A Study on Evaluation of Container Truck Interface System Efficiency in the Semi-Automated Container Terminal

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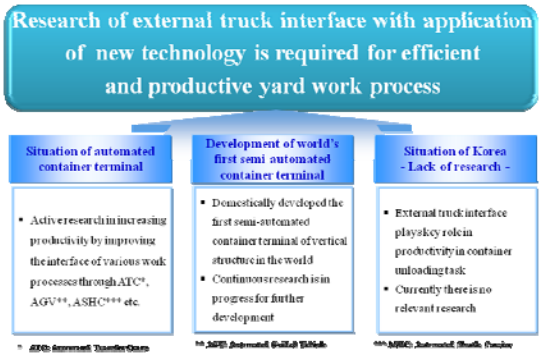
ABSTRACT

Along with the appearance of a super large containership, the port environment of the world is rapidly changing into the 'hub and spoke' type. To keep up with this trend, major ports all over the world are making every effort to improve their productivity and to build an automated container terminal, so that they will be able to become a hub port. In an effort to improve the productivity of horizontal layout-typed yard automation system, this study has analyzed the kiosk-based truck recognition method and the RFID-based truck recognition method. In particular, this study has tried to find out how these recognition methods affect the efficiency of Container Terminal Yard Work, the core work of semi-automated container terminal. To this end, this study has analyzed and compared the work process of both the kiosk-based system and the newly developed RFID-based system, and also has collected the real data of these systems. Finally, this study has made a simulation of these two systems by using the simulation software ARENA As a result of our simulation tests, we have found that the RFID-based truck interface system is much better than the kiosk-based truck interface system in terms of the turnaround time, travelling time, ATC's total work hours, and waiting time of the outside trucks.

Ⅰ. INTRODUCTION

With the recent trend of mega container ship, increase in port size, hub & spoke port strategy, change in operational organization and development in technology, the container terminals are required to establish competitiveness and maintain the competency. With this trend, a need has been identified to improve the efficiency of the container terminal, to reduce the cost by moving away from labor based unloading capability to quickly unload large scale ships and to establish a high efficiency state-of-the-art Automated Container Terminal. And foreign container terminals including ECT Container Terminal of Rotterdam and CTA Container Terminal of Hamburg, are developed and operated as fully automated and vertically structured container terminals. Domestically, KBCT (Korea Exchange Busan Container Terminal) #4 yards has been developed and operated as the automated container of horizontal structure. Stage 2-1 and 2-2 of

New Busan Port has recently been opened as semi-automated container terminal. Stage 2-3 is expected to open as semi-automated container terminal of vertical structure and stage 2-4 is expected to open as fully automated container of vertical structure, and the development for both has already begun.



<Fig. 1> Research background

Container terminal is largely composed of gate, yard and quay wall work process, and the interface among these work processes must be maintained smoothly in order to improve the work efficiency of the container terminal. In the case of fully automated container terminal, the interface between the work processes of gate, yard (Transfer and unloading) and quay wall are smoothly processed by using automated transfer equipment and unloading equipment, and in the case of the semi-automated container terminal, the interface of the yard (Transfer and unloading) process is automated by using external truck and transfer equipment, such as YT, and unloading equipment, such as RMGC.

Though the world's first semi-automated container terminal of horizontal structure has been developed domestically, there has not been any effort in continuous research for improvement, and especially the research related to the external truck interface, which is one of the interface of yard work process and the starting point of the automated work process in the semi-automated container terminal, is nonexistent contrary to the key role it plays in the work productivity. The semi-automated container terminal of horizontal structure developed domestically uses the external truck interface of kiosk type using the barcode card. But to process the yard work process more efficiently and productively in the ever changing port environment, there is a need to develop the external truck interface with new technology.

The scope of this research is the kiosk type external truck interface, one of the currently used systems in the semi-automated container terminal of horizontal structure, and the external track interface based on the new and recently active RFID technology.

First, this research reviews various researches related to container terminal to understand the issues of the existing researches and to propose a methodology to resolve the identified issues.

Second, the current work process of the semi-automated container terminal currently operated domestically is researched and analyzed to analyze the automated container terminal work.

Third, key considerations in introducing the external truck interface to select the external truck interface to apply to the semi-automated container terminal of horizontal structure have been summarized, and relevant issues analyzed to select the optimal solution.

Fourth, scenario has been established and simulation modeling executed for the actually operated semi-automated container terminal to evaluate the work productivity (External truck turn-around time, transfer time, total work time of ATC, standby time of loading/unloading before ATC) of optimal solutions (Kiosk based external truck interface and RFID based external truck interface). When preparing the simulation, simulation software ARENA, which is widely used in various industries including the current port, has been used, and the simulation has been executed using the data from the actual container terminal to ensure reliability of the results of the prepared simulation model.

