wheel rotating (independently), which helps to provide precise guidance to the place of loading or unloading a container and enables route planning and programming of such vehicles to achieve maximum flexibility. Furthermore, the symmetrical axle and move both forwards and backwards at the same speed, and up to 6 $m.s^{-1}$ (21.6 $km.h^{-1}$). In turns, this rate reduced to 3 $m.s^{-1}$ (10.8 $km.h^{-1}$). The stopping distance for a vehicle speed of 8 m and an emergency brake with a cargo of 60 t is made up braking distance of 6 m. Due to its length, which is 14.8 meters, is able to transport containers of different lengths (20' / 40' / 45') or two 20' containers. Thanks to computer control, they fulfil their travel orders on-schedule, working almost silently at high speed with position accuracy of within +/- 3 degrees. They travel forwards, in reverse, sideways and can even overtake each other. Even refuelling takes place automatically. They are controlled and supplied with data and orders by the management and navigation software, and so-called transponders, i.e. electro-magnetic route markers embedded into the ground of the terminal. (2)

Tab. 1 - Technical parameters for the AGV ans Lift AGV

Technical data	AGV, Lift AGV
Length (depending on bumper)	14,8 m
Width	3 m
Loading area height	1,7 m (2,2 m*)
turning radius	11,8 m
Positioning accuracy	+/- 25 mm
Dead weight	25 t (34 t*)
Max. weight of a single container	40 t
Max. weight of 2 x 20' containers	60 t
Max. speed forward / reverse	6 $m.s^{-1}$
Max. speed in curves	3 $m.s^{-1}$
Fuel tank capacity	1 400 l
Fuel consumption	approx. 8 $l.h^{-1}$ (10 $l.h^{-1}$*)
Power	257 kW

* Different data for the Lift AGV

Source: Gottwald Port Technology GmbH

Safe movement of vehicles is provided by a number of laser detectors, which detect the presence of obstacles in the road way. The actual transmission process then begins by bringing the ship to land. At that moment the ship is assigned reloading crane and container carriers. Each container carries the information, which is to be translated and it is automatically forwarded to a support container, the container ships to their destination. Driving the way media is composed of straight sections, which are supplemented with an angle of rotation curves of 90 °. With these automatic operation of container carriers is closely linked to the development of navigation and control system. The integrated communication system is able to process more than 250 information simultaneously and continuously communicates with the control system. The navigation and control systems are a prerequisite for proper and safe operation of the system. The navigation system includes a passive transponder is embedded in the terminal surface of transportation routes. When the AGV crosses the transponder, it is possible to determine its precise location in the coordinate system and this position is sent to the computer for processing.

Source: HHLA, Port of Rotterdam

Fig. 3 - Automated Guided Vehicles AGV in CTA and ECT

AGV are in operation with two drive options – diesel-hydraulic and the new diesel-electric. AGV has driven all the wheels on both axles are powered by diesel-hydraulic engine. The tank has a capacity of 1400 liters, allowing several days continuous operation. The diesel-hydraulic engine is replaced with newer versions of the diesel-electric propulsion. July 2009, the CTA terminal area tested new AGV battery powered and are considered as its introduction into normal operation (in year 2011).

Source: Gottwald Port Technology

Fig. 4 - Lift AGV

A further boost to productivity in automated container transport is provided by the latest development, the active Lift AGV (see Fig. 4). The Lift AGV is a further development of existing AGV technology, which has been proven several hundred times over. Compared with the conventional AGV, the Lift AGV features a pair of electrically operated lifting platforms. These enable the vehicle to raise its load and deposit it independently and automatically on racks in the stacking crane interface zone and to pick up containers from those racks.

The Lift AGV decouples container transport from the storage processes. As an active, independent handling machine, it is constantly in motion. Fleet size can be considerably reduced as a result of the increased working frequency and the overall number of AGVs required to service each quay crane can be reduced by up to 50% compared with conventional AGVs.

Source: Port of Rotterdam

Fig. 5 - Automated Guided Vehicles AGV in Euromax

Based on the existing AGV technology which has proved its worth over many years, the Lift AGV features a pair of lifting platforms to enable the vehicle to deposit and pick up containers independently on / from racks (2):

- to decouple the transport and storage processes,
- to provide a further increase in working frequency and productivity,
- to enable the size of vehicle fleets to be considerably reduced.

