

A STUDY ON THE TECHNOLOGY DEVELOPMENT FOR NONSTOP AUTOMATED GATE SYSTEM

Hyung Rim Choi*, Nam Kyu Park**, Dong-Ho Yoo***, Hae Kyoung Kwon****

*Professor, Dong-A University, hrchoi@dau.ac.kr

** Professor, Tongmyung University of Information and Technology, nkpark@tit.ac.kr

*** Doctor's Course, Dong-A University, eastsky@dau.ac.kr

**** Doctor's Course, Dong-A University, hkkwon@dau.ac.kr

ABSTRACT

With the appearance of the super large container, a lot of studies are actively being made to enhance competitiveness of the port logistics industry, trying to bring about a logistics revolution by grafting high-tech information technology. The introduction of an automated container terminal is expected to break through the limit of a traditional container terminal and bring a revolution on the whole port logistics industry. Some business models are being performed in Korea in order to realize the environment of an automated container terminal. However, those business models are undergoing difficulty because of lack of studies on technology introduction strategy and insufficient knowledge of actual problems.

This paper has tried to suggest a nonstop-automated gate system to realize an automated container terminal. To this end, this study has presented some types of a nonstop-automated gate and suggested a detailed technology alternative for each type. Also, by means of validity evaluation, this paper has tested the technology alternatives of each type as well as introduction procedures. We expect that this paper will contribute to establishing a practical guideline for the introduction of a nonstop-automated container terminal.

Key Words: *Container Terminal, Nonstop Automated Gate System, Identification Systems (RFID, OCR, DSRC, ACDI, Mobile).*

1. INTRODUCTION

Geographically Korea is located not only in the main trunk route of the world, but also makes every effort to be a logistic hub in the Northeast Asia. Accordingly, the port and logistics field is Korea's strategic industry. As an essential task for the realization of a ubiquitous container terminal, this study has suggested a nonstop-automated gate system. A container terminal gate plays the role of interface connecting container cargoes between a container terminal and the outside world.

Recently the issues related to the port security including the ISPS Code (International Code for the Security of Ships and of Port Facilities) of SOLAS treaty and CSI (Container Security Initiative) are coming to the fore, thus increasing the importance of the gate. In particular, in order to enhance productivity and reduce expenses by means of speedy container handling, the necessity of developing a nonstop-automated gate system is being raised. For the introduction of nonstop-automated gate system, this paper has studied the situation and feature of the container terminal gates at home and abroad, and classified the gate systems by stage and by pattern. Also, the technologies available by pattern have been analyzed, thus suggesting the technology alternatives by pattern through the combination of core technologies.

2. ANALYSYS OF EXISTING GATE OPERATION SITUATION

To analyze the domestic container terminal gates operation, we have visited several terminals and have interviewed with working-level specialists, but in case of foreign container terminal gates, our studies have been made through preceding literatures, benchmarks, and websites. And based on these materials, this paper has analyzed the feature, function, and role of a container terminal gate.

2.1. Gate Work of Container Terminals

2.1.1 Gate Work of the Domestic Container Terminals

In this section, this study aims to find out the core factors to be considered from the aspect of operation in the development of a nonstop-automated gate system. Currently, the gate work can be classified into two: gate-in and gate-out. The procedures for the gate-in are as follows: an external vehicle arrives at the gate, and it will be crosschecked in comparison with prior information, and if there is no problem, the storage position will be allocated. And it will move to the corresponding TP (Transfer Position). If we analyze the stage of a gate-in work, first, the shipping company or transporter sends prior information to the container terminal; the external vehicles arrives at the gate and undergoes the procedures of checking and confirming the container number and the vehicle number, and then receives the slip or EIR (Equipment Interchange Receipt) notifying the storage position and moves to the corresponding TP (Refer to Figure 1). The gate-out has similar procedures. The procedure of confirming the container will be omitted. The container will move to the location for a gate-out, and will be loaded on the truck, and return the slip to the gate, thus finalizing the gate-out procedure. The normal errors could happen in the process of work handling. Therefore, if the kind of errors and the response measures against the errors are defined in advance, it will be very helpful at the time of error occurrence (refer to Table 1). However, domestic container terminals have not yet introduced this system as shown in Table 1. They used to correct errors and mistakes on a case-by-case basis instead of taking a systematic measure. Therefore, this paper would like to point out the importance of defining those errors and of taking necessary measures against them.