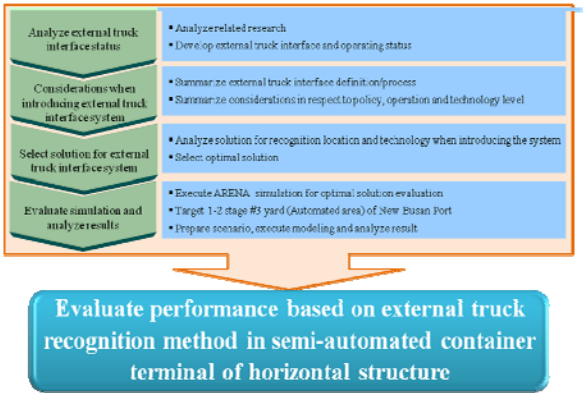


Fig. 2 Research content and method

Ⅱ. Review of existing research

Based on the result of analyzing relevant documents, the research on automated container terminal is actively done in foreign countries but not actively done for external truck interface. Domestically, the research on automated container is insufficient and the research on the external truck interface is significantly insufficient. Additionally, the research on productivity and efficiency improvement of container terminal has made progress but there has not been any simulation related to the research on interface for external truck recognition in horizontal structure yard.

Table 1. Analysis of existing research related to container terminal

Classification	Development	Operation	Others
Traditional container terminal	Man Soon Song(03‘) Sang Hee Choi(03‘) Gyoo Suk Gwak (99‘)	Peter(01‘) Seung Jin Wang(02‘) Woo Sun Kim(03‘)	Gyoo Suk Gwak and 7 others(99‘)

Semi-automated container terminal	Research related to this part is currently insufficient		Gap Hwan Kim and 5 others(02‘) Choong Hoon Lee(07‘) Chang Ho Yang and 4 others(01‘) Joong Bae Park and 2 others(03‘) Bum Joong Kim(97‘)
Fully automated container terminal	Hyung Lim Choi (05‘), Chang Ho Yang and 5 others(02‘) Bum Joong Kim(97‘) Yung Hwang Jun(08‘) Jong Lul Kim(01‘)	Dong Ho Yoo(07‘) Hae Gyung Kwon(07‘) Seung Jin Wang(02‘) Sang Hee Choi(98‘) Gi Chan Nam(00‘) Bum Joong Kim(97‘)	Dong Ho Yoo(07‘) Joong Jo Shin(07‘) Gi Chan Nam(00‘) Yang Geun Kim(03‘) Bum Joong Kim(97‘) Hae Gyung Kwon(07‘)

Ⅲ. External truck interface of horizontal structure container terminal

1. Container terminal interface

<Fig. 3> Container terminal interface

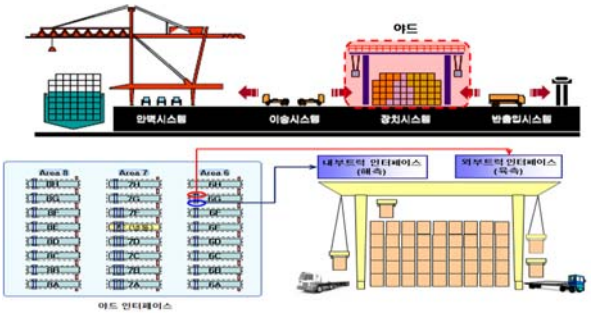
The dictionary meaning of interface refers to the physical or virtual contact point between objects or between object and human to enable communication with the purpose of temporary or permanent access.

The representative interfaces from the perspective of processing the inflow/ outflow work of the container in the container terminal are the gate that physically connects the container terminal to the external side and starts the container terminal work, yard where the container transferred into the terminal is located and the quay wall where the containers to be imported/exported are loaded to or unloaded from the ship.

2. Container terminal yard interface

The work carried out on the container terminal yard can be categorized into 4 work processes of inflow, load, unload and outflow process.

Because such work actually on the terminal is carried out simultaneously in equipment site, the key issue of improving the productivity of the terminal depends on how smoothly the interface between the work processes are done.



<Fig. 4> Container terminal year interface

3. Internal truck and external truck interface in the yard

3.1 Internal/External truck interface

The interface between the inflow and outflow work process in the yard occurs at the internal truck (YT) interface and external truck interface. Both the internal truck interface and external truck interfaces uses the YT and external truck respectively for the container loading/ unloading process. The application status of the internal/external interface to process the load/unloading work of the container in the yard is shown in Table 2.

Table 2. Internal/External truck interface application status

Classification		Case	Crane	Transfer equipment recognition technology (Yard)	
Traditional		Existing Busan Port	Manned	External truck	-
				YT(Manned)	WebPAD
Semi-automated	Horizontal structure	KBCT	Unmanned (Auto, remote)	External truck	Barcode + TPDU
				YT(Manned)	Webpad
		New Busan Port 1-1, 1-2	Manned/Unmanned Automated Remote	External truck	OCR + RFID
				YT(Manned)	Webpad
		New Busan Port 2-1	Unmanned Automated Remote	External truck	Barcode + RFID
				YT(Manned)	Webpad
		New Busan Port 2-2	Unmanned Automated Remote	External truck	Barcode + RFID
				YT(Manned)	Webpad
	Vertical structure	PSA	Unmanned (Remote)	External truck	Barcode + OCR
				YT(Manned)	PDA
Fully automated		CTA, ECT	Unmanned (Auto, remote)	External truck	Barcode, RFID
				AGV (Unmanned)	Transponder
		New Busan Port 2-4	Unmanned (Auto, remote)	External truck	TBD
				TBD	TBD

3.2 External truck interface access and work procedure in foreign container terminal

Assuming that the load/unloading work, the basics of yard work, is done in a foreign container terminal, the access method and work procedure of TC and external truck are as shown in Table 3.

