

A study on efficient gate system based RFID at the container terminal

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Abstract : It is a world trend to construct large terminal and develop automated container terminal to attract Super Post-Panamax and provide service which is based on differentiation. In fact, there is insufficient research for automatization of terminal gate since the automatization of current constructed container terminal is only focused on increasing productivity and unmanned system through the automatization of quay, yard, etc. In this paper, we have investigated advantage/disadvantage of existing gate operation systems and compared each gate operation system in the aspect of raising terminal image and the productivity. For the specific study, we have used data from actual terminal gate operation and RFID model business sponsored by MOMAF (Ministry of Maritime Affairs and Fisheries). As a result, this paper carried out an efficient gate operation system and it has been expected that it will be performed as groundwork of automated gate operation system which is for design of container terminal and improvement of gate operation system.

Key words : Gate, Container terminal, Productivity, RFID, Non-stop gate system

1. Introduction

In the 21st century, every container terminal from all over the world are concentrating on developing huge new port to attract Super Post-Panamax and provide the different service level compared to neighbor port. As an example of differentiation of service, some of world ports such as Rotterdam, Hamburg and Singapore operate fully automated container terminal and Shanghai, Busan and Kaoshung are under construction or at least having construction plan for automated container terminal (Korea Maritime Institute, 1998; Korea Maritime Institute, 1999). But the automatization of container terminal as currently constructed only converged on increasing productivity and unmanned system by automatic quay and yard system (Kim and Nam, 1998; Jung, 1999; Chen, 1999; Gribson, 1996). Because of this, researches about automatization of terminal gate could not get enough attention so far.

In general, the dictionary meaning of gate is an entrance or exit. Especially, terminal gate has some important meanings that are a critical point of responsibility between the shipper and inland transporter, the point of information management in the terminal and the start point of terminal productivity. Firstly, a critical point of responsibility means the point of contact which is for clarifying where the responsibility lies since measuring and checking such as damage inspection of container and Seal investigation are performed at the terminal gate. Secondly, the point of contact in the information management means we can

check the right container and have proper yard allocation plan according to the destination and freight's characteristic using information generated from gate. Thirdly, a start point of productivity means that it is possible to raise shipping productivity based effective yard planning or shipping plan. Beside, it can be possible to avoid overlapping of the cargo handling through the pre-information at the gate.

On the other hand, although our container terminal gate system has been run by various ways and methods, there still remain some doubts that which methods is the best for adopting gate system. Until now, gate system has been applied different systems according to the view of practical field or the view of management of terminal image (Kim, 2005). Therefore, this study will show not only the type of terminal gate system but also current situation of the existing terminal gate system. Also, we have performed estimating productivity and cost analysis of each gate recognition methods. In conclusion, a purpose of this research is to find out efficient automated gate operation system using RFID.

2. Current situation of terminal gate recognition methods

A gate operation system can be divided four types which are commonly used in many world ports so far. First, a manual system in the terminal without automatic concept. Second, a bar-code system in the automatic concept

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terminal and third, a letter recognition (a camera image letter recognition) method in the terminal with automatic concept. Last, in the latest non-stop gate system based RFID method appeared by unmanned automated terminal in the time of ubiquitous. In this paper, we are focusing on the gate operation system which is running on automated container terminal.

2.1 Type of a terminal gate recognition system

1) A camera image-letter recognition method

A camera image-letter recognition method has been paid attention as the most advanced technology and skill in the latest. The strength of this method is to remove the errors in advance where generated in the part of carry in/out by recognizing both container and vehicle number at the same time. This is the reason why operators who drive unmanned or fully automated container terminal prefer this kind of automatic gate system.

An image letter-recognition method using camera can be variously embodied according to the manufacturer, but generally it implements following procedure as shown in Fig. 1.