Table 1. Kind of errors and correction measures at the gate

Kinds of errors	Correction measures
In case of no prior information	Ask the corresponding transporter to send necessary information, and then handle the problem.
When there is no information necessary for the gate-in work	Ask the corresponding transporter to send necessary information, and then handle the problem.
When the vehicle is registered as a fled car	After confirmation, the restriction upon the vehicle should be lifted first.
In case of no confirmation of dangerous goods	Person in charge of dangerous goods should confirm it first, and after inputting the related data, handle the problem.
When some items such as a mother ship, arrival port, and ISO number don't correspond with the prior information.	Correct the erroneous data, and after receiving new data, take a necessary action.
Delayed arrival owing to an accident or a mistake	After receiving information from the planner's room, take a necessary action.
When there is no container in the yard	After confirming the related data, take a necessary action for gate-out.

2.1.2 Gate Work of Overseas Container Terminal Gates

Generally, the type of overseas container terminal gates is divided in two: one is the “single-stage” gate, which uses only one stage, and the other one is the “two-stage” gate, which introduces the pre-gate operation like the CTA in Germany.

The single-stage gate has a similar workflow to the domestic container terminals, but the two-stage gate has the following infrastructures additionally – the pre-gate (gate operator’s function, security issue, traffic control, visitor’s identification, etc.), check gate (the checkpoint for examining the vehicles and containers), document center, truck parking area, and self service equipment (use this place when prior information is perfectly transmitted). When an external vehicle arrives at the check gate, the vehicle’s number and its container number are recognized, and this information passes the visual gate in the examiner’s handy terminal screen. And the examiner compares the physical inspection with the information on his screen. If necessary, he will correct the data and record the container damage. Also, he keeps a record of the direction and location of the container loaded in the vehicle. If the procedures are over, the relevant data will be filed away in the database. The driver is to receive the transponder card and the job ticket that contains the following information.

- Transponder card number
- Truck registration number (plate number)
- Sequence of foreseen activities
 - Container number and prefix,
 - storage location (block number or special area)
 - kind of activities (loading or unloading)
- Date and hour

Before the checking procedures are finished and the transponder card is given to the driver, the transponder card number is recorded in the data system, and this card number is connected to the corresponding container data. Also, if the driver wants, the interchange receipt that proves the safe transportation of the container will be given to him. According to the working sequence recorded in the job ticket, the truck will move the appointed storage space, and has to let the reader equipped in the dispatch points of the yard recognize his transponder card. After confirmation of his arrival at the yard, all the gate-in procedures are finished. As mentioned above, well-managed overseas container terminals have classified all the gate work into the group of a similar function to enhance the work efficiency. This factor has to be considered from the operation aspect of domestic container terminals.

2.2. Function of Gate

Based on our research through preceding literatures, survey by visiting, and benchmarks, the function of a container terminal gate can be divided into three groups: the function of security and confirmation, the function of information management, and the function of service provision.

Table 2. Major functions of a container terminal gate

Section	Detailed Function
Security and confirmation	<ul style="list-style-type: none"> ·Container number confirmation ·Container seal confirmation ·Driver confirmation ·Chassis number confirmation (overseas) ·Container weight confirmation ·Container specification confirmation ·Container damage confirmation ·Empty container confirmation ·Reefer's temperature confirmation
Information management	<ul style="list-style-type: none"> ·Prior information management ·Container information storage ·Container-related abnormal information storage ·Storage position notice ·Real-time information provision
Service provision	<ul style="list-style-type: none"> ·Statistical information provision ·Provision of information on the containers waiting for gate-out ·Container damage information

First, the security and confirmation sector includes the function of making a comparison between prior information and an arrived container, and of protecting containers from dangerous goods or terror. It also includes container number confirmation, driver confirmation, container seal confirmation, external vehicle number confirmation, chassis number confirmation, and empty container confirmation. According to the service contract type between a container terminal and a shipping company, the security and confirmation sector can be divided into a compulsory function and an additional function.