Table 3. Interface of TC and external truck of foreign container terminal

Classification	CTA	TMP	PPT	OI	KBCT
TC Access procedure of external truck	After passing gate Block TP	After passing gate Block TP	Next to RMGC after TP arrival	Next to RMGC after TP arrival	After passing gateMove to TC work location
Vehicle recognition method	Recognition using magnetic card	Recognition using magnetic card	RMGC technician checks with naked eye	RMGC technician checks with naked eye	Contact ID/SLIP card for recognition
Container number recognition method	Check with camera from remote office	Site worker checks with naked eye	RMGC technician checks with naked eye	RMGC technician checks with naked eye	Check with camera from remote office
TC load/unloading work method	CCTV/Remote work	Joystick operation from block TP	RMGC technician checks with naked eye	RMGC technician checks with naked eye	CCTV/Remote work
Location recognition method of container in yard	Install mark for swing sensor detection/surface detection	Install mark for swing sensor detection/surface detection	Sensor detection/RMGC technician checks with naked eye	Install mark for swing sensor detection/surface detection	Install mark for swing sensor detection/surface detection
Correct location checking method of truck in case of TP arrival	Truck driver checks with naked eye	Truck driver checks with naked eye	Truck driver checks with naked eye	Truck driver checks with naked eye	Truck driver checks with naked eye
TC work scheduling method and work directing time point	Check truck arrival in operating system/block	Check truck arrival in operating system/block	TP technician selects work after truck arrives to block TP	TP technician selects work after truck arrives to block TP	Check truck arrival in operating system/block
2 processing method of 20 containers	Same block equipment if possible	N/A	N/A	N/A	Process in order by SLIP
Truck driver location during work	Unload	Unload	N/A	Load	Load

3.3 Need for research of external truck interface

Between the internal truck interface and external truck interface, this research targets the external truck interface. The reason this research excludes the internal truck (YT) interface is because the external truck interface is more important from the terminal perspective than the internal truck interface.

For the internal truck interface, the number of internal truck (YT) that must be managed in the terminal is small and the operating range is limited to yard and quay wall, and the separate TP is not required for internal truck too process load/unloading work. And the internal truck has a wireless terminal (WebPAD, PDA) installed to check the location and condition of the internal truck and does not have any major difficulty in the interface to other work because it is relatively convenient to manage compared to the external truck from the terminal perspective.

Also for the internal vehicle, it can be controlled based on the operating policy of the terminal but the for the external truck, it is difficult to control from the terminal as the truck temporarily comes into the terminal and leaves the terminal for the inflow/outflow work process. Therefore the external truck interface has been considered with higher priority.

3.4 External truck interface system

There are several types of external truck interface systems used for recognizing the external truck, but the representative type of system is the kiosk based external truck interface system as shown in <Fig. 5>.

Kiosk based external truck interface system is the system of processing the load/unloading work by scanning the barcode card provided by the driver on the barcode scanner on the kiosk after the driver arrives with the external truck in the target bay of the yard and then approaches the kiosk.

<Fig. 5> Kiosk based external truck interface (Actually operated)

<Fig. 6> RFID based external truck interface (Installed form)

Aside from this, currently the RFID based external truck recognition interface system is being established in the semi-automated container terminal as shown in <Fig. 6>. Unlike the existing kiosk based external truck interface system, this does not require the driver to get off the

truck and the RFID tag is recognized remotely to process the load/unloading work.

Ⅳ. Considerations when introducing the external truck interface system

1. Considerations at policy level

1.1 TP location of external truck

Positioning the TP of the external truck at the end of the block is helpful in precisely parking the external truck, and this does not require additional work and equipment to check and adjust the parking location and enhances the safety of the external truck driver. But setting the TP at the end of the block extends the moving distance of RMGC and affects the productivity, which requires various solutions including adding RMGC, adjusting the length of the block or supplementing with additional equipment.

1.2 Buffer area to limit the access of external truck

Buffer area is the standby location before entering the equipment system and is required to reduce the traffic complexity within the equipment system. Method of installing the buffer can be divided into external control plan and internal control plan.

External control plan is ⑴ the method of keeping the external truck outside of the gate and utilizing as the buffer area and the internal control plan is ⑵ the method of passing truck through the gate first and then installing the buffer are in a completely new area, ⑶ method of having the truck wait outside the entrance of each block, ⑷ the method of passing the truck through the gate first and then having it wait on another block temporarily before processing, and ⑸ the method of installing the automated yard gate.

1.3 Number of RMGC vehicles by block

Decision of the number of RMGC vehicles by block is an important decision from the work productivity aspect. In advanced automated container terminal, two ATC units are inserted by block but the number of RMGC vehicle by block must be considered by the environment and operating method.

