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A Sensitivity Risk Analysis for Additional Truck Turnaround Time (ATTT) by Container Inspection Stations Derived from C-TPAT and CSI.

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Abstract : *After World Trade Center's Terror in 2001and promulgating Maritime Transportation Security Act (MTSA, 2002) and Security and Accountability For Every Port Act (SAFE Port Act, 2006) in the United States, most of the attention on security of international transportation including marine carrier and facility has focused increasingly. Inspection stations in foreign seaport terminal including Busan, South Korea, have been installed by Container Security Initiative (CSI) and Customs Trade Partnership against Terrorism (C-TPAT). The inspection station, however, may directly and indirectly affect delay of truck turnaround time in the seaport, especially high and severe level of security. This paper was analysed a risk for the additional average delay of truck turnaround time incurring by the inspection station under the all level of security, C-TPAT and CSI. As a result of this risk analysis, the higher weighted inspection time based on raising security level, the less number of trucks to be inspected, which will derive high delay in the inspection station.*

Key words : *Marine security, Truck turnaround time, Risk analysis, Inspection station, C-TPAT, CSI*

1. Introduction

After September 11, 2001, as international trade continues to increase, there is greater opportunity for terrorists to conceal their attack materials within commercial cargo and containers. After passing Maritime Transportation Security Act (MTSA) in 2002, Security and Accountability for Every Port Act (SAFE Port Act)[1] is promulgated on October 13th, 2006 in the United States. Therefore, these acts became mostly perfect system of security in maritime and port facility. Especially, many of security professionals have prospected that the SAFE Port Act (2006) will big affect all field of transportation in the maritime world. Aim of the act set up several measurements focusing on anti-terrorism during the transportation of container freight. Furthermore, this act allows container security initiative (CSI) and customs-trade partnership against terrorism (C-TPAT) to be a law and include 100% pre-inspection at foreign CSI member port including Busan. As a beginning of the work in 2007, trial exam is on the way at Hong Kong, Egypt, and England. The plan ranges from sophisticated analytical computer databases to gamma-ray and X-ray imaging systems, radiation isotope identifiers, explosive detectors, as well as sensors and cameras located along isolated stretches of the national border.

The objectives of this sensitivity analysis are to identify relationships between security levels, inspection time and arrival rate, evaluate the effectiveness of the inspection equipment's utilization rate for the delay time, and analyze the number of container and delay time in terms of various lay-outs of the inspection station. In addition, this paper also presented a proper plan in our country, South Korea, for significance of the international maritime security flow derived from these acts and laws.

This research summarized that number of truck arrival at inspection station follows a probability distribution in terms of independent and identically distributed random variables. The inspection time is exponentially distributed and will rely on the following factors including contents, empty or full, type of inspection equipment, non-C-TPAT, and CSI container. The inspection time for individual containers does not affect the others. Utilization rate in the inspection system is close to 1, a little increase in the number of arriving trucks and inspection rate (IR) can affect a big change in the average truck turnaround time. The higher weighted inspection time based on raising security level allows less number of trucks to be inspected, which will derive high delay in the inspection station.

2. Literature Review and Applications

The United States government and the private sector

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1) SAFE Port Act (2006) is an integrated security act of transportation focused on container' inspection. Most professionals ofmaritime security expect that this act will big affectall fiel of freight seaport termina in the worl

have recently set up several container security measures such as CSI and C-TPAT. The following describes these security measures.

2.1 Container Security Initiative (CSI)

CSI[2] is a bilateral agreement between the United States customs and foreign customs. Once the CSI agreement is signed, United States Officers, who are dispatched to the origin port, target and pre-screen US bound cargo containers before they are shipped. As of 2006, a total of 45 ports have signed the CSI agreement. By the end of 2007, the number is expected to grow to 50 ports covering 90 percent of transpacific maritime containerized cargo shipped to the United States. (CBP, 2006). CSI continues to expand to strategic locations around the world. The World Customs Organization (WCO), the European Union (EU), and the G8 support CSI expansion and have adopted resolutions implementing CSI security measures introduced ports throughout the world.

