

Research on the Management-Control Integration (MCI) System Technology for Automated Container Terminal(ACT)

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Abstract: At present, the ACT concept is widely used worldwide. Based on the comprehensive study of international ACT operation examples, this paper analyzes the typical ACT handling process layout, positioning and navigation technology. As a result, the MCI technology for ACT will be further discussed and this paper will suggest a feasible prospect for the use of the technology, too.

Keywords: Automated Container Terminal; Management Control Integration

INTRODUCTION

As the integration of word economy, the container transport volume is growing rapidly. In order to reduce the transportation costs, improve the cargo handling efficiency and enhance the competitiveness of container terminal, the ACT technology has been fast developed and practised in the high labor cost or labor shortage areas.

THE CONTAINER TERMINAL TECHNOLOGY AND ITS CURRENT SITUATION

ACT of Europe Combined Terminals

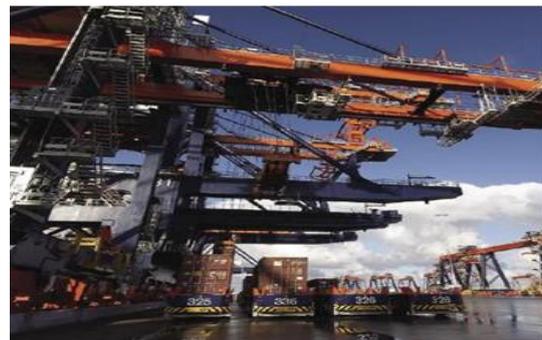
The Europe Combined Terminals (ECT) at Rotterdam harbor located in the estuary of Maas river of Maasvladkte area, which is composed by 4 automated terminal, namely Delta Sealand, DDE, DDW and Euromax.

Delta Sealand Terminal is an early constructed ACT, which has been developed using the AGV technique of Gottwald Company. At this terminal, only one container could be handled at one time with a limited velocity of 3 m/s, and FROG positioning system is used as the navigation and control system. The FROG positioning system will determine the AGV position by tracing the transponder machine's message, velocity and steering angle of AGV [Bish *et al.*, 2010].

DDEACT container terminal is developed on the basis of Delta Sealand ACT, DDW container terminal has been built as an expansion project, since DeltaSealand and DDEACT reach an annual throughput of 500,000 TEU. However, the old management software is still used in the new container terminal, which lead to a system redundancy and the additional storage capacity didn't reach the desired effects. Since 2002, ECT use three years to update the software systems. Practice has proved that the use of Dynacore can offer AGV a more flexible path to run, thereby improving the speed of AGV and increasing the ship productivity [Chan *et al.*, 2010].

The Euromax terminal started the trial operation since September 2008 and began its formal operation in June 2010, which used the AGV and ARMG technique. The designed terminal annual capacity is 2.3 million TEU.

Automated double FEU double trolley quay cranes are equipped in this Terminal with a lifting weight of 100 ton, outreach of 64m, and 23 rows of containers could be handled at the same time. The layout of Euromax ACT is shown as figure 1 below:



a) Aerial View of Terminal Status



b) Terminal Layout and Handling Process

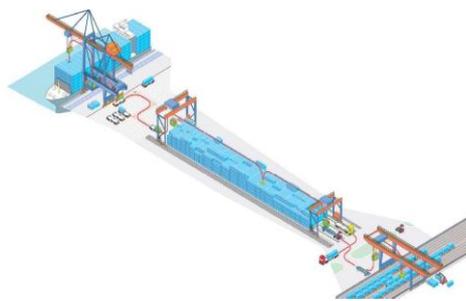
Figure 1. Euromax ACT Layout

ACT of Container Terminal Altenwerder

The first phase of container terminal project of HHLA Altenwerder (CTA) in Hamburg was constructed in 1999, and put into use in June 2002. The container terminal was equipped with 35 units

Gattwald AGV with an operating speed of up to 21 km/h. The AGV navigation system depends on the buried electronic signs. When AGV is passing by the electronic signs, the information is read in accordance with the instruction of terminal management system from electronic signs. Then, the container cranes will make four parallel lanes for AGV within their extending range, in order to make AGV provide the container transit services for them with the same efficiency [Moorthy *et al.*, 2010].

The ACT terminal layout of CTA and its handling process, and the train handling process at the terminal are shown as below:



a) Terminal Layout and Handling Process

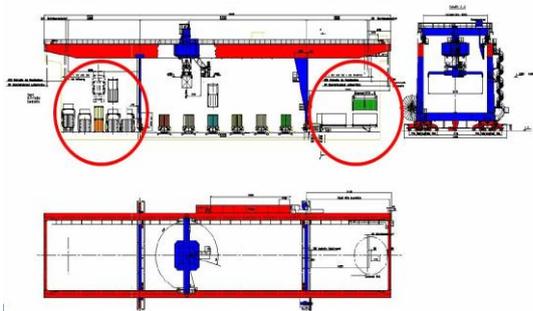


Figure 2. CTA ACT Layout and Handling Process

Xiamen Ocean Gate Container Terminal

Xiamen Ocean Gate ACT project is located at the 14# and 15# berths in Haicang bonded area. The total investment is 658 million CNY, and the design throughput is 900,000 TEUs per year.