1.4 Yard driveway operation

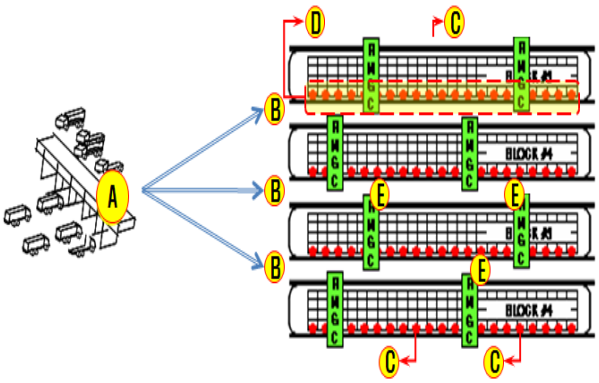
Decision of the external truck and internal truck driveway must be planned considering the traffic complexity of inflow, unload, load and outflow work processes. Also for smooth traffic flow of the external and internal truck, the yard driveway operation plan is required.

For this, the easiness of work for the external truck and access to the card reader by the truck driver must be considered. Especially, for the easiness of the work, it is recommended that the driveway between the external and internal truck be distinguished.

2. Consideration at operational and technical level

2.1 Recognition location of external truck

When the external truck enters the container terminal, the points of recognition within the workflow are marked A, B, C and D as shown in <Fig. 7>.



<Fig. 7> Solution for recognition location of external truck

For the existing gate (A), the arrival of the external truck to the terminal can be checked and the yard work location can be notified, but to be judged to have arrived at the work location is difficult due to the numerous exceptions. For block entrance (B), it is effective to check whether the vehicle has entered within the block for work efficiency of ATC, and reduces the cost compared to installing the scanner at the target bay and all the bays within the block, but requires a certain level of installation and maintenance cost. There could be solution to recognize the external truck at the TP at the target bay (C) within the block and the reason would be to provide final notice to ATC when the load/unloading work preparation is completed for the external truck. For all the bays (D) within the block, the equipment must be installed to all the bays increasing the rate of recognition, resulting in increased work accuracy, but the highest equipment installation and operation cost is expected. Lastly, there is a solution of recognizing the external truck to work by attaching the scanner on ATC, which improves the technical stability by having the ATC equipment recheck prior result, but the technology that can be applied is limited. Of the several recognition location solutions, the solution of the existing gate (A) is excluded in this research due to the high level of exceptions.

2.2 Recognition technology of external truck

The interface to recognize the external truck requires the equipment for ATC, Automated Transfer Crane, to recognize the arrival of the external truck and process the work.

The technologies that can be utilized for recognizing the external truck includes barcode (ID card), RFID, OCR (Camera) and wireless transmission terminal (WebPAD, PDA) etc. But for the case of OCR (Camera), the recognition rate is low compared to other

technologies and for the case of wireless transmission terminal, it is technically feasible but the cost from the terminal perspective can be excessively high. Both cases are excluded from the scope of this research for these reasons.

Ⅴ. Selection of interface for external truck recognition

1. Applicable solution

There can be numerous system solutions that can be configured depending on the location and technology of recognizing the external truck when the interface system for external truck recognition is introduced. But as described in chapter III, the applicable solutions can be narrowed down to 4 solutions of block entrance, target bay within block, all bays within block and recognition equipment on ATC, and two technologies of barcode and RFID considering the operating environment and cost element of the terminal. But for the case of ATC, a scanner that can be read from long distance must be attached and therefore the barcode is excluded and only RFID is considered for this solution. The system that can be configured based on the combination of above recognition location and technology, is listed in total of 9 solutions as shown in Table 4.

Table 4. Solution by recognition location and technology

Classification	Recognition location	Recognition technology	Remarks
Solution 1	Block entrance	Barcode (ID card)	<Fig. 7> Path B
Solution 2	Block entrance	RFID	<Fig. 7> Path B
Solution 3	Target bay within block	Barcode (ID card)	<Fig. 7> Path C
Solution 4	Target bay within block	RFID	<Fig. 7> Path C
Solution 5	All bays within block	Barcode (ID card)	<Fig. 7> Path D
Solution 6	All bays within block	RFID	<Fig. 7> Path D
Solution 7	Block entrance recognition, ATC recognition	RFID	<Fig. 7> Path B → E
Solution 8	Target bay within block, ATC recognition	RFID	<Fig. 7> Path C → E
Solution 9	All bays within block, ATC recognition	RFID	<Fig. 7> Path D → E

Among the solutions, solution 7, 8 and 9 are the solutions of recognizing the information one more time from a different location after the information is captured from the block entrance, which is only applied to the RFID technology. The reason, the barcode technology has been excluded from the solutions 7, 8 and 9 is because of the safety concern of the driver having to get off the truck to scan the barcode when the ATC approaches the truck for load/unloading work.

As describe above, there are 9 interface system solutions for the external truck considering the operation and technology level discussed ahead. To select the optimal solution, an appropriate criterion must be set to analyze and evaluate each of the solutions. And as the 9 solutions are derived from the combination of recognition location and technology, the criteria to decide the optimal solution must be relevant to the recognition location and technology.

Based on the result of collecting the opinion of the experts of the area related to the current work, the criteria to select the optimal interface system solution for external truck includes, recognition location, recognition technology, worker safety and cost.

For the criteria of recognition location, the ATC must be able to recognize the external truck entering the yard for containers load/unloading work. ATC includes the recognized external truck into the work order so that it affects the work efficiency of container load/unloading work by deciding the work order ahead based on where the external truck is recognized.