2.2 Customs Trade Partnership Against Terrorism (C TPAT)

C-TPAT[3] is a voluntary government-business initiative to build cooperative relationships that strengthen and improve overall international supply chain and U.S. border security. C-TPAT recognizes that U.S. Customs and Border Protection (CBP) can provide the highest level of cargo security only through close cooperation with the ultimate owners of the international supply chain such as importers, carriers, consolidators, licensed customs brokers, and manufactures. Through this initiative, CBP is asking businesses to ensure the integrity of their security practices and communicate and verify the security guidelines of their business partners within the supply chain (CBP, 2005).

Regarding truck arrival rates at seaport terminals, previous researchers, Andrea et al. (1999) and Jay et al. (2003) used a random arrival process to estimate the truck turnaround time at container picking yard and entrance gate in seaport terminal. This random arrival constitutes a Poisson distribution. This research assumed that the probability distribution for the number of truck arrivals in a particular interval of time at an inspection station follows a Poisson distribution.

2.3 Security Levels and Average Inspection Time

There are five security levels in the United States including severe, high, elevated, guarded, and low each having its own color and impact on security measurement. These levels and their corresponding colors are shown in Table 1.

Table 1 Security levels in the United States.

Level of Security	Color	Behavior
Severe (SSL)	Red	Severe Risk of Terrorist Attacks
High (HSL)	Orange	High Risk of Terrorist Attacks
Elevated (ESL)	Yellow	Significant Risk of Terrorist Attacks
Guarded (GSL)	Blue	General Risk of Terrorist Attacks
Low (LSL)	Green	Low Risk of Terrorist Attacks

[4]Source: Department of Homeland Security

Based on whether the inspection system is a passive or active system, there are average times taken to inspect a container. Table 2 shows the average time to inspect a container during a period of low level of security (LSL) and based on the type of equipment used for inspection.

Table 2 Average Time to Inspect a container under Low Security Level (LSL)

Average Time to Inspect in Low Security Level (LSL)					
Passive Systems			Active Systems		
Kind of Equipment	Screen For	Inspection Time in LSL	Kind of Equipment	Screen For	Inspection Time in LSL
Vapor Detection	Prohibited gases	30~60 sec	X-ray	Explosive, stolen materials, drug	2-5 min
Trace Detection	Explosives, drugs	30~60 sec	Gamma Ray		2-5 min
Radiation Detection	Radiation	30~60 sec	Pulsed Fast Neutron Analysis	Explosives, drugs	1 hr +
Canines	Explosives, drugs	10~60 sec	Thermal Neutron Activation	Explosives	1 hr +

[5]Source: Roundtree (2005)

2) ThreeUnited StateCBP officials (2007) staying at Busanin orde to pre screen for containers coming into the United States

3) Business types related to the U.S. import supply chain cargo handling and movement have been enrolled to this C TPAT and includeU.S Importers of recor,U.S./Canada Highway Carrier,U.S./Mexico Highway Carrier Rail Carrier,Sea Carrier,Air Carrier,U.S. Marine Port Authority/Terminal Operator,U.S. Air Freight Consolidators, Ocean Transportation Intermediaries and Non Vessel Operating Common Carriers (NVOCC,Mexican Manufacture,Certain Invited Foreign Manufacturer, andLicensed U.S. Customs Broker. This system wasworking voluntaril at thebeginning however, it is changed bcompulsoy environment because foreign manufactures should follow his act athat US importe can joi

4) http://www.dhs.gov/xinfoshare/programs/Copy_of_press_release_0046.shtm

5) Rountree, C. D. and M. J. Demetsky. A Framework for Analysis o Security Measures withi Cargo Facilities. CD ROM. Transportation Research Board, National Research Council, Washington, D.C., 2006.