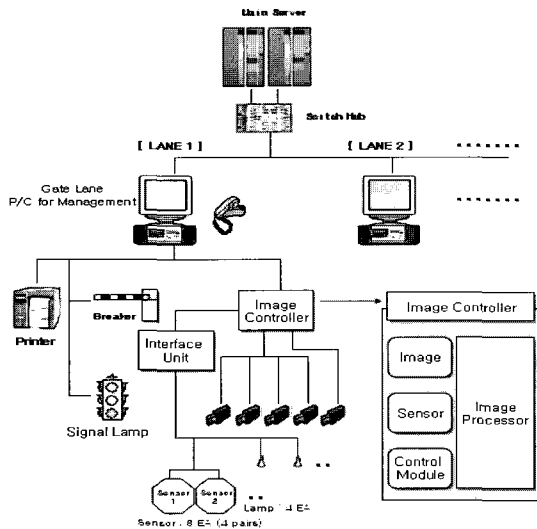


Fig. 1 An automatic system configuration of image letter recognition method

The camera recognition system receives container information at the gate by the image-letter recognition system and then sends guide-sheet which reports a yard location to trailer driver.

As shown in Fig. 2, the gate is composed by linked modules such as a camera for recognizing image, a sensor which controls camera, a service ticket machine that prints location of a container yard and the breaker which works for passing vehicle after data processing.

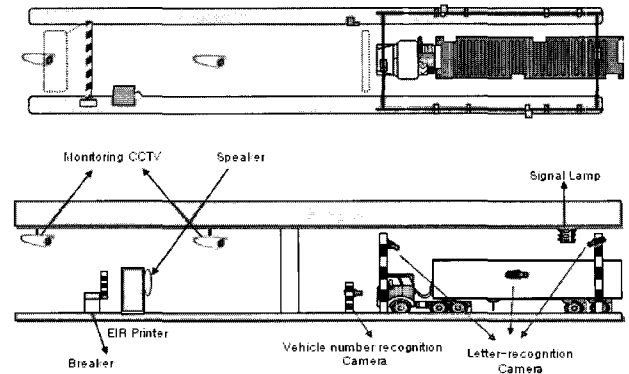


Fig. 2 A gate configuration of an image letter recognition method

2) A bar-code recognition method

A bar-code recognition method is the most common gate operation system in Korea. This method is very popular because of its convenience to operate, maintain and raise productivity and inexpensive initial investment cost. However, the bar-code recognition method does not catch what kind of container is carried by vehicle because this method simply checks vehicle number through recognizing the bar-code card on trailer. Beside, if it can not get any information from a transport company beforehand, it is impossible to transact a container data. It means the container data should be transferred to the terminal system before starting transport and then the system can works properly. Basically, the bar-code recognition method is standardized since among the individual terminals has no differences in the system composition. As shown in Fig. 3, a service ticket machine reads a bar-code and then a server completes data processing and print out guide-sheet for a container yard location.

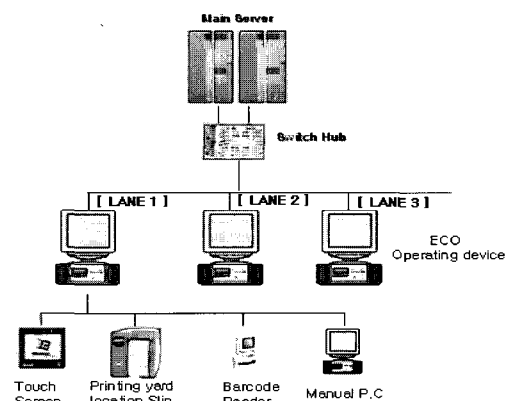


Fig. 3 A system Configuration of a bar-code recognition method

A hardware system of a bar-code recognition method is composed of a scanner for recognizing a bar-code card, a

sensor for recognizing vehicle and a bar-code printer for printing out a service ticket. The vehicle number, achieved from a bar-code scanner, collates with COPINO which is sent from transport company and if there is pre-information of matched vehicle, it gives guide-sheet with yard allocation information to a connected container.