For the recognition technology, it must be able to accurately judge the work area when the external truck reaches the work area. When the location is recognized from the external truck and ATC perspective, this can received as the ready signal for loading or unloading the container of the applicable external truck to ensure stability of the applicable work.

For worker safety, it is considered safer when the external truck driver does not have be get off the truck during container load/unloading work and this can be decided by the recognition location and technology to affect the work safety.

For the cost, cost to establish the proposed system solution is considered, which can affect the overall required cost from the terminal perspective.

2. Selection of optimal solution

As describe above, there are 9 interface system solutions for the external truck considering the operation and technology level discussed ahead. To select the optimal solution, appropriate criteria must be set to analyze and evaluate each of the solutions. And as the 9 solutions are derived from the combination of recognition location and technology, the criteria to decide the optimal solution must be relevant to the recognition location and technology.

Based on the result of collecting the opinion of the experts of the area related to the current work, the criteria to select the optimal interface system solution for external truck includes, recognition location, recognition technology, worker safety and cost.

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For the recognition technology, it must be able to accurately judge the work area when the external truck reaches the work area. When the location is recognized

Table 5. Solution analysis and evaluation

Classification		Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6	Solution 7	Solution 8	Solution 9
Recognition location		Low	Average	Average	High	High	Very high	Very high	Very high	Very high
Recognition technology		Average	Very low	Very high	Very low	Very high	Very low	High	Very low	Very low
Worker safety		Average	High	Average	High	Average	High	High	High	High
Cost	Installation	Low	Very low	High	High	Very high	High	High	Very high	Very high
	Operation	Low	Very low	Average	Average	Very high	Average	Average	High	Very high
Evaluation		•Vehicle needs to stop •More stable compared to solution 2	•Vehicle does not need to stop •Low recognition rate due to lack of cross-checking	•Vehicle needs to stop •Optimal work stability and cost when using barcode technology	•Very low technical stability due to frequency interference •High rate of exception	•Highest technical stability •Highest installation and maintenance/repair cost	•Very low technical stability due to frequency interference •High rate of exception	•Improve efficiency by creating ATC work list early and improve technical stability by cross-checking block and ATC	•Improve efficiency by creating ATC worklist early •Reduce work stability by interference	•Improve efficiency by creating ATC worklist early •Reduce work stability by interference •High installation and maintenance/repair cost

from the external truck and ATC perspective, this can received as the ready signal for loading or unloading the container of the applicable external truck to ensure stability of the applicable work.

For worker safety, it is considered safer when the external truck driver does not have been get off the truck during container load/unloading work and this can be decided by the recognition location and technology to affect the work safety.

For the cost, cost to establish the proposed system solution is considered, which can affect the overall required cost from the terminal perspective.

Ⅵ. Solution analysis and evaluation

As shown in Table 5. based on the recognition location, recognition technology, worker safety and cost, the optimal solution is solution 3 when using barcode technology and solution 7 when using RFID technology for the interface system of external truck.

1. Evaluation of interface solution of external truck based on simulation

To evaluate the two solutions selected from chapter Ⅴ, the ARENA simulation program has been used to test the prepared model and the result values are compared and analyzed.

1.1 Simulation environment

To simulate the interface solution of external truck in the semi-automated container terminal of horizontal structure the environment has been configured as shown in the following table. The simulation environment used in this research has been designed based on the basic details of 1-2 stage #3 yard (Automated yard) of New Busan Port currently in operation, and the key details of the environment are shown in Table 6.

As shown in Table 5. based on the recognition location, recognition technology, worker safety and cost, the optimal solution is solution 3 when using barcode technology and solution 7 when using RFID technology for the interface system of external truck.