At the first stage at an inspection station of a seaport terminal, radiation detection is used. Using this equipment, an inspection of a container may take between 30~60 sec. This average inspection time is applied as the basic inspection time under low level of security. X-ray and Gamma ray used at the second stage is used to screen for explosive, stolen materials, people, and drugs. This equipment requires between 2~5 min to inspect a container.

2.4 Application of Inspection Time and Rate

The research shows the inspection rate under a low security level is between 30 and 60 seconds. In this research, it is assumed that there is a 30 second increase in the inspection rate as the security level increases. Therefore, for a "Guarded" security level, which is one security level above a low security level, the inspection rate is assumed to be 30 seconds higher than the low security level or between 60 and 90 seconds. A 60 second increment between security levels is used for active system. Table 3 shows the inspection rates using these assumptions.

Table 3 Average Inspection Time by Security Level

	Passive System	Active System
Level of Security	Average Time to Inspect	
Low (LSL)	30~60 sec	2~5 min
Guarded (GSL)	60~90 sec	3~6 min
Elevated (ESL)	90~120 sec	4~7 min
High (HSL)	120~150 sec	5~8 min
Severe (SSL)	150~180 sec	6~9 min

Source: By Author

Developing of inspection rate such as advancing technology and effecting system of inspection allows inspection rate more effective and higher in all level of security is occur in the seaport terminal. These incrementing inspection rates increase the number of trucks to be inspected proportionally.

3. Sensitivity Analysis for Additional Truck Turnaround Time at Inspection Station in USA

The study models to be used in analyzing and evaluating the truck turnaround time at container seaport inspection stations in container seaports are several queuing models covering a single M/M/1 model (SMM), a multiple M/M/c model (MMM), a single channel and multiple stages model (SCMSM), and multiple channels and multiple stages model (MCMSM).

Table 4 Inspection Diagram and Formulation.

Notation	Inspection Diagram
SMM	→ [Single Equipment] →
Formulation For ATTT (SMM) (Additional Truck Turnaround Time)	$ATTT_{SMM} = \frac{L}{\lambda} = \frac{\sum_{n=0}^{\infty} n\psi^n(1-\psi)}{\lambda} = \frac{1}{\mu(1-\psi)}$, where, λ = container arrival rate, μ = inspection rate ψ = utilization rate.
MMM	→ [Multiple Equipment] →
Formulation For ATTT (MMM)	$ATTT_{MMM} = \frac{\sum_{n=c}^{\infty}(n-c)P_n}{\lambda} + \frac{1}{\mu} = \frac{\frac{(c\psi)^c}{c!} * \frac{\psi}{(1-\psi)^2} P_0}{\lambda} + \frac{1}{\mu} = \frac{\frac{\psi}{(1-\psi)^2} P_c}{\lambda} + \frac{1}{\mu}$ where, $P_0 = \left[\sum_{k=0}^{c-1} \frac{a^k}{k!} + \frac{a^c}{c!} * \frac{1}{(1-\psi)} \right]^{-1}$ where, $\psi = \frac{\lambda}{c\mu}$, $a = \frac{\lambda}{\mu}$ $P_n = \begin{cases} \frac{(c\psi)^n}{n!} * P_0 & (1 \le n \le c-1) \\ \frac{(c\psi)^c}{c!} * \psi^{n-c} P_0 & (n \ge c) \end{cases}$
SCMSM	→ [Single Equipment] → [Single Equipment] →
Formulation For ATTT (SCMSM)	$ATTT_{SCMSM} = ATTT_{1s,SMM} + ATTT_{2s,SMM}$
MCMSM-SM	→ [Single Equipment] → [Multiple Equipment] →
Formulation For ATTT (MCMSM-SM)	$ATTT_{MCMSM-SM} = ATTT_{1s,SMM} + ATTT_{2s,MMM}$
MCMSM-MS	→ [Multiple Equipment] → [Single Equipment] →
Formulation For ATTT (MCMSM-MS)	$ATTT_{MCMSM-MS} = ATTT_{1s,MMM} + ATTT_{2s,SMM}$
MCMSM-MM	→ [Multiple Equipment] → [Multiple Equipment] →
Formulation For ATTT (MCMSM-MM)	$ATTT_{MCMSM-MM} = ATTT_{1s,MMM} + ATTT_{2s,MMM}$