Secondly, the information management sector includes comparing the situation of external vehicles and containers' gate-in/ gate-out with prior information, while sending this information to the integrated operation system of the terminal on a real-time basis. This information is to be filed away for statistical purpose later on. This sector also includes prior information management, container information storage, container-related abnormal information storage, storage position notice, and real-time information provision.

Thirdly, the service provision sector covers the container terminal's services provided for its customers – transporters, shipping companies, and forwarders. These services include the statistical information, information on the containers waiting for gate-out, and container damage information. These services should be provided to secure superiority in competing with rival container terminals.

3. OPERATION SITUATION OF CONTAINER TERMINAL GATES AT HOME AND ABROAD

As mentioned in the above section, the major functions of a container terminal gate include three sectors – security and confirmation, information management, and service provision. Meanwhile, to find out the key technologies applied to perform the detailed functions of these sectors, this paper has made a survey of 9 domestic container terminals in Busan and major overseas container terminals.

3.1. Container Security and Confirmation

To perform the detailed function of container security and confirmation, the domestic terminals are usually using a bar code system along with naked eye confirmation, and some

terminals have concurrently introduced an image recognition system. Meanwhile, some major overseas terminals are trying to introduce an image recognition system or a high-tech automation system.

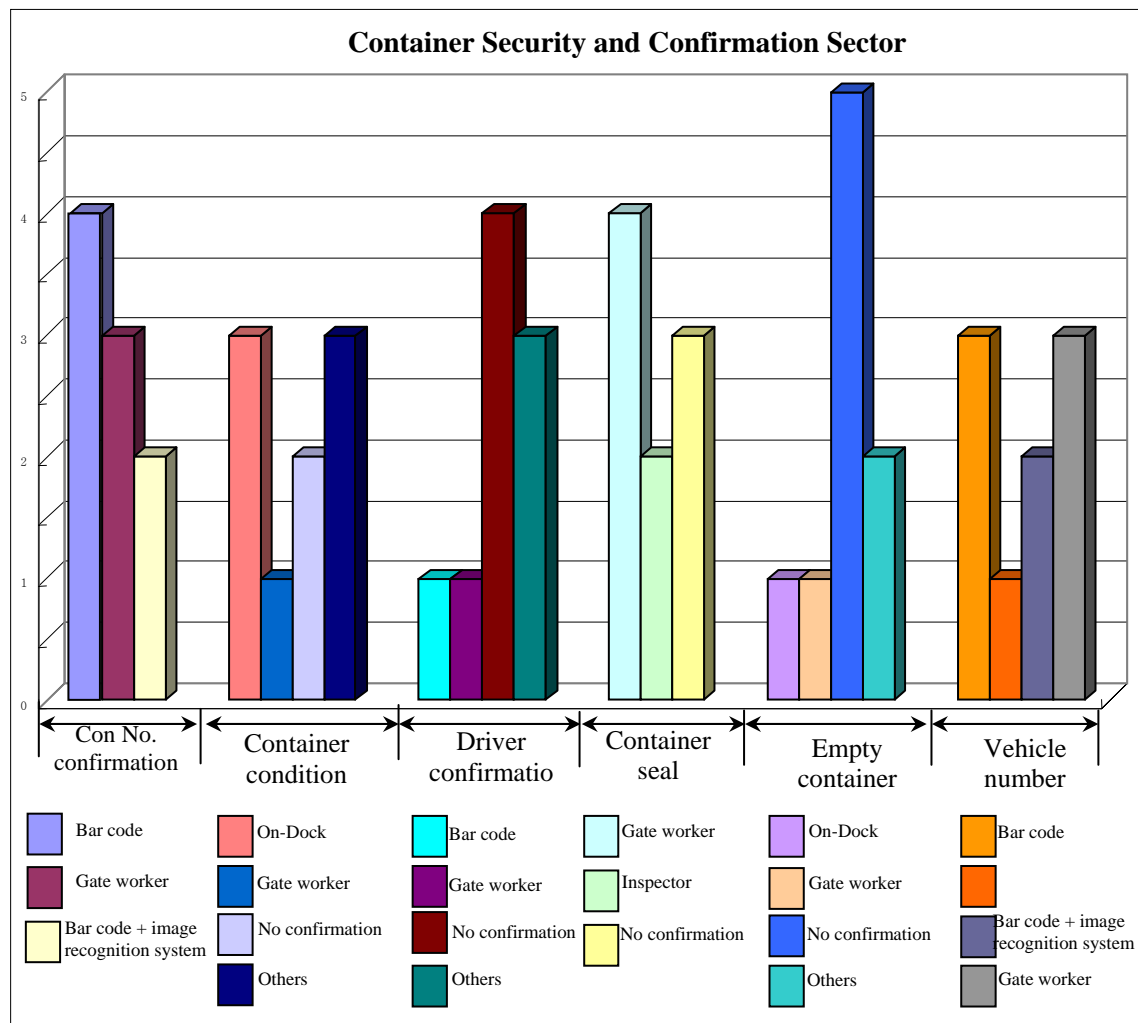


Figure 1. Operation situation for container security and confirmation