1.2 Evaluation of interface solution of external truck based on simulation

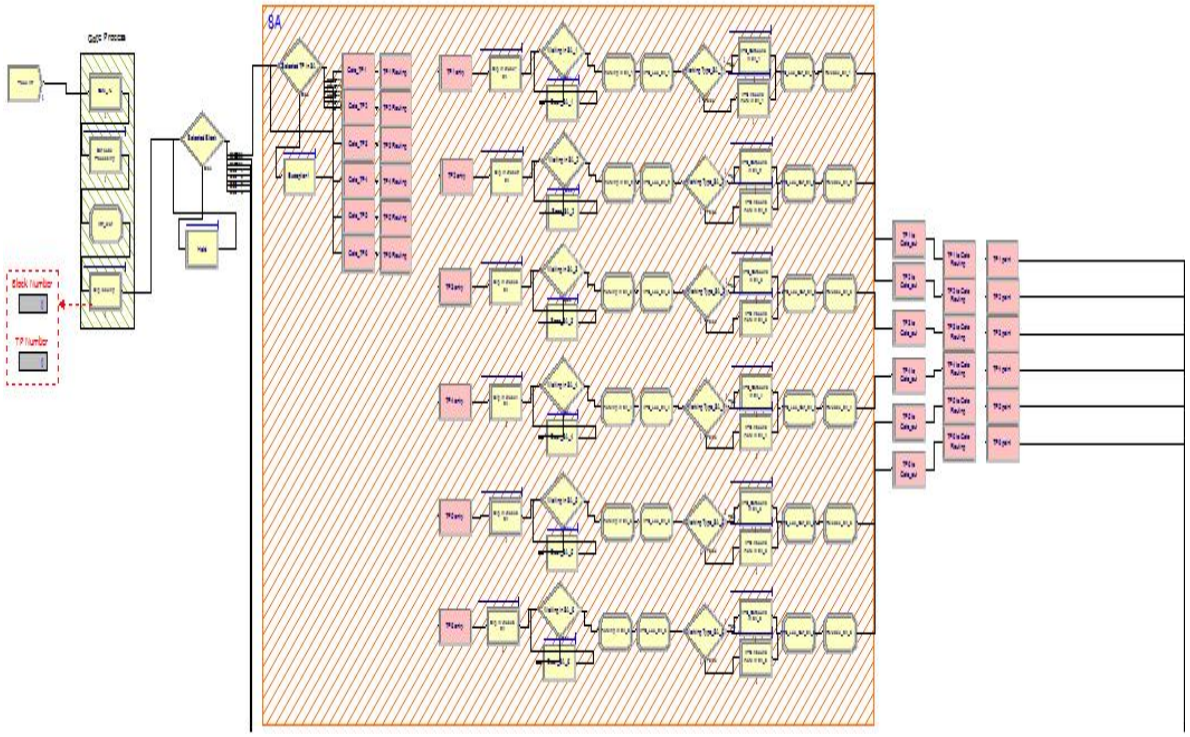
To evaluate the two solutions selected from chapter Ⅳ, the ARENA simulation program has been used to test the prepared model and the result values are compared and analyzed.

Table 6. Solution Simulation environment

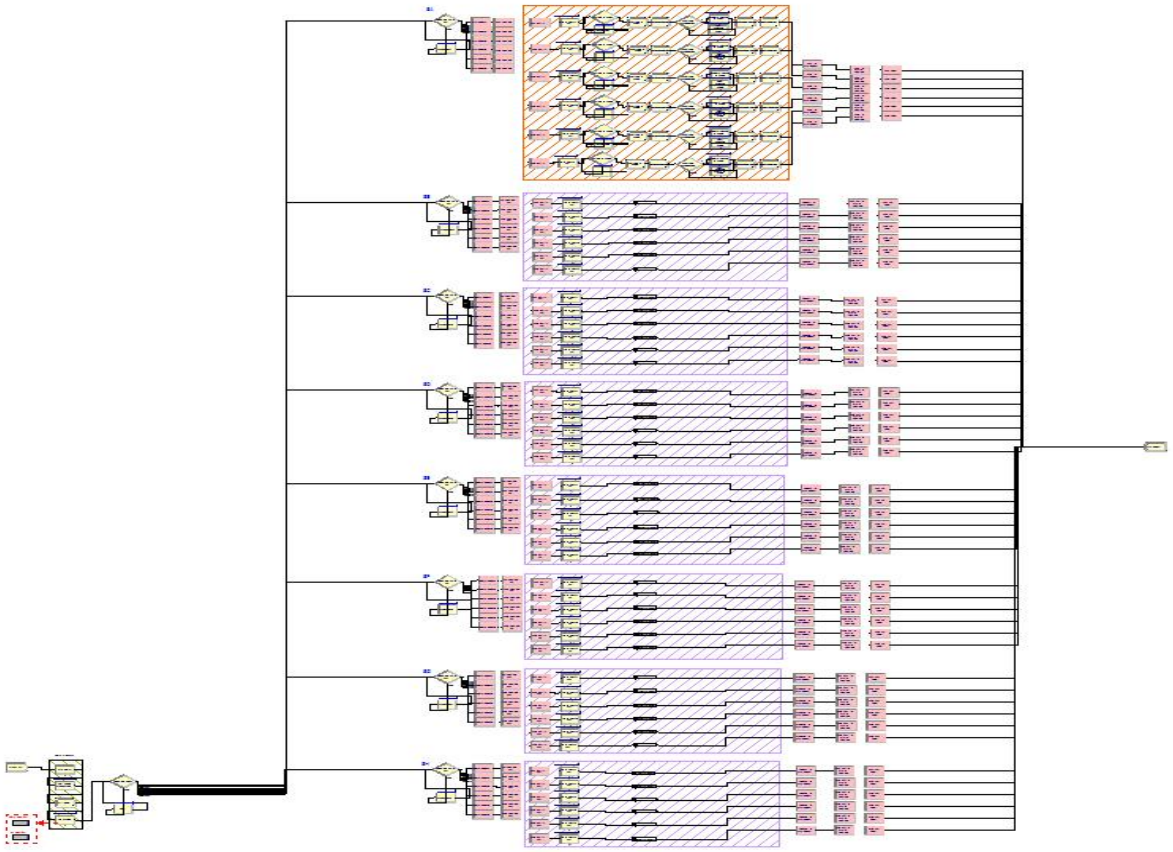
Classification	Content	
Processing capacity	•Based on New Busan Port design. Per yard: 370,000 TEU (9 yards, 3,400,00TEU)	
In/Outflow gate	•External truck (Container truck): 10,000 trucks •External truck arrival time. Average: 43 seconds, Deviation: 1 minute 47 seconds,	
Number of yards	•1 yard in horizontal structure	
Distance	•Distance from gate to block entrance: 3039.43m •Distance between TPs: 65.7m •Distance between bays: 6.56m	
ATC	•Number of units	RMGC 8 units
	•ATC transfer speed	Maximum speed: 180m/min [Based on machine design] Average speed: 150m/min
	•Average load/unloading work time	Average time of land side: 2 minutes 10 seconds Average time of sea side: 1 minute 40 seconds
Equipment system area	•1 yard 8 blocks 50 bays	
Simulation system environment	•Simulation software: ARENA 10.0 •OS: Windows XP Professional	