[6]Source: By Author based on Queuing theory

6) Conway, A. E. and N. D. Georganas (1989). Queuing Nworks Exact Computational Algorithms, MIT Press, Cambridge, Massachusetts

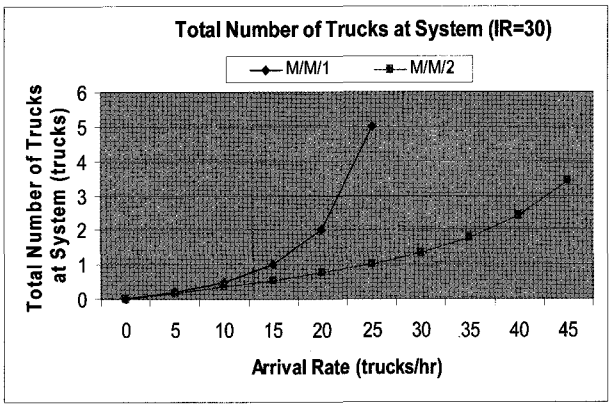
This sensitivity analysis are performed in various aspects including effectiveness of installing additional inspection equipment, equipment utilization, relationship between arrival rate and Green Lane usage rate, and additional truck turnaround time with various layouts of inspection station in USA.

3.1 Effectiveness of Installing Additional Inspection Equipment

This analysis analyzed how additional inspection equipment affects the inspection system by comparing a M/M/1 to a M/M/2 system. All queuing models have three factors including: (1) a random arrival process (2) a probabilistic service time distribution function, and (3) a deterministic number of available servers. The Poisson arrival process is routinely described by the letter M. The second letter M is also used to symbolize the inspection time distribution functions. Finally, the non-stochastic number of servers is typically denoted by some positive integer and describes the number of inspection equipment. In the M/M/1 system, inspection equipment is used. In the M/M/2 system, two inspection equipments are used. Figures 1 show the total number of trucks and average truck turnaround time in the system. The figures show that if the trucks' arrival rate is 25 (trucks/hr), a total of 5 trucks will stay in the system for one server, while only 1 truck will stay for two servers probabilistically. It will take approximately 12 minutes of truck turnaround time in the system for one server, while less than 3 minutes will take for two servers under inspection rate equaling 30 (trucks/hr).

When the utilization rate is close to 1, this is a more dramatic impact of additional inspection equipment. Therefore, if the arrival rate is λ =1 truck/min, and the average inspection time is μ =1.01 truck/min in the M/M/1 system, the utilization rate is ψ = 0.99, number of container at queue equal to waiting time at queue at 99.01 ($L_q = W_q$ = 99.01) in which the average number of trucks ($L_{q,M/M/1}$) and waiting time in the queue ($ATTT_{q,M/M/1}$) are equal because λ =1. After setting up another inspection station in the system, the average number of trucks ($L_{q,M/M/2}$) and waiting time in the queue ($ATTT_{q,M/M/2}$) are just 0.32 trucks and 0.32 minutes in the queue, respectively.

Therefore, in the M/M/2 model, the difference between the $L_{q,M/M/2}$ and $ATTT_{q,M/M/2}$ is almost 308 times with those of M/M/1. It is should be considered this effectiveness when decision for additional inspection equipment in the seaport terminal is required.



