FY2020 Project for Ministry of the Environment Japan

City-to-City Collaboration for Zero-carbon Society in FY2020

(FY2020 Feasibility Study for ports in Thailand to reduce GHG emission by advancing modal shift and enhancing terminal efficiency)

Report

March 2021

Yokohama Port Corporation

City of Yokohama

Green Pacific Co., Ltd.

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1. Work Overview

1.1 Purpose and Content

This project, under City-to-City Collaboration between the City of Yokohama and Port Authority of Thailand (hereafter PAT), is making use of the Yokohama Port Corporation's (YPC) achievements and expertise in initiatives to promote modal shift and decarbonized operations, as well as Green Pacific Co. Ltd.'s quarter century of experience with climate change countermeasures, in order to promote a "modal shift" of container logistics for inland transportation in Thailand, from truck to railway or coastal shipping at Laem Chabang Port and Bangkok Port, which are managed by PAT.

Based on the results of the basic study conducted last year, four items shown below will be considered. Efficient operation methods and deployment plan of cargo handling equipment etc. to further promote modal shift will be formulated, and study for assisting transformation to low-carbon and decarbonized distribution system will be conducted.

1) Study on enhancing efficiency of terminal operation through modal shift
2) Study on GHG reduction effect by promoting modal shift
3) Study on enhancing efficiency by cooperation between container terminal, rail terminal (SRTO) and inland-depot (ICD)
4) Study on introduction of support measures for promoting modal shift

1.2 Previous Work

(1) About the Port Authority of Thailand (PAT)

PAT was established in 1951 as a port administrator under the jurisdiction of Thailand's Ministry of Transport. It manages and operates five ports in Thailand (Bangkok Port, Laem Chabang Port, Chiang Saen Commercial Port, Chiang Khong Port, and Ranong Port). PAT will celebrate its 70th anniversary in 2021.

Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

Figure 1: Location of five ports managed/operated by PAT

The Yokohama Port and Harbor Bureau signed a memorandum of understanding on cooperation in April 2014 (described below), and a basic agreement for its implementation in January 2015. There has been a continuous cooperative relationship with YPC under the memorandum, and since 2015 joint discussions have been underway regarding utilization of the JCM.

PAT is currently working to promote various measures under its "To be World Class Port with Excellent Logistics Services for Sustainable Growth in 2030" initiative, and in the environmental area, promotion of an environmentally-conscious port under a five-year plan (2015-2019) entitled the "Green Port Project" has been actively proceeded. This plan's target is to reduce projected CO2 emissions from PAT's operations in 2019 by 10% of the 2013 emissions. Unfortunately this target was not achieved as at the end of 2019 and target year has been extended to 2020. PAT is developing a new plan to further strengthen its environmentally conscious effort.

(2) Relationship between Port Authority of Thailand (PAT) and City of Yokohama

Yokohama in Japan is a crucial port city located in the country's capital region, has experienced rapid urbanization and population growth, and has also encountered and tackled and solved various urban issues. Since 2011, Yokohama has been promoting international technical cooperation through public-private collaboration (the Y-PORT project), utilizing its various resources and technologies, and making full use of its expertise and know-how on urban management and infrastructure development that has been accumulated through these efforts. This Y-PORT project in particular is actively providing support for urban development in emerging countries in Asia and beyond.

During the Bangkok municipal government's process of formulating the Master Plan, Yokohama City provided technical advice to JICA and Bangkok. Besides the issue of climate change, Bangkok is also experiencing other urban problems such as waste, sewage and air pollution resulting from rapid urbanization. Recognizing the opportunities, the two cities signed a "Memorandum of Understanding on Technical Cooperation for Sustainable Urban Development" in October 2013. Based on that arrangement, further efforts have been made to promote technical cooperation, making use of Yokohama's expertise in urban development and the advanced technologies of the city's enterprises, through city-to-city collaboration under the Y-PORT project. Then, the "Bangkok Climate Change Master Plan 2013-2023 Implementation Capacity Building Project" was launched in December 2017 as a new project in collaboration with JICA to support implementation of the Master Plan, and this has included capacity building and a sharing of Yokohama City's urban planning knowledge and experience with municipal personnel from Bangkok.

As a recent trend in the Port of Yokohama, in August 2010, through a selection process for target ports for the national government's "International Container Strategy and Port Policy" program for intensive investment and to strengthen competitiveness, the Port of Yokohama was selected as a Keihin region port. The International Container Strategy and Port Policy is a national port policy of the national government to promote Japanese ports as hub ports for container logistics, in response to a decline in relative status of Japanese ports in the context of the development of other Asian major ports in recent years. Based on the International Container Strategy and Port Policy, in January 2016, the Yokohama-Kawasaki International Port Co., Ltd. (YKIP) was established through the corporate split from YPC, centering on the Port of Yokohama.

As for the Port of Yokohama, since 2010, based on the basic policies of the International Container Strategy and Port Policy (consolidating freight, generating freight, boosting international competitiveness), the Port and Harbor Bureau, City of Yokohama, which is the port authority, collaborating with YPC, has promoted various efforts for freight consolidation and for development of new container terminals. In particular, to increase the volume of freight handled, which is one of the most important challenges, they have been promoting stronger collaboration with Southeast Asian countries which have been experiencing remarkable growth, and on April 22, 2014, the Port and Harbor Bureau, City of Yokohama signed a memorandum of understanding with PAT which manages and operates five major domestic ports including Bangkok Port and Laem Chabang Port, regarding partnership aiming to develop beneficial relationships for the development of the Port of Yokohama and domestic ports in Thailand.

This partnership aims at concrete measures that are beneficial to both sides and sets up a cooperative system with fixed periods in specific fields, with the benefits being constantly measured. In particular, it stipulates that an emphasis is placed on cooperative installations to increase cargo volume and technical information exchanges, and the implementation of concrete measures are in specific areas. Major cooperation components include (1) information exchange for the development of both sides (port management, shipping trends, international trade, the use of IT, technology and environmental measures), and (2) port sales (promotion and marketing activities to increase port freight handling volume, and promote port use). Started as a 5-year temporary partnership, after the main study began in 2016, the scope of study has been continually expanded, and the memorandum was renewed in March 2019 introducing a new collaboration menu which covers a variation of areas as follows; (1)Port technology and innovation, (2)Port sustainable development and environmental issues, (3)Trend of shipping trade between ports, (4)Technical partnership, (5)Port management and challenges, (6)Promotion port and shipping marketing, and (7)Collaboration in any other areas that may be mutually decided upon by participant.

A basic agreement on the following concrete action items for implementation of the original memorandum was signed on January 19, 2015. The main points of agreement include (1) mutual assistance through information provision and the exchange of personnel (human resources development, technical exchanges, information exchanges), and (2) cooperation on port sales (mutual implementation of seminars and promotions). As for the renewed memorandum, a basic agreement was signed in March 2019, which includes (1) training, (2) technical exchanges, (3) information exchanges, in addition to mutually holding seminars, meetings and promotion activities. Basic agreements are planned to be renewed in March, 2024.

Based on this agreement, the Port of Yokohama and PAT are undertaking the following efforts on an ongoing basis including trainings to address various issues, receiving study tours, holding port seminars, and regular exchanges of opinion. Major activities include as follows;

In the fiscal year 2020, COVID-19 pandemic has made concrete exchanges in person impossible, major exchanges are the information exchange regarding various issues which ports are facing under this circumstance.

1) On April 22, 2014, the City of Yokohama and PAT signed a memorandum of understanding regarding partnership to develop beneficial relationships for the development of the Port of Yokohama and domestic ports in Thailand.

2) On August 4 and 5, 2014, YPC received an observation tour from Laem Chabang Port (Port Authority of Thailand) and Thammasat University. A lecture was conducted relating to the MM21 District and redevelopment plans.

3) On January 19, 2015, the City of Yokohama signed a basic agreement with PAT on concrete actions to fulfill the agreement in the aforementioned memorandum of understanding.

   Seminar organized by PAT on January 19, 2015. Yokohama City Port and Harbor Bureau Director made a presentation on “Efforts of the Port of Yokohama to Become an International Hub Port.”

4) From November 10 to 13, 2015, the City of Yokohama received a delegation from PAT and held a training, based on a memorandum of understanding and the basic agreement with PAT.

5) In April 2016, the FY2016 “Feasibility Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’” was approved as a Feasibility Study for JCM Project by City-to-City Collaboration, and a feasibility study on CFS Export for Bangkok Port was launched, with the cooperation of PAT.

6) In July 2016, YPC, the City of Yokohama Climate Change Policy Headquarters and Yokohama International Affairs Bureau visited PAT for site research and for discussions about the JCM.

7) In April 2017, the “Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’” was approved as a JCM Project Feasibility Study based on the FY2017 City-to-City Collaboration Project for Low-Carbon Development, and as a follow-up to the previous year’s work on CFS Export, a study was initiated regarding CFS Import for Bangkok

Port, with the cooperation of PAT.

8) In August 2017, Port and Harbor Bureau, City of Yokohama participated as a speaker at workshop organized by PAT.

9) In May 2017, the “Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’” was selected under the “FY2018 City-to-City Collaboration Programme for Low-Carbon Society,” and discussions began in cooperation with PAT regarding a visioning scheme to introduce low-carbon equipment at terminals of Laem Chabang Port.

10) In July 2018, a seminar was held at Port of Yokohama on request of PAT. The delegation of 12 persons included representatives of PAT Laem Chabang Port.

11) In March 2019, a memorandum of understanding regarding partnership arrangements with PAT and a basic agreement for implementation were renewed.

12) In April 2019, the “Study for Assisting Ports in Thailand to Reduce CO2 Emissions by Promoting Modal shift and Terminal Efficiency Improvements” was selected as a FY2019 City-to-City Collaboration Programme for Low-Carbon Society, and discussions started.

13) In Aril 2020, “FY 2020 Feasibility Study for ports in Thailand to reduce GHG emission by advancing modal shift and enhancing terminal efficiency” was selected as a FY2020 City-to-City Collaboration Programme for Low-Carbon Society, and discussions continued.

In the area of port environmental measures, based on the policy of being “a safe, secure and environmentally-friendly port” as stated in the Yokohama port plan, the City of Yokohama and YPC are promoting efforts to create a low-carbon and “smart” port that is also resilient to disasters, and as technical cooperation with PAT, they are making use of Yokohama’s knowhow and experience to conduct discussions to support environmental initiatives being promoted by PAT. These steady and ongoing efforts resulted in PAT becoming actively engaged in the JCM project.

(3) Relationship between Port Authority of Thailand (PAT) and Yokohama Port Corporation (YPC)

YPC declares “a safe, secure and environmentally-friendly port” as one of the three pillars for its policy. Under that policy, examples of efforts so far by YPC include the installation of photovoltaic panels on the roofs of terminal gates, terminal office buildings and Container Freight Stations (CFS: facilities for container freight loading) of the container terminals at the Port of Yokohama, the installation of LED lighting in the yard, and the preparation for introducing ship-to-shore power supply system planned in the future etc., In addition, YPC provides support for introducing hybrid cargo handling equipment used in the container yard, developing a standby berth for special vessels aiming to develop LNG bunkering facilities, etc.

Based on partnership regarding cooperation between PAT and City of Yokohama, YPC has had an ongoing and positive cooperative relationship with PAT, and has been actively supporting PAT’s “Green Port Project” by providing knowledge and expertise drawing on environmental measures taken at the Port of Yokohama.

Following discussions with PAT starting in 2015 regarding the potential for introducing low-carbon facilities at the Port of Bangkok using the JCM, in 2016 and 2017, YPC, Green Pacific Co., Ltd. (GP), and the Overseas Environmental Cooperation Centre, Japan (OECC) as three parties together conducted the “Feasibility Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’ ”.

Based on the findings, YPC, PAT and GP formed an international consortium, and submitted a project application under the “FY2017 to FY2019 CO2 Emission Reduction Countermeasures Project Fund Financing (Equipment Financing Program Under the Joint Crediting Mechanism Financing Program)” (hereinafter “JCM equipment financing project”) for low-carbon facilities PAT would introduce to its export CFS (container freight stations, facilities for container loading and unloading). The funding decision was made, and after which implementation began (project name: “Introduction of Energy-Efficient Equipment to Bangkok Port, Thailand”).

Starting from 2018, focusing to Laem Chabang Port, the largest port in Thailand, as the subject of study, “Feasibility study for assisting ports in Thailand to reduce CO2 Emissions and to become “Smart Ports”“” was conducted. In the following year 2019, expanding the scope of study to ports and their hinterland, the study aiming to promote low carbon and decarbonization by advancing modal shift started (project name: Feasibility Study for ports in Thailand to reduce GHG emission by advancing modal shift and enhancing terminal efficiency”. This is the second year of the study.

Previously mentioned JCM equipment financing project (project name: “Introduction of Energy-Efficient Equipment to Bangkok Port, Thailand”) ended before introducing the actual equipment due to the revision of the redevelopment plan of Bangkok Port caused by the changes of Thai economy etc. However, based on the experience of sharing many issues with PAT through this process, YPC, with collaboration with PAT, has been continuing its efforts to introduce even more effective initiatives.

Together with the other partners including the City of Yokohama’s Port and Harbour Bureau, YPC has been developing a positive cooperative relationship with PAT over the course of many years. Below is a summary of specific achievements.

Major Initiatives after Signing of Cooperative Partnership Agreement

2014 (Apr)	Eight-person delegation from PAT led by the acting chief director visited the Port of Yokohama
2014 (Aug)	Observation tour received from Laem Chabang Port (Port Authority of Thailand) and Thammasat University
2015 (Jan)	Eight-person delegation including YPC executives led by Director General of Port and Harbor Bureau, City of Yokohama, visit PAT, and seminar is held on Thailand-Japan trade and port topics
2015 (Jul)	Yokohama International Affairs Bureau officials visit PAT, conduct interviews on technical cooperation with the Bangkok Metropolitan Administration (Thailand) relating to urban development
2015 (Oct)	City of Yokohama representatives visit PAT to observe overseas government. YPC visits PAT to discuss JCM.
2016 (Jul)	YPC, City of Yokohama (Climate Change Office), and Yokohama International Affairs Bureau visit PAT, conduct on-site observation and discuss JCM
2016 (Sep)	JCM project feasibility study for PAT-managed ports (with cooperation from PAT, and YPC as implementation body) selected by Ministry of the Environment as a “FY2016 Feasibility Study of Joint Crediting Mechanism Project by City to City Collaboration”
2017 (Feb)	YPC, Yokohama City, GP visit PAT to provide final report on results of FY2016 feasibility study project PAT delegation visits Port of Yokohama. Yokohama City Port and Harbour Bureau hosts training program (human resources development, personnel systems, etc.)

	PAT participates in high-level seminar in Chiang Rai, Thailand, makes presentation on PAT's “Green Port Project” environmental plan
2017 (Apr)	JCM project feasibility study for PAT-managed ports (with cooperation from PAT, and YPC as implementation body) selected by Ministry of the Environment for “FY2017 City-to-City Collaboration Programme for Low-Carbon Society,” Yokohama City participating as partner
2017 (May)	Regarding equipment for PAT to introduce to Bangkok Port, YPC, PAT and GP create international consortium, and apply for selection as a FY2017 JCM equipment subsided project (project name: “Introduction of Energy Efficient Equipment to Bangkok Port”). Financing approved January 2018.
2018 (Feb)	YPC, Yokohama City, GP visit PAT to provide final report on results of FY2017 feasibility study project
2018 (May)	Feasibility Study to formulate JCM project at Laem Chabang Port, conducted by YPC (with cooperation from PAT, and YPC as implementation body) was selected by Japan’s Ministry of the Environment for “FY2018 City-to-City Collaboration Programme for Low-Carbon Society,” with Yokohama City participating as partner.
2018 (Oct)	PAT travels to Japan to attend Ministry of the Environment “Seminar on City-to-City Collaboration for Creating Low-Carbon Society.”
2019 (Jan)	YPC, Yokohama City, GP visit PAT to provide final report on results of activities in FY 2018 described above. PAT, YPC and GP sign international consortium agreement for implementation of Smart Port Project for Bangkok Port, Thailand, making use of Financing Programme for Joint Crediting Mechanism (JCM) Model Projects
2019 (Apr)	“Study for Assisting Ports in Thailand to Reduce CO2 Emissions by Promoting Modal shift and Terminal Efficiency Improvements,” was selected by Ministry of the Environment for “FY2019 City-to-City Collaboration Programme for Low-Carbon Society.”
2020(Jan)	YPC, Yokohama City, GP visit PAT to provide final report on results of FY2019 feasibility study project.
2020(Jun)	FY2017 JCM equipment subsided project (project name: “Introduction of Energy Efficient Equipment to Bangkok Port”) was cancelled.
2020(Apr)	This study, the “FY 2020 Feasibility Study for ports in Thailand to reduce GHG emission by advancing modal shift and enhancing terminal efficiency” was selected by Ministry of the Environment for “FY2020 City-to-City Collaboration Programme for Zero-Carbon Society.”

2. Preparation of Study

2.1 Information Gathering

(1) Overview of Laem Chabang Port and Effects of Covid-19

1) Overview of Laem Chabang Port

Construction began on Laem Chabang Port in 1986, it opened as an international trade port in 1991, and in 1997 it overtook the cargo handling volume of Bangkok Port to become the largest port in Thailand. The port handled an annual 8.06 million TEU of container cargo in 2019, and besides containers, it also has terminals for bulk carriers and vehicle carriers.

The terminal layout of Laem Chabang Port is shown in Figure 2. In addition to the three sections A to C, currently in service, a part of section D started operation in the middle of 2019. In the future, there are plans to develop the Laem Chabang Port Phase III Development Plan (sections E and F terminal development), under the Eastern Economic Corridor (EEC) Development Project.

Source: https://www.slideshare.net/boinyc/laem-chabang-port-development-project

Figure 2: Laem Chabang Port terminal layout

2) Laem Chabang Port Management and Operation Structure

At Bangkok Port, PAT is managing everything from construction and improvements to terminal operations. In contrast, at Laem Chabang Port, PAT owns the land and manages all areas of the port as the port manager, but private sector operators are given terminal operator contracts based on long-term leases, and operations are being done by operators that have obtained contracts on a terminal by terminal basis. Improvements in the structures, as well as operations, are done by operators who have obtained the rights for each terminal (concession contracts). Terminals being operated by private sector companies based on concession contracts and terminal operators are shown in Table 1. Many Japanese companies participate in the terminal operation, such as Nippon Yusen Kaisha at A1, Mitsui & Co. at B2, Marubeni Corporation and Kamigumi Co. at B3, Nippon Yusen Kaisha and Mitsui O.S.K. Lines at B4, and Nippon Yusen Kaisha at C0.

Table 1: List of current terminal operators

Terminal	Operator	Area (m2)	Use of terminal	Container ground slots (TEU)
A0	LCMT CO., LTD.	170,000	Multi-purpose, coastal cargo	3,551
A1	NYK AUTO LOGISTICS THAILAND CO., LTD.	31,500	Ro-Ro, passenger	—
A2	THAI LAEMCHABANG TERMINAL CO., LTD.	170,000	Multi-purpose	2,970
A3	HUTCHISON PORTS (THAILAND) LTD.	170,000	Multi-purpose	1,688
A4	AAWTHAI WAREHOUSE CO., LTD.	128,000	Molasses, sugar	—
A5	NAMYONG TERMINAL PUBLIC CO.,LTD	240,000	General cargo, Ro-Ro	—
B1	LCB CONTAINER TERMINAL 1 CO.,LTD	120,000	Container	2,362
B2	EVERGREEN CONTAINER TERMINAL (THAILAND) LTD.	105,000	Container	1,742
B3	EASTERN SEA LAEM CHABANG TERMINAL CO., LTD.	105,000	Container	1,522
B4	TIPS CO., LTD.	105,000	Container	1,908
B5	LAEM CHABANG INTERNATIONAL TERMINAL CO., LTD.	82,089	Container	2,892
C0	LAEM CHABANG INTERNATIONAL RORO TERMINAL CO., LTD.	315,400	General cargo, Ro-Ro, passenger	—
C1-2	HUTCHISON PORTS (THAILAND) LTD.	540,000	Container	9,540
C3	LAEM CHABANG INTERNATIONAL TERMINAL CO., LTD.	231,668	Container	3,278
D1,D2,D3	HUTCHISON PORTS (THAILAND) LTD.	765,000	Container	13,410

Source: Annual Report 2018, Port Authority of Thailand, 2019

3) Performance of Laem Chabang Port

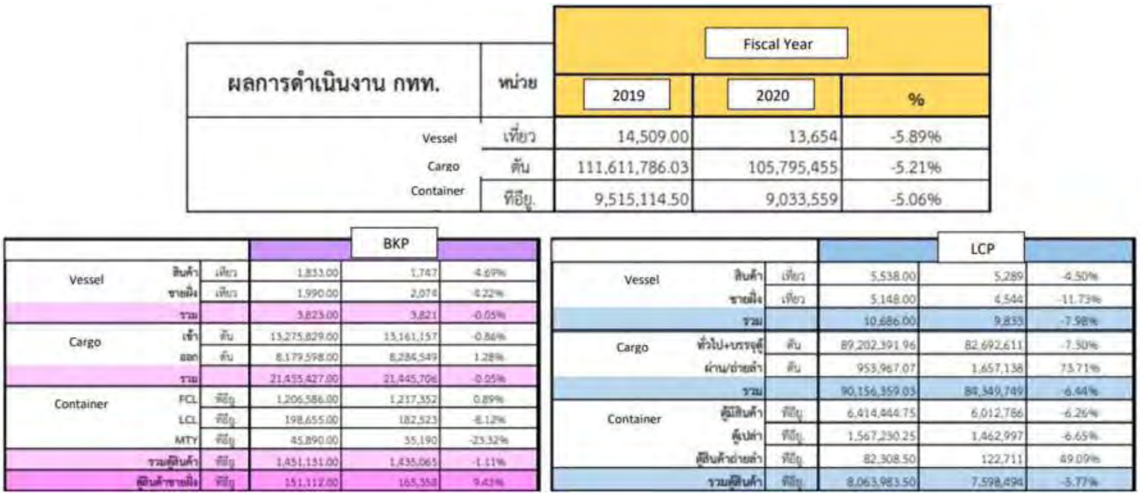
a) Container Throughput

According to the trade statistics of 2020 published by Ministry of Commerce Thailand, export from Thailand has decreased by 6% to 23.14 million dollars, which was the decrease for two consecutive years. Import has decreased by 12% to 20.69 million dollars, which was also the decrease for two consecutive years.

Global shortage of containers and raw materials etc. caused by Covid-19 has given an impact. As for export, main items such as automobile and parts decreased by 22% whereas computers and parts increased by 2% due to growing demand for remote working. As for import, decrease in fuel demand and down of oil prices has brought a 20% decrease of oil import whereas slowdown of industrial manufacturing has caused a 13% drop in machinery and parts.

In the case of Laem Chabang Port, container throughput has shown an increase year by year, by nearly 20% every year, reaching 8.06 million TEU in 2019. However, in 2020, throughput was 7.59 million TEU, about a 5.8% decrease from 2019. Port arrivals for Laem Chabang Port in 2020 was 9,833 ships, showing a 7.98% decline from 10,686 ships in 2019. At the same time, the volume of freight handled at the port was 84,349,749 tons which was a 6.44 % decline from 90,156,359 tons in 2019.

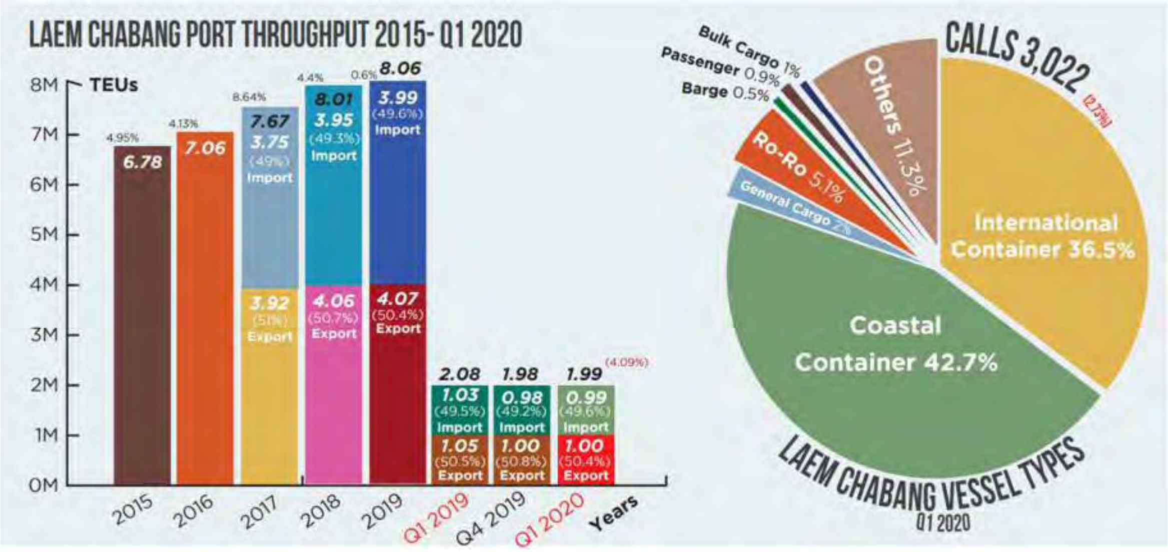
Table 2: Cargo Handling Volume of Bangkok Port and Laem Chabang Port
(tentative figure provided by PAT)



ผลการดำเนินงาน กทท.	หน่วย	Fiscal Year		
		2019	2020	%
Vessel	เที่ยว	14,509.00	13,654	-5.89%
Cargo	ตัน	111,611,786.03	105,795,455	-5.21%
Container	ทีอียู.	9,515,114.50	9,033,559	-5.06%

			BKP		
Vessel	สินค้า	เที่ยว	1,833.00	1,747	-4.69%
	ชายฝั่ง	เที่ยว	1,990.00	2,074	4.22%
	รวม		3,823.00	3,821	-0.05%
Cargo	เข้า	ตัน	13,275,829.00	13,161,157	-0.86%
	ออก	ตัน	8,179,598.00	8,284,549	1.28%
	รวม		21,455,427.00	21,445,706	-0.05%
Container	FCL	ทีอียู	1,206,586.00	1,217,352	0.89%
	LCL	ทีอียู	198,655.00	182,523	-8.12%
	MTY	ทีอียู	45,890.00	35,190	-23.32%
	รวมตู้สินค้า	ทีอียู	1,451,131.00	1,435,065	-1.11%
	ตู้สินค้าชายฝั่ง	ทีอียู	151,112.00	165,358	9.43%

			LCP		
Vessel	สินค้า	เที่ยว	5,538.00	5,289	-4.50%
	ชายฝั่ง	เที่ยว	5,148.00	4,544	-11.73%
	รวม		10,686.00	9,833	-7.98%
Cargo	ทั่วไป+บรรจุตู้	ตัน	89,202,391.96	82,692,611	-7.30%
	ผ่าน/ถ่ายลำ	ตัน	953,967.07	1,657,138	73.71%
	รวม		90,156,359.03	84,349,749	-6.44%
Container	ตู้มีสินค้า	ทีอียู	6,414,444.75	6,012,786	-6.26%
	ตู้เปล่า	ทีอียู.	1,567,230.25	1,462,997	-6.65%
	ตู้สินค้าถ่ายลำ	ทีอียู.	82,308.50	122,711	49.09%
	รวมตู้สินค้า	ทีอียู.	8,063,983.50	7,598,494	-5.77%



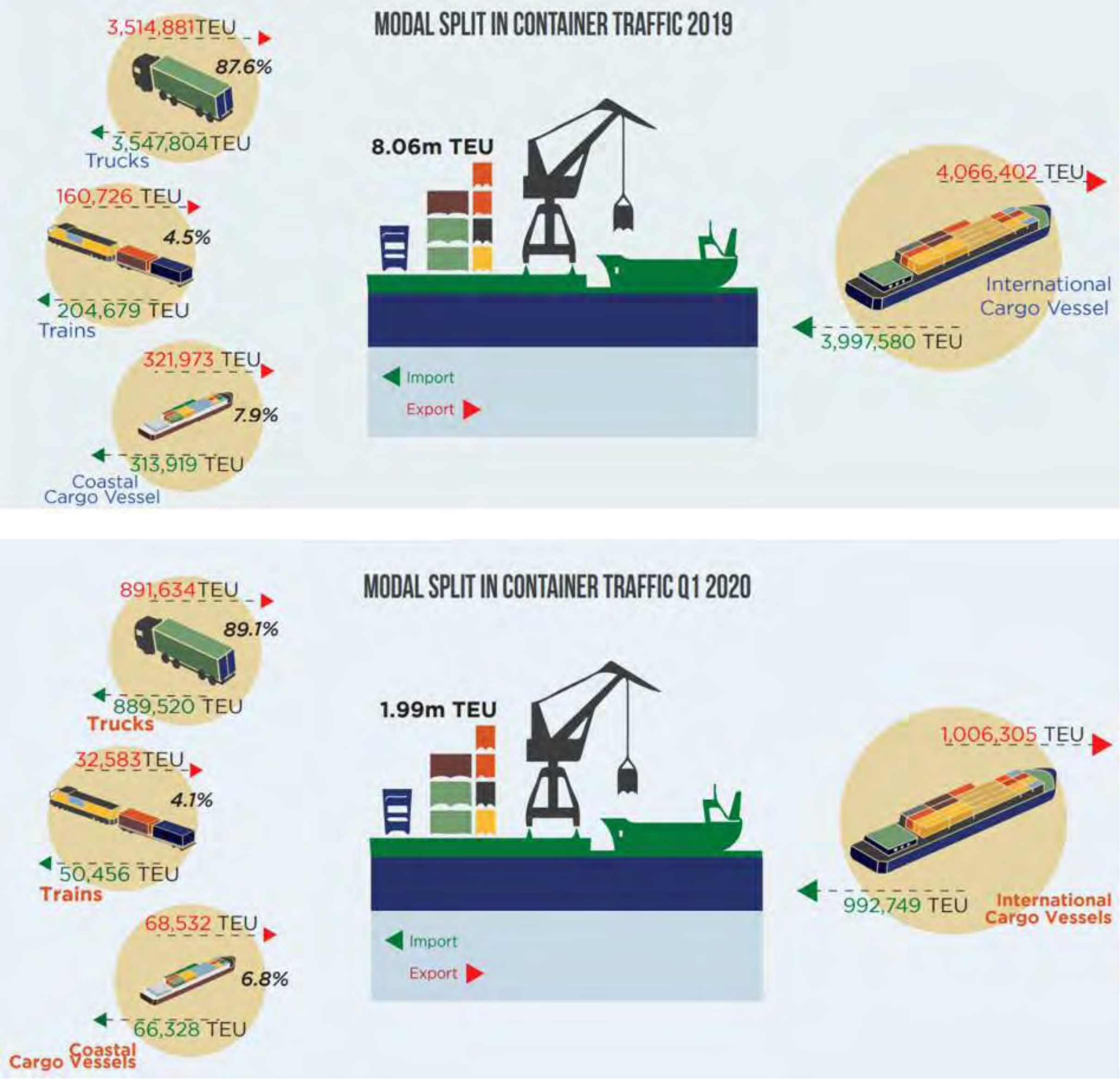
Source: “STATISTICS OF LAEM CHABANG PORT Q1 2020” Laem Chabang Port HP, viewed in Jan. 2021

Figure 3: Laem Chabang Port container throughput

Source: “STATISTICS OF LAEM CHABANG PORT Q1 2020” Laem Chabang Port HP, viewed in Jan. 2021

Figure 4: Rail Container Throughput (2016 to 2020Q1)

Looking at the transportation mode of Laem Chabang Port, container throughput was 8.06 million TEU in 2019, trucking accounted for 87.6% of domestic transport, compared to 4.5% for rail and 7.9% for coastal cargo vessel. Meanwhile, in the first quarter of 2020, trucking accounted for 89.1% of domestic transport, compared to 4.1% for rail and 6.8% for coastal cargo vessels, which means that modal shift has yet to be promoted.