While checking the technologies applied to the container security and confirmation sector, this study has found out the fact that major overseas container terminals pay more attention up to the detailed part of container security and confirmation than domestic terminals. This factor also has to be considered to upgrade the security and service quality.

3.2 Container Information Management

In case of domestic container terminals, most of them are providing necessary information on a real-time basis, and some of them have introduced a state-of-the-art PDA system. The information on the container condition has been well checked. There has been no much difference in the storage position notice between domestic terminals and overseas terminal. Meanwhile, the CTA of Germany has been using a job ticket.

What matters in the information management sector is whether a terminal is providing necessary information to the customers on a real-time basis. Fortunately, most terminals at home and abroad are well performing this function, still trying to make efforts to improve this service. As for the information service provision sector, most major container terminals have flexibly been dealing with the matter of information service according to their own situation

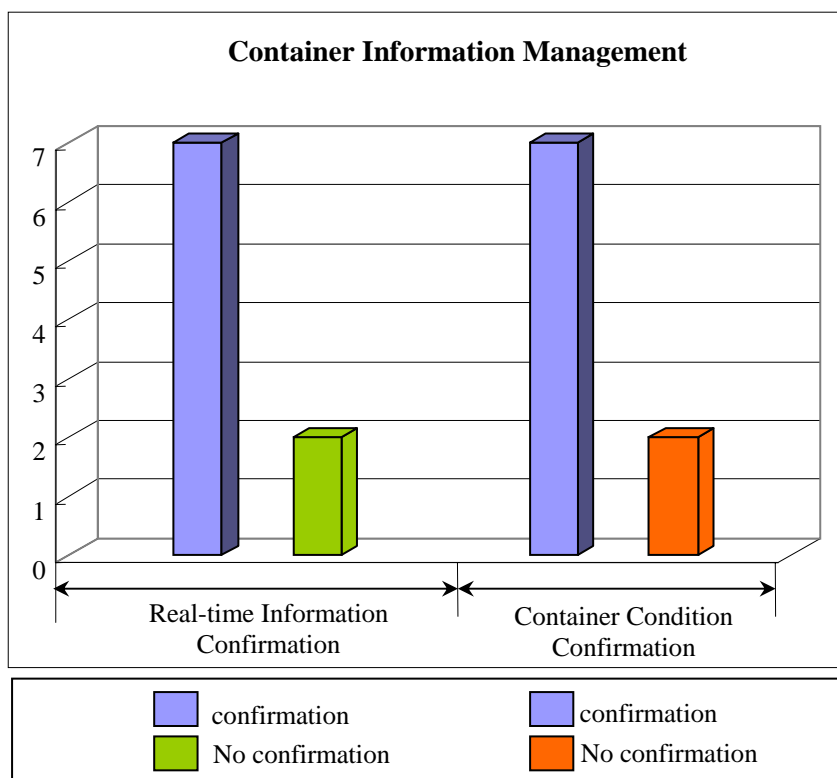


Figure 2. Container Information Management

4. SUGGESTION OF NONSTOP AUTOMATED GATE SYSTEM

In the existing container terminal gate, the vehicle should be at a stop to perform the following jobs – container seal confirmation, storage position notice, and empty container confirmation. And the job of confirming container seal and confirming the inside of a container has to be done by manual work. But now many high-tech technologies have enabled these gate works to be done without stop of a vehicle at the gate. In this respect a nonstop-automated gate can be defined as the gate that can automatically perform its major functions without stop at the gate.