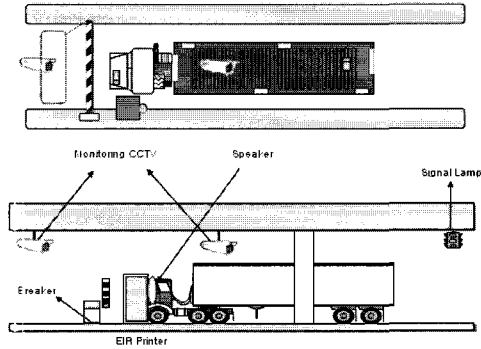


Fig. 4 A gate configuration of a bar-code recognition method

3) A RFID recognition method

This method is already using in our life as one of ubiquitous styles. The standard frequency of a container tag and a frequency of logistics vehicle tag almost complete its international standardization. Therefore, the RFID operating method will create benefits in many aspects. Though RFID method is not chosen any terminal at all, many terminals consider this method because the ratio of tag recognition is approximately up to 100%. The MOMAF (Ministry Of Maritime Affairs and Fisheries) has developed RFID related business. And their first RFID model business has been successfully done.

adopted advanced ubiquitous technology. We can expect same effects as an image-letter recognition method since it removes errors in the part of carry in/out in advance through recognizing a container(433Mhz Tag) and a vehicle(900Mhz Tag) number at the same time. The RFID recognition method has been evaluated that it is the only option to operate gate efficiently at the unmanned automated container terminal. The RFID recognition method has mostly same working procedure as a camera image-letter recognition method.

A hardware system of RFID recognition method is composed of a reader for recognizing RFID tag, a sensor for touching vehicle and a bar-code printer for printing out a service ticket. As ever, the vehicle number achieved from a RFID reader collates with pre-information from the transport company and then it allocates the position of container yard and prints out guide-sheet. The linking configuration of the H/W and S/W of the RFID recognition method is shown on Fig. 6.

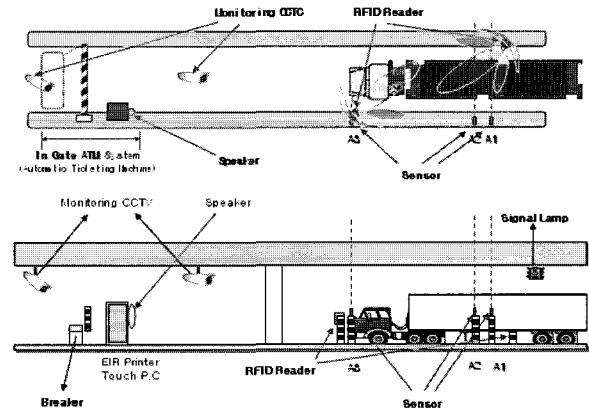


Fig. 6 A gate configuration of a RFID recognition method

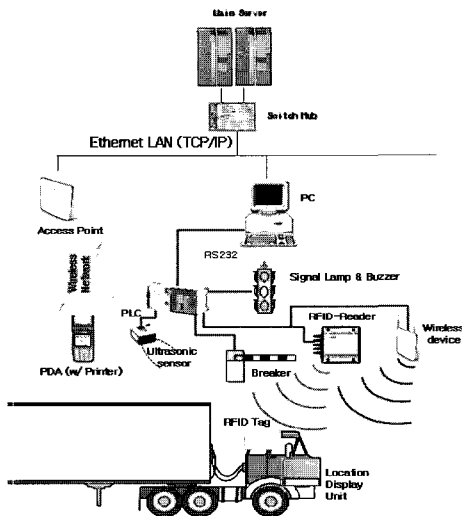


Fig. 5 A system configuration of a RFID recognition method

The common RFID recognition method is a system which

2.2 Comparison characteristics of a gate recognition method

An image-letter recognition and a bar-code recognition method can be distinguished by the way of information and container number recognition. The characteristics and advantage/disadvantage of the image-letter and the bar-code recognition method have been shown in Table. 1 (Choi et al., 2005; Yu et al., 1998).