Source: "STATISTICS OF LAEM CHABANG PORT Q1 2020" Laem Chabang Port HP, viewed in Jan. 2021

Figure 5: Modal Split in Container Traffic

COVID-19 has also caused a global container shortage. According to the newspapers, while export from China to Europe and the United States increases, export from Europe and the United States to China has been slowing down due to COVID-19, which causes export containers being piled up. In addition, growing number of shippers (exporters) in China and Vietnam are trying to secure empty containers by paying extra charge, which makes the container shortage even more serious. Responding to this issue, Thai government has been working to promote reuse of used containers and export of non-container cargo by making efforts in the following 6 areas through discussions with parties concerned; Ministry of Commerce, PAT and private sectors cooperate in securing empty containers, refurbishing used containers in Thailand and reusing them, promoting export of non-container cargo, encouraging a joint advanced reservation of containers by small and middle sized companies, expanding ship length received at east Laem Chabang Port from 300m to 400m, and exploring ways to import empty containers at low cost. Furthermore, for reducing burden of exporters, PAT is going to review various charges including exemption of service charge which costs 1,800 Baht (about 6,230 yen) per 20-feet container during January to June of next year.

b) Vehicle Throughput

According to the announcement made by Federation of Thai Industries (FTI), vehicle production in Thailand in 2020 has fallen by 29% to 1,426,970 units compared to that of 2019. This is the low level for the first time in 11 years since 2009 when production dropped after the Lehman shock financial crisis, because of the temporary shutdown of the factories of major manufactures caused by the spread of COVID-19. Export accounted for about 704,000 units, decreased by 32%, and domestic sale was 722,344 units, decreased by 26%. Continued appreciation of Thai Baht as well as the slowdown of global economy caused by COVID-19 has given an effect. Yet, there is a recovery trend showing that 142,969 cars were produced in December 2020, a 7% increase year on year basis, exceeding previous year's result for 2 consecutive months.

(2) Latest News about Promotion of Modal Shift in Thailand

1) Air Pollution in Bangkok

Promotion of modal shift in Thailand aims at reducing air pollution, traffic congestion, and CO2 emission etc. In that line, PAT has been instructed to promote modal shift by Thai government. Citizen of Bangkok is highly interested in the air pollution as it worsens especially from December to February every year.

According to the newspapers, when Pollution Control Department (PCD), Ministry of Natural Resources and Environment conducted a survey in Bangkok, it was found that 36% of large size vehicles such as bus and truck did not meet the exhaust gas standards. The survey was conducted from October 2019 to September 2020, and penalty was imposed to those who violated the emission standards. PCD, collaborating with police and the Ministry of Transportation, has been exercising control such as setting up checkpoints to strengthen the surveillance, based on the idea that large vehicle is one of the sources of PM2.5 emission.

2) Securing Connectivity with EEC etc.

Thai government has been implementing projects for securing and enhancing connectivity with domestic areas as well as neighboring countries. Many of them are consistent with the perspective of promotion of modal shift. The followings are the latest information in this regard;

In October 2020, EEC Policy Committee (chaired by H.E. General Prayut Chan-o-cha, Prime Minister) which controls development of the Eastern Economic Corridor (EEC), special economic zone (SEZ) in three eastern provinces of Chachoengsao, Chonburi, and Rayong, approved to conduct feasibility studies of 3 additional projects, aiming for enhancing connectivity between EEC and southern areas. These studies include development of inland container depot (ICD, dry port) in Chachoengsao, development of deep water ports, express ways and dual track railways which provides better connection between the Gulf of Thailand and the Andaman Sea, and development of “Thai Bridge” which is an undersea tunnel connecting Chonburi Province and Phetchaburi Province in the south. Details of the projects are as follows;

Development of Inland Container Depot (ICD, dry port)

The plan aims to relieve heavy traffic of Laem Chabang Port and traffic congestion of the roads by developing inland-depot and railways which provide one-stop service for distribution and Customs clearance. There are plans to construct inland-depots in 3 provinces that are Chachoengsao Province, Khon Kaen Province and Nakhon Ratchasima Province in the northeast. Survey will be completed within 2021 in Chachoengsao Province, by 2022 in Khon Kaen and Province and Nakhon Ratchasima Province. Each facility will be ready after about 2 years.

Development of deep water ports, express ways and dual track railways which provides better connection between the Gulf of Thailand and the Andaman Sea

The project aims for developing deep water ports, one in Chumporn Province which faces the Gulf of Thailand in the south and the other in Ranong Province which faces the Andaman Sea, as well as constructing city-to-city express ways and dual track railways connecting those ports, which contributes to reduce distribution cost. It is expected to enhance connectivity between Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation initiative or BIMSTEC which consists of Thailand, Myanmar, India, Bangladesh, Sri Lanka, Nepal and Bhutan, and South China Sea. Target year for construction is 2025 for deep water ports and express ways, and 2027 for dual track railways.

Development of “Thai Bridge” which is an undersea tunnel connecting Chonburi Province and Phetchaburi Province in the south.

Thai Bridge connects EEC and southern areas, detouring Bangkok, and it aims for exploring a new international distribution route without passing the Strait of Malacca by developing Ranong Port as a distribution hub. Target completion year is 2032.

Ranong Port is the port which is managed by PAT and consideration for redevelopment has already started. The plan includes renovation of 2 piers of Ranong Port at the cost of 41.8 million Baht (about 140 million yen). The first pier will be 130m long and be capable of berthing a vessel of 12,000DWT by installing fenders. For the second pier, the length will be 150m and be capable of coping with a 65-ton cane and a 22-wheel truck. Two piers will be connected by a bridge.

Source: Prepared based on Bangkok Post by YPC

Figure 6: Thailand Connectivity Plans

In addition, Port Authority of Thailand, Ministry of Transport has a plan to operate ferryboat to connect the Sattahip Port in Chonburi Province in the north and the Bang Saphan Port in Prachuap Khiri khan Province in the south in 2021. It is also considering to start ferry service for trucks between Laem Chabang Port in Chonburi Province and Bang Saphan Port.

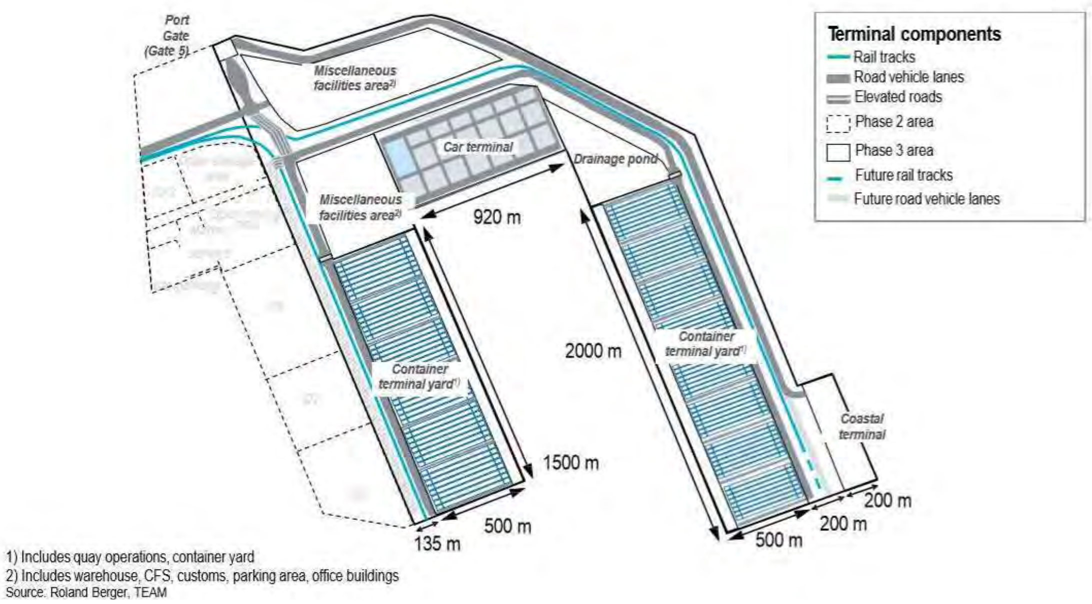
3) Information about Development and Contract of Phase III

One of the large-scale projects in the Eastern Economic Corridor (EEC) Development Project is the Phase III development plan of Laem Chabang Port. The scale of the development project totals

114 billion baht (about 410.4 billion yen), and container terminals and multi-purpose terminals will be created in Sections E and F, newly reclaimed land, and construction of railway terminal and coastal shipping terminal is planned. With container handling capacity of 7 million TEU (twenty foot equivalent unit) at Phase III, the port capacity of Laem Chabang Port is expected to increase to 18 million TEU per year.

Phase III development plan (terminal F) consists of 4 projects which Thai government directly invests and a PPP project which government and private sectors cooperate. Among these, marine development projects such as reclamation and excavation of seaside are expected to start in the beginning of 2021 and be completed in 2023. CNNC Joint Venture led by Prima Marine Prima won the e-bidding, and the scale of the development project totals 20.7 billion baht (about 71.7 billion yen). After the completion in 2023, the projects will be handed to PPP operator. Among other 3 governmental projects, the second public hearing was conducted for the project which includes infrastructure development such as ports and roads and building construction (project scale of 7.425 billion baht).

Rail terminal (SRTO 2) is planned to be developed in the area, the bidding for terminal development (600 million baht) and installation of machine and communication equipment (2.2 billion baht) is expected to be held in around 2024. GPC Joint Venture won the bidding for PPP project which includes development and operation (for 35 years) of port system such as cranes and container storage.



1) Includes quay operations, container yard
2) Includes warehouse, CFS, customs, parking area, office buildings
Source: Roland Berger, TEAM

Source: www.laemchabangportphase3.com/

Figure 7: Phase III Development Plan

2.2 Confirmation of Means to Proceed Studies under COVID-19 Pandemic

(1) Means of Proceeding this Study

At the beginning of the study, it was originally planned to visit Thailand about twice for conducting field studies and having meetings with PAT executives. However, assuming that conducting study at Thailand would be difficult considering extended effects of COVID-19, the schedule has been arranged to conduct study as follows;

Study arrangement made by Japanese side

Prior to the start of the study, it was proposed to proceed study by having meetings on-line with PAT and to have meetings by hierarchical levels such as working-level and executive level, etc., as in the past, and it was carried out in that manner. This time, as the study include repeating trial-and-error works using simulators for terminal operation, technical meetings which discuss simulations with operations staff were added, so the meetings were held at three different levels. E-mails were also used for study to facilitate the meetings.

Online interviews were also conducted with stakeholders etc. other than PAT.

Field Studies

Detailed consultation with PAT and interviews with Thai government-affiliated organizations such as TGO etc., and experts including university professors and professional consultants were conducted by staff of our local office. However, the interviews were online for the most part to avoid meeting in person for prevention of COVID-19 in Thailand as well.

Confirmation of Site

Previously the situation of the terminal for modal shift had been usually confirmed at the site, but this time, it was carried out through interviews with PAT staff and by using photo data etc. provided by PAT staff.

3. Study Findings

3.1 Overview of Site Visits and Interviews, etc.

(1) First Online Meeting with PAT

As there have been changes in some details since being confirmed at the final meeting last fiscal year, those changes were explained and information was shared about how to move forward with these discussions in the current fiscal year. The meeting also included a report on simulations already under way.

Related documentation for the meetings is provided as Attachment 2(1) in the documents package.

1) Date and Participants

Meeting dates and participants are indicated in Table 3.

Table 3: Meeting Dates and Participants

Date and Time	October 19, 2020, 12:00 to 14:30 (JST)	
Location	Online meeting (via Zoom)	
Local Participants	Port Authority of Thailand (PAT)	Mr. Ud Tuntivejakul, Chief of Cargo Operation, SRTO Division Mr. Nuttapon Boonchokchuray, Chief of Cargo Operation, Coastal Terminal Division Ms. Suphattra Phisaisawat, Technical Officer 12 (Environment) Ms. Mayuree Deeroop, Technical Officer 11
Participants from Japan	Yokohama Port Corporation (YPC)	Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Mr. Takahiro Sakurai, Chief, Engineering Planning Division, Engineering Department Mr. Ken Urushibara, Engineering Planning Division, Engineering Department Mr. So Okada, Engineering Planning Division, Engineering Department
	Port and Harbor Bureau, City of Yokohama (COY)	Mr. Yuki Murata, Ms. Chihiro Masaoka (Policy Coordination Division) Mr. Akinari Nakaizumi, Ms. Ayane Emiya (Logistics Planning Division) Ms. Ayako Nakano, Ms Rino Okubo (Port Promotion Division)
	Green Pacific Co. (GP)	Mr. Kazuhito Yamada, President Ms. Mariko Fujimori, Vice President Mr. Darmp Phadungsri, Consultant Ms. Ryoko Goto, Consultant
Interpretation		Mr. Pornthep Lersaktanadorn

2) Key Discussions and Points Confirmed

Confirmation of Discussion Items for the Current Fiscal Year

- It was confirmed that automation and remote operations will not be a topic for detailed discussions this fiscal year, but next year and beyond.
- The shared concept for output of the study this year is as follows:
    - Based on the results of discussions about Laem Chabang Port (LCP), a roadmap noting throughput, capital investment, and the relationship with CO2 emission reductions will be prepared and reported to LCP senior management, as well as a report about the potential to utilize the JCM for capital investment.
    - Topics for the use of the JCM and procurement approaches that raise the potential for success will be discussed with PAT and summarized.
- Regarding the approach and schedule for moving forward with this study, the meeting confirmed various points, including the impacts of COVID-19.

Procurement Plans and Operational Methods for Rail Terminal (SRTO)

- The latest equipment procurement plans, operational methods, and cargo handling volumes at the rail terminal (SRTO) were confirmed.
- Procurement plans were confirmed for tractor heads and chassis (external trailers) for container hauling between the rail terminal (SRTO) and each terminal at Wharf B, as well as for RTGs at the SRTO.
- Improved cargo handling efficiency was confirmed at the coastal terminal (Coastal-A) as a result of cargo handling being switched from direct transfer to storage method.

Simulation Studies

- It was confirmed that simulation studies for the rail terminal (SRTO) were done not to solve current issues, but rather, to examine how to increase future throughput.
- For the rail terminal (SRTO) simulation study, on which work is already underway, an explanation was provided of the simulation results to date (CASE 1 and CASE 2 simulations to determine whether or not operations can be done efficiently for the target throughput volume with the configuration and number of units of cargo handling equipment being considered by PAT) as well as the additional CASE 3 that was conducted.
- Also, regarding equipment procurement plans for the optimal number and type of units, an explanation was provided of details of the proposal planned for the next executive level meeting.

Approach to CO2 Emission Reductions

- As for CO2 emission reductions at terminals, it was confirmed that PAT is not using its own set indicators such as emission factors.
- In order to calculate CO2 emission reductions based on the Thai government's published emission factors, it was determined that PAT would provide statistics on the weights of containers being handled at Laem Chabang Port, specifications of coastal vessels, and specifications of diesel engines procured by SRT.

Topics for Utilizing the JCM

- If the JCM financing program is to be used during Japan’s next fiscal year, procurement agreements could potentially be signed in about July or August. Because of different timing of Thai and Japanese fiscal years, to utilize the JCM it would be necessary to slightly delay the order placement in Thailand in order to match Japan's fiscal year.
- JCM rules have changed to allow procurement by leasing so that the bid price of bid participants can directly reflect the effect of the subsidy. Meanwhile, in general, PAT does not use leasing for the procurement of equipment, and it is up to senior management to decide whether or not to PAT will alter its normal pattern to use leasing under the JCM.
- In the case of procurement by leasing, the JCM applicant owns the asset/property, so a Japanese company and Thai company need to establish a consortium. If that approach is taken, PAT and YPC do not need to establish a consortium.
- If only converting RTGs to hybrid or electric power, the financing ratio by JCM would be low, so it would probably be necessary to include the introduction of other low-carbon equipment, such as photovoltaic power generation and EV trucks for cargo handling.
- In terms of explanatory documentation for PAT senior management, YPC needs to provide PAT a table summarizing the necessary tasks on the PAT side, such as the cost-benefit analysis in the case of introducing solar power and EV trucks for cargo handling, and a procurement schedule, etc.

(2) Second Online Meeting with PAT

At this meeting, information was provided about initiatives at the Port of Yokohama and the details of the current year’s study, as well as interim report on status of the study.

Explanatory documents for the meetings are provided as Attachment 2(2) in the documents package.

1) Date and Participants

Meeting dates and participants are indicated in Table 4.

Table 4: Meeting Dates and Participants

Date and Time	December 04, 2020, 12:00 to 14:00 (JST)	
Location	Online meeting (via Zoom)	
Local Participants	Port Authority of Thailand (PAT)	Mr. Tanabodee Toopteanrat, Assistant Managing Director Mr. Veerachart Puttharaksa, Director Office of Operation Mr. Ud Tuntivejakul, Chief of Cargo Operation, SRTO Division Mr. Nuttapon Boonchokchuray, Chief of Cargo Operation, Coastal Terminal Division Ms. Suphattra Phisaisawat, Technical Officer 12 (Environment) Ms. Praew Ruttikarn, Scientist 10
Participants from Japan	Yokohama Port Corporation (YPC)	Mr. Hidenori Kishimura, Senior Executive Director Mr. Yuichi Takagi, Director Mr. Tetsuya Koizumi, Director Mr. Koji Kumamoto, General Manager, Engineering Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Mr. Takahiro Sakurai, Chief, Engineering Planning Division, Engineering Department, and others
	Port and Harbor Bureau, City of Yokohama (COY)	Mr. Yasuhiro Shimbo, General Manager, Policy Coordination Division Mr. Kosei Narita, Chief, Policy Coordination Division Masayuki Takenouchi, Section Head, Policy Coordination Division Ms. Chihiro Masaoka, Policy Coordination Division
	Green Pacific Co. (GP)	Mr. Kazuhito Yamada, President Ms. Mariko Fujimori, Vice President Mr. Darmp Phadungsri, Consultant
Interpretation		Mr. Pornthep Lersaktanadorn

2) Key Discussions and Points Confirmed

Interim Report

- Based on simulation results, proposals were made for cargo handling methods and cargo handling equipment deployment plans to make operations more efficient. It was also explained that at the same time when more cargo handling equipment is being deployed to handle increased throughput, it is very beneficial to ensure that the new cargo handling equipment will have remote operations capabilities.
- Information was presented regarding potential GHG emission reductions from a modal shift, calculated using TGO-published emission factors (EF) for trailers, vessels, and rail.
- In response to questions from PAT regarding whether or not GHG emissions could be calculated

for operations at the rail terminal (SRTO), it was explained that calculations had been done, and that they showed that they amounted to several percentage points relative to total emissions from transport from the inland depot to terminals at Laem Chabang Port.

- PAT viewed automation as something for Phase 3, and recognized the need for improvements and upgrades toward automation at the rail terminal (SRTO) as well. Accordingly, an explanation was provided regarding different implications for design and costs as well as general differences in bidding prices, depending on whether or not automation is considered in advance.
- It was decided to engage in more detailed discussions by e-mail and other means regarding the deployment of cargo handling equipment and future remote operations.

Other Matters

- Regarding a partnership between PAT and the City of Yokohama for next year and beyond, it was decided to arrange other opportunities to discuss specific topics for activities.

(3) Third Online Meeting with PAT

A detailed briefing was provided regarding the promotion of modal shift at Laem Chabang Port and a final report for this fiscal year was presented.

Explanatory documents for the meetings are provided as Attachment 2(3) in the documents package.

1) Date and Participants

Meeting dates and participants are indicated in Table 5.

Table 5: Meeting Dates and Participants

Date and Time	February 2021, 12:30 to 14:00 (JST)	
Location	Online meeting (via Zoom)	
Local Participants	Port Authority of Thailand (PAT)	Research and Organization Development Division Ms. Theerakarn Suriyakul, Na Ayudhaya, Director of Research and Organization Development Division Ms. Pitinoot Kotcharat, Assistant Director of Research and Organization Development Division Ms. Preaw Ritthirungrat, Chief of International Affairs Section Ms. Chutarat Nakthong, Technical Officer of International Affairs Section Environmental division Ms. Suphattra Phisaisawat, Technical Officer (Environment) Ms. Mayuree Deeroop, Technical Officer Ms. Ruttikarn Chamsub, Scientist Laem Canbang Port Mr. Ud Tuntivejakul, Chief of Cargo Operation, SRTO Division Mr. Nuttapol, Chief of Cargo Operation, Coastal Terminal Division
Participants from Japan	Yokohama Port Corporation (YPC)	Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Mr. Takahiro Sakurai, Chief, Engineering Planning Division, Engineering Department, and others
	City of Yokohama (COY)	Mr. Kosei Narita, Chief, Policy Coordination Division Masayuki Takenouchi, Section Head, Policy Coordination Division Ms. Chihiro Masaoka, Policy Coordination Division Ms Rino Okubo, Port Promotion Division
	Green Pacific Co. (GP)	Mr. Kazuhito Yamada, President Ms. Mariko Fujimori, Vice President Mr. Darmp Phadungsri, Consultant
Interpretation		Mr. Pornthep Lersaktanadorn

2) Key Discussions and Points Confirmed

Final Report

- A report was made on the following points regarding studies conducted this year; 1) enhancing efficiency of terminal operation through modal shift, 2) GHG reduction effect by promoting modal shift, 3) enhancing efficiency by cooperation between container terminal, rail terminal (SRTO) and inland-depot (ICD) and 4) introduction of support measures for promoting modal shift.

- Study on efficiency improvement of terminal operation was carried out with PAT members, using simulators. A plan was made noting that cargo handing being switched from direct transfer to storage method, and appropriate deployment and additional purchase of cargo handling equipment to cope with cargo throughput growth. Proposal was made for introduction of automation at the time when cargo throughput reaches 1.5 million TEU/ year.
- As for CO2 emission, reduction effects by modal shift from trailers to rails were not confirmed, partly because available data for emission factor of ships and rails were old whereas data for trailers were new. However, based on the estimation making use of emission factor data used in other country, it was confirmed that if renewal of diesel electric locomotive which was promoted by State Railway of Thailand is making progress, Thai government's published emission factor will be reviewed, then definite results will be achieved.
- Regarding cooperation between parties involved in container transportation, the renewal procedures for concession contracts of Lat Krabang ICD, SRTO and Wharf B has been on hold, it was explained to PAT that collaboration is particularly important to promote modal shift.
- Anticipating future throughput of 1.5 million TEU /year at SRTO, the shared concept includes a roadmap for introducing automation both at SRTO and Coastal-A, support measures and issues regarding introduction of automation.

(4) Information about Operations at a Terminal for Modal Shift at Laem Chabang Port

The latest information was gathered relating to a modal shift terminal, based on interviews with PAT, site visits conducted in cooperation with PAT personnel, and external interviews. The results are summarized below.

Coastal Terminal (Coastal-A)

Regarding the coastal terminal (Photo 1) that was developed on available land (about 17.5 acres) between Berth A0 and Berth A1, operations did not begin after the planned start date in May 2019, but eventually the decision was made to go with JWD (a company that handles dangerous goods at Laem Chabang Port) as the operations company (five-year contract), and service began on March 13, 2020. As described by a PAT manager, it was decided at a stakeholder meeting on July 15 to adopt the rule that coastal vessels using Laem Chabang Port will only use Coastal-A. The implementation of this rule means that the target of 300,000 TEU is expected to be reached quickly. Currently, about 4 vessels (3 to quays with container cranes, and 1 to the quay with the mobile harbor crane) are docking and about 500 containers are being handled per day, but there are plans to increase the daily throughput to 700 containers in the future.

The initial intention was mainly to use direct operations (to transport containers unloaded from coastal vessels directly to each terminal without temporarily storing in the yard, or to directly load containers hauled from each terminal onto coastal vessels), but in reality, containers are generally being stored in the yard, and only in urgent cases are direct operations being used. Direct operations account for about 5% to 10% of the total. According to PAT, the reason for changing from the original plan of direct operations to mainly using yard storage was to shorten the handling time for ship cargo to avoid ships waiting in the berths. There is no charge for yard storage up to three days, so demurrage is charged if that period is exceeded. Handling begins 24 hours before the scheduled berthing time of a coastal vessel. Reefers are also frequently used, and there are plans to add 18 more units by 2022, up from the current 54.

The quay has two 120-meter berths with a water depth of 10 meters and is capable of docking 3,000 DWT-class coastal vessels. The cargo handling equipment currently includes 1 STS, 1 mobile harbor crane, and 2 RTGs, but a decision was made to utilize 2 hybrid RTGs at Coastal-A that were originally planned to for procurement for the CFS construction project for exports at Bangkok Port. Until recently, with that project being cancelled, the plan was altered to take delivery of one unit at the Laem Chabang Port SRTO and one unit at Coastal-A, but this was later changed to place both units at Coastal-A. However, due to the impacts of COVID-19, delivery is likely to be delayed until June 2021 from the original plan of February.

On the above points, an operator at Laem Chabang Port commented that instead of having some coastal vessels dock directly at each terminal, the shift to having all of them use Coastal-A will increase cargo handling costs due to double handling, and some shippers have been heard saying they may not be supportive, so it will be important to monitor trends going forward.

Photo credit: PAT

Photo 1: Coastal terminal (Coastal-A) (birds’-eye view)

Photo credit: PAT

Photo 2: Operations at the coastal terminal (Coastal-A)

Single Rail Transfer Operator (SRTO) Terminal

The rail terminal (SRTO) built between Wharf B and Wharf C started temporary service in September 2018, and even with the COVID-19 situation it is currently handling 10,000 to 24,000 TEU per month.

Direct operations for cargo handling are only being done at B-1 to B-5, and some operators at Wharf B are not dealing directly with the van pool operating within Laem Chabang Port. Thus, among the current cargo handling equipment of 2 RMG units (60 t, twin spreader) and 1 cable reel RTG, the RTG unit is not being used.

As for trailers, they are prepared at the user side for B-1 to B-5, and the cycle time totals about 30 minutes, including about 5 minutes dwell time within the SRTO, and about 25 minutes for moving to and from each terminal and loading work within each terminal.

Within the terminal, up to 4 trains are being loaded simultaneously. Twelve hours are required per train, from the time of entering the SRTO until it leaves, of which 8 hours are taken up not for loading operations but for customs procedures or waiting for processing. Because of this, PAT initiated discussions with State Railway of Thailand (SRT) in June 2020, and began discussions about how to increase this to 5 or 6 trains in order to further increase throughput, but there appear to be no current prospects for improving customs processing, which is a core issue.