The first phase of the ACT project starts a trial production in the December 19th 2014, and is expected to operate officially in April 2015. The power-driven energy system of the whole terminal solves many traditional problems, such as noisy, excessive emissions and environment pollution. As a result, the modern terminal can not only save more than 25% energy, but also reduce carbon emissions by more than 16% than the traditional terminal. In addition, the Xiamen Ocean Gate ACT project can also realize unmanned operation as a fourth-generation ACT.

The simulated production of automatic quay crane and automated guided vehicle of Xiamen Ocean Gate is shown as below:



a) Automated Guided Vehicle of Xiamen ACT



b) Terminal Layout of Xiamen ACT

Figure 3. Simulated Production of Automatic Quay Crane

There are 3 automated double trolley quay cranes, 16 automated gantry cranes, 18 automated guided vehicles and 8 automated transport platforms are equipped for the first phase of the ACT project. All of the equipments are made in China and power-driven. After calculation, comparing with the traditional terminal, more than 25% energy can be saved and more than 15% carbon emissions can be reduced by using modern equipments.

ACT Cargo Handling Process

Most of the harbor companies worldwide are committed themselves to develop high efficiency container handling process based on their own situations. The most widely used and typical ACT handling process is “shore gantry crane ←→ AGV ←→ ARMG/ ARTG”. ECT, CTA, Tobishima, Higashi Ohgishima, ADPC are using this kind of handling process. The whole procedure of this handling process will be described as below:

The trolley of harbor bridge crane transport the container down from the container ship to the AGV [Kim *et al.*, 2010] stopped in the extending range of the quay crane. Then the AGV will transport the container horizontally to the shore-side container storage yard according to the designed route and wait for the automated yard crane to load the container. After the container been loaded, the AGV will then plan to load another container.

The container storage yard will be designed along the vertical direction of the shoreline. At the

shore-side container storage yard, the automated yard crane will transmit the AGV transported container to its certain slot, or load the container to be processed on to the AGV[Liu et al., 2010]. At the land-side

container storage yard, the yard container will be fully automatic or controlled by the central control center to finish the container towing operation.

The typical ACT handling process is shown below:

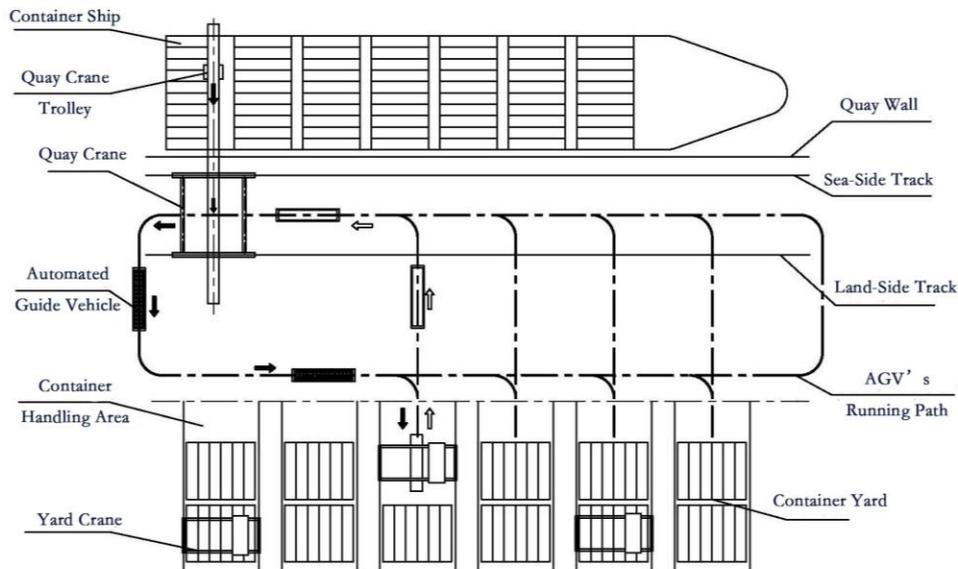


Figure 4. Typical ACT Handling Process

RESEARCH ON THE ACT MIC SYSTEM

Classic positioning and navigation technology of container terminal

The positioning and navigation techniques mainly used by most of ACT are electromagnetic induction embedding navigation technology [Rui et al., 2010], laser detection technology, ultrasonic detection technology, optical reflection detection technology, inertial navigation technology, image recognition technology and coordinate recognition technology.