Table 1 Comparison advantage/disadvantage between a bar-code and an image-letter recognition

	Bar-Code	Camera
Characteristics	· Not checking container freight, only checking driver's ID Card and collating with vehicle in the COPINO information from transport company	· After image data processing of container's and vehicle's number in the recognition program, data processing by collating with pre-delivered COPINO documents

Pros	<ul style="list-style-type: none"> Comparatively easy and flexible to construct system for operation Recognizing/processing only bar-code, keeping complete system as long as without outside intervention Convenient system operation and maintenance 	<ul style="list-style-type: none"> Pre-cutoff exceptional items generated from differences between actual data and pre-information Raising marketing effect with many advanced facilities against rival terminal
Cons	<ul style="list-style-type: none"> Necessity additional countermeasures for errors generated by gaps between actual data and pre-information (Exist probability of freight which has different data from Bar-Code Data: necessity of checking by naked eye) No guarantee of comparative predominance against rival terminal 	<ul style="list-style-type: none"> Limitation of recognition (dirty number plate and unique font), expensive investment cost for increasing recognition Required additional M/H for manual data work Hard system operation and maintenance Bad compatibility

Effectiveness	NOT GOOD	GOOD	GOOD
System application	NOT GOOD	GOOD	GOOD
Effect of marketing & advert	NOT GOOD	GOOD	NOT GOOD

3. Productivity and cost analysis by gate recognition methods

3.1 Comparison of technological success factors and productivity

In the Table 2, we have evaluated technological success factors based on the result of examining of advantage/disadvantage and problem of gate recognition method in the Chapter 2. It regards RFID as a solution for the problem of identifying container number in the system. But whatever a recognition method can be applied, it still needs human's eye observation for a record of last step of shipment. It means that all the recognition methods have one advantage that is minimization of labor demand. A cost in the technological success factors shown in Table 2 has been divided three levels of evaluation those are "Good", "Not Good" and "Bad". These levels of evaluation are just simple comparison without effectiveness and an effect by cost comparison. The result of comparison of technological success factors is that the RFID recognition method and the bar-code recognition method have comparatively high success factors.

Table 2 Comparison technological success factors among the Gate recognition methods

Success Factors	Camera	RFID	Bar-Code
Stability	NOT GOOD	GOOD	BAD
Labour & work	NOT GOOD	GOOD	GOOD
Recognition ratio	NOT GOOD	GOOD	GOOD
Cost	BAD	NOT GOOD	GOOD

A comparison productivity among the gate recognition methods is evaluated by the gate transit time (Choi et al., 2005; Yu, 1998), for a RFID method we have taken the value from latest RFID model business run by MOMAF. Although there is no terminal which has adopted any RFID recognition method so far, it is possible to construct combine system which is taking advantages from the bar-code and the camera image-letter recognition through attaching a RFID tag on vehicle and a container at the same time. The result of comparison productivity through gate transit time is that the RFID and the bar-code recognition method are comparatively higher than the one of camera recognition method.

Table 3 Comparison productivity among terminal gate recognition methods

Division	Gate transit time	Remarks
Camera	avg. 25 ~ 40sec	
Bar-code	avg. 15 ~ 25sec	
RFID	avg. 15 ~ 25sec	Vehicle 900Mhz Container 433MHZ
	avg. 10 ~ 15sec	LDU or SMS

** LDU:Location Display Unit, SMS:Short Message Service
* Taken from Internal data of H container terminal in Busan port which performed RFID model business of MOMAF

Also, LDU(Location Display Unit: marking system of yard location) which is one of RFID recognition methods makes possible to materialize non-stop gate system and reduces gate transit time maximum in 7 seconds. It also tremendously raises gate productivity. However, it needs discussion that where and how performs a container damage inspection and a seal investigation since some of the terminal implements those kind of work in the gate.