1.3 Simulation modeling

The kiosk based external truck interface modeling using the ARENA simulation is shown as follows.

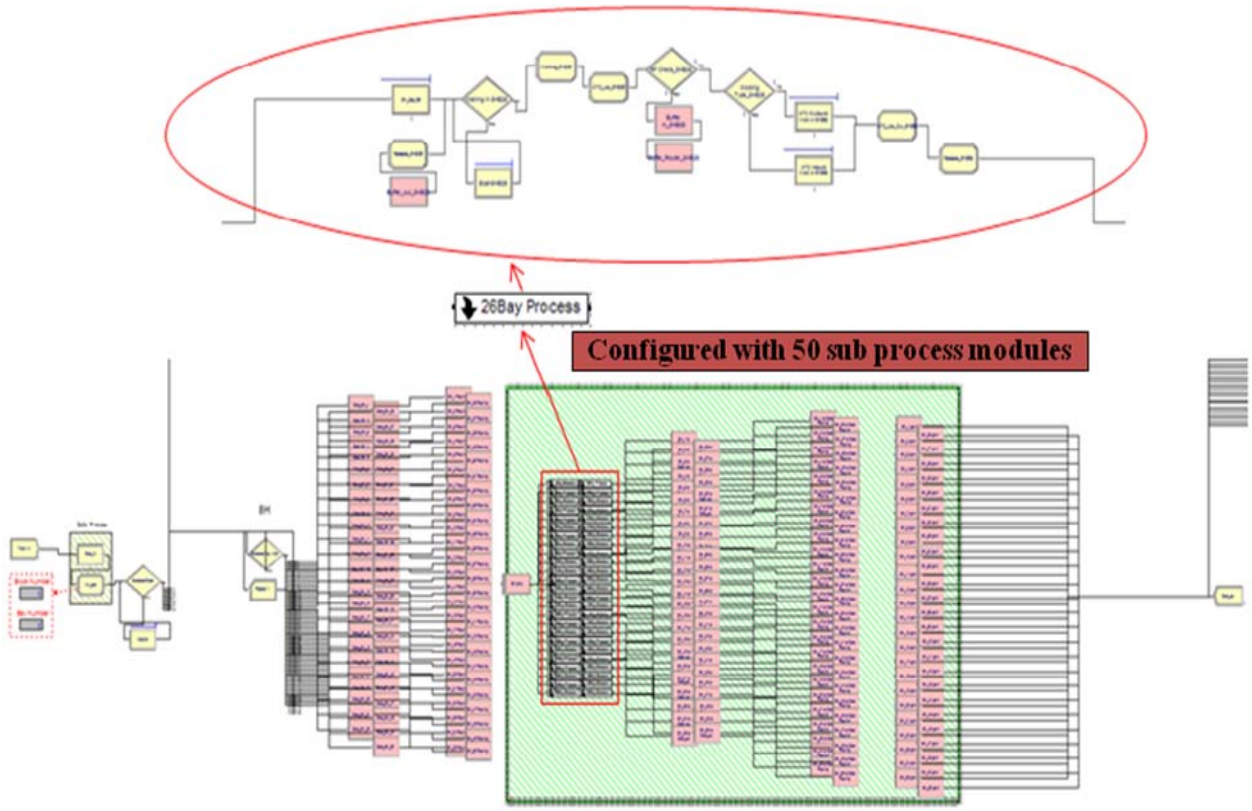


<Fig. 8> Kiosk based external truck interface modeling (1 block)