Next, in terms of securing operators responsible for operations, due to continued bidding delays, PAT staff from Bangkok Port were being dispatched temporarily until January 2020. This changed to short-term contracts for labor only for a half year starting February 2020 and then a half year starting in August, and ESCO (operator of B3 terminal) was contracted starting in February, and then TIPS (operator of terminal B4) starting in August.

The main cause of problems with bidding was the low price ceiling on cargo handling unit prices posted by PAT. According to PAT personnel, under direction from the Thai government, the initial price ceiling when bidding started was set at about 20% below actual unit prices estimated by PAT. PAT encouraged a review of the price ceiling in discussion with the Thai government in order to re-announce the bid, and after a public hearing in October 2020, implemented the bid in early December. An announcement of the bid results was expected in January, but the review was still under way as of the end of January 2021. As a result, PAT has decided to extend the short-term contract with TIPS for another 4 months from the end of January 2021.

Photo credit: PAT

Photo 3: Rail terminal (SRTO) (bird's-eye view)

Photo credit: PAT

Photo 4: Operations at the rail terminal (SRTO)

Photo credit: PAT

Photo 5: Operations at the rail terminal (SRTO)

3.2 Study of efficiency improvements in modal shift terminal operations

The ultimate annual throughput target at the rail terminal (SRTO) is 2 million TEU, but for the near future the target is 1 million TEU. This study uses a simulator to examine the unit numbers, deployment, flow lines, and operational methods of cargo handling equipment, asks what should be introduced in addition to the current equipment (2 RMGs, 1 RTG), and examines what operational changes could produce the most efficient operations. While there is limited storage space at the existing container terminal at Laem Chabang Port, the study also considers ways to make optimal use of the extensive container storage space already available at the SRTO.

While not yet common in Japan, the use of simulators has become common overseas at the planning stages to determine the layout of container terminals, optimize operations, and make the transition to automation.

(1) Development of model for simulator and setting of parameters for cases

Based on the parameters used in the simulation model developed last year (see Table 1, Table 2), the model was revised this year through a series of briefings (technical meetings) with PAT. An iterative trial-and-error process with the simulator used the flow shown below to determine the optimal unit numbers and deployment of each type of cargo handling equipment.

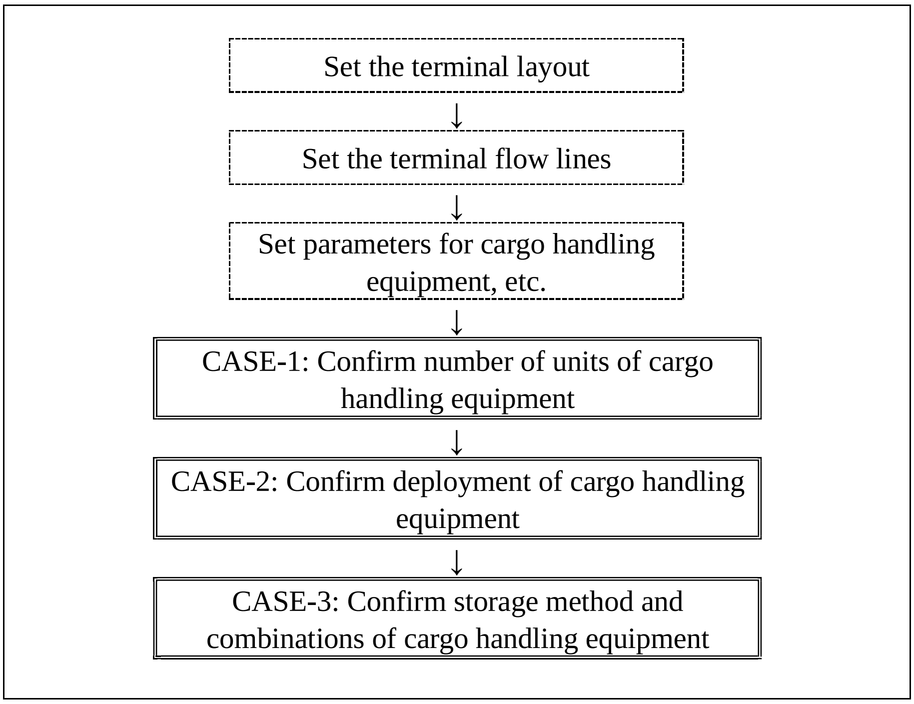


Figure 8: Flow for consideration using simulator

Table 6: Simulation model (SRTO)

Equipment	Parameters
Rail terminal	Layout: As shown in Figure 10 IN gate: 2 locations OUT gate: 2 locations * Flow lines within the terminal are shown in Figure 9. Rail (train) tracks: 6 tracks * Each track can accommodate 2 trains, with the 4 outer tracks for loading and 2 inner tracks for bringing trains in.
Trains	Each train: 32 cars (64 TEU) 1 RMG is assigned to 1 train.
Trailers	100 trailers available Of which 4 yard trailers are allocated to each RMG, and the remainder are external trailers.

* All are 40-foot containers (assuming 20-foot containers are handled by twin lifts).
* The assumed import/export ratio is 50:50 (based on actual data).

Figure 9: Flow lines in rail terminal

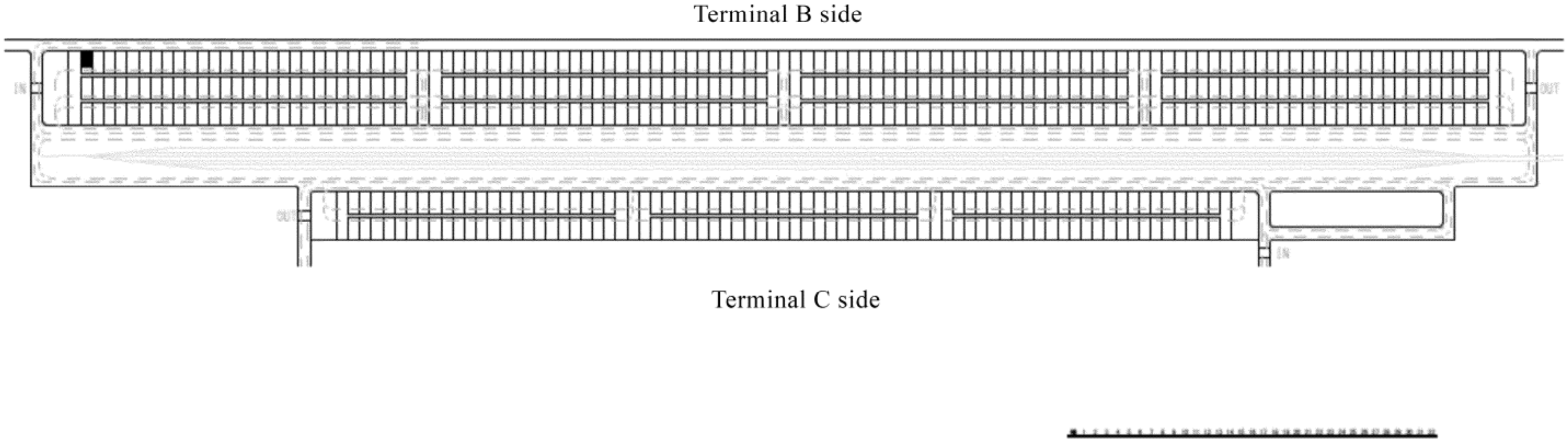


Figure 10: Rail terminal layout

Table 7: Parameters for cargo handling equipment, etc.

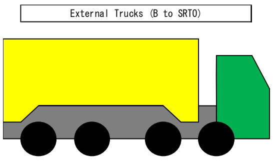
Equipment	Parameters
RMG	Travel speed: 7.2 km/h (2m/s) Cycle time: 134 s/move (including travel)
RTG	Travel speed: 7.2 km/h (2m/s) Cycle time: 92 s/move Handling time: 180 s (layer 1), 120 s (layer 2), 60 s (layer 3), 0 s (layer 4) * External trailers only
Trains	Speed within terminal: 30 km/h
Trailers	Speed within terminal: 30 km/h

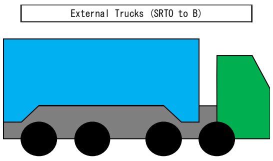
For cargo handling equipment, a combination of 1 RMG, 1 RTG and 4 trailers is counted as one group for repositioning containers between rail and storage areas. It is assumed that RTGs and trailers would be prepared separately for cargo handling equipment assigned to repositioning of containers coming from/to SRTO.

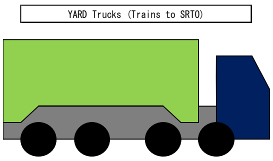
In the simulation, containers are color-coded as shown in Table 8 to more easily understand trailer flows.

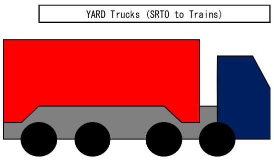
Table 8: Color coding of containers by purpose

Purpose	Color coding of containers in simulation
Import	External terminal→SRTO 🟨 Yellow
Export	SRTO→External terminal 🟦 Blue
Inbound	Rail→SRTO 🟩 Green
Outbound	SRTO→Rail 🟥 Red









To maximize the handling capacity of the SRTO, repositioning for rail was given the top priority, and the storage area for repositioning for rail was set as the block as close to the tracks as possible. With regard to train operation, to achieve 1 million TEU throughput, scheduled operations were set as 1 train arrival and 1 train departure per hour. [1 train set (64 TEU) × 2 trains (arrival and departure) × 24 hours × 365 days = 1,121,280 TEU > 1 million TEU]

(2) Case studies done by simulation

This study was conducted with three cases examined (CASE-1, CASE-2, CASE-3) in accordance with the flow shown above.

At a container terminal the handling count (number of moves per hour) and operating rate (loading time + travel time per hour) of cargo handling equipment depends on the operation methods and types of containers being handled (ratios of local cargo and transshipment cargo, etc.); typical numbers are 20 to 30 moves per hour for handling count and 50% to 60% for operating rate, and those numbers provide a measure for evaluation. The simulations in this study recreate 24-hour operations, so they do not include rehandling for the next day’s loading, such as changing the stacking order of containers stored in the terminal, or moving containers to other storage blocks. The volume of rehandling varies with operational methods being used, but for the cases considered here, the evaluations were done by adding about 10% to the RTG operating rate as the rehandling work volume. As for the actual operating rate, the assessment was done with about 65% set as a reasonable number, considering factors such as maintainability or serviceability of cargo handling equipment.

The next section provides a review of the results for each case considered.

CASE-1 (4 RMGs, 18 RTGs, 1 million TEU/year)

The simulation was done with an allocation of 18 RTGs to all 18 blocks of storage space in the rail terminal (SRTO) and use of the entire area.

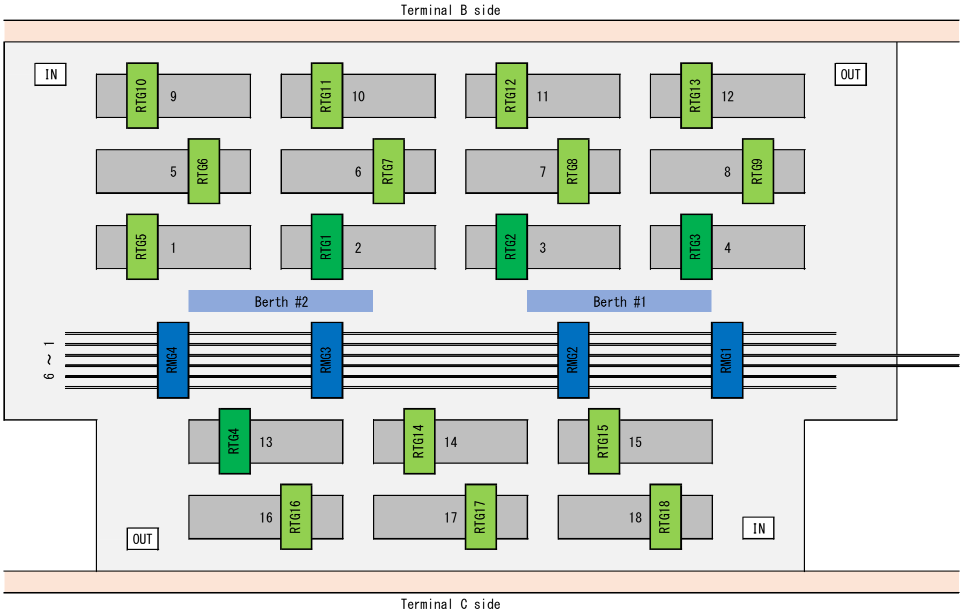


Figure 11: CASE-1

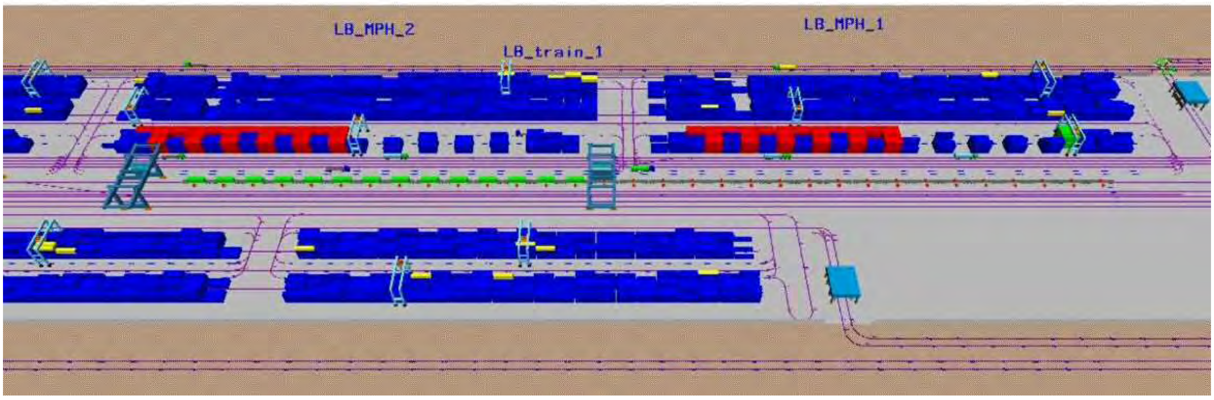


Figure 12: CASE-1 simulation

The simulation result for RMGs (4 units) shows the handling count at about 22 to 25 moves per hour, and the allocation seems to be reasonable. However, for RTGs (18 units), the handling count is about 3 to 5 moves and the operating rate is extremely low at 14% to 28%. Thus, it is possible to handle 1 million TEU per year, but there appears to be an excess of cargo handling equipment (number of units).

CASE-2 (4 RMGs, 12 RTGs, 1 million TEU/year)

Moving ahead from CASE-1, a simulation was conducted with 12 instead of 18 RTGs. The entire storage area was used, and as shown in the figure below, each RTG moves in more than one zone.

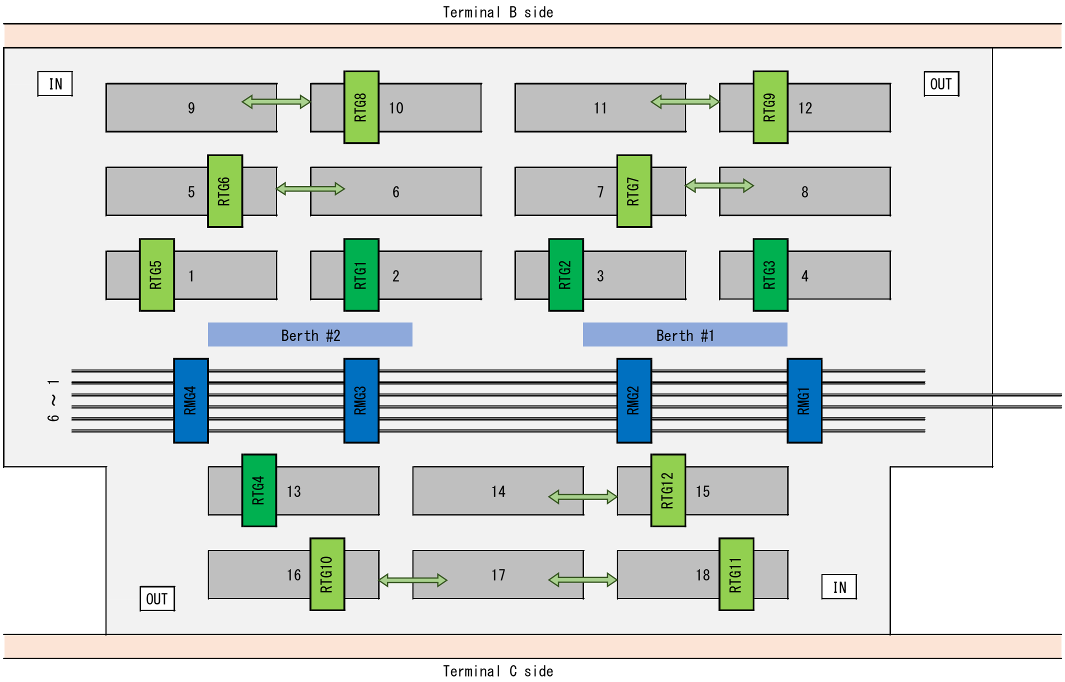


Figure 13: CASE-2

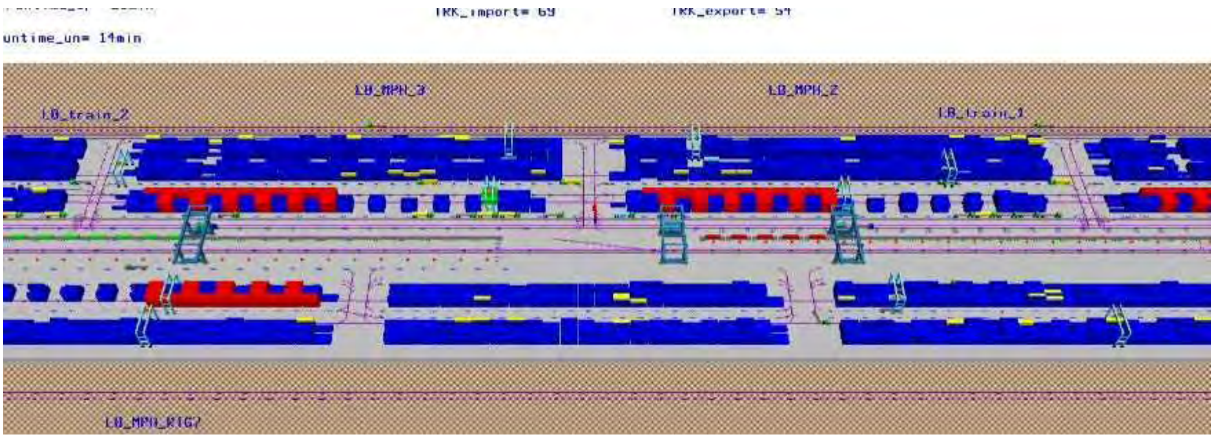


Figure 14: CASE-2 simulation

Reviewing the simulation results with a focus on the RTGs, the handling count ranges from about 4 to 10 moves per hour, but the operating rate ranges widely, from 27% to 92%. One factor behind the high operating rate is that compared to CASE-1 (with RTGs placed in every block and travel distance of about 6 to 15 km), in CASE-2, each RTG repositions cargo in multiple blocks, resulting in very large travel distances, ranging from 16 km to 91 km. Travel distances of 91 km per day are not realistic.

CASE-3 (4 RMGs, 10 RTGs, 1 million TEI/year, Case-A, B, C)

Moving ahead from CASE-1 and CASE-2, the CASE-3 simulation was done with the following points reflected.

- Confine the amount of storage space used, to match throughput
- Create zones for storage space, based on purpose of zone
- Create more than one pattern for allocation of cargo handling equipment to discover the case with the optimal allocation

Regarding the purpose-based zoning of storage space, although the flow lines become more intricate when the area used is confined, the aim is to simplify the flow lines by creating zones for storage space based on purpose of use (import/export, inbound/outbound).

In addition, as shown in Table 9, we created 3 sub-cases (A, B, C) in this model to reflect different patterns for allocation of cargo handling equipment and to discover the optimal case.

Table 9: Area zoning

	Throughput	RMG (units)	RTGs moving cargo from rail	RTGs moving cargo to/from other terminals (units)
Case-A	500,000 TEU/year	2	2	2
Case-B	250,000 TEU/year	1	2	2
Case-C	250,000 TEU/year	1	1	2

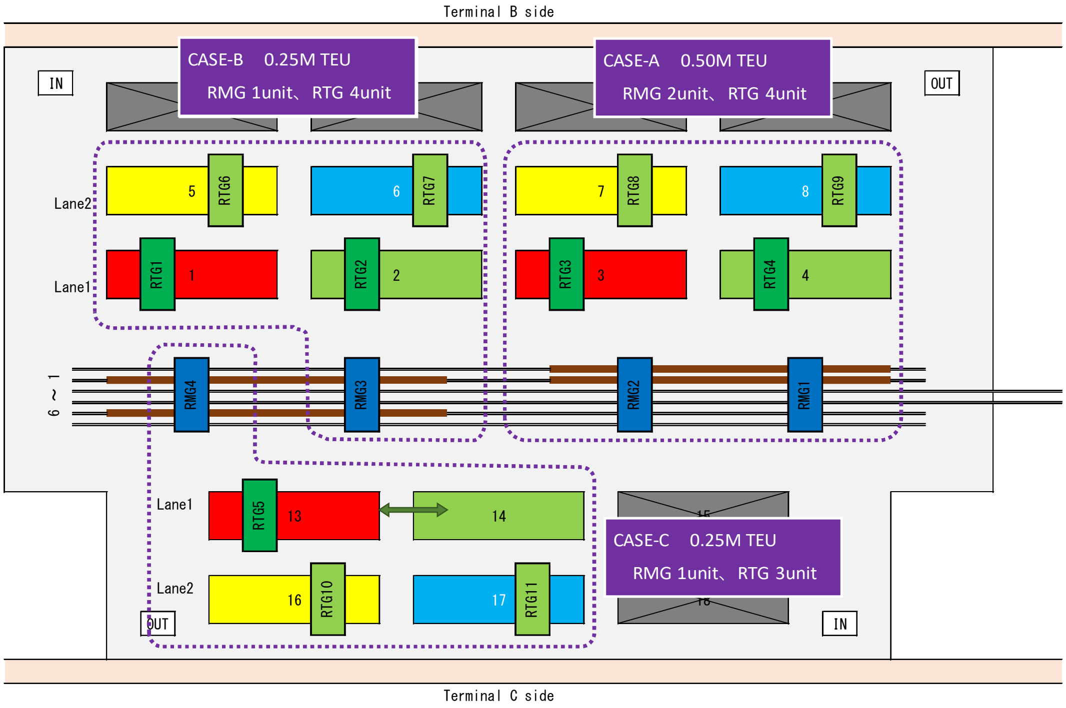


Figure 15: CASE-3

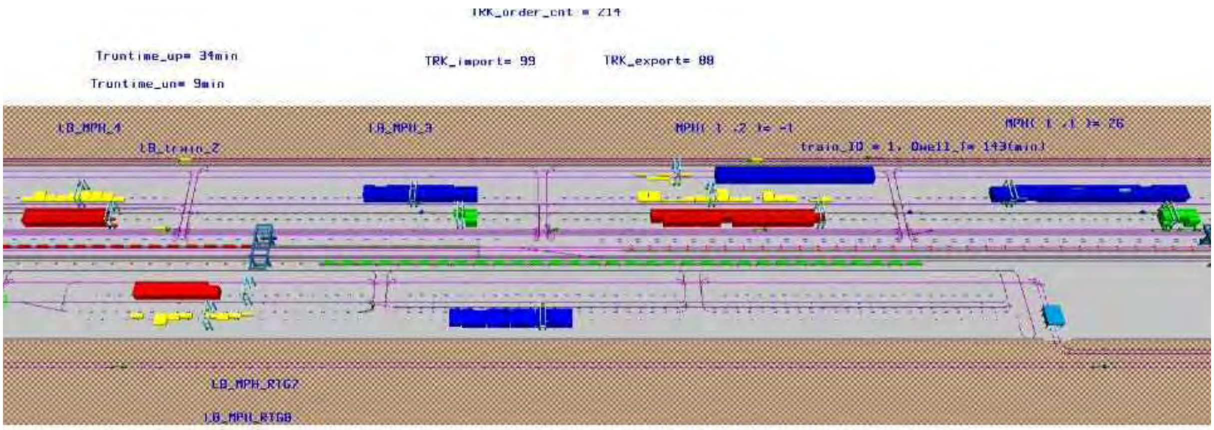


Figure 16: CASE-3 simulation

The simulation results are provided in Table 10.

In Case-A the operating rates for RTGs moving cargo to/from external terminals were 65% to 81%, which are unrealistic numbers. Meanwhile, in Case-B, the operating rate for moving cargo from rail was extremely low at about 20%, which is not considered to be efficient.

In Case-C, RTG operating rates for moving cargo to/from rail and for moving cargo outbound range from 28% to 41%, travel distances are short, and the variation is also low. Considering rehandling, the operating rate is about 50%, which could generally be considered reasonable.

Table 10: CASE-3 results

CASE	RMG	RTG Lane1	RTG Lane2	Target (TEU/Year)	RTG 1unit Average (Lane1 : RTG - RMG)			RTG 1unit Average (Lane2 : RTG - External Trucks)		
					Handling Count (move/Day·unit)	Traveling distance (km/Day·unit)	Operating Rate (24h)	Handling Count (move/Day)	Traveling distance (km/Day·unit)	Operating Rate (24h)
A	2	2	2	500,000	384.0	0.30	**41.1%**	409.0	28.61	**73.2%**
B	1	2	2	250,000	192.0	0.20	**20.6%**	234.0	8.76	**38.0%**
C	1	1	2	250,000	320.0	3.36	**36.0%**	214.0	9.11	**35.2%**

(Note: The operating rate is the value before considering rehandling.)

(3) Summary of simulation results

Cargo handling efficiency

This section provides a summary of simulation results for CASE-1 to CASE-3.

The most efficient operations are in CASE-3 (C). Specifically, the main points are as follows.

* The area used is confined based on throughput.

* Zones are created in the storage area based on purpose of the zone.

* Cargo handling equipment is combined into sets of 1 RMG and 3 RTGs.

* The annual throughput per set is about 250,000 TEU.

Thus, 4 sets of cargo handling equipment would handle 1 million TEU per year, and 6 sets 1.5 million TEU per year.

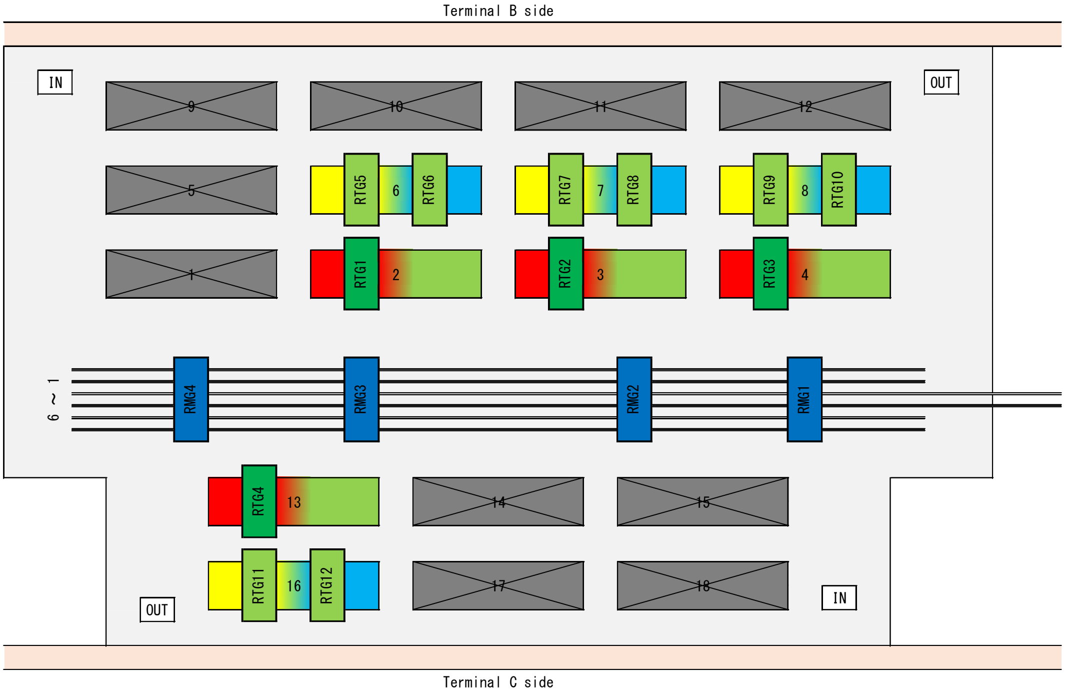


Figure 17: Most efficient cargo handling method and equipment allocation to handle 1 million TEU per year (concept)

Minimizing rehandling operations

In the simulation done in this study, rehandling for the next day is not included, and for assessment, 10% is added to the operating rate as the rehandling portion. Rehandling work actually does arise, but limiting that work as much as possible leads to better efficiency.

In the simulation, if the storage area for cargo handling to/from rail is assigned to the first row storage block and always kept in that block, rehandling work becomes necessary to reposition all containers from the second row to the first row (in the area for rehandling to/from the external terminal) to prepare for the next day, and that approach is inefficient. However, since the SRTO terminal operates 24-hours a day, there is generally no extra time available.