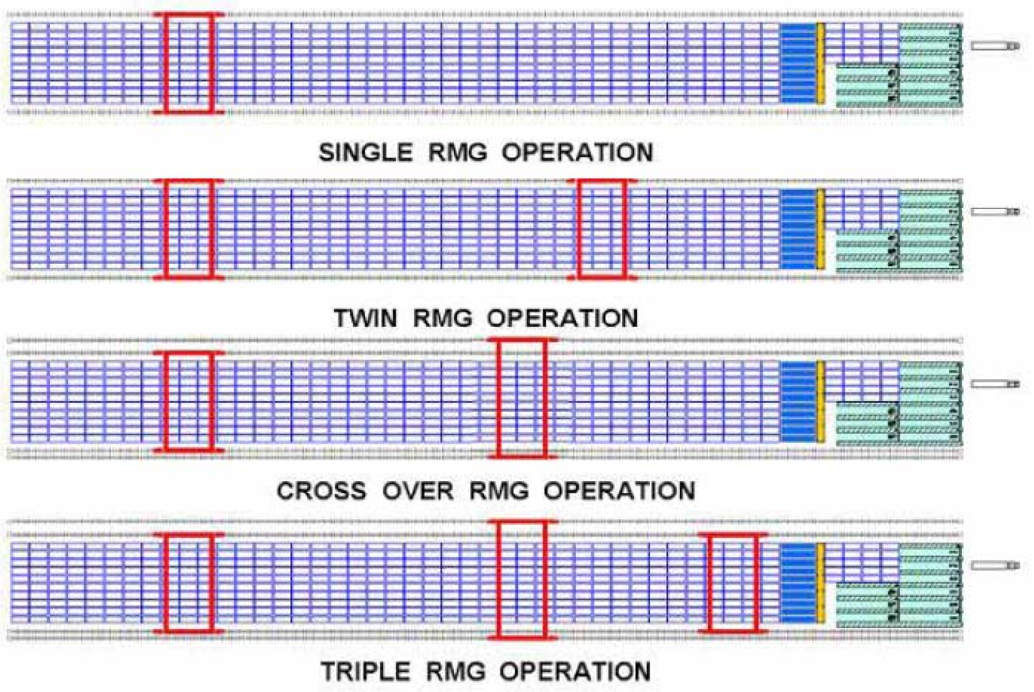
The new Gottwald Lift AGV is particularly suitable in these cases:

- new terminal projects,
- conversion of existing AGV terminals,
- where conventional terminals are to be converted, depending on the size of the apron.

In large container terminals involving container transport, storage and transloading, AGVs work hand-in-hand with Automated Stacking Cranes (ASC). Together with ASC Automated Stacking Cranes,they create fully-automated, integrated solutions handling containers from quay to stackyard to gate.

2. AUTOMATED STACKING CRANES

Another significant improvement and acceleration of container transshipment terminal at enabling automatic gantry crane, called the ASC (Automatic Stacking Crane). These cranes provide transport for the container terminal inside most of the waterfront, which is mainly for loading and unloading containers on a container ship into the predetermined storage terminal sector.



Source: (7)