3.2 Building and operating cost analysis among the gate recognition methods

We have compared an initial building cost and operating cost because advantage/disadvantage among gate recognition methods were not clearly appeared in operation side. The cost shown in Table 4 is real terminal data and the cost of

RFID recognition method referred to data from RFID model business run by MOMAF. First of all, we assumed the initial building cost of camera image-letter recognition method to be 100%, then RFID recognition method recorded 29.74% and Bar-code recognition method recorded 18.50%.

Table 4 Initial building cost among gate recognition methods(Unit: Thousand Won)

Name of System	EA	Camera	RFID	Bar-Code
Image recognition SYSTEM	4	419,664	-	-
Image Supervisory	2	96,000	-	-
RFID Control Sys.	4	-	58,000	-
Image recognition Supervisory Sys.	1	-	25,000	-
Service Ticket Machine	4	50,400	50,400	64,800
Gate control zone	1	27,570	27,570	27,570
Exceptional vehicle handler	1	15,750	15,750	15,750
Issue a vehicle admission	1	6,450	6,450	6,450
Total cost		615,834	183,170	114,570
Rate of Building cost against Camera		100.00 %	29.74 %	18.50 %

* Taken from Internal data of H container terminal in Busan port which performed RFID model business of MOMAF

Table 5 Maintenance cost among the gate recognition methods(Unit: Thousand Won)

Name of System	Camera	RFID	Bar-Code	
Maintenance (15% of building cost)	646,626	137,378	85,928	
Extendibles	353,385	217,385	224,585	
Supplies	Head	44,800	44,800	44,800
	Lamp(1shift)	13,600	-	-
	Paper (approx.700 thousand per year)	122,500	122,500	122,500
	Incidental change (0.5 time)	50,085	50,085	57,285
Total Cost	1,000,011	354,763	310,513	
Ratio of Maintenance cost against Camera	100.00 %	35.47 %	31.05 %	

* Taken from Internal data of H container terminal in Busan port which performed RFID model business of MOMAF

Table 5 is a maintenance cost for every gate recognition methods. For this calculation, we assumed durable period of system maximum 7 years and applied same labor cost to every methods. As shown in Table 5, a bar-code

recognition method is the cheapest one. Table 6 has been calculated by initial building cost in Table 4 and maintenance cost in Table 5. Comparing operation cost of every gate recognition method during 7 years, the result is similar as technological success factor's that is the bar-code recognition and the RFID recognition method comparatively predominate and camera image-letter recognition method is comparatively lower than the others.

Table 6 7 years operating cost by Gate recognition methods (Unit: Thousand Won)

Name of System	Camera	RFID	Bar-Code
Building cost	615,834	183,170	114,570
Maintenance cost	646,626	137,378	85,928
Extendibles	353,385	217,385	224,585
Total Cost	1,615,845	537,933	425,083
Against Camera system	100.00 %	33.29 %	26.30 %

4. Effective operation method for automated gate

Some of terminals which are located in Busan and Kwangyang port have adopted the camera image-letter recognition method, however it has been founded not effective terminal gate operating method any more since this method led some bad effects those are a decline of work efficiency and productivity because of low-recognition and excessive initial building cost.

In the meantime, a research trend of the bar-code recognition method which kept step with MOMAF's EDI policy has been improved its efficiency through easy acquisition of vehicle information and processing information of pre-input vehicle bar-code. Moreover, the case of bar-code recognition method, errors generated by differences between actual information and pre-information can be solved by vehicle driver since a driver is able to check it when he gets in gate. When the handling equipments such as T/C are working, container number can be checked twice on working order and container number on the working window in the terminal inside. But camera image-letter recognition method and Bar-Code recognition method are only possible to check container number by naked eye, so we need new gate recognition method, not present two methods. RFID method seems to have enough comparativeness in the productivity and financial aspect and it has close relationship with U-Port building policy under the government control. If RFID method which has solutions for recognition problem of container and vehicle

number is applied into terminal gate, it will show quite good effects on integrated logistics data management through linking with inland logistics strategic point.