Thus, we considered how to minimize rehandling by daily alternation of the function of the rows in the storage block for handling rail cargo, using row 1 on day 1, row 2 on day 2, row 1 on day 3, and so on. This approach further increases efficiency and helps reduce GHG emissions from cargo handling operations in the yard.

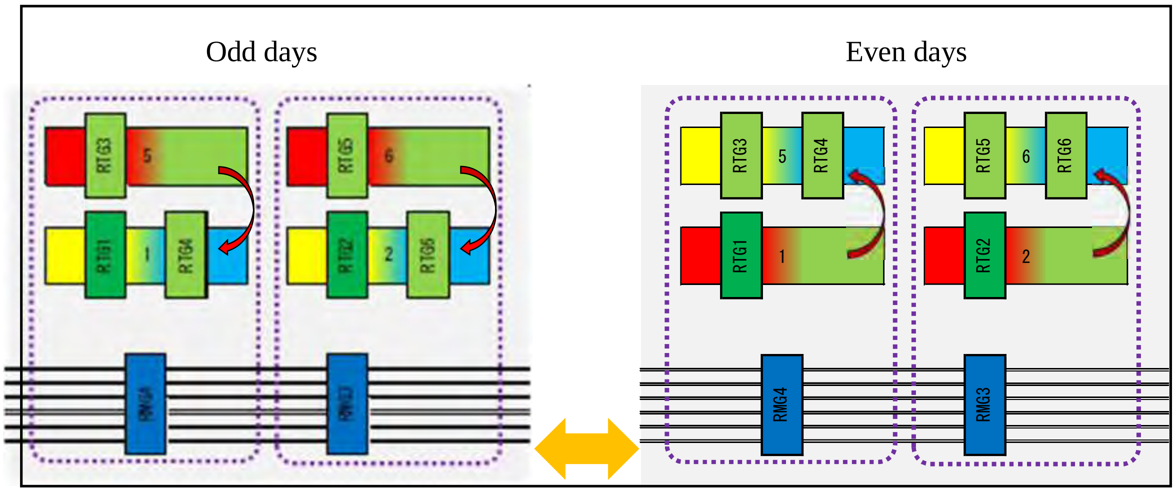


Figure 18: Concept of operation method to reduce rehandling

Flow lines and travel distances

Here we also summarize the flow lines and travel distances to achieve the above-stated cargo handling efficiency and minimize rehandling.

For RMGs, the range of movement is confined to their rails so there are no issues with flow lines, and the travel distances for sequentially loading and unloading containers are minimized.

For RTGs, there are no major issues as we selected the most suitable method from the simulation results, but if the role of the storage block is changed every day to minimize cargo handling, a lane change will be required each day to reposition the RTG to another block accordingly. Since the RTGs to be introduced at the SRTO are cable reel type electric RTGs, the cable has to be disconnected when changing lanes and separate power is needed to change lanes. In addition, the cable of the one RTG already being used will hinder the flow lines of trailers since it the cable lays exposed on the pavement, so some improvement is needed.

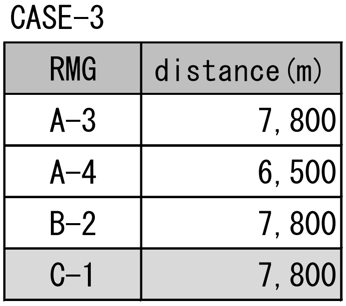
Photo 6: Power supply equipment for electric RTGs at the rail terminal (existing system)

Regarding trailers as well, cargo handling efficiency decreases proportionally to any increase in travel distances. In addition, as the travel distances increase, the life cycle cost of trailers increases, and energy consumption also increases, which is disadvantageous both environmentally and economically. As a result, while the rail terminal (SRTO) has a large yard, it is much more efficient to confine the storage space to match throughput, and to deploy the cargo handling equipment within that area, and this is also more efficient for trailers as well.

For this simulation the travel distances of trailers in each case are also calculated. By using these numbers, it becomes possible to estimate the travel distance of trailers in CASE-3 which was the most efficient, as well as CO2 emissions associated with trailers.

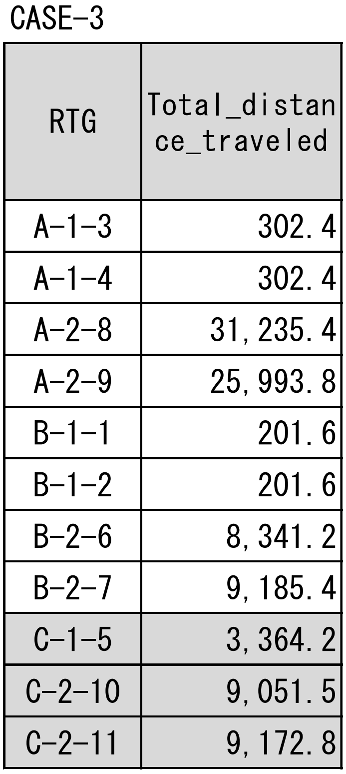
The travel distances for each unit of cargo handling equipment in CASE-3 are summarized below.

Table 11(1): Travel distance of each cargo handling equipment in CASE3



CASE−3

RMG	distance(m)
A−3	7,800
A−4	6,500
B−2	7,800
C−1	7,800



CASE−3

RTG	Total_distance_traveled
A−1−3	302.4
A−1−4	302.4
A−2−8	31,235.4
A−2−9	25,993.8
B−1−1	201.6
B−1−2	201.6
B−2−6	8,341.2
B−2−7	9,185.4
C−1−5	3,364.2
C−2−10	9,051.5
C−2−11	9,172.8

Table 11(2): Travel distance of each cargo handling equipment in CASE3

YARD TRACK

TRK_no	distance(1day)
1	130,067 m
2	130,067 m
3	130,067 m
4	134,747 m
5	130,697 m
6	126,017 m
7	126,017 m
8	126,017 m
9	143,400 m
10	143,400 m
11	143,400 m
12	148,080 m
13	135,052 m
14	135,012 m
15	133,062 m
16	132,373 m
TOTAL	2,147,474 m
	2,147 km
	1,472 unit
	1.46 km/unit

EXTERNAL TRACK

TRK_no	distance
1	2.558 km
2	1.874 km
3	2.556 km
4	1.854 km
5	2.558 km
6	2.558 km
7	1.874 km
8	2.556 km
9	1.854 km
10	2.558 km
11	2.548 km
12	2.556 km
13	2.548 km
14	2.558 km
15	1.874 km
16	1.854 km
17	2.556 km
18	1.854 km
19	2.558 km
20	1.874 km
…	…
1,689	2.556 km
1,690	2.558 km
1,691	1.874 km
1,692	2.548 km
1,693	2.556 km
1,694	2.558 km
1,695	2.548 km
1,696	2.548 km
1,697	2.558 km
1,698	2.556 km
1,699	2.558 km
1,700	2.556 km
1,701	1.874 km
1,702	2.558 km
1,703	1.874 km
1,704	2.558 km
1,705	1.874 km
1,706	2.556 km
1,707	2.558 km
1,708	1.874 km
AVE=	2.383 km

(4) Information gathering on further efficiency improvements by introducing automation technologies (remote operation)

As stated above, for 1 million TEU per year the best arrangement is to have 4 sets consisting of 1 RMG and 3 RTGs each, and for 1.5 million TEU per year, 6 sets would be optimal. The conceptual image for a 6-set arrangement is shown Figure 19.

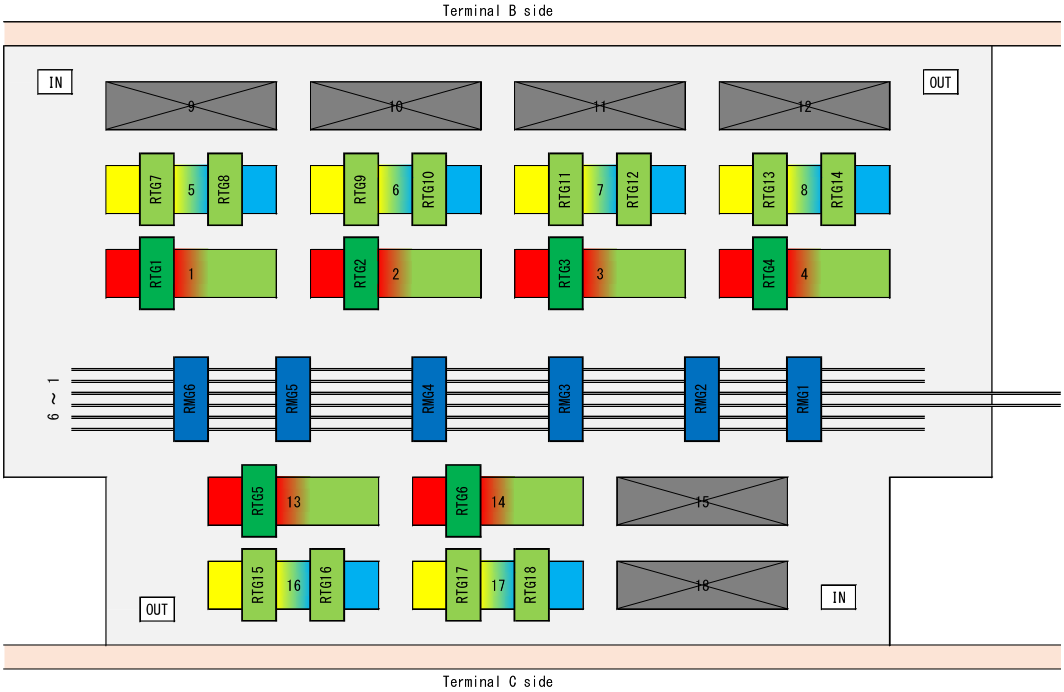


Figure 19: Most efficient cargo handling method and allocation of equipment to handle 1 million TEU per year (concept)

The use of 6 sets would require a considerable amount of equipment, at a total of 6 RMGs and 18 RTGs. If the 4 RTGs at the coastal terminal (Coastal-A) are also included the total comes to 22 RTGs. If the plan is to increase to such a scale, the automation (remote operation) of RMGs and RTGs could lead to cost merits and improved safety.

Thus, information was gathered relating to automation (remote operations).

Trends in Japan

Due to opposition by labor unions and other considerations, the Tobishima Container Terminal in Nagoya is currently the only automated terminal in Japan, and some time has already passed since it launched services in 2005. However, in October 2020, though there had been some concern about the introduction of remote-operated RTGs at container terminals in Japan, labor and management reached agreement on matters including that they would confirm the need to introduce remote-controlled RTGs, on the condition of securing employment and occupations and securing the necessary port fees. In December, central labor union approved and confirmed the confirmation which was reached by district labor and management for the three ports of Yokohama, Shimizu, and Kobe, with regard to the introduction of remote-controlled RTGs. Accordingly, the Ministry of Land, Infrastructure, Transport and Tourism announced the selection of these three ports for a project to provide support this fiscal year for the introduction a total of 42 remote-controlled RTGs.

As part of the Ministry's Ports and Harbours Bureau FY2021 budget, 45.4 billion yen (1.02 times the previous year) were allocated for items related to Strategic International Container Ports, a pillar of the national ports and harbors policy. The funds are aimed at developing strategic ports and, with the COVID-19 pandemic in mind, are intended to continue upgrading container terminals in Japan in order to bolster the capacities of "AI terminals that support people," and so on. "Advanced demonstration projects" to develop AI terminals will continue to promote various efforts and will also provide support for the introduction of remote-controlled RTGs in a program that was established for operators, since the previous fiscal year.

Based on these recent developments, the moves toward remote-controlled operations could soon accelerate significantly in Japan.

Potential to introduce automation technology in Thailand

The only terminals in Thailand using automation technologies are at the Hutchison Terminals D-1 to D-3 at Laem Chabang Port. Remote-controlled container cranes and RTGs have been introduced and are operating at those terminals, and last year testing began with automated operation of electric yard trailers. In both cases the equipment comes from Chinese manufacturers.

Also, it is assumed that automation technologies will be introduced at Terminal E and Terminal F to be built in Phase 3 at Laem Chabang Port, and at a new container terminal currently being considered for Bangkok Port.

For the SRTO and Coastal-A terminals featured in this study, operations section staff of PAT have expressed an interest in introducing automation technologies, but detailed discussions have yet to begin. As stated above, if the SRTO reaches 1.5 million TEU per year and Coastal-A reaches 300,000 to 500,000 TEU per year, the anticipated benefits of automation would be as follows:

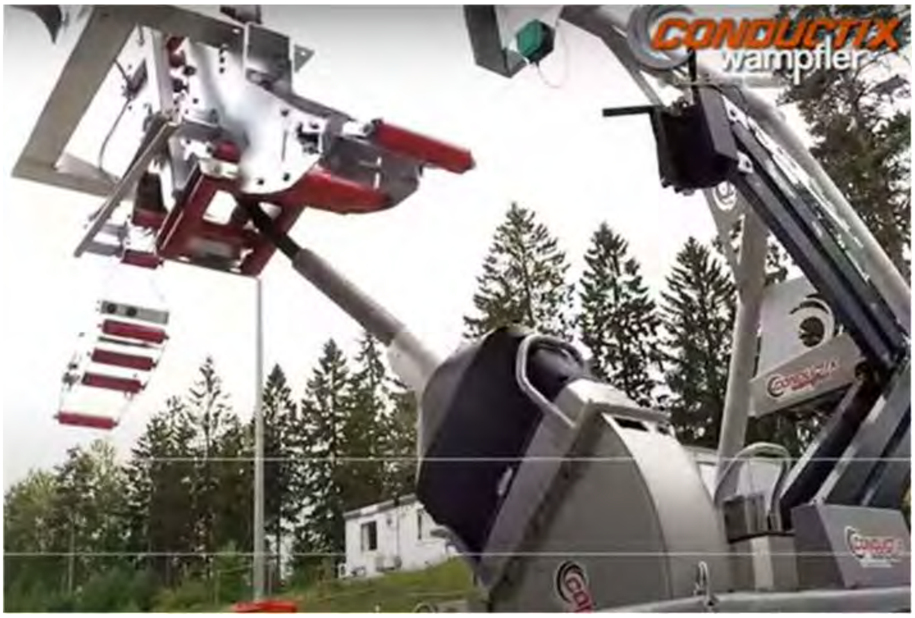
- Control of terminal costs by introduction of automated systems
- Improved efficiency and productivity (improved processing capacity, labor saving)
- Improved safety (achieving stable cargo handling capacity without being affected by environmental conditions)
- Improved labor environment (shift from outdoor crane work to indoor work)
- Reduced environmental impacts, reduced CO_2 emissions

However, some issues arise when considering automation, such as upgrades for automation of existing equipment, and issues related to procurement methods if PAT does the upgrades itself (constraints under the Procurement Act).

Issues relating to upgrades for automation of existing equipment

When new cargo handling equipment is being procured, it is possible to plan in advance, and design and fabricate the sensors and camera communications equipment needed for automation; however, it is difficult to upgrade existing equipment already in use because specifications may differ depending on the type of equipment. In particular, where information on specifications is not published, upgrades may not be feasible in some cases. Thus, if possible, in the near future, it would be desirable to determine the specifications for the possible introduction of automation technologies. However, this is difficult without an indication of what manufacturers and technologies will be used.

Also, the RTGs already delivered to the SRTO are cable-type electric RTGs, as stated above, and the cables must be disconnected and reconnected for lane changes. It is difficult, from the safety perspective, to have workers enter an automated area just for that work, and there are also efficiency impacts with this type of RTG, such as having to temporarily interrupt cargo handling. There may be ways to address these issues. For example, cable disconnection and reconnection could be done automatically, although the technology is still under development.



Source: Conductix Wampfler website

Figure 20: Example of automatic connection/disconnection equipment for power supply cables

Also, for the introduction of automation technologies, sensors and cameras must provide information in real time to the operations room that controls remote operations, but data volume is enormous, so the only current option is to transmit data via physical wiring. However, introducing automation at existing terminals would require new data lines to be in buried conduits, etc. For alternatives, 5G technologies may be able to provide solutions in defined local areas.

Issues related to procurement methods if PAT does the upgrades itself (constraints under the Procurement Act)

The introduction of automation technologies is a major project that could take several years to accomplish and require a variety of upgrades, such as the procurement of additional cargo handling equipment, modifications to existing equipment, upgrades to communications equipment, the installation of remote-control consoles, the development of automation software, and linking up existing terminal operation systems and gate systems, etc. If this is done by a private operator that is responsible for operations, various approaches are possible, but if done by PAT itself as a public entity, there would be various issues including constraints under Thailand’s Procurement Act.

3.3 Consideration of GHG Emission Reduction Effects of Modal Shift

(1) Consideration of GHG Emission Reduction Effects of Introducing Energy-saving Cargo-handling Equipment

GHG Emission Reduction Effects of Introducing Electric RTGs

Regarding RTGs to be added in response to increased cargo volumes handled at the rail terminal (SRTO), this study examined the case of replacing diesel with electric RTGs.

The RTGs considered for analysis assumed the typical specifications for models that can stack containers in six rows, six high, with a rated capacity of 40.6 tons.

The results are provided in Table 12.

Table 12: Results of review for RTGs

		Electric RTGs
Specs	Quantity	1 unit
	Rated load capacity	40.6 t
	Containers	Rows 6+1, stacked 1 over 6
	Legal durable years (statutory service life)	12 years
Return on investment	Initial cost (A)	47,287,356 THB (164,559,998 JPY)
	CO_2 emission reduction (B)	4,514 t-CO_2/12yrs (376.2 t-CO_2/yr)
	JCM financing (C)	5,154,321 THB (17,937,037 JPY)
	JCM cost/benefit (C)/(B)	1,141 THB/t-CO_2 (3,970 JPY/t-CO_2)
	JCM financing ratio	10.9%
	Running cost savings (Reduced fuel costs)	10,062,850 THB/12yrs (35,018,718 JPY)
	Evaluation	good

Note: The exchange rate used for this study is 1 THB = 3.48 JPY.

To introduce electric RTGs, the initial cost per unit is approx. 47 million THB, CO_2 emission reductions approx. 4,514 t-CO_2/12 years, JCM financing approx. 5.2 million THB, JCM cost/benefit approx. 1,141 THB/t-CO_2 (approx. 3,970 JPY), JCM financing ratio 10.9%, and running cost savings approx. 10 million THB/12 years.

To introduce electric RTGs, additional infrastructure is also needed in order to supply electricity to the RTGs (transformers and cables, buried conduits, and special equipment to connect to RTGs, etc.), so a more detailed review will be needed once the operators have been decided in relation to automation (remote operation).

(2) Consideration of GHG Emission Reduction Effects of Modal Shift

1) Overall Image of Modal Shift

Container freight in this study currently relies mainly on truck transport, so this study had the aim of examining the GHG emission reduction effects of a modal shift to rail between the rail terminal (SRTO) at Laem Chabang Port and Lat Krabang ICD, and modal shift to coastal transport between the Coastal-A terminal at Laem Chabang Port and Bangkok Port.

The overall image of the modal shift in this study is depicted in Figure 21.

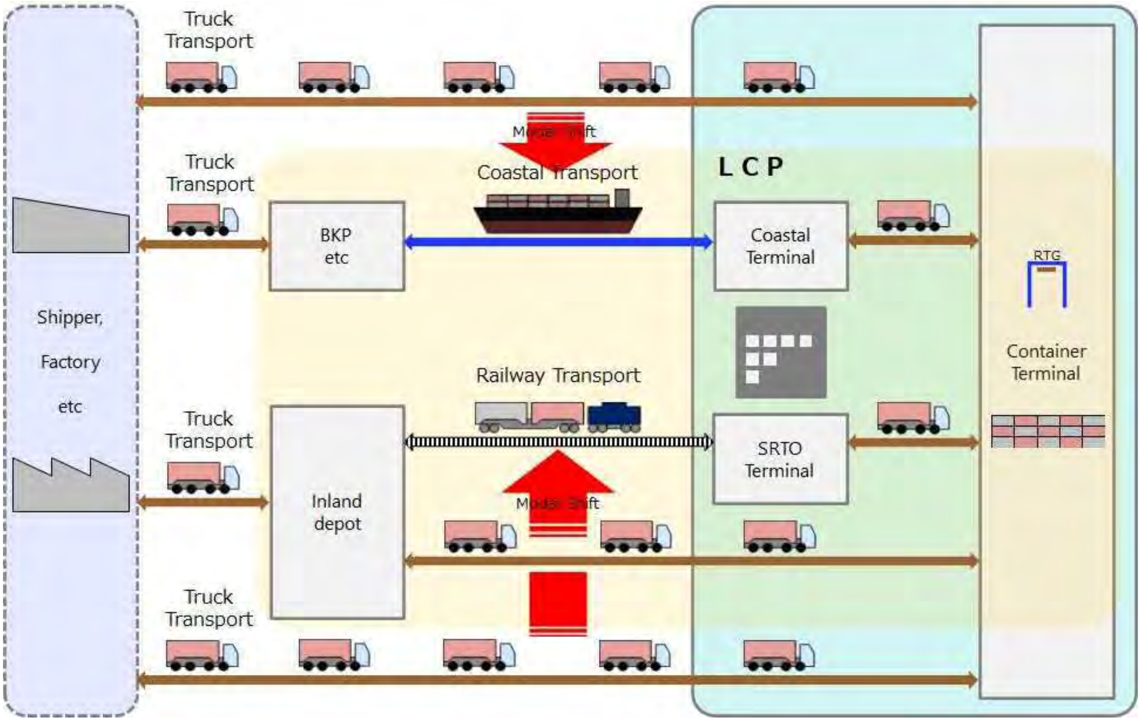


Figure 21: Overall image of modal shift considered in this study

2) Basic Formula for Calculating CO2 Emission Reductions from Modal Shift

The basic formula for calculating CO2 emission reductions from a modal shift is described below.

Modal Shift to Rail

CO2 emission reduction = A - B

A: CO2 emissions by truck

= CEF*[1] of trucks (t-CO2/ton-km) × transport distance of trucks (ton-km/year)

B: CO2 emissions by railway (*R*)

= CEF of *R* (t-CO2/ton-km) × transport distance of *R* (ton-km/year) + E_{opt}*[2] + E_{tkt}*[3]

Modal Shift to Coastal Transport

CO2 emission reduction = A - B

A: CO2 emissions by trucks

= CEF of trucks (t-CO2/ton-km) × transport distance of trucks (ton-km/year)

B: CO2 emissions by coastal ship (*CS*)

= CEF of *CS* (t-CO2/ton-km) × transport distance of *CS* (ton-km/year) + E_{opt} + E_{tkt}

*1: CEF = Carbon Emission Factor

*2: E_{opt} = CO2 emissions by operational facilities in terminal

*3: E_{tkt} = CO2 emissions by trucks in terminal

This study assumed a container throughput of 1 million TEU/year at the SRTO, and 3 million TEU/year at Coastal-A. Container weights were assumed to be 16 t/container for 20-foot containers and 18 t/container for 40-foot containers, based on statistics from interviews with PAT and Terminal B operators.

In the case of a modal shift to rail, new emissions that must be considered include “CO2 emissions from operations within the SRTO” and “CO2 emissions from truck transport from SRTO to each terminal.” In the case of a modal shift to coastal transport, new emissions that must be considered include “CO2 emissions from operations within Coastal-A” and “CO2 emissions from truck transport from Coastal-A to each terminal.” If these CO2 emissions are about 5% (or less) of total emissions, they would generally not be counted, as they would be considered “negligible,” but this study did include them in the analysis of CO2 emissions. Travel distance data for cargo handling equipment within the SRTO terminal, obtained from simulation analysis, was used to calculate CO2 emissions from operations within the terminal.

3) Determination of CO2 Emission Factors for Trailers, Coastal Vessels, and Rail

For this study, we investigated the CO2 emission factors (t-CO2/t-km) published by Thai governmental entities for rail, coastal vessels, and trucks, for the scenarios of modal shift to rail between Laem Chabang Port SRTO and Lat Krabang ICD, and a shift to coastal vessel between Coastal-A at Laem Chabang Port and Bangkok Port.

We learned that the Thailand GHG Management Organization (TGO) has published CO2 emission factors for Thailand. Table 13 shows the CO2 emission factors published by TGO.

Table 13: CO2 emission factors published by TGO for trucks, ships, and trains.

Truck (excerpt for 40-foot TEU size, 18-wheel, 32-ton max capacity)[1]

No.	Vehicle Type	Performance	Loading (%)	Fuel	Unit	EF (kgCO2e/unit)
146	Semi-trailer (Flatbed/side wall)  	Common use	0%	Diesel	km	0.8215
147		Common use	50%	Diesel	tkm	0.0803
148		Common use	75%	Diesel	tkm	0.0577
149		Common use	100%	Diesel	tkm	0.0449
150		Heavy duty	0%	Diesel	km	0.9963
151		Heavy duty	50%	Diesel	tkm	0.0914
152		Heavy duty	75%	Diesel	tkm	0.0655
153		Heavy duty	100%	Diesel	tkm	0.0523
162	Semi-trailer (container) 	Common use	0%	Diesel	km	0.8684
163		Common use	50%	Diesel	tkm	0.0802
164		Common use	75%	Diesel	tkm	0.0568
165		Common use	100%	Diesel	tkm	0.0443
166		Heavy duty	0%	Diesel	km	1.0657
167		Heavy duty	50%	Diesel	tkm	0.0975
168		Heavy duty	75%	Diesel	tkm	0.0687
169		Heavy duty	100%	Diesel	tkm	0.0533

Note: Reference for truck = Thai National LCI Database, TIIS-MTEC-NSTDA

Ships[1]

No.	Vehicle Type	Unit	EF (kgCO2e/unit)	Reference
256	Transport, barge (river)	tkm	0.0446	Ecoinvent 2.2, IPCC 2007 GWP 100a

Rail[2]

No.	Vehicle	Unit	EF (kgCO2e/unit)	Reference
N/A	Train	tkm	0.111	Train I, IDEMAT

Regarding the CO2 emission factors for rail, since the data sources are dated from 2012, we inquired with the TGO and National Metal and Materials Technology Center (MTEC) regarding the availability of more recent CO2 emission factors and any plans for updates. We learned that there are no plans for updates to the latest numbers.

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[1] TGO, Emission Factors, February 2020: http://thaicarbonlabel.tgo.or.th/admin/uploadfiles/emission/ts_117a1351b6.pdf

[2] TGO, Guideline for Carbon Footprint Organization, page 70, 2011: http://library.psru.ac.th/GreenLib/files/แนวทางการประเมินคาร์บอนฟุตพริ้นท์ขององค์กร.pdf

With assistance from PAT, we obtained guidance from Dr. Jakapong Pongthanaisawan (associate professor at Chulalongkorn University), an expert in climate change countermeasures in Thailand's transport sector, and upon obtaining information on rail-related CO2 emission factors we learned that the State Railway of Thailand (SRT) had issued a new tender for 50 diesel locomotives in 2020, and that a consortium which includes Chinese companies had won the bid.

Based on these findings, considering that rail was not included in the list of CO2 emission factors published in 2020, that the latest published values for CO2 emission factors for rail in Thailand were from 2011, and that published numbers many not represent the current situation for rail transport in Thailand with new diesel locomotives, for this study it was decided to utilize CO2 emission factors for rail from available literature.

Based on a review of existing literature on CO2 emission factors for diesel locomotives, we confirmed that examples from Canada are suitable for this study. The "Locomotive Emissions Monitoring Program 2016" report published by the Railway Association of Canada details trends over the past 20 years, stating that the CO2 emission factor has dropped from 0.025 t-CO2/tkm in 1990 to 0.014 t-CO2/tkm in 2016.

Since the latest CO2 emission factors for diesel locomotives in Thailand were not available, for this study it was decided to use the above-stated CO2 emission factors for rail with reference to the Canadian report. To reflect uncertainty inherent in the use of these alternative numbers, we decided to estimate the GHG emission reduction effects using a range for the CO2 emission factor (between 0.025 t-CO2/tkm and 0.014 t-CO2/tkm).