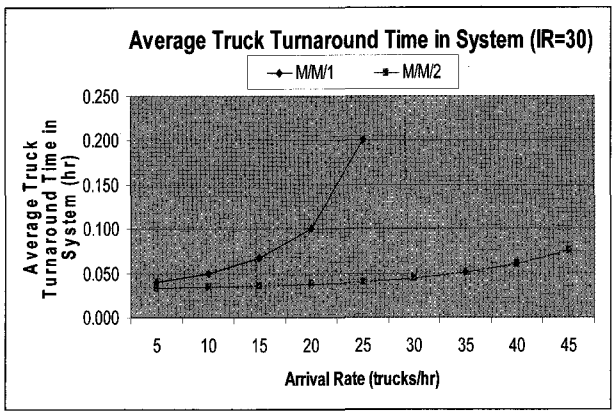


Fig. 1 Compare M/M/1 to M/M/2 system.

3.2 Effectiveness of Equipment's Utilization

The utilization (ψ) rate is equal to the arrival rate (λ) over the inspection rate (IR). The inspection equipment utilization at each stage will affect the truck turnaround time in the system and can impact the number of inspection stations needed at the terminal. Fig. 2 shows the average truck turnaround time for different numbers of equipment, arrival and inspection rate. The figure shows that average truck turnaround time in terms of the number of inspection equipment. Average truck turnaround time will be saved as the arrival rate approach the inspection rate at each number of inspection equipment in the seaport terminal.

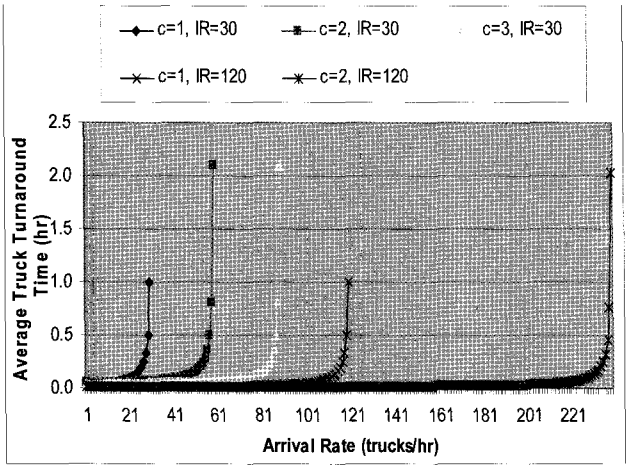


Fig. 2 Average truck turnaround time and number of equipment.

Comparing as inspection rate has 120 (trucks/hr), average truck turnaround time is getting more time and increase if inspection rate has 30 (trucks/hr). Figure 3 shows that different average truck turnaround time in terms of various number of inspection equipment of c=1, c=2, and c=3 and inspection rate (IR) = 30 and 120. The case of the c=2 and IR=120 has more 10 times of arrival rate (AR) than the one of c=1 and IR=30 by maintaining average truck turnaround time within 10 minutes.

3.3 Relationship Between Arrival Rate and Green Lane Usage Rate

The Green lane is a lane without inspection for the trusted shippers assigned by C-TPAT and CSI. The lane processes trucks outside of the inspection system, thereby removing trucks from the arrivals at the inspection station resulting in a lower truck arrival rate. Therefore, the Green lane may allow the capacity of the inspection station to not be exceeded. The increase of the Green lane usage rate (GR) allows a decrease of the arrival rate coming into the inspection station, which may derive benefits including the improvement of the inspection equipment when arrival rate close to inspection rate and reduce the average additional truck turnaround time at the inspection station.

3.4 Average Additional Truck Turnaround Time in SMM System

Based on the inspection rate (IR), the average truck turnaround time (ATTT) at Single M/M/1 Model (SMM) is shown in Fig. 3:

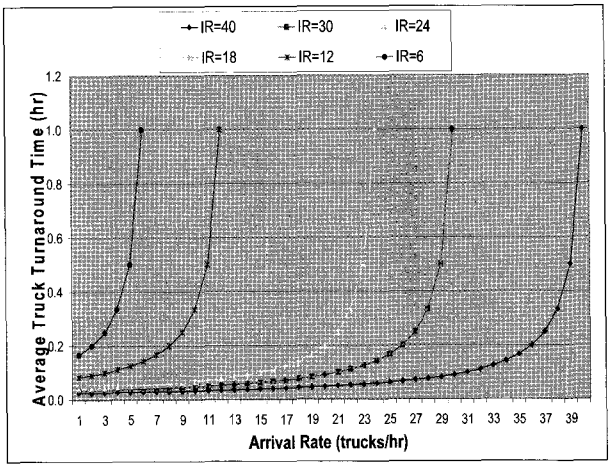
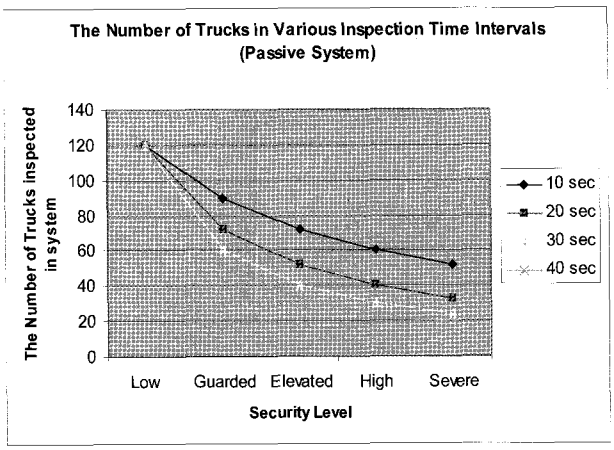


Fig. 3 Average truck turnaround time in SMM system.

According to the Fig. 3, if the arrival rate is equal to the inspection rate, the average truck turnaround time (hr) is increased dramatically. Therefore, U.S customs, terminal, and shipping operators need to consider reducing the delay time before the arrival rate becomes close to the inspection rate.

3.5 Sensitivity Analysis of Inspection Rates

Changes in the Security Level of the nation, issued by the Department of Homeland Security, will affect the inspection rate of containers entering the United States. There are two types of inspection time intervals including fixed and weighted. Fixed inspection time intervals refer to adding the same time intervals between security levels. Weighted inspection time intervals, however, refer to adding weighted time intervals between security levels. Figure 4 shows the fixed inspection time interval between security levels as a function of the nation's security level including 10 sec, 20 sec, 30 sec and 40 sec.



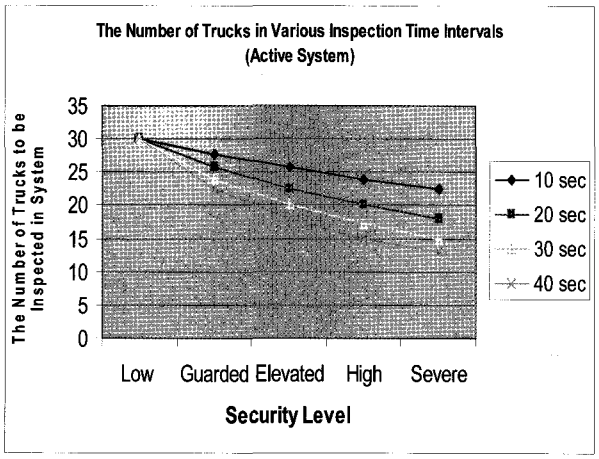


Fig. 4 The sensitivity analysis of inspection rates with fixed time interval.

Fig. 4 shows that the number of trucks will be greatly reduced if the inspection time interval of each security's level increases. For example, comparing the time interval of 10sec and 40sec, around 30 trucks per hour in difference will be occurred and inspected in the passive system under severe security level (SSL).