4.1 Technologies Applicable to Nonstop Automated Gate

The technologies applicable to the nonstop-automated gate are as follows: RFID tag, electronic seal (application of RFID technology), OCR, DSRC, ACDI technology, and mobile communication technology. The features of these technologies are shown in Table 3 below. The fields applicable according to the features of these technologies are diverse. For example, RFID and OCR technology can be applied to container number confirmation, driver confirmation, car number confirmation, chassis number confirmation, and container specification confirmation. ACDI technology can be applied to container damage confirmation, and mobile communication technology to storage position notice. Like this, by connecting the key technologies to each gate work, the possibility of application has been classified in the Table 3. And this classification will be helpful in generating the technology development pattern for a nonstop-automated gate.

Table 3. Major functions of a container terminal gate

Technology	Feature	Application field
RFID	<ul style="list-style-type: none"> ·Non-contact recognition by means of microchip ·Built-in memory of large capacity and recognition on the move ·Long-distance recognition and high confidence in data 	<ul style="list-style-type: none"> ·Container recognition ·Car number recognition
OCR	<ul style="list-style-type: none"> ·Noncontact recognition by means of image ·Recognition of cars and containers on the move 	<ul style="list-style-type: none"> ·Container recognition ·Car number recognition
DSRC	<ul style="list-style-type: none"> ·Short distance wireless data transmission ·Noncontact recognition by means of wireless LAN 	<ul style="list-style-type: none"> ·Application to ITS (Intelligent Transport System)
ACDI	<ul style="list-style-type: none"> ·By using 2D image secured by high resolution, the technology development for container damage confirmation is underway. 	<ul style="list-style-type: none"> ·The technology development for container damage confirmation is underway
Mobile communication	<ul style="list-style-type: none"> ·Speedy transmission of massive data on the move ·No spatial restriction High confidence and security in data transmission ·Economic merit by using a mobile phone 	<ul style="list-style-type: none"> ·Storage position notice

4.2 Generation of Nonstop Automated Gate Type

In the development of a nonstop-automated gate system, the scope of applicable technology depends on the current situation of a container terminal. For example, the performance function of a terminal gate can be changed according to the service contract between a container terminal and a shipping company. Also, owing to the terminal’s own problems, it can decide to introduce a step-by-step application of a nonstop-automated gate system. Considering these situations, this study has presented the technology development type by stage for a nonstop-automated gate system.

Considering the gate work and applicable technology mentioned in the previous section, this study has generated 8 types in the beginning, but there were some overlapped technologies or similar technologies. Because of this, this paper has selected four practical types among 8 types. (Refer to the table 5: the “type 0” means that the function of a gate can be done without introducing additional technology.) “**Type 1**” indicates that a nonstop-automated gate can be developed by using the technologies of OCR, RFID tag, DSRC, and mobile technology. “**Type 2**” means that the ACDI technology will be added to the “type 1” in order to perform the function of confirming container damage. “**Type 3**” shows that by adding an electronic sealing technology to the “type 2” the gate can perform the function of container seal confirmation. “**Type 4**” is the most ideal type, but in this case more applied technologies should be added to perform all functions automatically. In reality, some of these applied technologies can be developed theoretically, or others have already been developed, but they have not yet been proved to be practical in the field work. Therefore, it requires a lot of investment and operation expenses. So it is not easy to introduce them right now. Considering this reality, this study has come to the conclusion that “type 1, 2, and 3” can lead to the technology development stages for a nonstop automated gate. And we have summarized the technologies applicable to each type in the next Table 4.