4) Estimates of GHG Emission Reduction Effects of Modal Shift

The results of estimation of GHG emission reduction effects of modal shift are shown in Table 14. The estimated GHG emission reduction effect is 17,000 t-CO2/yr for a modal shift from truck[3] to coastal vessels at Coastal-A, and about 69,000 to 82,000 t-CO2/yr for a modal shift from truck to rail at the SRTO.[4]

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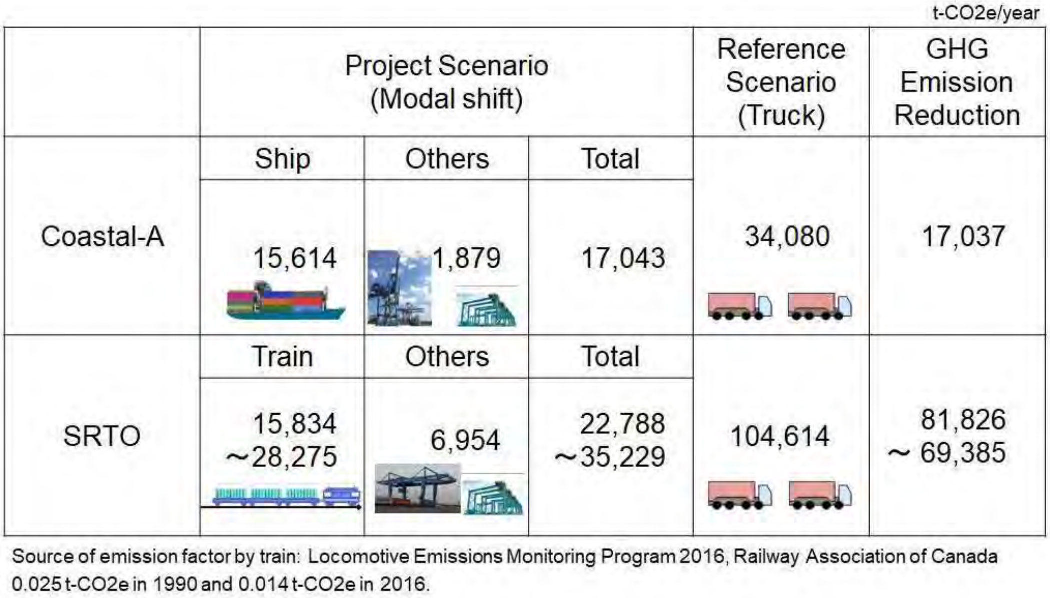
[3] Details such as load factors and travel distance for truck transport were determined with assistance from Japanese companies engaged transport-related operations in Thailand.

[4] "Others" in the figure include "CO_2 emissions from operations within the SRTO" and "CO_2 emissions from truck transport from SRTO to each terminal" for modal shift to rail, and "CO_2 emissions from operations within the Coastal-A terminal" and "CO_2 emissions from truck transport from Coastal-A to each terminal" for modal shift to coastal vessel. In both cases, the CO_2 emissions are less than emissions arising from vessels and from rail.

Table 14: Estimated GHG emission reduction effects of modal shift



t-CO2e/year

	Project Scenario (Modal shift)			Reference Scenario (Truck)	GHG Emission Reduction
	Ship	Others	Total		
Coastal-A	15,614	1,879	17,043	34,080	17,037
	Train	Others	Total		
SRTO	15,834 ～28,275	6,954	22,788 ～35,229	104,614	81,826 ～ 69,385

Source of emission factor by train: Locomotive Emissions Monitoring Program 2016, Railway Association of Canada
0.025 t-CO2e in 1990 and 0.014 t-CO2e in 2016.

3.4 Consideration of How to Increase Efficiency through Better Coordination between Rail and Inland Depot, etc.

(1) Information from State Railway of Thailand (SRT) and Lat Krabang ICD Operators, etc.

1) State Railway of Thailand (SRT)

Besides signing a contract with the SFR Joint Venture in August 2020 to procure 50 diesel-electric locomotives, the State Railway of Thailand (SRT) plans to issue a tender in early 2021 to procure 57 diesel-electric locomotives. Many of the locomotives currently being used are aged and have high GHG emissions, so replacing older cars gradually until 2025 can lead to improved operating efficiency, better on-time performance, and reduced GHG emissions.

After Lat Krabang there are plans for the inland depot and the laying of tracks and in anticipation of these plans, it may be useful to consider an inter-linked strategy at this stage.
However, as is evident from contract renewal delays at Lat Krabang, the Thai government wields significant influence, making it more difficult to make decisions in isolation. Also, strengthening coordination is not easy as it means more time is needed to make decisions.

2) Lat Krabang ICD

At Lat Krabang ICD there are plans to change from six modules to one, and early last year after a bidding process ALG (a consortium) obtained negotiating rights; however, operators continue to operate at their respective six modules, and as no contract had been settled yet.

Throughput at Lat Krabang declined slightly in 2020 due to COVID-19, so annual throughput is predicted at about 1.2 million to 1.3 million TEU. The ratio of rail use has also declined, to about 20%.

Based on interviews with concerned parties at the Lat Krabang ICD, no progress has been made subsequently with new contracts, and it appears SRT is unable to change the situation. Thus, it is unclear when operations will begin under ALG. Last year’s study mentioned that with the possible change in operations from six modules to one, new cargo handling equipment might be procured, as well as the introduction of remote operations, replacement of administrative buildings, gatehouses and storage structures, and the installation of new terminal communications equipment (including 5G networks), but it is still not possible to start working on details without the operator being firmly settled. Alternatively, it may become necessary to explore collaboration with SRTO in a scenario of continuing with the current arrangement of six modules.

3) Measures to Strengthen Coordination

Coordination efforts among the many stakeholders will be a crucial factor to promote a modal shift. Stakeholders in this context include companies involved in coastal shipping, the Coastal-A terminal, Lat Krabang ICD, State Railway of Thailand, and the rail terminal (SRTO) at Laem Chabang Port, as well as each domestic container terminal at Laem Chabang Port, and trucking companies, etc. Although there is still no progress with the signing of concession contracts at Lat Krabang ICD, the SRTO terminal, and the container terminal at Wharf B, we communicated to PAT about the special importance of coordination to promote modal shift, and recommended the creation of a forum for discussion.

Besides improving capacity at each facility, an important point to promote modal shift is the sharing of information about container handling by each of these stakeholders. There are various possible approaches, including the adoption of common systems, the development of systems with platform functions, and linking up these systems for better coordination. Such efforts would of course help to promote modal shift, but the sharing of container information could also help to increase actual trailer load ratios by having more trailers loaded with containers on their outbound trips after delivering containers to Laem Chabang Port on their inbound trips, and this too could reduce GHG emissions.

There would be costs incurred to introduce such systems, but it is important to evaluate the options in a comprehensive way by also considering how to make cargo handling more efficient, as well as costs that can be reduced by being more efficient, and CO2 emissions reductions.

3.5 Consideration of Support Measures to Promote Modal Shift

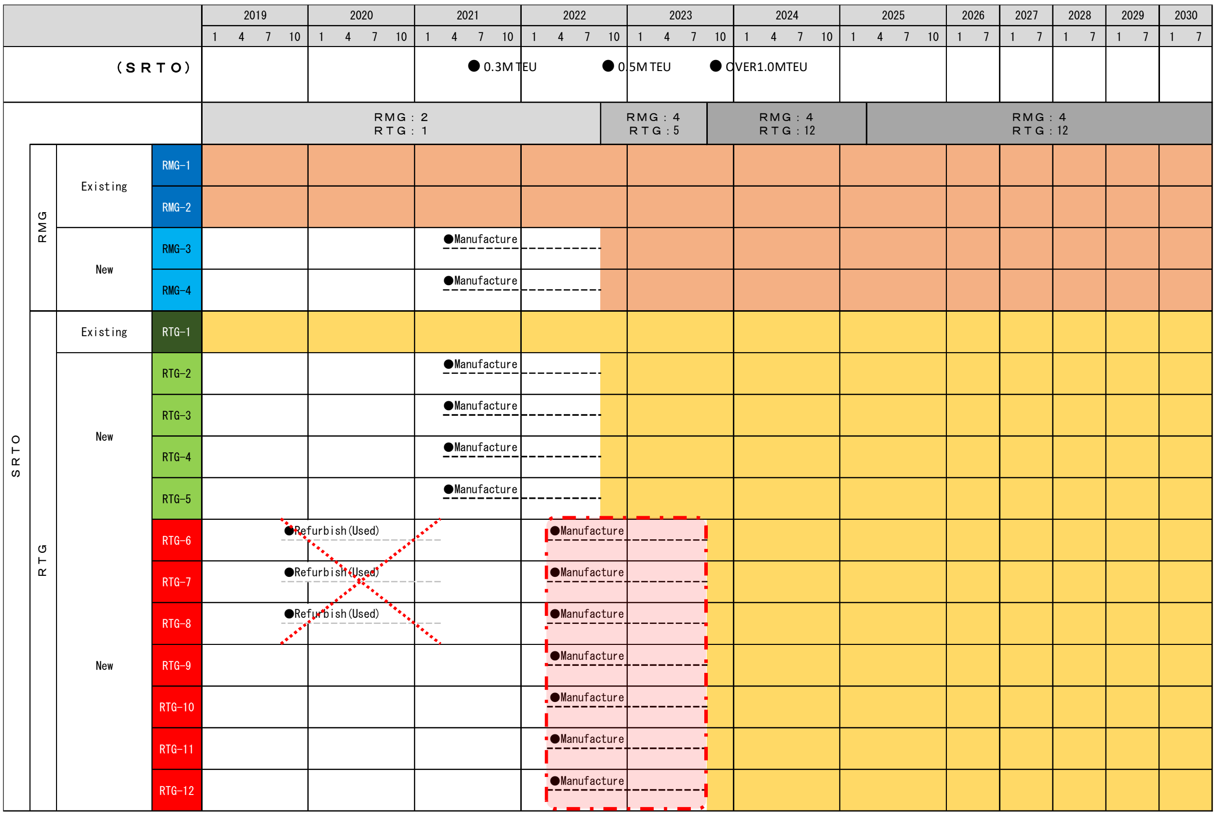
(1) Development of a Roadmap to Promote Modal Shift, and Summary of Approaches and Key Points to Realize the Roadmap

Introduction of Additional Cargo Handling Equipment to Promote Modal Shift

Among the terminals prepared for promoting modal shift at Laem Chabang Port, the shift to the coastal terminal (Coastal-A) has been proceeding gradually since service began last spring. There were plans for procurement of two additional RTGs, but due to various circumstances, two units that were being procured for Bangkok Port will be diverted here, so there is currently no need for additional capital investment for that purpose here. However, at the rail terminal (SRTO), due to a variety of factors, the services are still on a temporary basis, even though a few years have elapsed since construction was completed. In addition, the large yard space is still not being utilized effectively. Thus, it is crucial to consider mainly the SRTO for the introduction of additional cargo-handling equipment to promote a modal shift.

The following roadmap was developed with reference to the results of the simulation described further above as well as PAT's current procurement plans.

Table 15: Roadmap for promoting modal shift by introducing additional cargo-handling equipment



				2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
				1 4 7 10	1 4 7 10	1 4 7 10	1 4 7 10	1 4 7 10	1 4 7 10	1 4 7 10	1 7	1 7	1 7	1 7	1 7
（SRTO）						● 0.3M TEU	● 0.5M TEU	● OVER1.0MTEU							
				RMG : 2 RTG : 1			RMG : 4 RTG : 5	RMG : 4 RTG : 12		RMG : 4 RTG : 12					
SRTO	RMG	Existing	RMG-1												
			RMG-2												
		New	RMG-3			●Manufacture									
			RMG-4			●Manufacture									
	RTG	Existing	RTG-1												
		New	RTG-2			●Manufacture									
			RTG-3			●Manufacture									
			RTG-4			●Manufacture									
			RTG-5			●Manufacture									
		New	RTG-6	~~●Refurbish (Used)~~			●Manufacture								
			RTG-7	~~●Refurbish (Used)~~			●Manufacture								
			RTG-8	~~●Refurbish (Used)~~			●Manufacture								
			RTG-9				●Manufacture								
			RTG-10				●Manufacture								
			RTG-11				●Manufacture								
			RTG-12				●Manufacture								

(Key Points)

PAT already had a plan for the procurement of cargo-handling equipment listed in the new fiscal year plan that started October 2020, including 2 new RMGs, 4 new RTGs, and to refurbish 3 RTGs; however, based on the results of discussions in this chapter, the procurement of additional equipment is considered necessary to achieve the milestone throughput of 1 million TEU. Thus, while reconfirming various factors, including the existing plans and the actual status of tenders, it is necessary to make a transition to a new procurement plan. (The deadline for bidding on the refurbishment of 3 RTGs was in January 2020, but the results have not yet been announced. As for the new procurement of 2 RMGs and 4 RTGs, the public hearing has already been held, and one announcement of tender has been made. However, an announcement was later made to cancel the tender, and that was still the status as of the end of January 2021.)

Introduction of Technology for Automated Operations to Promote Modal Shift

Here we present a roadmap for the introduction of technology for automated operations to promote modal shift.

The introduction and operation of automation technologies and operate requires freight volume to be on a scale that justifies the additional investment. This plan was therefore designed to time the introduction of automation for the point when SRTO throughput reaches 1.5 million TEU. To achieve further economies of scale, besides introducing automation at Coastal-A, it is also assumed that remote operations will be controlled in the administration building at SRTO.

Any cargo handling equipment that has already been procured, and cargo-handling equipment indicated in the aforementioned roadmap, would be modified on site for automation. However, equipment that would be procured thereafter would be fabricated with automation already incorporated into the design. In parallel with the fabrication of the equipment, it would be necessary to have the development of automation systems and the design of a control panel for remote operations.

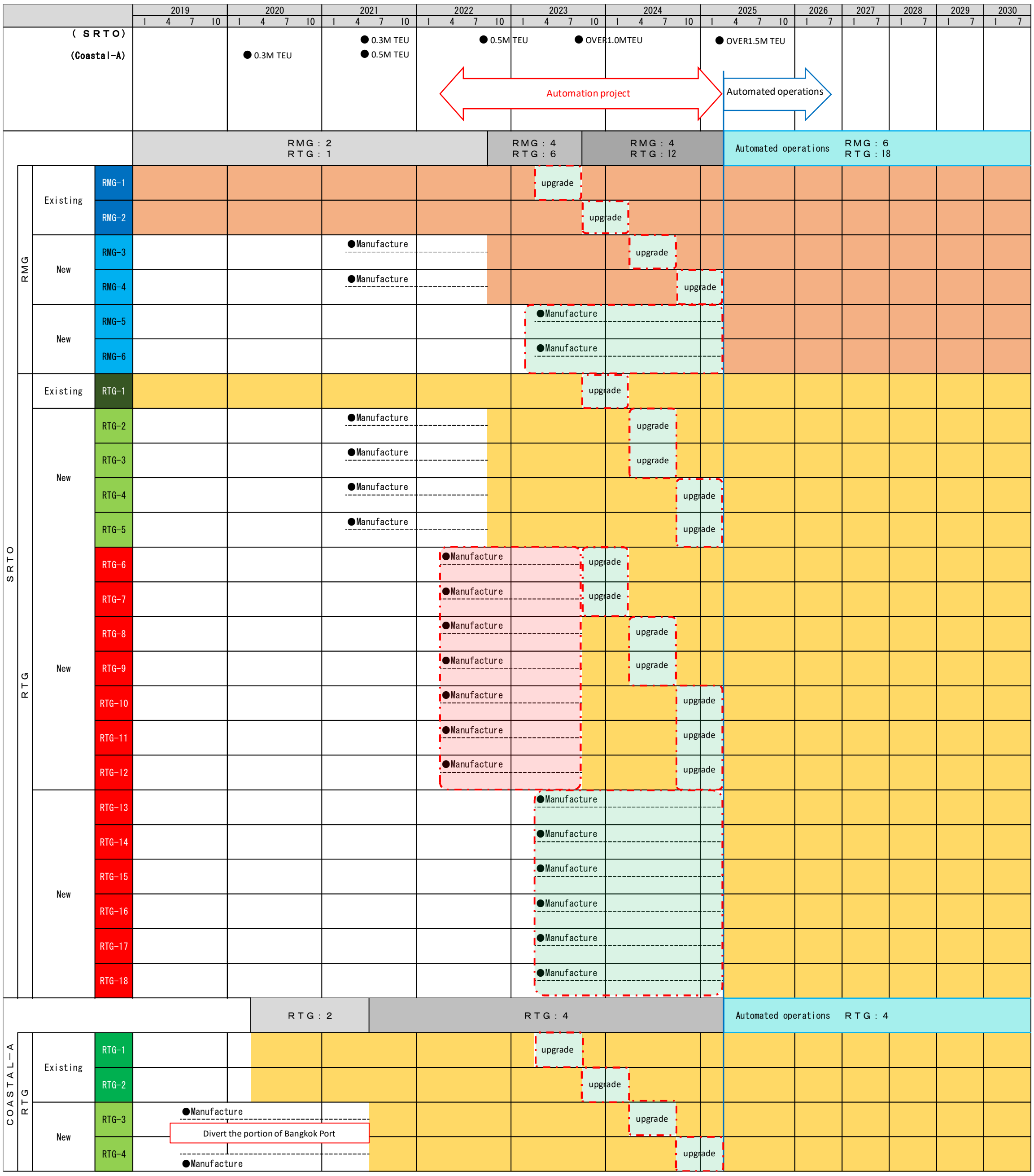
Because the automation project would have to be done without service interruptions, it would be implemented with adequate time allowed to minimize the impacts on operations, by making the modifications a few units at a time.

(Key Points)

The introduction of automation technologies is anticipated to improve the economics due to labor saving and safety improvements, but a corresponding level of throughput and initial costs are necessary in order to benefit from the economies of scale. Considering the ongoing status of the SRTO operator not yet being decided and the future not being clear due to COVID-19, is it assumed that some more time will be needed before PAT can make a decision on introducing automation technology.

Also, in this midst of these ongoing conditions, because PAT uses a tender process each time for the procurement of cargo handling equipment, the manufacturers and specifications could differ each time, so it could be difficult in some cases to make modifications or upgrades when the decision is eventually made to automate.

Table 16: Roadmap for promoting modal shift by introducing automation technologies



(2) Consideration of Support Measures to Promote Modal Shift (Project Schemes, Financing, Procurement Approaches, etc.)

Table 15 and Table 16 presents a plan for future additional procurement of RTGs at SRTO. Additional procurement would lead to improved throughput capacity of the SRTO and a modal shift promoted in concert would lead to GHG emission reductions; however electricity consumption would also increase if all RTGs at the SRTO were electric, due to an increase in the number of units under that plan. One could anticipate significant decarbonization of operations if all electricity consumed at the SRTO was generated from renewable energy.

Based on the above points, below is a summary of a case of utilizing JCM financing for procurement of electric RTGs combined with the installation of a photovoltaic power generation system.

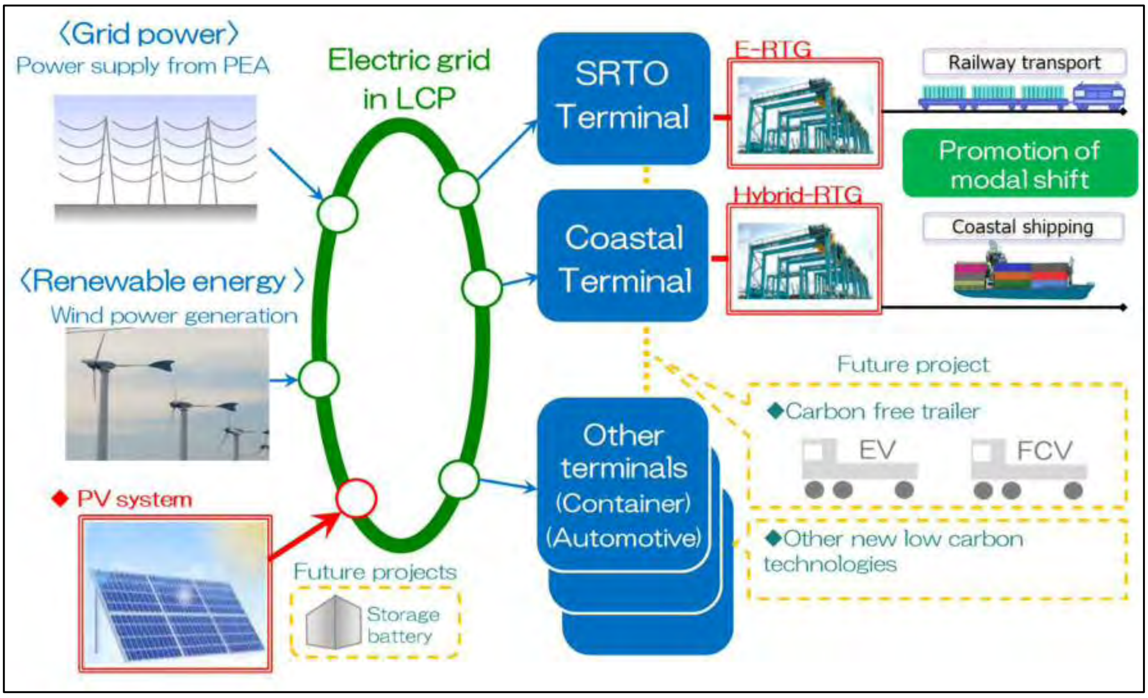


Figure 22: General image of energy conservation combined with renewable energy use at Laem Chabang Port

Table 17: Results of consideration of electric RTGs combined with photovoltaic power generation

	RTG	PV
Legal durable years	12	17
Quantity	7 unit	1set (2.73MW)
Initial cost (A)	331,011,492 THB	115,065,000 THB
J CM financing (B)	36,080,247 THB	27,615,000 THB
J CM financing ratio (C)	10.9%	24.0%
CO2 reduction (D)	31,603 t-CO2/12year (2,633.6 t-CO2/year)	35,370 t-CO2/17year (2,080.6 t-CO2/year)
J CM cost effectiveness (B)/(D)	1,142 THB/t-CO2	781 THB/t-CO2
Cost saving	346,500,000 THB	112,484,496 THB
Total J CM financing	63,695,247 THB (221,659,460 J PY)	
Total J CM financing ratio	14.3%	

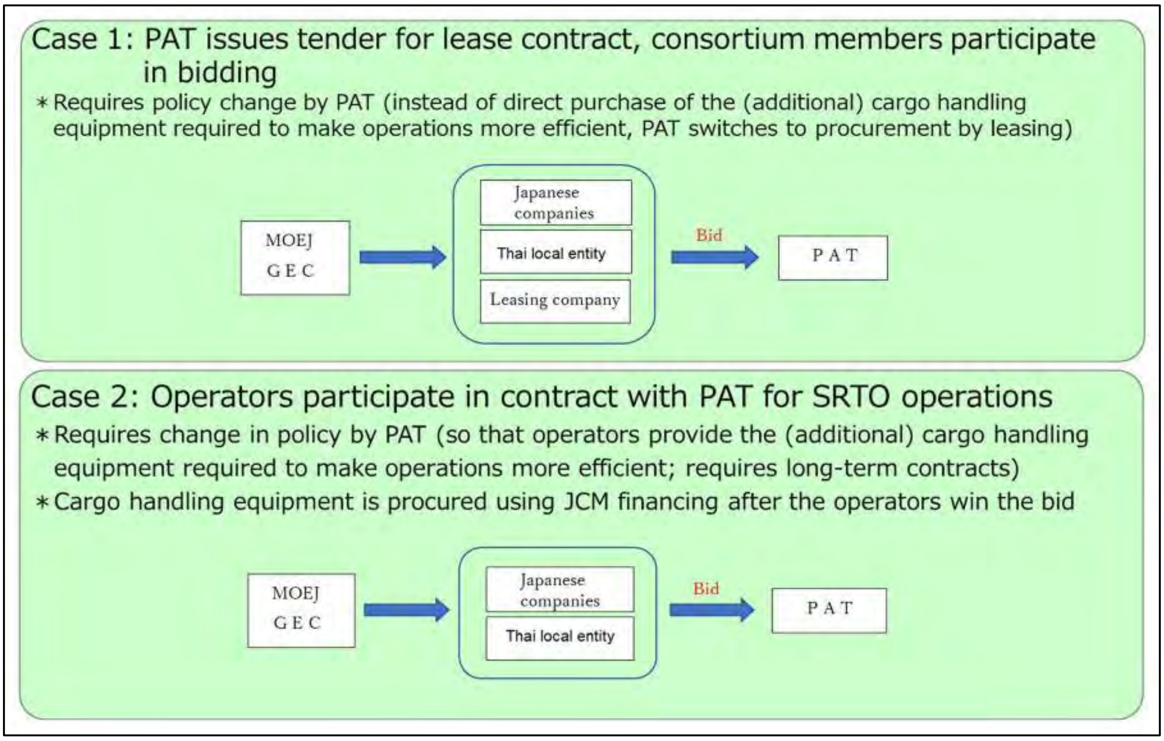
As shown in the above table, the emission reductions in this case are 66,973 t-CO2, and the JCM financing ratio is 14.3％. If it is assumed that electricity from photovoltaic power generation is used in the electric RTGs, there would be a minimal increase in the JCM financing ratio and in either case the JCM financing ratio is not particularly high. It would be difficult to utilize the JCM without taking into account the indirect CO2 emission reductions due to the introduction of cargo handling equipment for modal shift.

Still some issues remain in terms of the project scheme. If PAT implements the project on its own, the tender would be done based on Thai legislation, so PAT would become a consortium member as in the case of the project at Bangkok Port, utilize the JCM and attempt to do the procurement by competitive bid, but in this case the benefits of the JCM financing would not be realized during bidding. There are two ideas to address this, as shown in the Figure 23.

First, to address the issue of JCM financing benefit mentioned above, PAT would not enter the international consortium, the consortium members would simply be bid participants, and the consortium would participate in the tender with the equivalent of JCM financing considered separately. However, in that case, the assumed JCM financing amount can in some cases end up different from the actual amount financed, and the bid participants would end up bearing that risk.

Also, since the ownership of the equipment procured would end up belonging to PAT, this deviates from JCM rules because consortium members would not own the equipment. One way to address this issue of ownership is the idea of PAT switching from procurement to leasing. However, since whether or not JCM can be applied will depend on the outcome of the bid, it is difficult for PAT to decide to switch the procurement method to leasing prior to knowing the bid results.

Another idea is a case in which PAT does not do its own procurement, and instead, businesses that are responsible for terminal operations would procure the cargo handling equipment, have it delivered locally, and use it. Because PAT is not doing the procurement in this scenario, there is more freedom in terms of procurement approaches. However, at the current time PAT is considering an operations contract period of about five years, while under this scenario is would be necessary to switch to a long-term contract to reflect the payback period. While PAT has the status of port landlord at Laem Chabang Port, it has indicated a policy of doing the operations itself at SRTO and Coastal-A terminals, so there is a low likelihood PAT would decide to make a long-term concession contract with a private sector company.



Case 1: PAT issues tender for lease contract, consortium members participate in bidding

＊Requires policy change by PAT (instead of direct purchase of the (additional) cargo handling equipment required to make operations more efficient, PAT switches to procurement by leasing)

Case 2: Operators participate in contract with PAT for SRTO operations

＊Requires change in policy by PAT (so that operators provide the (additional) cargo handling equipment required to make operations more efficient; requires long-term contracts)

＊Cargo handling equipment is procured using JCM financing after the operators win the bid

Figure 23: Ideas for procurement approach (general concept)

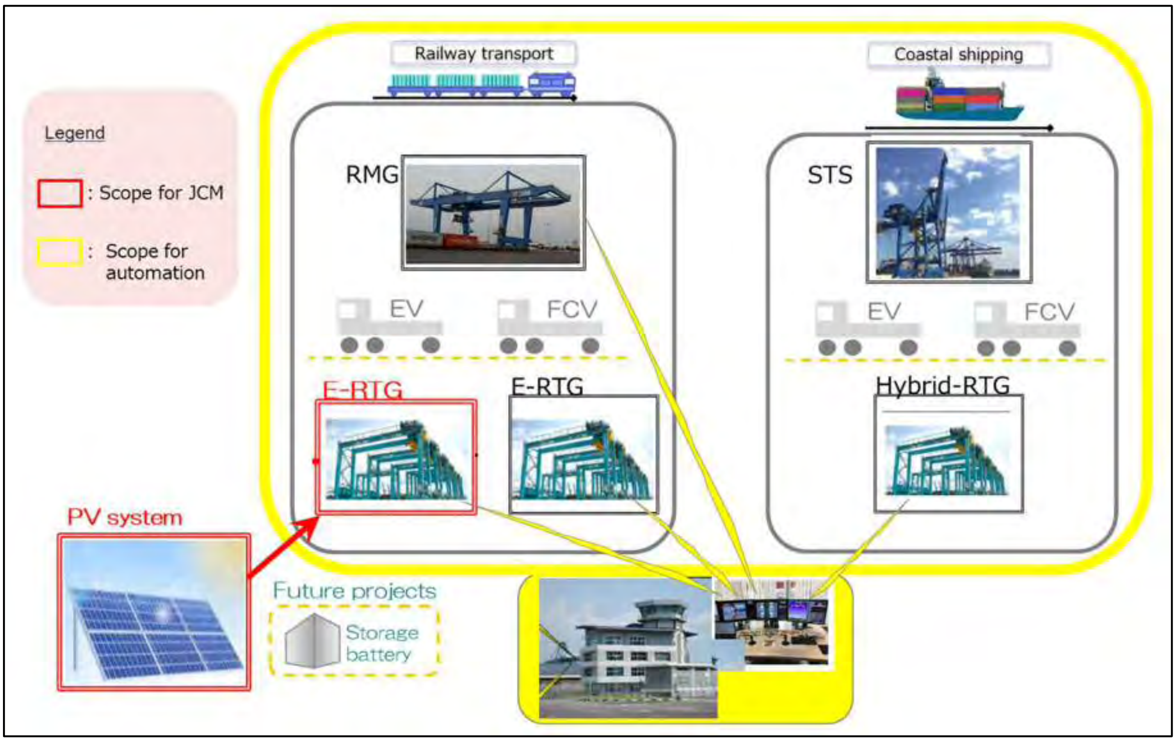


Figure 24: Combination of automation technology introduction project and use of JCM financing (general concept)

Next, we discuss the case of a project combining automation technology introduction and JCM financing. The general concept is depicted above. The introduction of automation technologies in itself does not have a CO_2 emission reduction effect, but there are economic, safety, and reliability benefits of automation after the throughput reaches a certain level, and it is anticipated that they would lead to the further promotion of modal shift. As it monitors the rising trend in throughput, PAT will procure additional cargo handling equipment and introduce automation technology, and it is anticipated that in this context PAT may choose to utilize the JCM (or other support schemes) for the procurement of low-carbon cargo-handling equipment and introduction of automation technologies.