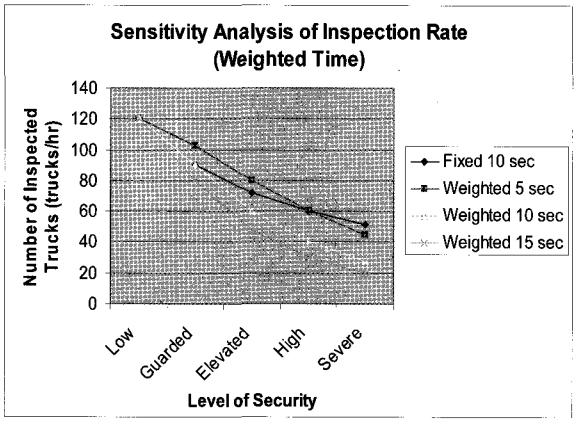
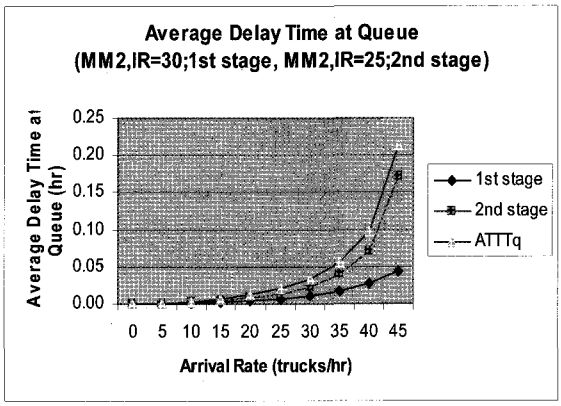


Fig. 5 The sensitivity analysis of inspection rates with weighted time interval.

Fig. 5 shows the assumed inspection time interval between security levels as a function of the nation's security level including the weighted time interval of 5 sec, 10 sec, and 15 sec. The figure demonstrates that the higher weighted inspection time based on raising security level allows less number of trucks to be inspected, which will derive high delay in the inspection station.

3.6 Average Truck Turnaround Time at the MCMSM system

Based on the change of the arrival rate (AR) and inspection rate (IR) at each stage with variable parameters, average truck turnaround time (ATTT) occurred by the inspection stations in Multiple Channel and Multiple Stage Model-Multiple and Multiple (MCMSM-MM) shows in Fig. 6:



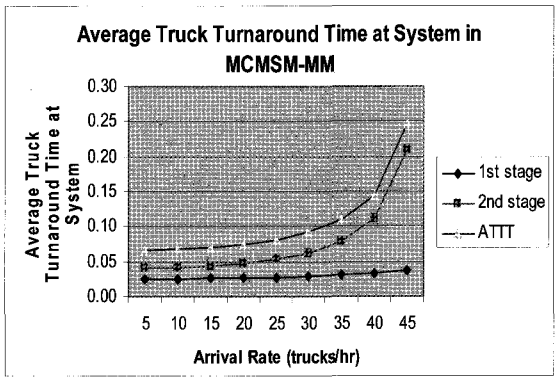


Fig. 6 Average truck turnaround time in MCMSM-MM.

In this system, if heavy delay is occurred due to the high utilization in the first and/or second stage, there are some methods including high Green lane usage, setting additional inspection equipment (or mobile equipment) and developing inspection technology.

Korea Coast Guard, seaport terminal officers, truck and marine carriers international freight related might use this sensitivity risk analysis as a frame step toward considering an effective and efficient plan to truck turnaround time for handling marine freight and containers in terms of various designs and security levels derived from C-TPAT and CSI.

4. Conclusion

With strengthening the SAFE Port Act (2006), the United States strongly request that foreign CSI member ports should follow the law including 100% pre-screening for all containers coming into the United States because it is impossible without support of the ports. Therefore, our

country need to deeply review the system of maritime security at the seaport terminal and reconsider ports' competitiveness in terms of international transportation security's developing and strengthening.

As a sensitivity risk result, increase of rate of Green lane usage (GR) will allow to decrease of the arrival rate, which may derive improvement of inspection equipment efficiency. The higher weighted inspection time based on raising security level allows less number of trucks to be inspected, which will derive high delay in the inspection station.

The models studied at this paper can use for analyzing an additional truck turnaround time (ATTT) at seaport terminal not only in the United States, but all other foreign terminals applying to the security level and inspection procedures of the U.S. If the port, however, maintain own inspection procedure, the models need to correct properly with specific parameters.

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