Fig. 6 - Systems for the automatic cranes

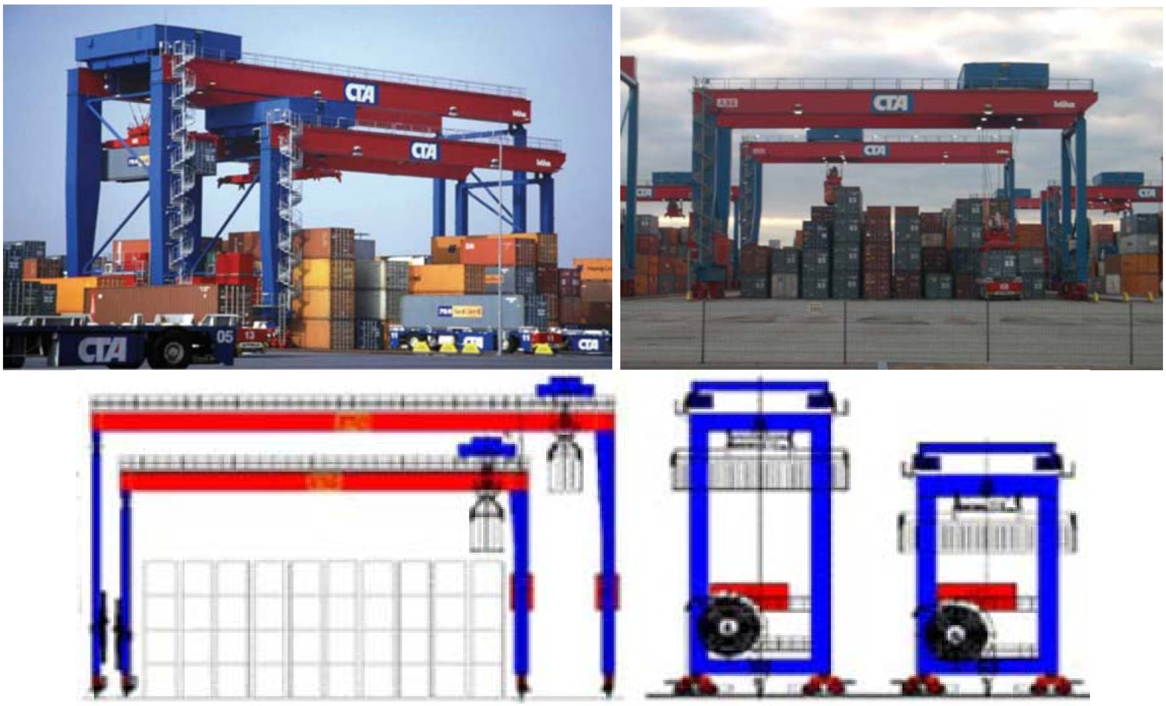
In the world there are several systems for the automatic cranes. The individual blocks may be in operation (See Fig. 6):

- Single ASC operation (ECT Rotterdam),
- Twin ASC operation (DP World Antwerp),
- Cross over ASC operation (CTA Hamburg),
- Triple ASC operation (CTB Hamburg).

ASC cranes provide transhipment containers at several levels:

- transhipment of containers from the automatic vehicle AGV edge of the waterfront blocks,
- move containers and stored in individual blocks of storage,
- transhipment containers, road vehicles on the land side of each block.

These cranes are characterized by automatic operation, short cycle times of individual operations and focus on high precision the position of the container. Fully automatic stacking system is capable of flexibly changing the amount of lift and can stack containers from one to five layers. Cranes are moving up at 21 $km.h^{-1}$ on rail track, which surrounds their geographic scope. The width can save up to 10 containers and with a long rail track can be stored in containers up to 37 lines. Safe movement of the crane runway and anti-collision system with stored containers is ensured by the control system, which incorporates integrated, anti-collision algorithms. These systems allow the transhipment of containers with a maximum error of position 50. Spreader is attached to the portal crane four simple cables, which ensure high durability of the crane (See Fig. 7).



Source: HHLA

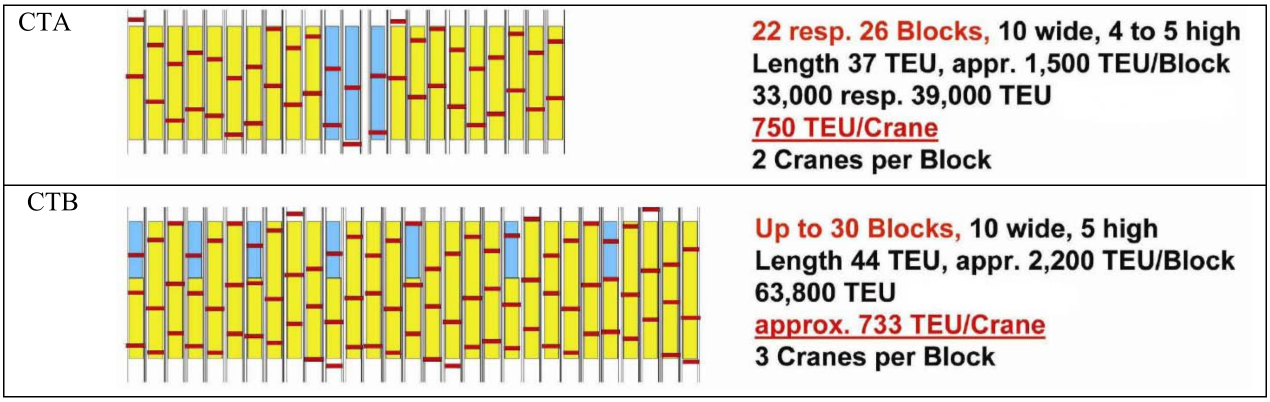
Fig. 7 - ASC in terminal CTA

Tab. 2 - Technical parameters for the ASC in terminal CTA

Technical data	smaller ASC	larger ASC
Working height	22 m 1 over 4 high cube	27 m 1 over 5 high cube
Working span	10 containers	11 containers
Track	31 m	40,1 m
Weight	220 t	285 t
Load Spreader	43 t	43 t
Travel speed	max. 60 m.min^{-1}	max. 60 m.min^{-1}