4. Conclusion

This study confirmed the operational methods to ensure efficient and safe operations at the modal shift terminals at Laem Chabang Port and help to achieve a modal shift for domestic container freight in Thailand; the study also reviewed the effectiveness of doing so, and considered ways to implement the ideas.

Regarding how to increase operational efficiency, we worked with PAT, the port administrator, to utilize a simulator to examine multiple cases and clarified the most efficient operational methods and deployment of cargo handling equipment in the context of promoting a modal shift. The study also confirmed that when throughput has increased, it would be beneficial to introduce automation technology possessed by Japanese manufacturers, from the perspective of promoting efficiency as well as measures against infectious diseases such as COVID-19.

As for emission reductions that could be achieved, after calculating new CO2 emissions that would arise from modal shift terminals as a result of modal shift, the study calculated emission reductions and confirmed the benefits of shifting from truck to ship transport mode between Bangkok Port and Laem Chabang Port, and shifting from truck to rail between the container terminals at Lat Krabang ICD and Laem Chabang Port Terminal B.

Further progress with the diesel-electric engine replacement program being advanced by the State Railway of Thailand (SRT) will increase the CO2 emission reduction benefits of the modal shift, so we would like to continue our cooperation with PAT in terms of gathering information on emission factors and actual data.

In terms of collaboration between the key parties involved in container transport, progress is slow with concession contract renewals for Lat Krabang ICD, SRTO, and Terminal B container terminal, and this presents some challenges when attempting to identify concrete measures for strengthening collaboration going forward. However, based on the current situation, collaboration between the relevant parties is clearly very important to promote modal shift going forward; examples include the challenges facing efforts to promote efficient SRTO operations while there are still lengthy wait times in customs procedures for rail freight. In that context, we made a recommendation for PAT to bring together all concerned parties and convene roundtable meetings, using them as a platform for collaboration and partnership to promote modal shift.

We also confirmed that not only is it important to improve the physical infrastructure to promote modal shift, but also to boost efficiency by developing information platforms such as container location information for operations, and a “matching function” for freight owners and trailers. Operating trailers loaded with containers both outbound and inbound rather than just one way would have the dual benefits of addressing both the driver shortage and reducing CO2 emissions.

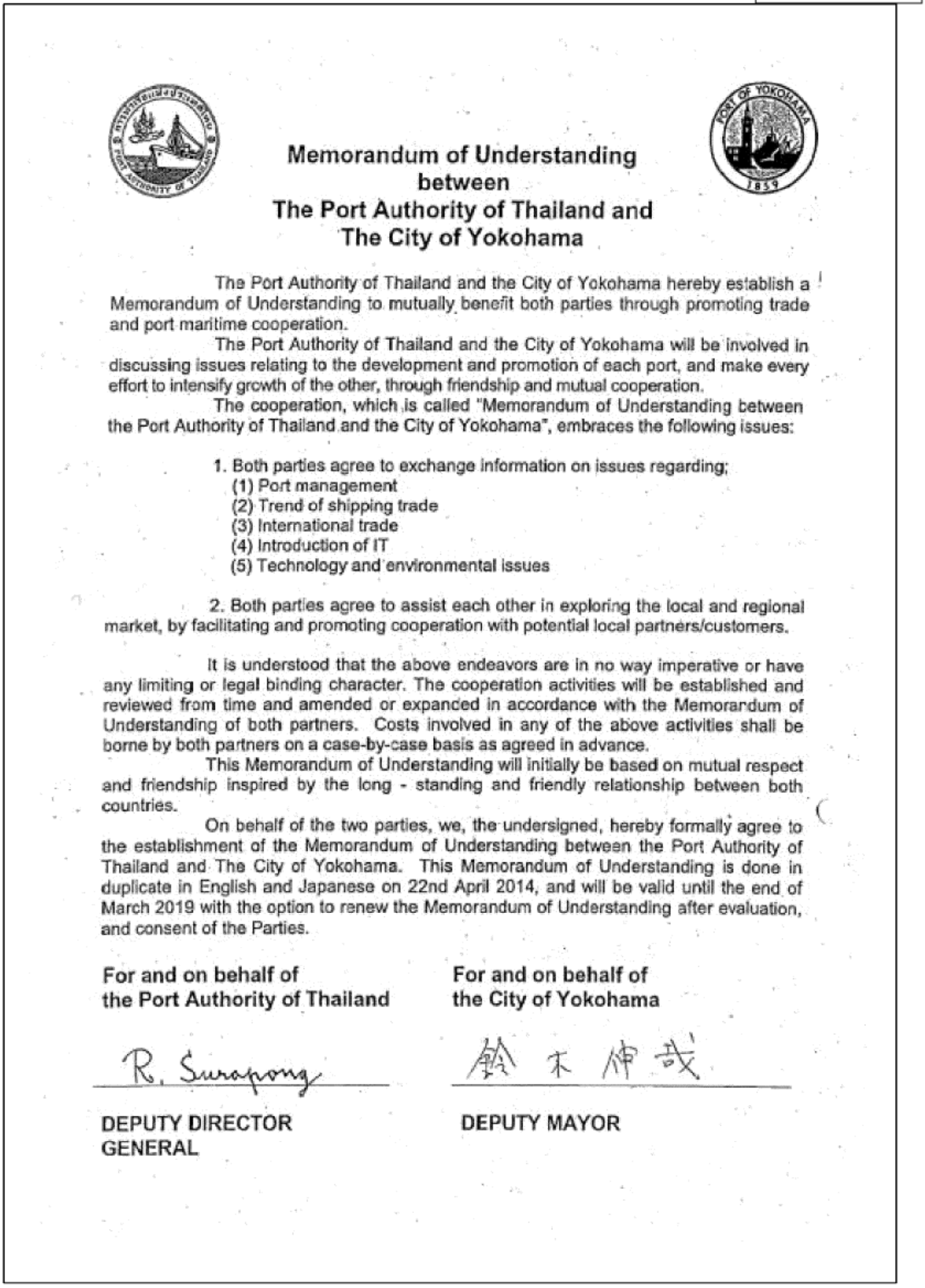
Finally, to support PAT's ongoing efforts to promote modal shift, we developed a roadmap for the procurement of cargo handling equipment being advanced by PAT to keep up with increased throughput, and discussed future plans with PAT. Although COVID-19 continues having economic impacts at the moment, we are committed to maintain ongoing communications with PAT in terms of the timing of future equipment procurement plans, so that we may support the introduction of low-carbon and decarbonizing equipment, and this include the use of the Joint Crediting Mechanism (JCM) and support for the introduction of automation technologies. We are also committed to continue our collaboration with PAT in order to promote the decarbonization of Thailand’s ports and harbors, by sharing the results of “soft” measures such as CONPAS as well as carbon neutral port measures, currently undergoing trials at the Port of Yokohama, led mainly by Japan’s Ministry of Land, Infrastructure, Transport and Tourism.

Attached Documents

Attachment 1: MOU for Cooperation with PAT, etc.

(1) Memorandum of Understanding between Port Authority of Thailand and City of Yokohama

Original version



Memorandum of Understanding
between
The Port Authority of Thailand and
The City of Yokohama

The Port Authority of Thailand and the City of Yokohama hereby establish a Memorandum of Understanding to mutually benefit both parties through promoting trade and port maritime cooperation.

The Port Authority of Thailand and the City of Yokohama will be involved in discussing issues relating to the development and promotion of each port, and make every effort to intensify growth of the other, through friendship and mutual cooperation.

The cooperation, which is called "Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama", embraces the following issues:

1. Both parties agree to exchange information on issues regarding;
   (1) Port management
   (2) Trend of shipping trade
   (3) International trade
   (4) Introduction of IT
   (5) Technology and environmental issues

2. Both parties agree to assist each other in exploring the local and regional market, by facilitating and promoting cooperation with potential local partners/customers.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character. The cooperation activities will be established and reviewed from time and amended or expanded in accordance with the Memorandum of Understanding of both partners. Costs involved in any of the above activities shall be borne by both partners on a case-by-case basis as agreed in advance.

This Memorandum of Understanding will initially be based on mutual respect and friendship inspired by the long - standing and friendly relationship between both countries.

On behalf of the two parties, we, the undersigned, hereby formally agree to the establishment of the Memorandum of Understanding between the Port Authority of Thailand and The City of Yokohama. This Memorandum of Understanding is done in duplicate in English and Japanese on 22nd April 2014, and will be valid until the end of March 2019 with the option to renew the Memorandum of Understanding after evaluation, and consent of the Parties.

For and on behalf of the Port Authority of Thailand	**For and on behalf of the City of Yokohama**
R. Surapong	鈴木伸哉
DEPUTY DIRECTOR GENERAL	**DEPUTY MAYOR**

Renewed version

Memorandum of Understanding
Between
the Port Authority of Thailand and
The City of Yokohama

The Port Authority of Thailand and the City of Yokohama hereby establish a Memorandum of Understanding to mutually benefit both ports through promoting trade and port maritime cooperation.

The Port Authority of Thailand and the City of Yokohama will be involved in discussing issues relating to the development and promotion of each port, and make every effort to intensify growth of the other, through friendship and mutual cooperation.

The cooperation is called "Memorandum of Understanding between the Port Authority of Thailand and the Port of Yokohama".

The Port Authority of Thailand and the City of Yokohama, hereinafter referred to as "Both Participants".

1. The Participants agree to cooperate in the following areas.
   (1) Port Technology and innovation
   (2) Port sustainable development and environmental issues
   (3) Trend of shipping trade between ports
   (4) Technical partnership
   (5) Port management and challenges
   (6) Promoting port and shipping marketing
   (7) Collaboration in any other areas that may be mutually decided upon by the participants.
2. Both Participants agree to assist each other in exploring the local and regional market, by facilitating and promoting cooperation with potential local partners/customers.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character. The cooperation activities will be established and reviewed from time and amended or expanded in accordance with the Memorandum of Understanding of both Participants. Costs involved in any of the above activities will be borne by both Participants on a case-by-case basis as agreed in advance.

This Memorandum of Understanding will initially be based on mutual respect and friendship inspired by the long - standing and friendly relationship between both countries.

The MOU will come into effect on the date of signing and continue to be effective until terminate by either Participant giving written notice to the other Participant at least ninety (90) days before the date of proposed termination and the termination of the MoU shall take effect upon written agreement of the other Participant. Whereas, any implementation of obligation/activities under this MoU that have been done prior to the date of the termination will be considered and agreed upon in advance on a case by case basis.

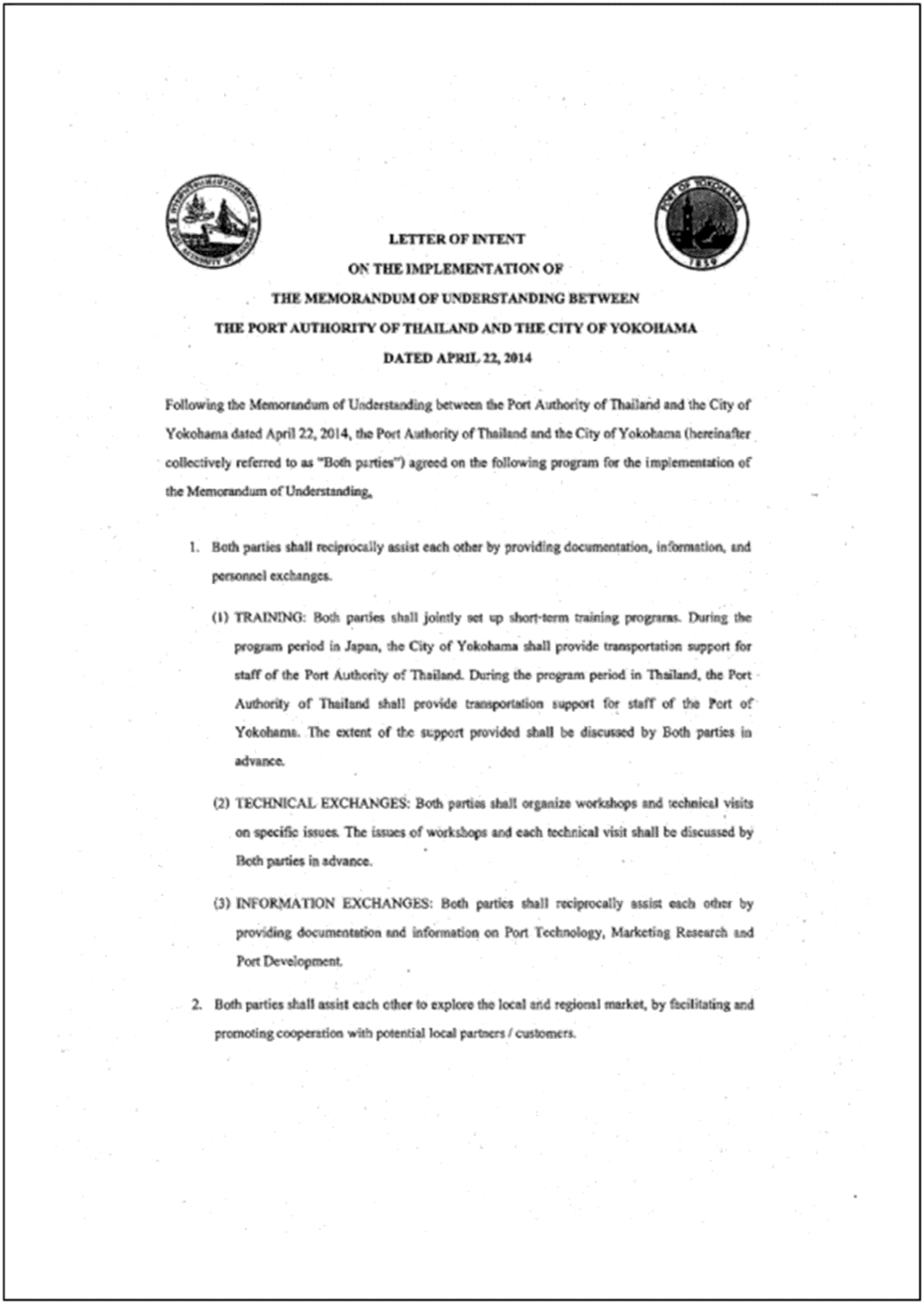
This MoU is made in two (2) duplicate originals in English language, both texts being equally authentic and each Participant holding one copy. Both Participants have read and fully understood the contents therein and thereafter duly signed the MoU on 31st March 2019.

For and on behalf of the Port Authority of Thailand	For and on behalf of the Port of Yokohama
	平原 敏英
DIRECTOR GENERAL PORT AUTHORITY OF THAILAND	DEPUTY MAYOR CITY OF YOKOHAMA

Attachment 2

(2) Letter of Intent of the implement of the MOU between the Port Authority of Thailand and the City of Yokohama

Original version



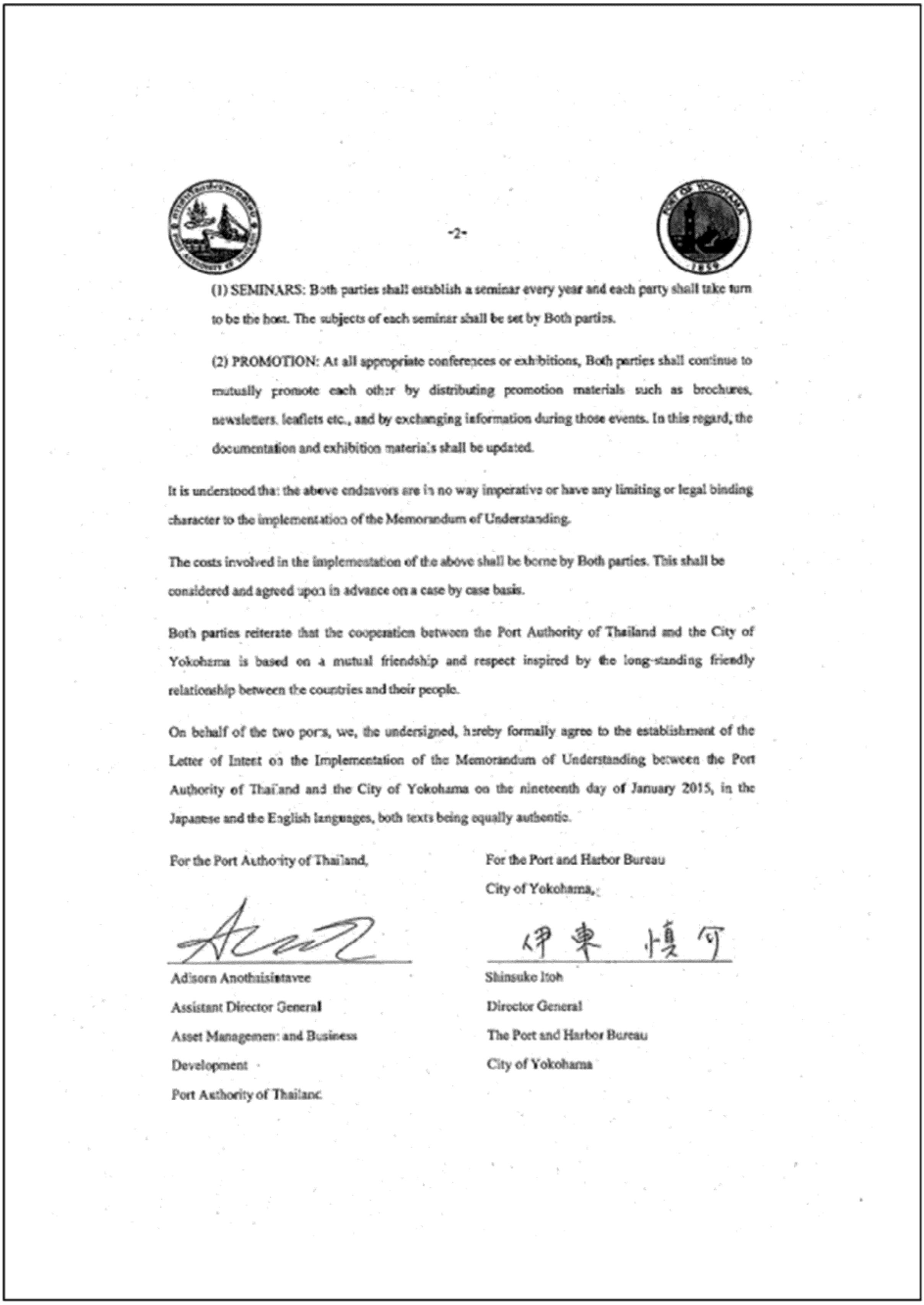
LETTER OF INTENT
ON THE IMPLEMENTATION OF
THE MEMORANDUM OF UNDERSTANDING BETWEEN
THE PORT AUTHORITY OF THAILAND AND THE CITY OF YOKOHAMA
DATED APRIL 22, 2014

Following the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama dated April 22, 2014, the Port Authority of Thailand and the City of Yokohama (hereinafter collectively referred to as "Both parties") agreed on the following program for the implementation of the Memorandum of Understanding.

1. Both parties shall reciprocally assist each other by providing documentation, information, and personnel exchanges.
    (1) TRAINING: Both parties shall jointly set up short-term training programs. During the program period in Japan, the City of Yokohama shall provide transportation support for staff of the Port Authority of Thailand. During the program period in Thailand, the Port Authority of Thailand shall provide transportation support for staff of the Port of Yokohama. The extent of the support provided shall be discussed by Both parties in advance.

    (2) TECHNICAL EXCHANGES: Both parties shall organize workshops and technical visits on specific issues. The issues of workshops and each technical visit shall be discussed by Both parties in advance.

    (3) INFORMATION EXCHANGES: Both parties shall reciprocally assist each other by providing documentation and information on Port Technology, Marketing Research and Port Development.
2. Both parties shall assist each other to explore the local and regional market, by facilitating and promoting cooperation with potential local partners / customers.



(1) SEMINARS: Both parties shall establish a seminar every year and each party shall take turn to be the host. The subjects of each seminar shall be set by Both parties.

(2) PROMOTION: At all appropriate conferences or exhibitions, Both parties shall continue to mutually promote each other by distributing promotion materials such as brochures, newsletters, leaflets etc., and by exchanging information during those events. In this regard, the documentation and exhibition materials shall be updated.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character to the implementation of the Memorandum of Understanding.

The costs involved in the implementation of the above shall be borne by Both parties. This shall be considered and agreed upon in advance on a case by case basis.

Both parties reiterate that the cooperation between the Port Authority of Thailand and the City of Yokohama is based on a mutual friendship and respect inspired by the long-standing friendly relationship between the countries and their people.

On behalf of the two ports, we, the undersigned, hereby formally agree to the establishment of the Letter of Intent on the Implementation of the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama on the nineteenth day of January 2015, in the Japanese and the English languages, both texts being equally authentic.

For the Port Authority of Thailand,

Adisorn Anothaisintavee
Assistant Director General
Asset Management and Business
Development
Port Authority of Thailand

For the Port and Harbor Bureau
City of Yokohama,

伊東 慎可

Shinsuke Itoh
Director General
The Port and Harbor Bureau
City of Yokohama

Attachment 4

Renewed version

LETTER OF INTENT
ON THE IMPLEMENTATION OF THE MEMORANDUM OF UNDERSTANDING BETWEEN THE PORT AUTHORITY OF THAILAND AND THE CITY OF YOKOHAMA
DATED 21st MARCH, 2019

Following the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama dated 21st March, 2019, both Participants agreed on arranging on the following program for the implementation of the Memorandum of Understanding.

The Port Authority of Thailand and the City of Yokohama, hereinafter referred to as "Both Participants".

1. Both Participants will reciprocally assist each other by providing documentation, information, and personal exchanges.

   (1) TRAINING: Both Participants will jointly set up short-term training programs. During the program period in Japan, the City of Yokohama will provide transportation support for staff of the Port Authority of Thailand. During the program period in Thailand, the Port Authority of Thailand will provide transportation support for staff of the City of Yokohama. The extent of the support provided will be discussed by Both Participants in advance.

   (2) TECHNICAL EXCHANGES: Both Participants will organize workshop and technical visits in the specific issues. The issues of workshops and each technical visit will be discussed by Both Participants in advance.

   (3) INFORMATION EXCHANGES: Both Participants will reciprocally assist each other by providing documentation and information on port technology, marketing research and port development.

2. Both Participants will assist each other to explore the local and regional market, by facilitating and promoting cooperation with potential local participants / customers.

   (1) SEMINARS/CONFERENCES: In order to achieve objectives of the MoU, both Participants will establish seminar mutually and each party will take turn to be the host. The subjects of each seminar will be set by Both Participants.

Attachment 5

(2) PROMOTION: At all appropriate conferences or exhibitions, Both Participants will continue to mutually promote each other by distributing promotion materials such as brochures, newsletters, leaflets etc., and by exchanging of information during those events. In this regard, the documentation and exhibition materials will be updated.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character to the implementation of the Memorandum of Understanding.

The costs involved in the implementation of the above will be borne by Both Participants. This will be considered and agreed upon in advance on a case by case basis.

Both Participants reiterate that the cooperation between the Port Authority of Thailand and the City of Yokohama is based on a mutual friendship and respect inspired by the long-standing friendly relationship between countries and their people.

Both participants agree that this Letter of Intent is a part of the Memorandum of Understanding signed on 31st March, 2019. This Letter of Intent is made in two (2) duplicate originals in English language, both texts being equally authentic and each Participant holding one copy. Both Participants have read and fully understood the contents therein and thereafter duly signed the MoU on 31st March, 2019 and will be valid until the end of March 2024.

For and on behalf of the Port Authority of Thailand,	For and on behalf of the Port of Yokohama,
	伊東 慎介
Director General Port Authority of Thailand	Director General Port and Harbor Bureau, City of Yokohama

Attachment 6

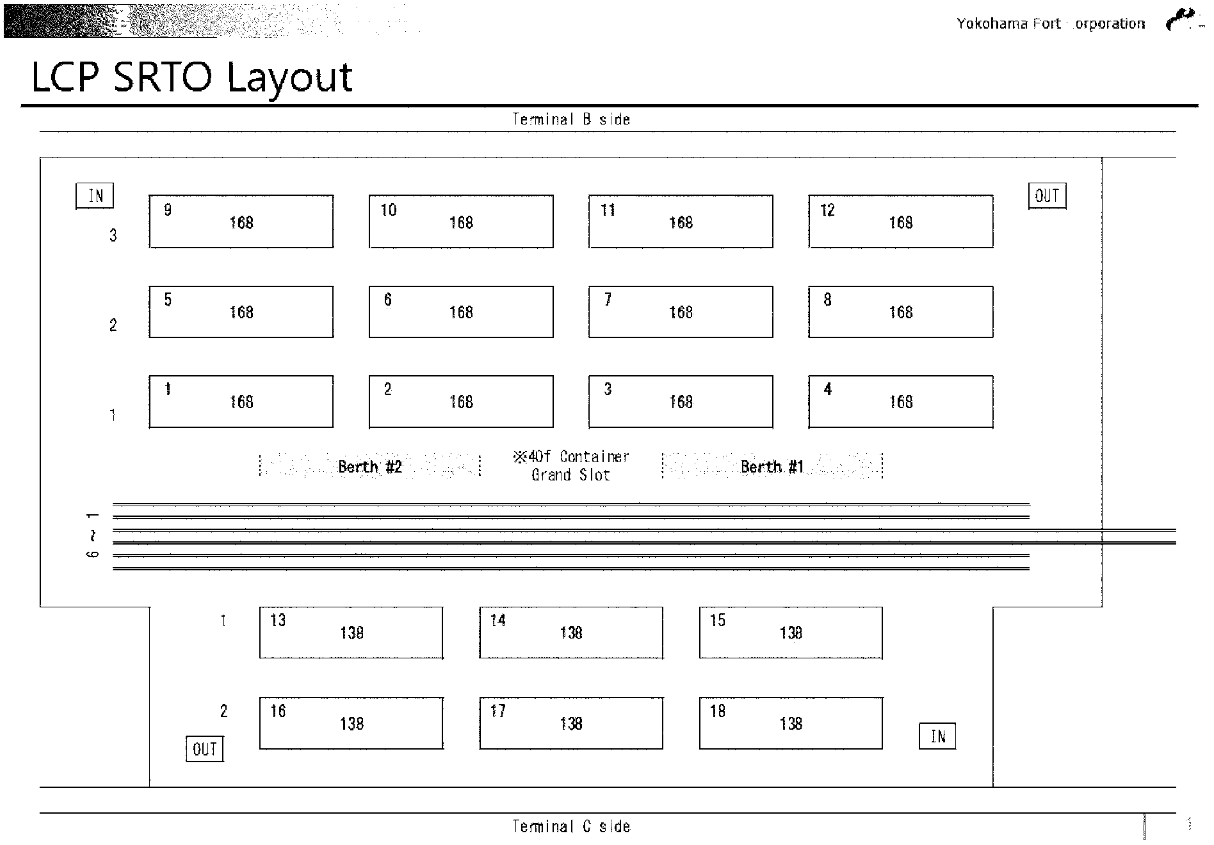
Attachment 2: Documents of the meetings with PAT

(1) Documents of the 1st online meeting (Kick off meeting)

LCP SRTO
Simulation Results

19th Oct 2020
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.