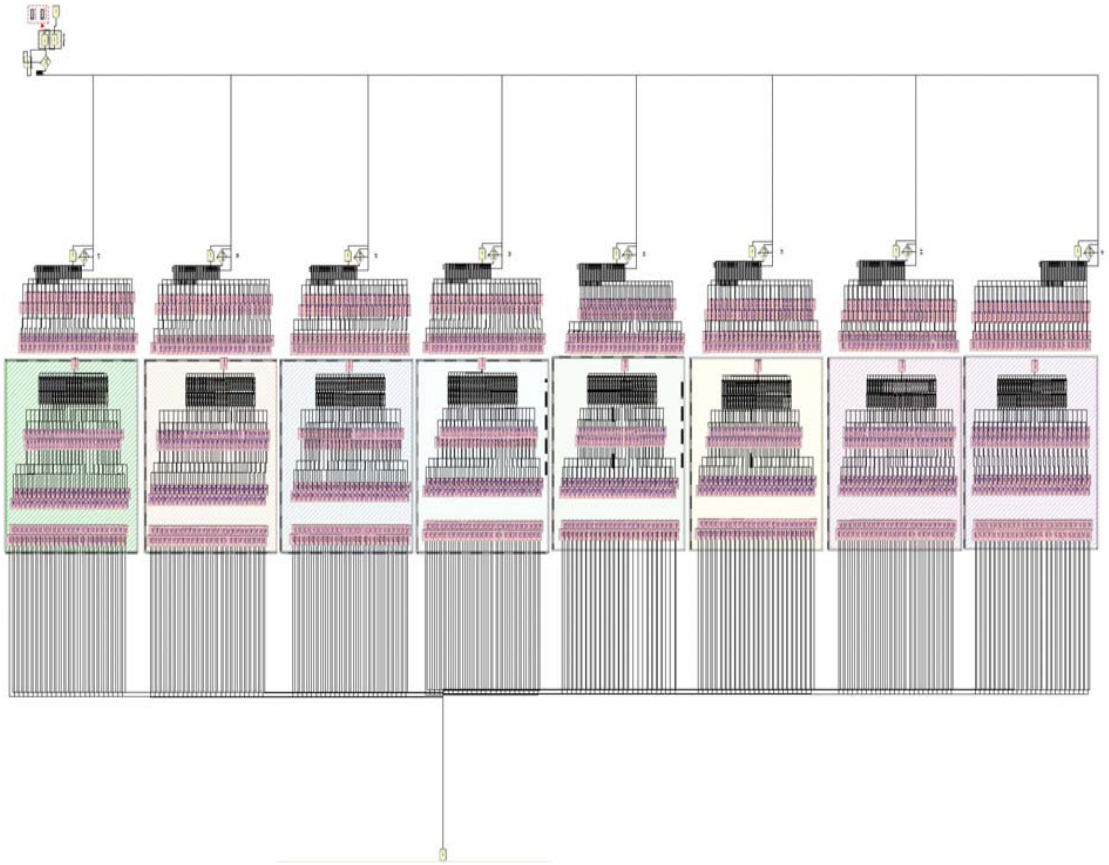


<Fig. 9> Kiosk based external truck interface modeling (8 blocks)

RFID based external truck interface modeling using the ARENA simulation is shown as follows.



<Fig. 10> RFID based external truck interface modeling (1 block)



<Fig. 11> RFID based external truck interface modeling (8 blocks)

2. Simulation analysis result

Table 7. shows the summary of the simulation result of the kiosk based and RFID based external truck interface system described in previous chapters.

Table 7. Analysis of simulation evaluation index result

Classification	Evaluation index (* All values are averages)			
	External truck T/T (Turn around Time)	Transfer time (Exclude ATC work)	ATC total work time (Based on 10,000 units)	Standby time before load/unloading work
Kiosk based external truck interface	0.316 hours per external truck (18.9 minutes)	0.201 hours per external truck (12 minutes)	192.9 hours required (8.03 days)	155.2 seconds (1 minute and 55.2 seconds)
RFID based external truck interface	0.265 hours per external truck (15.9 minutes)	0.211 hours per external truck (12.66 minutes)	189.6 hours required (7.9 days)	39.6 seconds

3. Analysis of system establishment cost

Based on the result of analyzing the kiosk based and RFID based external truck interface system, the cost of RFID based external truck interface is less as shown in Table 8.

Table 8.Analysis of system establishment cost

Classification	Content
Kiosk based external truck interface (Company A)	•6 kiosks/block: •1 kiosk: 10,000 EU ~ 13,000 EU [Based on 2005] •1 kiosk: 10,000 EU X 6 = 60,000 EU •8 kiosks: 60,000 EU X 8 = 480,000 EU
RFID based external truck interface (New Busan Port)	•RFID based external truck interface (New Busan Port) * RFID system contains total of 24 blocks(RFID reader and antenna, middleware, network equipment): 284,800 EU [Based on 2008] •Structure (Pole): 60,000 EU •1 Block: 344,000 EU / 24 Block = 14,300 EU •8 Block: 14,300 EU X 8 = 114,400 EU

7. CONCLUSION

Based on this research, the optimal solution is the kiosk based external truck interface (Solution 3) that recognizes the external truck using the barcode at the TP of the block and the RFID based external truck interface (Solution 7) that recognizes the external truck at block entrance and ATC using the RFID. And based on the simulation from the two selected solutions, the RFID based external truck interface system showed better external truck T/T, external truck transfer time (Excluding ATC work time), external truck total ATC work time and external truck standby time compared to the kiosk based external truck interface system.

The expected effect from this research is that the expected results are calculated based on the simulation from the actual data and applicable solution. Also during the simulation modeling, the reliability of the result has been ensured by utilizing the exceptions that can occur in the real world and the data actually measured from the site, which can be utilized as the base material when introducing the interface system. Also by executing the simulation by solution, this research can be utilized in providing expected results when selecting the system to fit the right operating situation of each individual container terminal.

Though exceptional cases that can occur on the s it have been considered during the simulation modeling, but there is a limitation of not being able to apply various types of environments for the exceptions. In the future, various exceptions induced from the actual operation of the system are expected to be additionally reflected and additional research on internal truck interface must also be done.

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