Table 4. Nonstop Automated Gate Type

Type	Jobs to be done at a stop	Jobs to be done without stop	Application technology
0	Car number, Container number, Chassis number, Container specification, Driver, Container damage, Container seal, Empty container, Reefer temperature, Container weight confirmation, Storage position notice, Container number, Chassis number, Container specification, Driver,	Prior information management Container information Container-related abnormal information Real-time information provision Statistical information provision Provision of container information on the containers waiting for gate-out. Container damage information provision	These functions can be done without introducing additional technology
1	Container damage, Container seal, Empty container, Reefer temperature, Container weight confirmation, Driver,	Type 0 + car number + storage position notice + container number (chassis number, container specification) + driver confirmation	OCR, RFID tag, and mobile technology
2	Container damage, Container seal, Empty container, Reefer temperature, Container weight confirmation	Type 1 + Container damage confirmation	ACDI
3	Container damage, Container seal, Empty container, Reefer temperature, Container weight confirmation	Type 2 + Container seal confirmation	RFID Electronic seal
4	-	Type 3 + empty container confirmation + reefer temperature confirmation + container weight confirmation	Applied technology (Ex: gamma ray, connection of electronic thermometer and RFID, super-speed pressure sensor

This study has tried to define the scope of a nonstop automated gate according to the current situation of a container terminal, so that it may be used a guideline for the technology development of a nonstop automated gate system.

5. CONCLUSION

To cope with rapidly increasing container volume all around the world, major global container terminals are making every effort to improve their productivity by means of port construction, stevedoring equipment expansion, and renovation of their terminal operating system. However, the study on the container terminal gate, which is the gateway for all the import-export containers, has not been made enough until now. Therefore, this study has tried to systematically summarize the function and role of the existing gates, and suggest the future direction for the realization of a nonstop-automated gate. For this purpose, first of all, this study has analyzed the technologies that can be applicable to the fieldwork, and has tried to produce certain types through combination of analyzed technologies in an effort to suggest a technological alternative and also to be a guideline to the study on a container gate in the future.

However, owing to the time limit for study, the analysis of global technology situation and expected future movements has not been made enough. Also the applicability of the suggested technologies to the gate and forecasting of application time has not been studied enough. Therefore, from now on we are going to step up the analysis of future technology and marketability analysis.

ACKNOWLEDGEMENTS

This research was supported by the Program for the Training of Graduate Students in Regional Innovation which was conducted by the Ministry of Commerce, Industry and Energy of the Korean Government.

REFERENCES

- Bernaerd, A. (2003), Camco Technologies, *Securing the Gate*, Container Shipping Security Conference, Antwerp 2003.
- Elovi, P. (2003), *Implementation of Gate and Crane OCR Systems for Container Terminal Automation and Security*, TOC 2003 Asia.
- Elovic, P. and Scheppman, L. (2002), *Practicalities of Implementing OCR: A Case Study of the World's Largest Installation*, TOC 2002 Americas.
- Jeong, B. S. (2000), *Development of Automated Gate System Using DSRC*, Proceeding of Center for Intelligent & Integrated Port Management Systems.
- Jeong, B. S. et al. (2001), *A Study on Merchandising of Automated Gate System*, Proceeding of Center for Intelligent & Integrated Port Management Systems.
- Lee, J. C. M., Wong, W. K. and Fong, H. S. (1999), *Automatic Character Recognition for Moving and Stationary Vehicels and Containers in Real-life Image*, Proc. International Joint Conference on Neural Networks (IJCNN '99) , Washington, D.C..
- Murty, K. G. (2003), A decision support system for operation in a container terminal, *Decision Support System*, **39(3)**, 309–332.
- Park, S. W. (2002), *A Study on Performance Improvement of Automated Gate System*, Dong-A University Graduate.
- Stromgren, C. (2002), Report Industry Requirements for Electronic Container Seal, CCDoTT.
- Yang, C. H. et al. (2003), *A Study on Strategy & Technology of Operation Systems for Next Generation Container Terminal*, Korea Maritime Institute.