Electromagnetic induction embedding navigation technology is based on the frequency electromagnetic theory which can be further divided into single frequency and multi-frequency. Single frequency navigation system controls the operation procedure by controlling the single frequency current signal. Multi-frequency navigation system controls the operation procedure by delivering s of different frequencies, and the automated vehicle can only be driven by the electromagnetic signal of corresponding frequency.

Laser detection technology mainly relies on receiving the real-time fixed three-point positioning laser signal by the automated vehicle s. The instantaneous position and direction will be measured to compare with the set path, in order to guide the vehicle. By using this technology, high navigation and positioning accuracy, diversification and flexible path are realizable.

Ultrasonic detection technology uses wall or similar object reflected ultrasonic signal to navigate. It can not only improve the path flexibility in certain circumstances, but also reduce the navigation cost, due to the mirror surface is not necessary.

There are two methods of image recognition technology. First one is to determine the current position and preset route by using CCD system, by which can access the passing by surrounding image information dynamically. The second is guide line identification. By using this method, the automated vehicle will be controlled by comparing the current movement direction and distance deviation measured by CCD system with presetted guide line.

Coordinate recognition technology realizes signal acquisition by using the micro- electronic coordinate sensor. The sensor's yaw angle and pitch angle relative to the starting point could be defined by measuring the electromagnetic fields with the supporting by double-coordinate sensor positioning.

Management-Control Integration (MCI) System

MCI system is a production management integrated automation system which is based on many kinds of technologies, such as computer, network, database, automatic control and interface communication technology, and then gathers and uses information to evaluate the performance of the system as a whole to implement organizational strategies.

The ACT's MCI system plan and the network structure of intelligent platform are shown below:

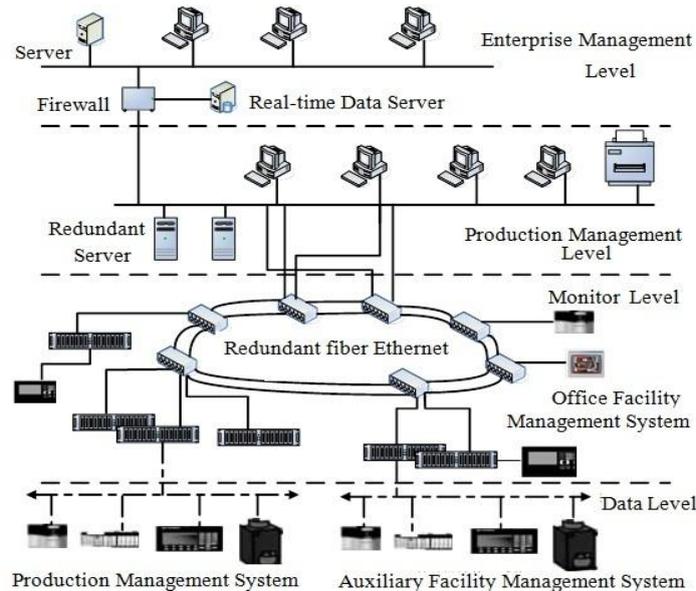


Figure 5. ACT's MCI system plan and the network structure of intelligent platform

The ACT monitoring platform is based on 100/1000 MB Ethernet switches. Network connection process monitoring systems, subsystems, database server, real-time data servers and other related equipments and systems achieve a transparent connection of the whole storage control system.

Between the control centre subnets and the enterprise backbone network need to set up a firewall to enhance system security. The server uses an Oracle database, which can be accessed not only within the storage control system, but also by the trusted computer in the enterprise backbone network.

Table 1. Comparison of Positioning and Navigation Methods

Nr.	Method	Theory	Advantage	Disadvantage
1	electromagnetic induction embedding navigation technology	Frequency electromagnetic	High reliability	complex, high cost
2	laser detection technology	optical ranging	simple, flexible	complex, high cost
3	ultrasonic detection technology	sound ranging	simple, low cost	difficult to use in complex environment
4	optical reflection detection technology	optical reflection	High reliability, stable, high accuracy	High cost
5	inertial navigation technology	Inertia	good real-time performance	complex
6	image recognition technology	Pattern recognition	flexible	Bad real-time performance, complex
7	coordinate recognition technology	Electronic measurement	Simple, high reliability	High electromagnetic interference, low accuracy by long distance

CONCLUSIONS

ACT can not only reduce the transport costs, improve the container handling efficiency, break the manpower bottlenecks of high labor costs and lack of skilled labor countries and regions, but also bring new vitality to the large harbor area. Although the construction investment for automated terminal is very huge, but because of its ability to improve the terminal capacity, optimize processing layout, and

improve the cost-effectiveness ratio, if it can be operated efficiently, the total operating costs will be reduced to compensate the investment.

ACKNOWLEDGMENT

The authors wish to thank the helpful comments and suggestions from my colleagues in lab. This research was financially supported by the Plan of Science and Technology Program of WTI (No.51406).

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