横浜港埠頭株式会社
Yokohama Port Corporation



Yokohama Port Corporation

LCP SRTO Layout

Simulation for SRTO : Preconditions

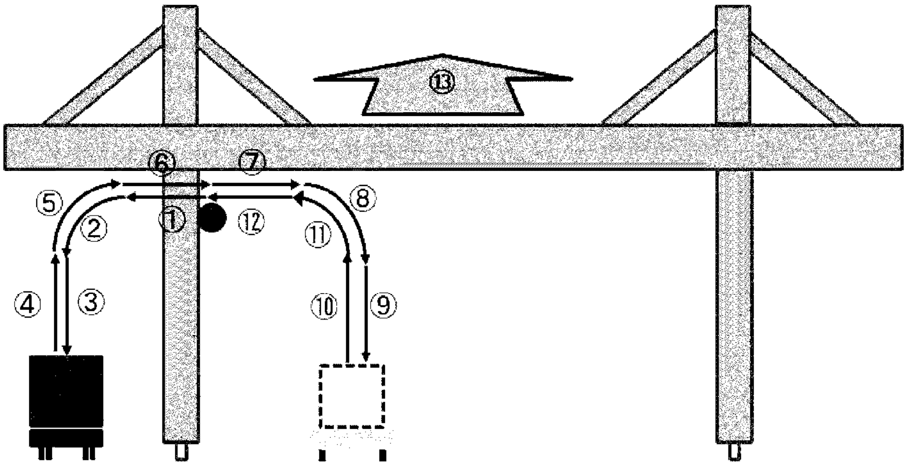
- Settings of Terminal Equipment

☐ Train velocity 30 km/h (8.333m/s)
☐ Truck velocity 30km/h (8.333m/s)
☐ RMG traveling velocity 7.2km/h (2m/s)
☐ RTG traveling velocity 7.2km/h (2m/s)
☐ RMG cycle time (One car traveling) 134 sec
☐ RTG cycle time (No traveling) 92 sec
☐ RTG re-handling time 180(tier1), 120(tier2), 60(tier3), 0(tier4) sec

- Settings of Railroad operation

☐ 1 train operation per hour (64TEU×23unit×2)
2,944 TEU/Day × 365 Day = 1,074,560 TEU/year > 1.0M TEU
☐ 1 train operation per 2 hours (64TEU×12unit×2)
1,536 TEU/Day × 365 Day = 560,640 TEU/year > 0.5M TEU

RMG cycle time



RMG pickup time = ① + ② + ③ + ④ + ⑤ + ⑥

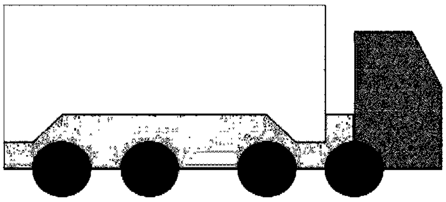
RMG set down time = ⑦ + ⑧ + ⑨ + ⑩ + ⑪ + ⑫

RMG travel time (1 bay move) = ⑬

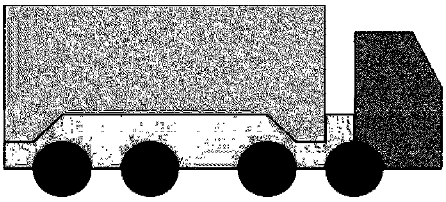
RMG cycle time = RMG pickup time + RMG set down time + RMG traveling time

Container and Trucks

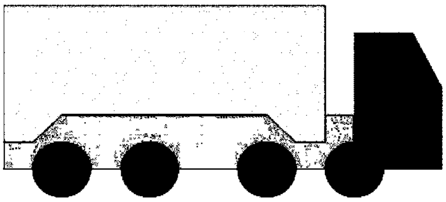
External Trucks (B to SRTO)



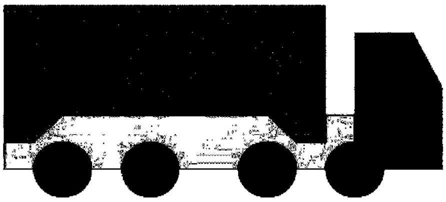
External Trucks (SRTO to B)



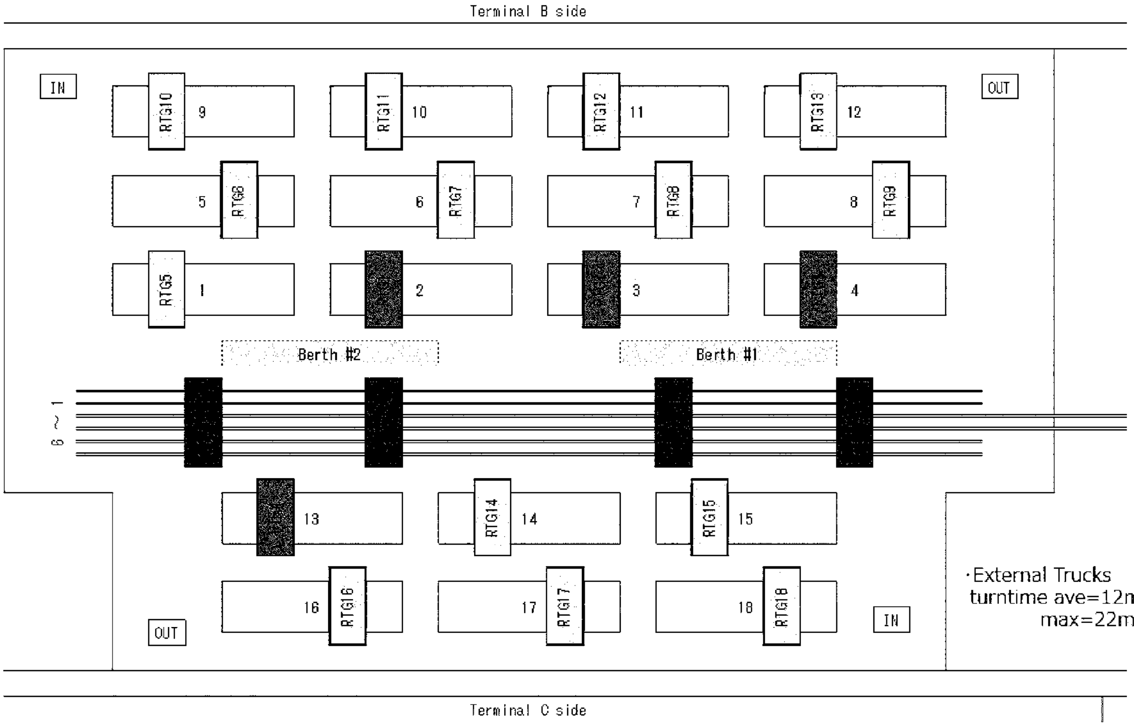
YARD Trucks (Trains to SRTO)



YARD Trucks (SRTO to Trains)

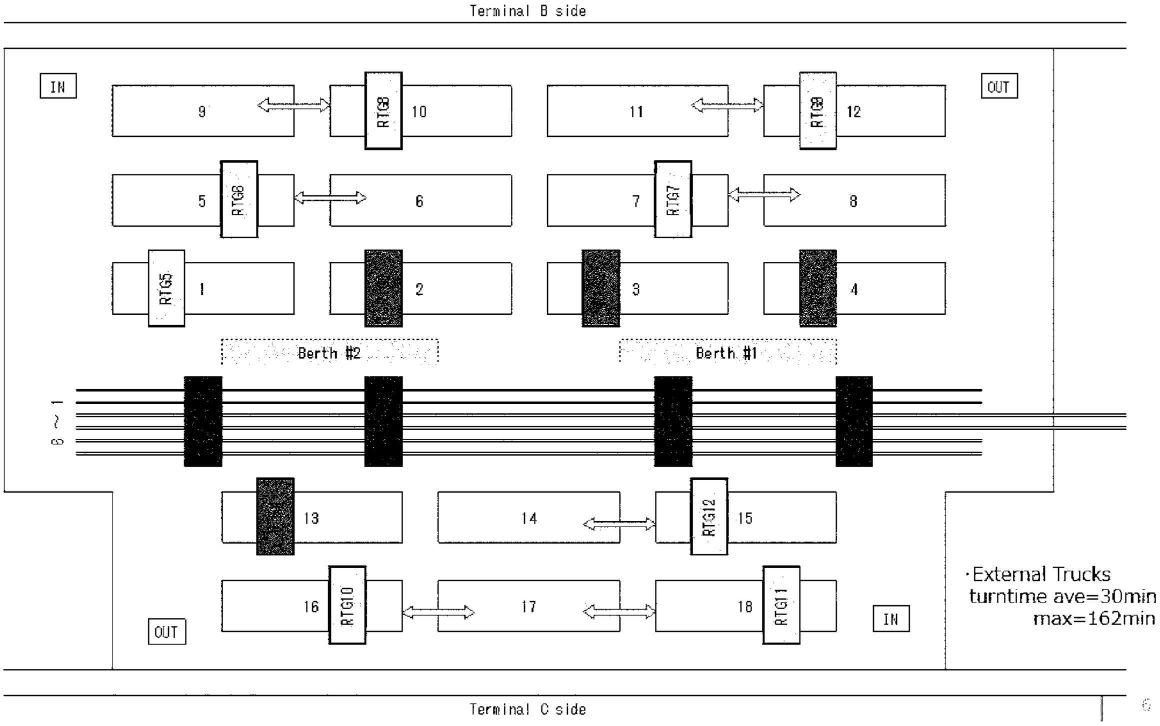


CASE1 Layout RMG4:RTG18 1.0M TEU (Last time)



·External Trucks
turntime ave=12min
max=22min

CASE2 Layout RMG4:RTG12 1.0M TEU (Last time)

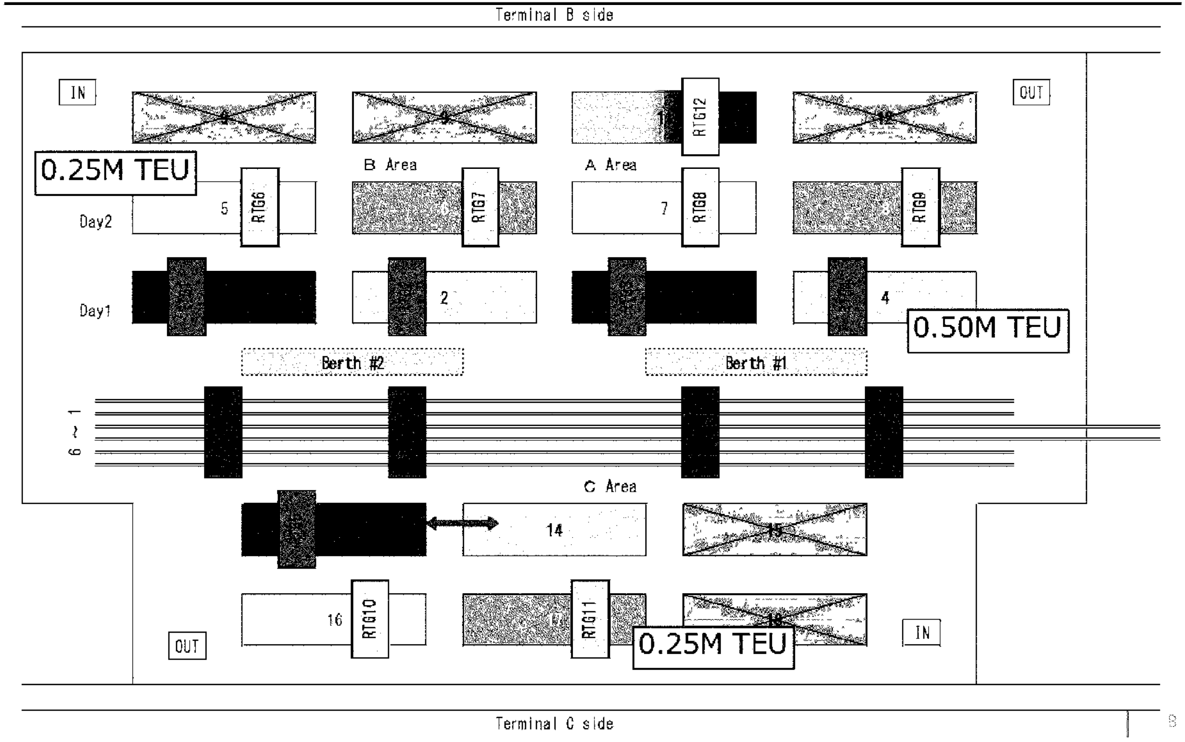


·External Trucks
turntime ave=30min
max=162min

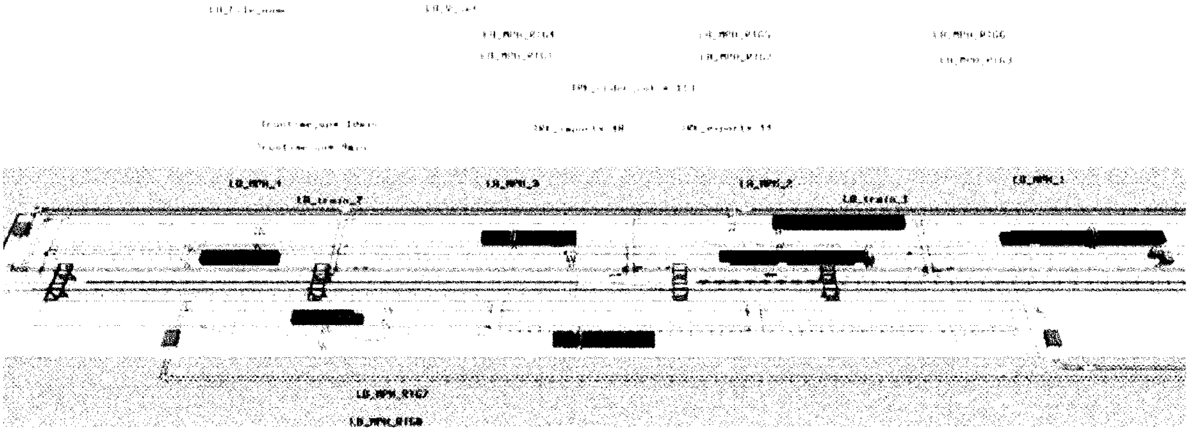
Notes: Results of the Study using Simulator

- Terminal operation will become ineffective when using whole yard which is huge
  - →Use the limited area of the yard
- Terminal operation will become ineffective when travel distance of cargo handling equipment becomes longer
  →Use designated storage area according to the purpose
- Need to secure more than 3 days for free storage time
  →Effective use of storage area
  - →Rehandling by RTGs (need ample capacity of RTG)

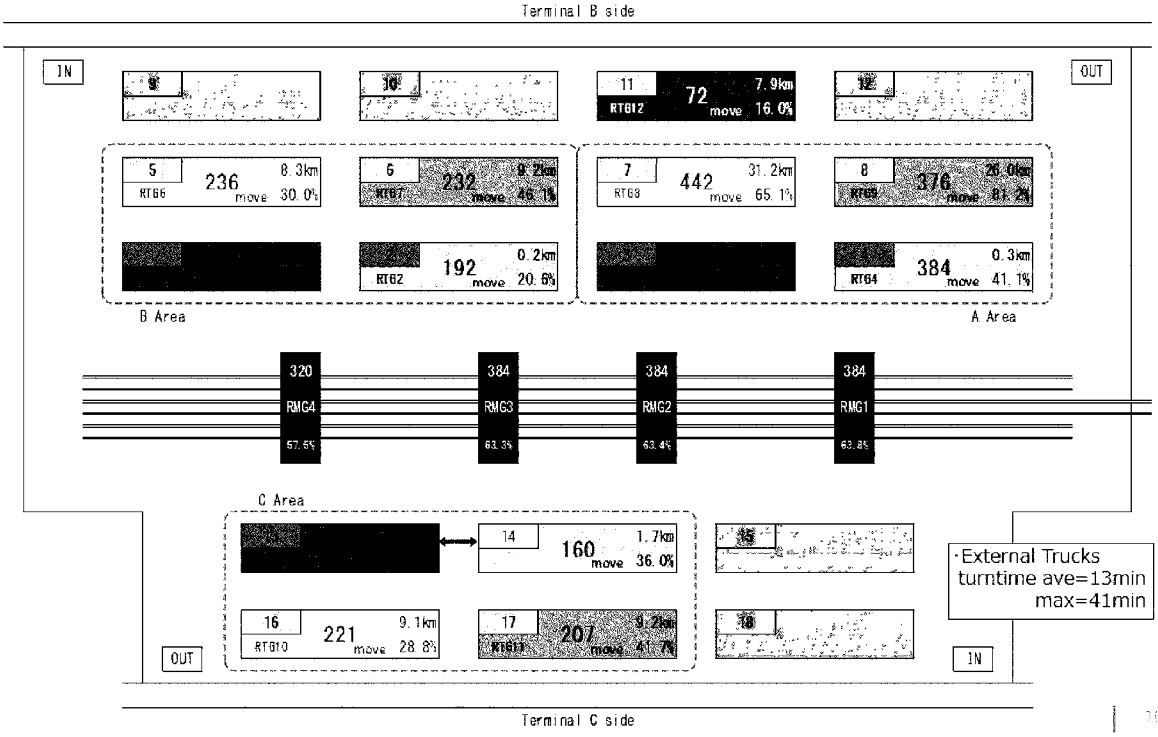
CASE3 Layout RMG4:RTG11+1 1.0M TEU



Simulation Model



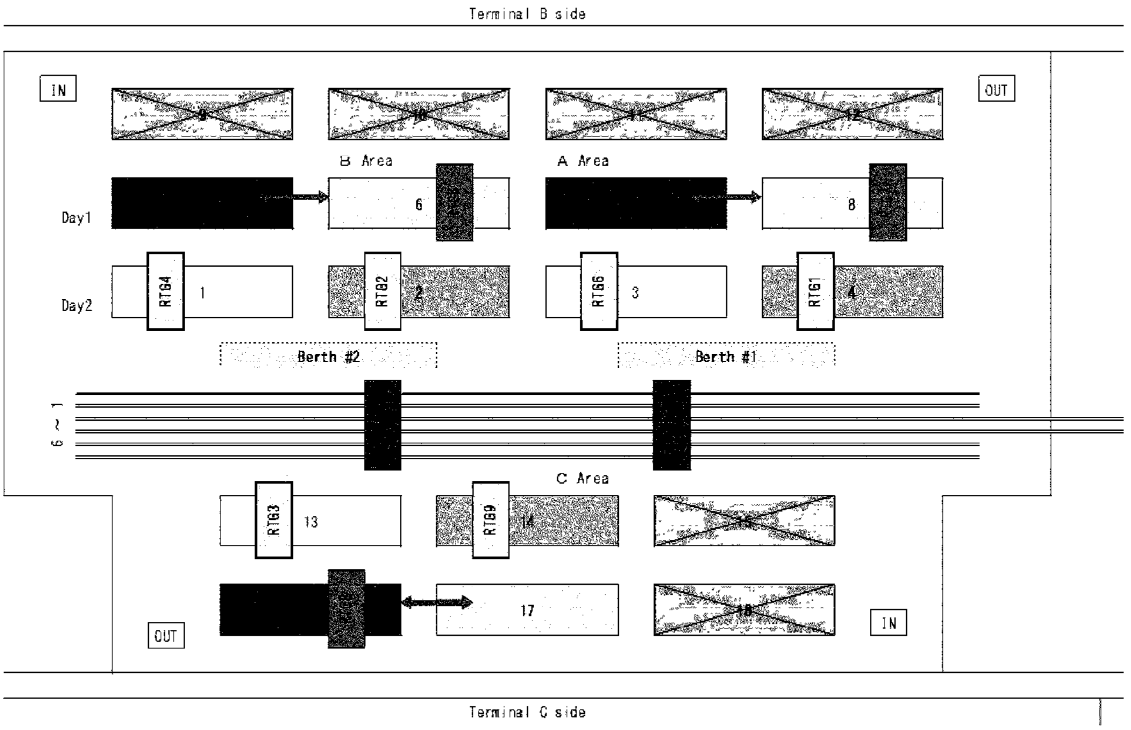
CASE3 Result　RMG4:RTG11+1　1.0M TEU



CASE3 Results

		RMG	RTG1	RTG2	Target (TEU)	RTG (I) move	RTG (I) distance (km)	RTG (I) Operating_rate	RTG (II) move	RTG (II) distance (km)	RTG (II) Operating_rate
CASE3	A Area	2	2	2	500,000	768.0	0.6	41.1%	818.0	57.2	73.2%
	B Area	1	2	2	250,000	384.0	0.4	20.6%	468.0	17.5	38.0%
	C Area	1	1	2	250,000	320.0	3.4	36.0%	428.0	18.2	35.2%
		4	5	6	1,000,000	1,472.0	4.4		1,714.0	93.0	
	11lane			1					72.0	7.9	16.0%

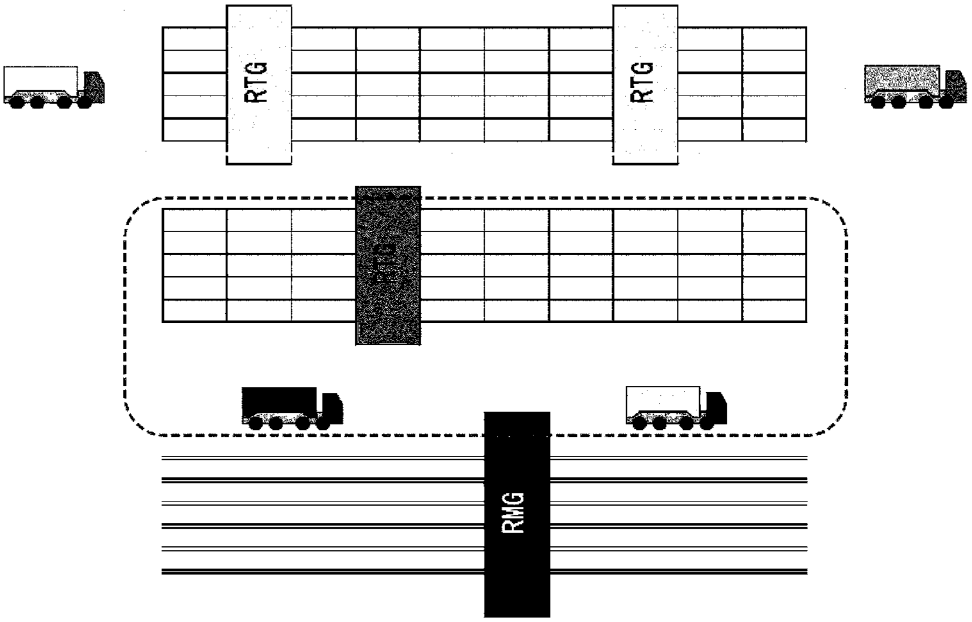
CASE4 Layout　RMG2:RTG9　0.5M TEU



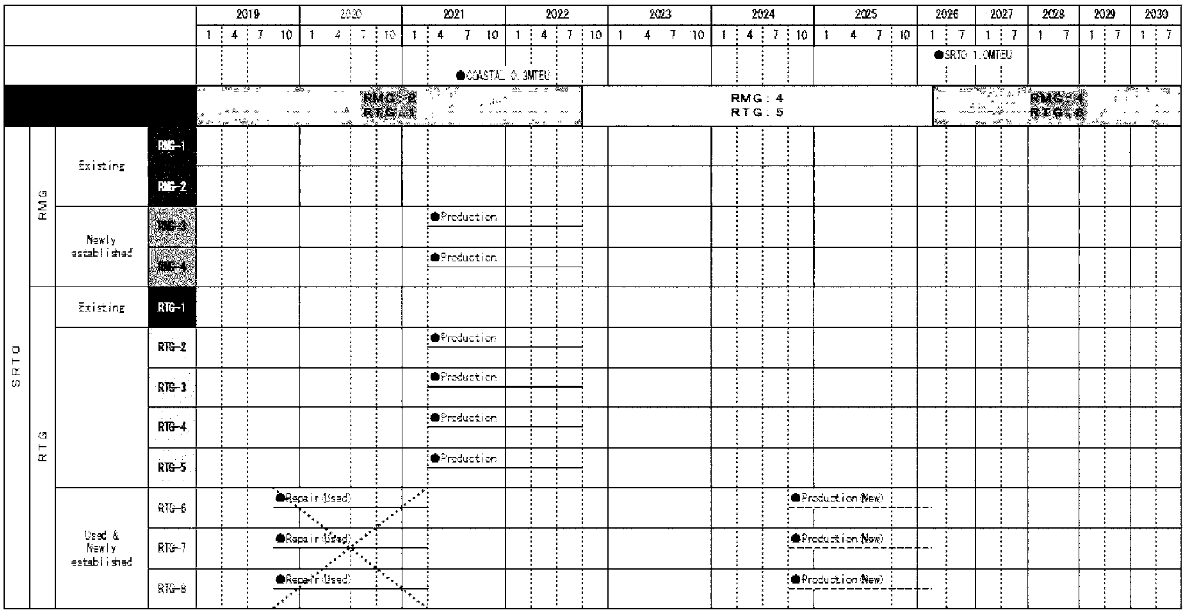
CASE4 Results

		RMG	RTG1	RTG2	Target (TEU)	RTG (Ⅰ)			RTG (Ⅱ)		
						move	distance (km)	Operating_rate	move	distance (km)	Operating_rate
CASE4	A Area	1	1	2	250,000	384.0	4.5	43.5%	398.0	13.9	32.2%
	B Area	1/2	1	2	125,000	192.0	2.1	21.7%	222.0	4.4	17.1%
	C Area	1/2	1	2	125,000	192.0	2.0	21.6%	232.0	4.2	17.4%
		2	3	6	500,000	768.0	8.5		852.0	22.5	

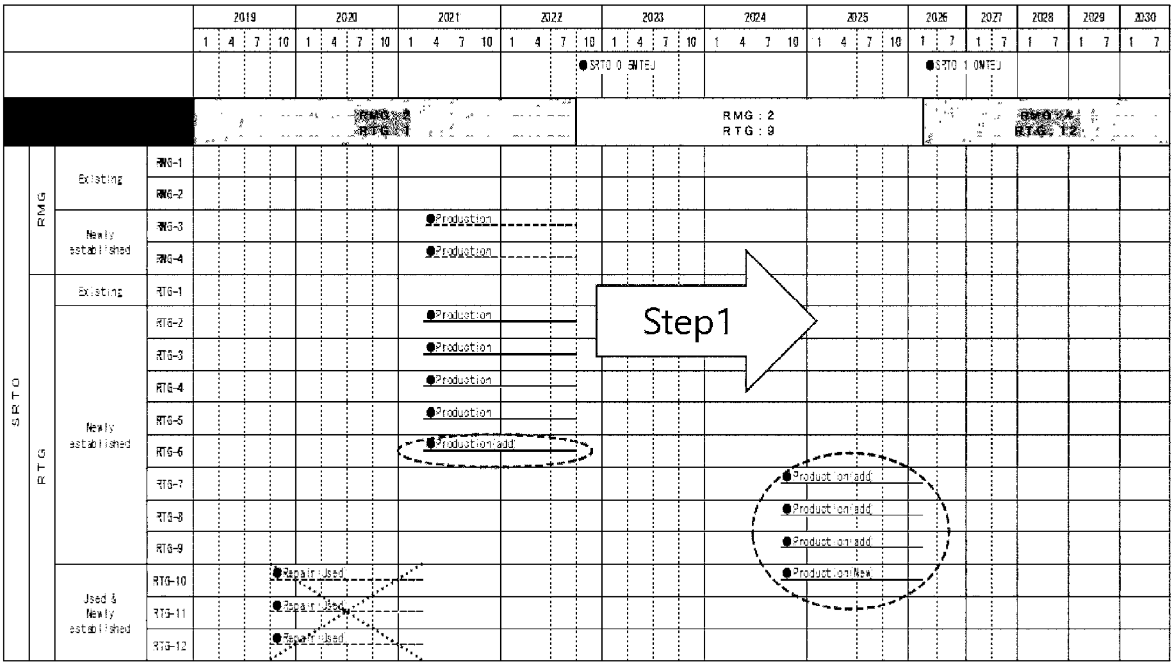
Optimal Layout 0.25M TEU/unit



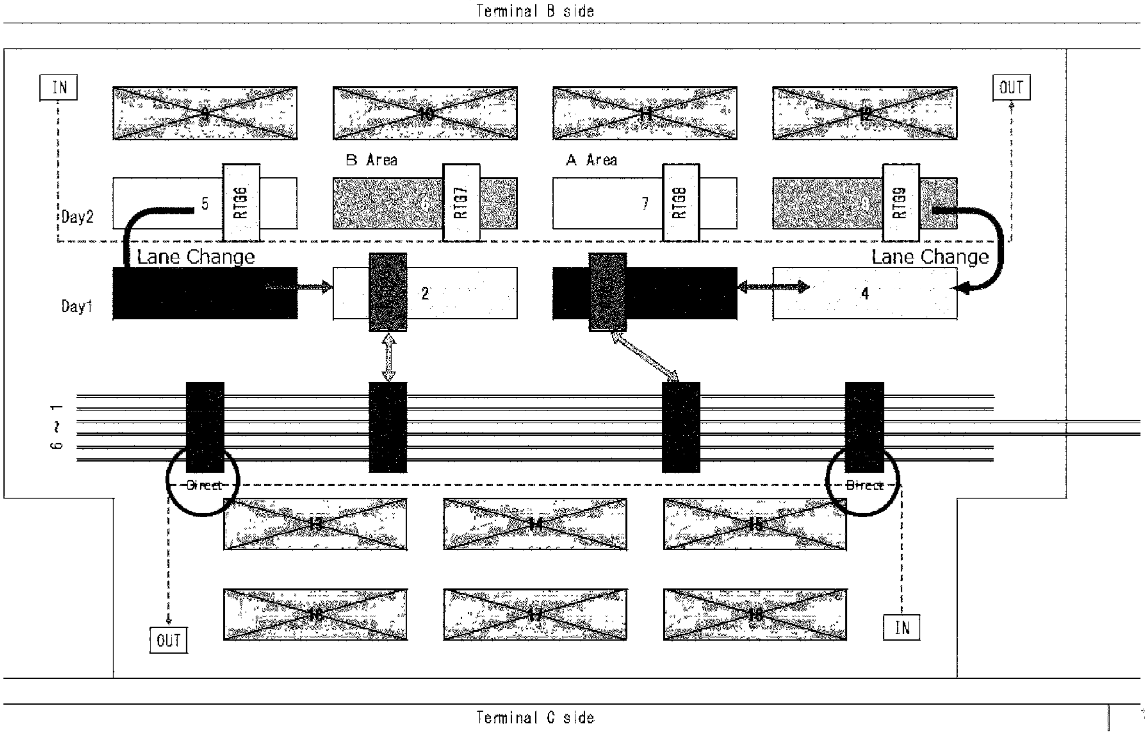
Equipment introduction Schedule (Present)