First of all, currently the Gate with RFID method is applied only few terminals as a model, it means that RFID is not adopted in the real work yet. But as mentioned before, after a model business, RFID method will be adopted in the real business since it has a high comparativeness in the productivity and financial aspect. As explained in Fig. 5, RFID method can be built as following two systems; LDU (Location Display Unit) and SMS. Above all, RFID method does not need separate yard allocation paper, but instead of this, it uses SMS which is mobile short sentence message transmission or LDU which is transmitted yard location by wireless network and generating non-stop system. Further, the method informed yard location is composed of two systems, one is sending yard information to LDU using terminal wireless network and the other is, namely SMS system, sending yard information to mobile or PDA using by existing service from mobile communication company.

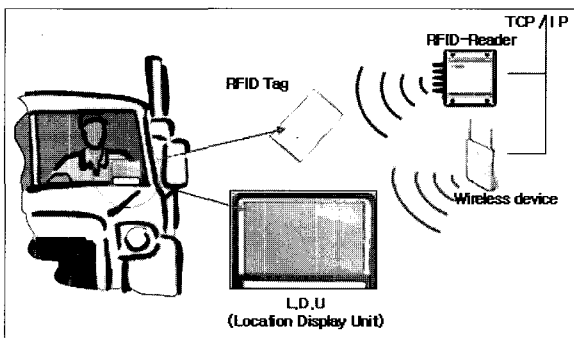


Fig. 7 LDU mode

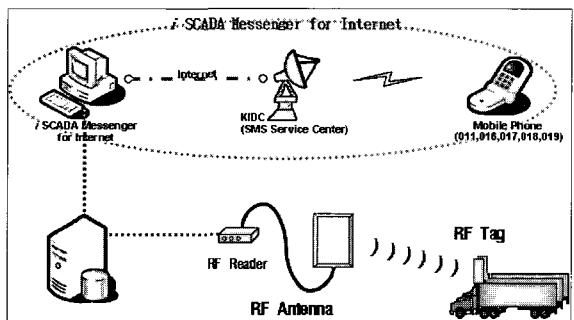


Fig. 8 SMS mode

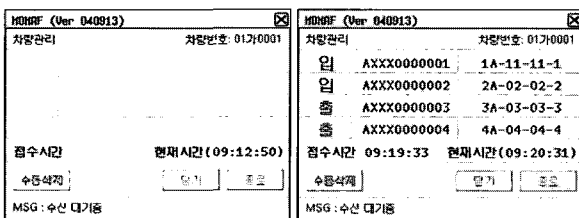


Fig. 9 Vehicle's LDU/PDA user Interface screen

Fig. 10 explains when a tag has been recognized, a gate breaker runs immediately and it turns non-stop system. Moreover, port security is considered very importantly. If an error is generated by the tag un-recognition, the breaker blocks opening the gate. It means that the tag error can be examined at the gate.