Source: HHLA

There is in CTB (Container Terminal Burchardkai) is currently rebuilding the terminal. The individual blocks will be operated by three cranes (2 smaller and 1 larger). Capacity comparison of CTA and CTB are shown in Fig. 8.



Source: (4)

Fig. 8 - Capacity comparison of CTA and CTB

The manufacturer of automated systems ferry Gottwald Port Technology, which is a member of the Demag Cranes Group and ranks among the global leaders of crane suppliers of automated systems, in addition to the production of the AGV specializes in the development and manufacture of gantry cranes ACS. These cranes equipped container terminal in Antwerp (see Fig. 9). The actual construction and container transshipment system is slightly different from that ASC, which is introduced in CTA in the port of Hamburg.

Zdroj: Gottwald Port Technology

Fig. 9 - ASC in terminal Antverp

Tab. 3 - Technical parameters for the ASC in terminal Antwerp

Technical data	ASC
Working height	13 m 1 over 5 high cube
Working span	9 containers
Weight	240 t
Load Spreader	43 t
Travel speed	max. 60 $m.min^{-1}$
Max. crane speed; acceleration	240 $m.min^{-1}$; 0,4 $m.s^{-2}$
Max. spreader speed; acceleration	60 $m.min^{-1}$; 0,4 $m.s^{-2}$
Hoisting/lowering; acceleration	39-72 $m.min^{-1}$; 0,4 $m.s^{-2}$

Source: Gottwald Port Technology

Each stack module uses two ASCs (in Antwerp), or Twin ASCs, running on a single pair of rails. This configuration allows terminal operators to save a significant amount of space – up to 18% compared to other well-known configurations such as cross-over systems, and yet allows for redundancy in each stack module, a requirement that customers demand. Storage and retrieval frequencies and container dwell time in the stack are the key factors when defining the span, which is between 8 and 11 containers, where the stackyard length is typically between 35 and 50 TEUs. These cranes because of its height to allow transhipment of containers up to 5 layers (High-Cube - 9'6"). Cranes can ride on a track with a full load up to 240 $m.min^{-1}$. and characterized by an acceleration to 0.45 $m.s^{-2}$. The cranes are designed to be able to work in extreme conditions. They are designed for work in wind speeds of up to 10 Beaufort scale (The Beaufort Scale is an empirical measure for describing wind speed based mainly on observed sea conditions).

The transhipment of containers is suspended vertically by sliding beam, which is located on the spreader. Speed sliding beam is up to 72 $m.min^{-1}$. The minimum distance from each of the two cranes is proposed in landscape 2 TEUs (about 12 m). The containers are stored more efficiently in blocks so that the distance between the stored container is 500 mm and the number of containers each having between them a distance of 400 mm.

Exceptionally high working speeds in all three axes (crane and trolley travel and hoisting action), coupled with redundancy and the opportunity to run in parallel in the most compact space are just some of the unique features that increase terminal performance.

Key features of the new ASC are (2):

- increased area utilisation through high-density stacking,
- short cycle times and high position accuracy under any load conditions,
- flexible stack layout without ground markers,
- container stack width variable, lifting height up to 1 over 5 containers,
- fully automated stacking and housekeeping,
- automated interchange at water side and land side,
- remote control for road truck interchange,
- crane and stack management system with integrated anti-collision algorithms,
- heavy-duty crane concept built up from proven components,
- rigid guiding beam on stiff triangular main girders,
- simple 4-rope hoist system ensuring long rope lifetime.

3. CONSLUSIONS

Together with the AGVs, the ASCs form fully-automated, integrated system solutions – from the quayside to the stackyard. Or they replace conventional stacking cranes and straddle carriers or work on the quayside in conjunction with existing fleets of straddle carriers. The AGV and ASC work hand-in-hand using innovative management software from Gottwald. The management software can be integrated without problem into higher-ranking terminal management systems, and guarantee smooth interaction with other terminal components.

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