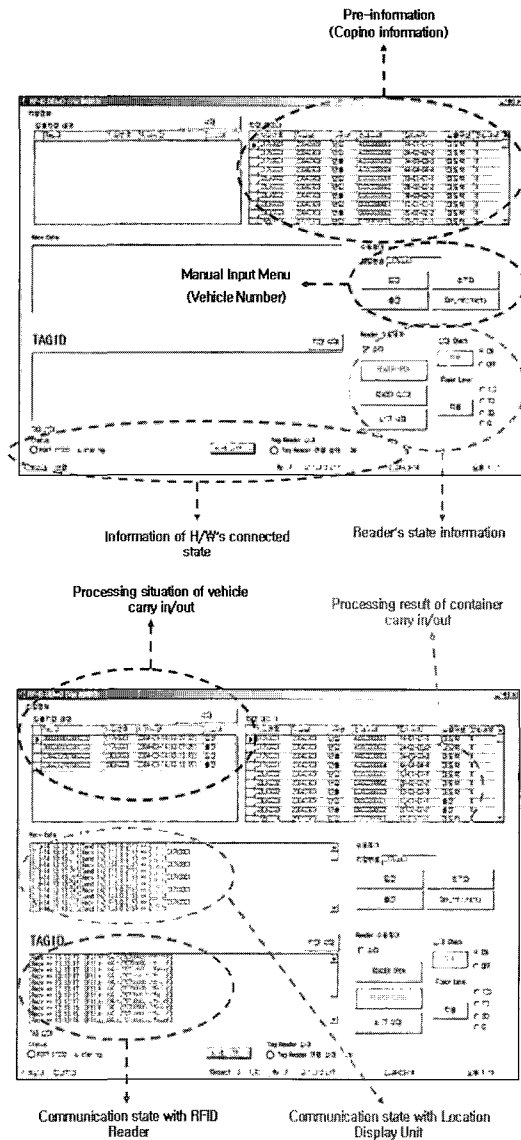


Fig. 10 Screen for recognizing RFID and data processing

The most important thing for constructing RFID Gate is how precisely put 'Tuning' of RFID's Reader. Only through the precise management of RFID Reader's recognition scope, it does not make recognition confuse between the vehicle passing the gate and vehicle passing the surrounding. Also, it recognizes vehicle and container tag simultaneously and performs LDU or SMS transmission after the same data be transferred by pre-information.

Lastly, Fig. 11 is overall working flowchart based RFID which included working sequence of carry in/out and

connection part of CY's inland transport. Although an each implementation of RFID is different, the working flow is same.

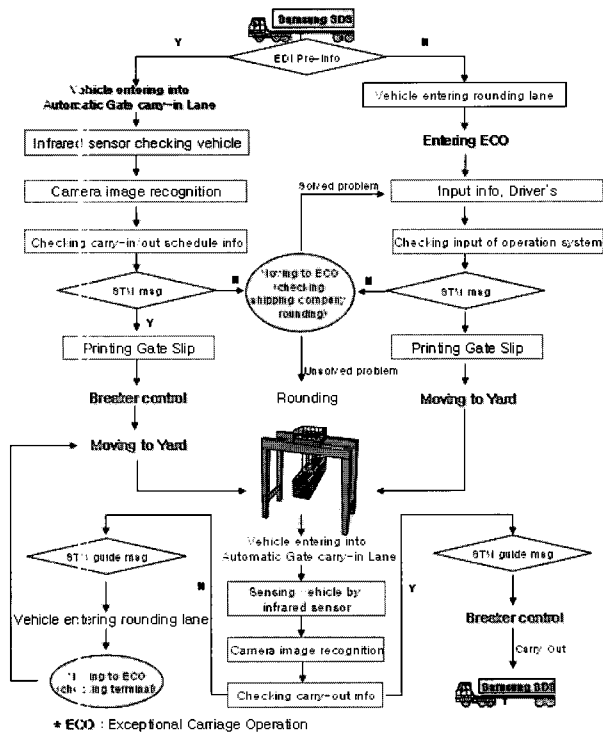


Fig. 11 Flowchart on connection of inland transport based RFID application

5. Conclusions

The gate at the container terminal has an important meaning in many aspects. Most of all, the gate system is very important since it performs a role for activating initial data and the start point of terminal productivity. If it is not working properly, it will cause delay and traffic congestion in the vicinity.

This paper has been examined advantage/disadvantage and system procedure in the operation aspect of three gate system methods. With above investigation, we have focused on finding out optimal solution of gate operation method for the future. The Gate system based RFID method in the container terminal seems to have a role as supplement for the lack of existing system. Moreover, it has a competitiveness even compared to Bar-Code system, though Bar-Code system is the cheapest system. Additionally, this system is easy to link with other system. If every service point has RFID Reader, it can be possible to recognize vehicle and container without any additional facilities. So, it makes data centralized and convenient to manage and those data management will be possible to

increase quality of customer service that means advertisement effect from advanced system operation might be raising terminal marketing effect and so on. Hence, the container terminal gate should be operated unmanned automated system based RFID.

However, next matters must be considered; compulsory tag attachment on the container and vehicle, time required to implement and the amount of government initial fund.

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