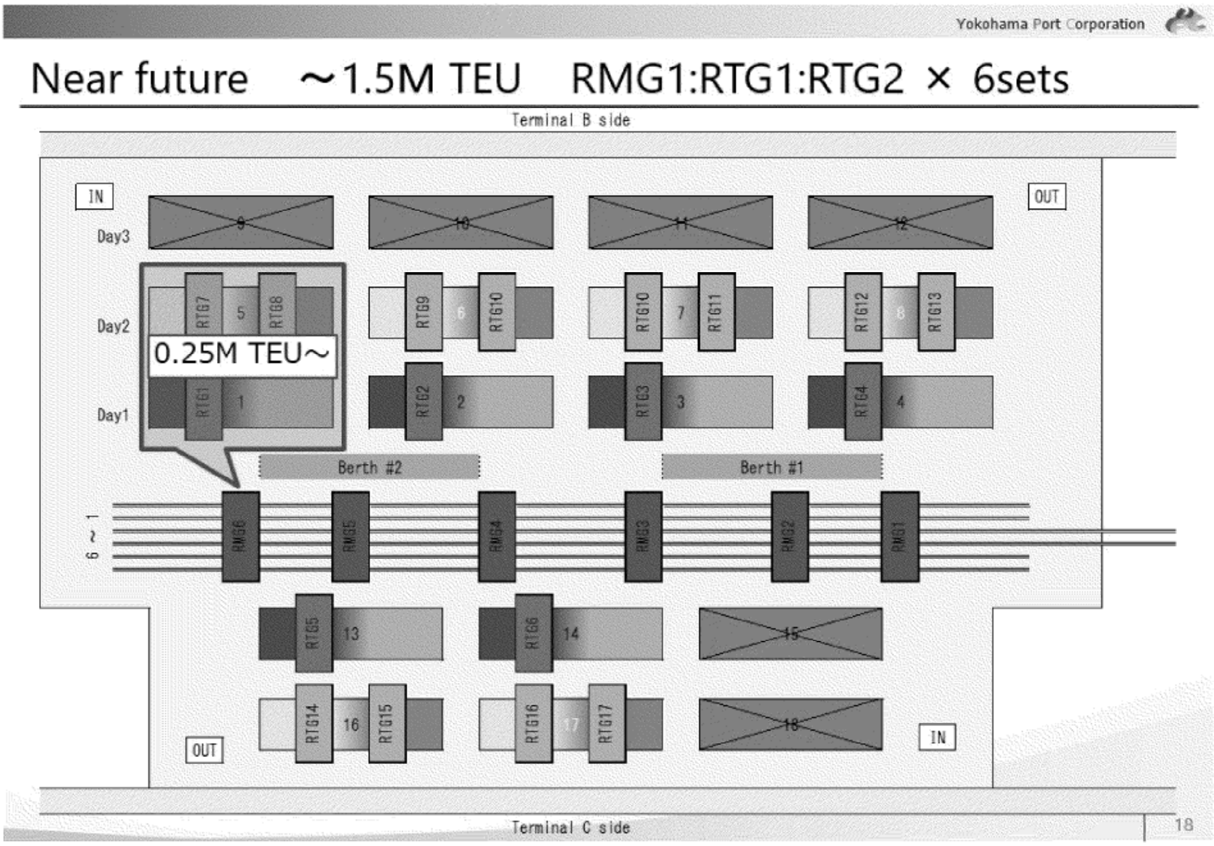


Equipment introduction Schedule (YPC's plan)



Step1 RMG4:RTG6 0.5M TEU~

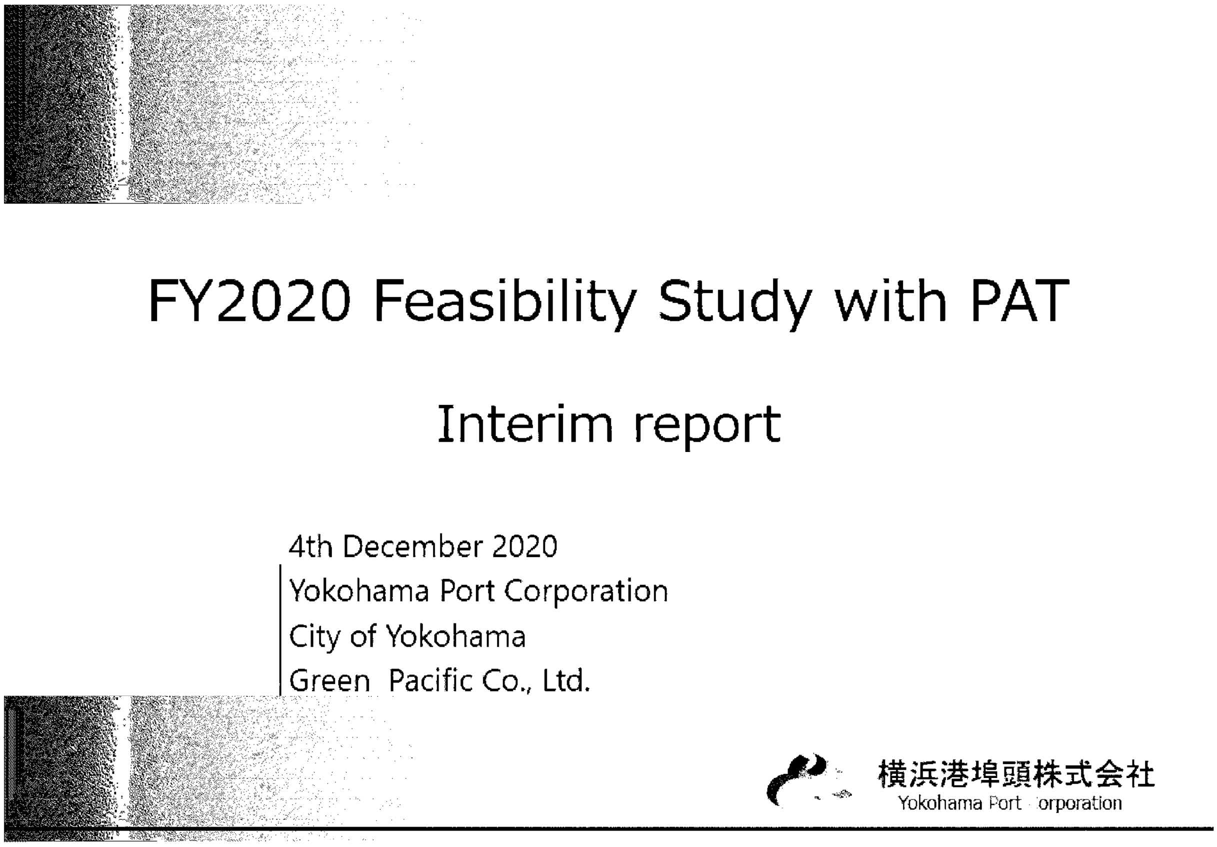




Near future ∼1.5M TEU RMG1:RTG1:RTG2 × 6sets

0.25M TEU∼

(2) Documents of the 2nd online meeting (Interim report)

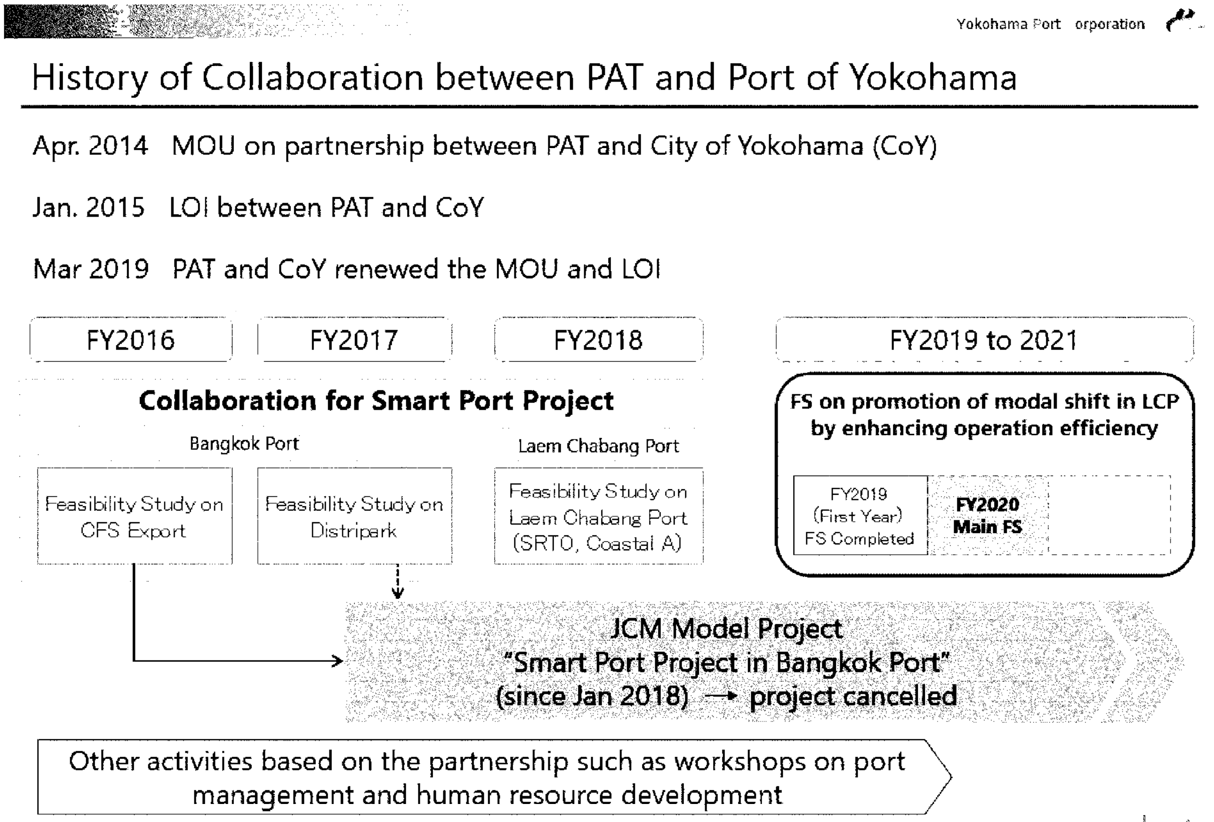


FY2020 Feasibility Study with PAT

Interim report

4th December 2020
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.

横浜港埠頭株式会社
Yokohama Port orporation



Yokohama Port orporation

History of Collaboration between PAT and Port of Yokohama

Apr. 2014 MOU on partnership between PAT and City of Yokohama (CoY)

Jan. 2015 LOI between PAT and CoY

Mar 2019 PAT and CoY renewed the MOU and LOI

FY2016 | FY2017 | FY2018 | FY2019 to 2021

Collaboration for Smart Port Project

Bangkok Port

- Feasibility Study on CFS Export
- Feasibility Study on Distripark

Laem Chabang Port

- Feasibility Study on Laem Chabang Port (SRTO, Coastal A)

FS on promotion of modal shift in LCP by enhancing operation efficiency

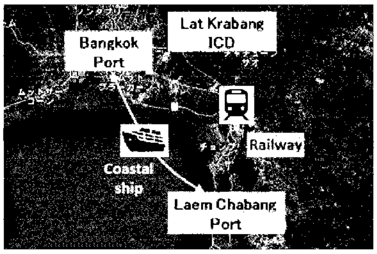
- FY2019 (First Year) FS Completed
- **FY2020 Main FS**

JCM Model Project
"Smart Port Project in Bangkok Port"
(since Jan 2018) → project cancelled

Other activities based on the partnership such as workshops on port management and human resource development

Three-year Project Plan FY2019 to FY2021

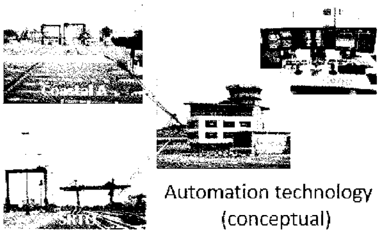
FY 2019



- Study on current situation
  - Challenges for enhancing operation efficiency
  - Plan and target of modal shift in LCP

Completed

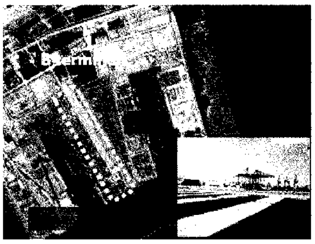
FY 2020



Automation technology (conceptual)

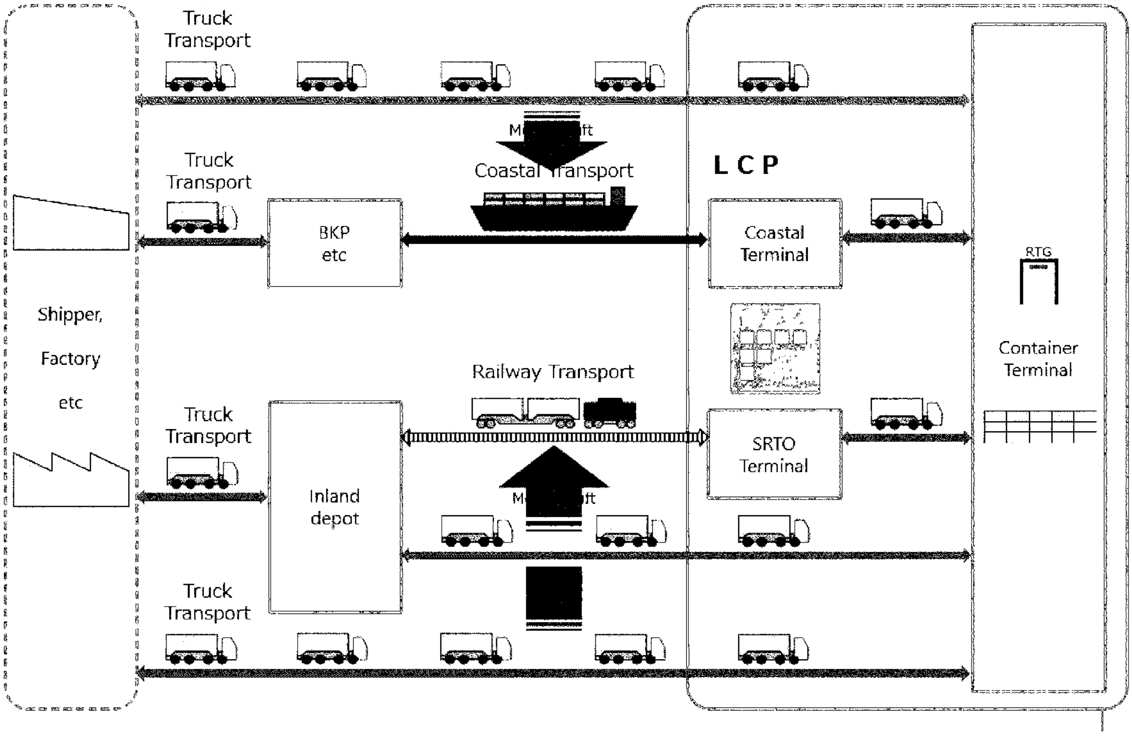
- Study on enhancing efficiency of terminal operation through modal shift
- Study on CO2 reduction effects by promoting modal shift
- Study on enhancing efficiency by cooperation between container terminals, SRTO and ICD
- Study on introduction of support measures for promoting modal shift

FY 2021



- Demonstration experiment at SRTO

Concept of Modal Shift in Ports in Thailand



Truck Transport

Truck Transport

M ft

Coastal ransport

L C P

BKP etc

Coastal Terminal

RTG

Shipper, Factory etc

Railway Transport

Container Terminal

Truck Transport

SRTO Terminal

Inland depot

M ft

Truck Transport

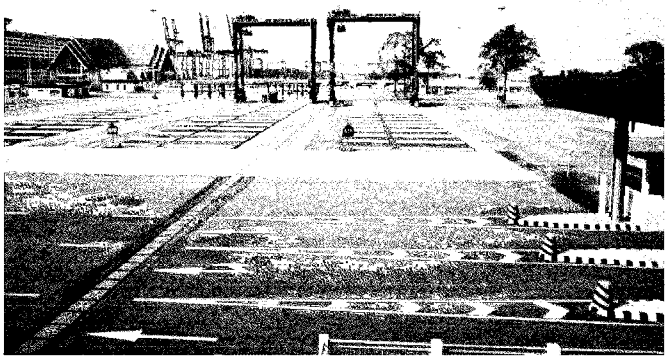
Outline of FS

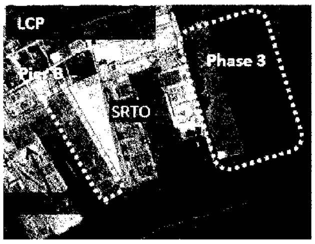
Study content of 2020FS

1. **Study on efficiency improvement of terminal operation for modal shift**
2. **Study on CO2 reduction effect through promotion of modal shift**
3. **Study on efficiency improvement through collaboration with railways and ICD etc.**
4. **Study on support measures for promoting modal shift**

Current Situation (Coastal-A)

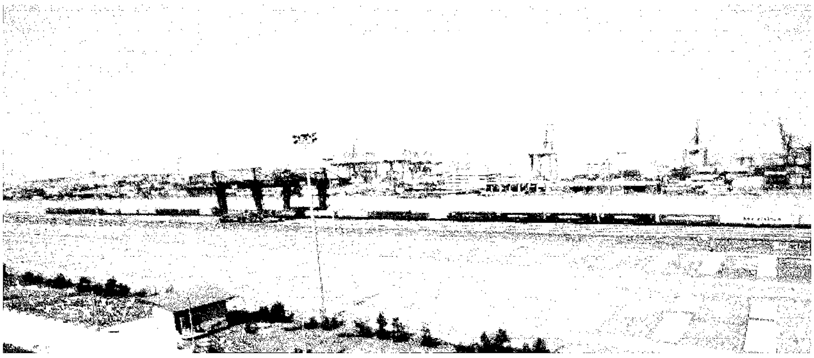
- Started a full-scale operation on March 13, 2020 and will achieve annual target of 0.3 mil TEU throughput in an early stage.
- The cargo handling method is yard storage instead of direct transportation, to keep vessel schedule. (Cargo must be delivered 24h prior to vessel cargo handling. Storage is free of charge for 3 days)
- 2 units of RTG will be introduced in June 2021 which were initially planned to be installed in Bangkok Port.

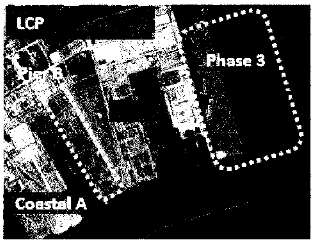




Current Situation (SRTO)

- Tentative service has started in September 2018. It currently handles 10,000 to 24,000 TEUs /month.
- Cargo handling requires 12 hours per a train including waiting time for customs clearance, while 4 trains can park at the same time.
- Operation method is direct transportation between Terminal B.
- 2 RMGs and 1 RTG is introduced, but the RTG has not been used.
- Additional 2 RMGs and 4 RTGs are to be introduced.





Suggestions from YPC: Operation Method of SRTO

We suggest the operation method to be changed from direct transport to yard storage for upgrading service quality of SRTO in terms of cargo throughput and punctuality.

Operation by direct transportation

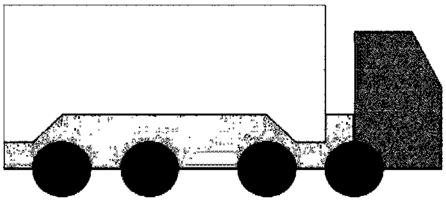
- Efficiency of railway cargo handling depends on trucks from outside.
- Burden on B terminals operators is large. (e.g. need of arranging many trucks and prioritized gate operation for them, etc.)
- Large storage area of SRTO has not been used effectively.

Operation by yard storage

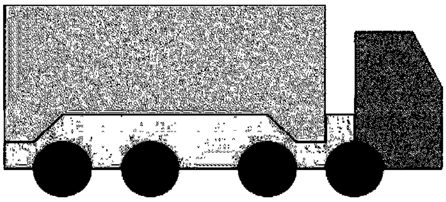
- Efficiency of operation will be enhanced by giving priority to railway cargo handling.
- Burden on B terminals operators would be small.
- Large storage area of SRTO can be used effectively.

Simulation: Colors of Container and Trucks

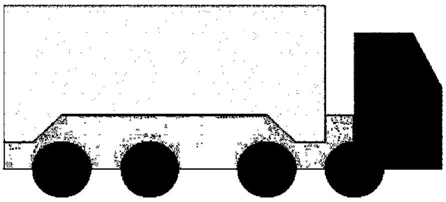
External Trucks (B to SRTO)



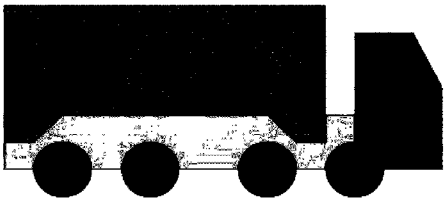
External Trucks (SRTO to B)



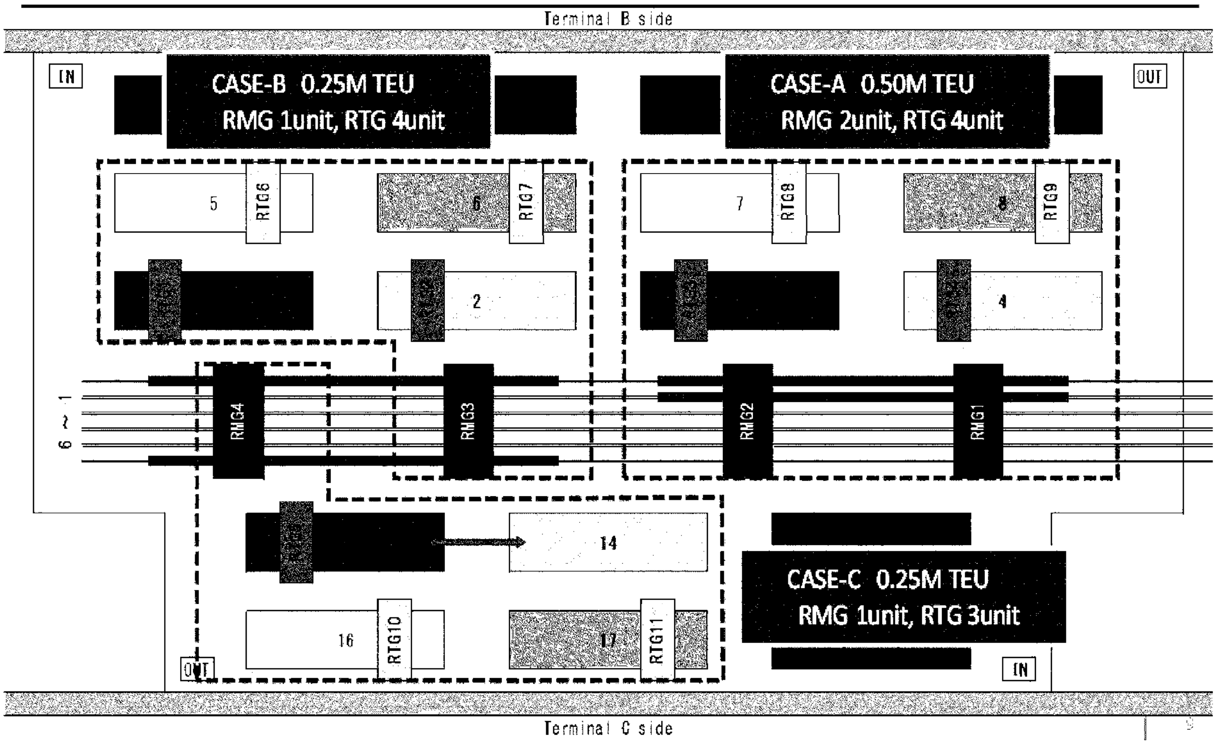
YARD Trucks (Trains to SRTO)



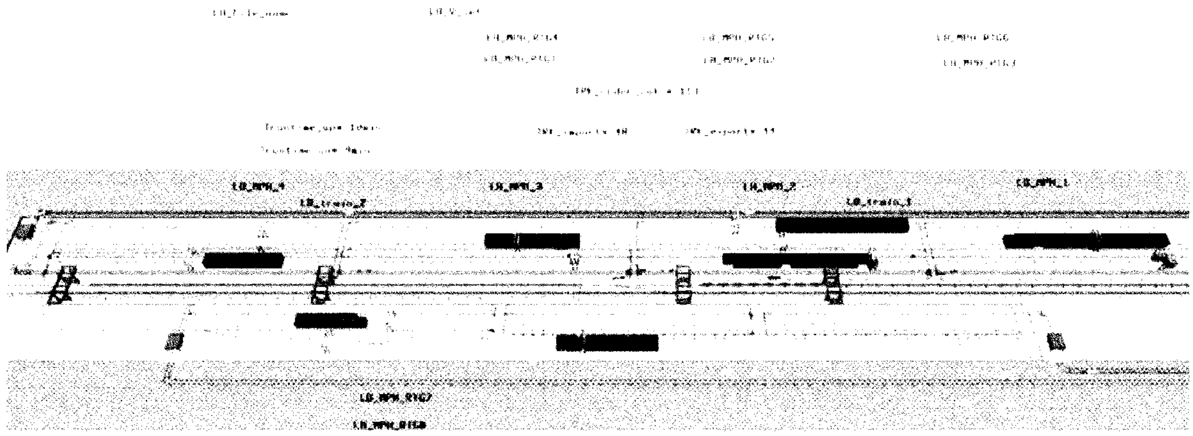
YARD Trucks (SRTO to Trains)



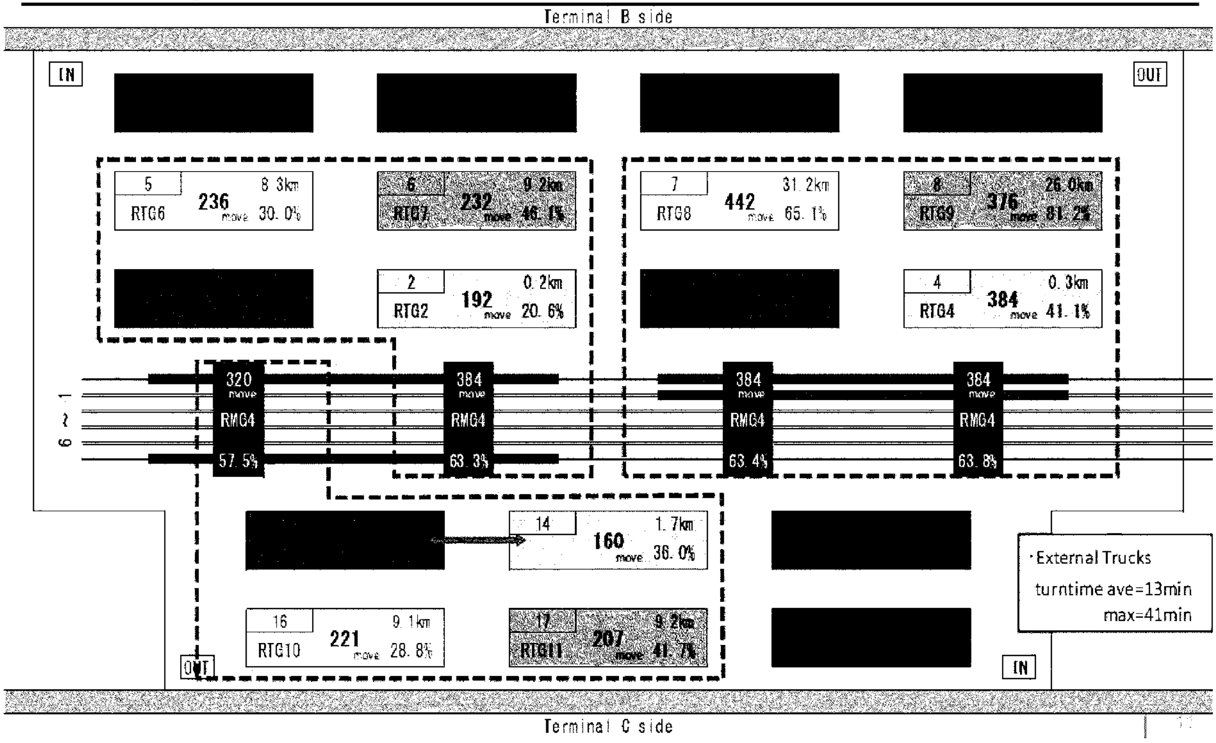
Simulation: Case A, B and C



Simulation Model



Summary of Simulation Results



·External Trucks
turntime ave=13min
max=41min

Analysis on RTG in each case

CASE	RMG	RTG Lane1	RTG Lane2	Target (TEU/Year)	RTG 1unit Average (Lane1 : RTG - RMG)			RTG 1unit Average (Lane2 : RTG - External Trucks)		
					Handling Count (move/Day·unit)	Traveling distance (km/Day·unit)	Operating Rate (24h)	Handling Count (move/Day)	Traveling distance (km/Day·unit)	Operating Rate (24h)
A	2	2	2	500,000	384.0	0.30	**41.1%**	409.0	28.61	**73.2%**
B	1	2	2	250,000	192.0	0.20	**20.6%**	234.0	8.76	**38.0%**
C	1	1	2	250,000	320.0	3.36	**36.0%**	214.0	9.11	**35.2%**

Proposal on Arrangement of Cargo Handling Equipment

Optimal combination : 1 RMG + 3 RTGs 0.25M TEU/set

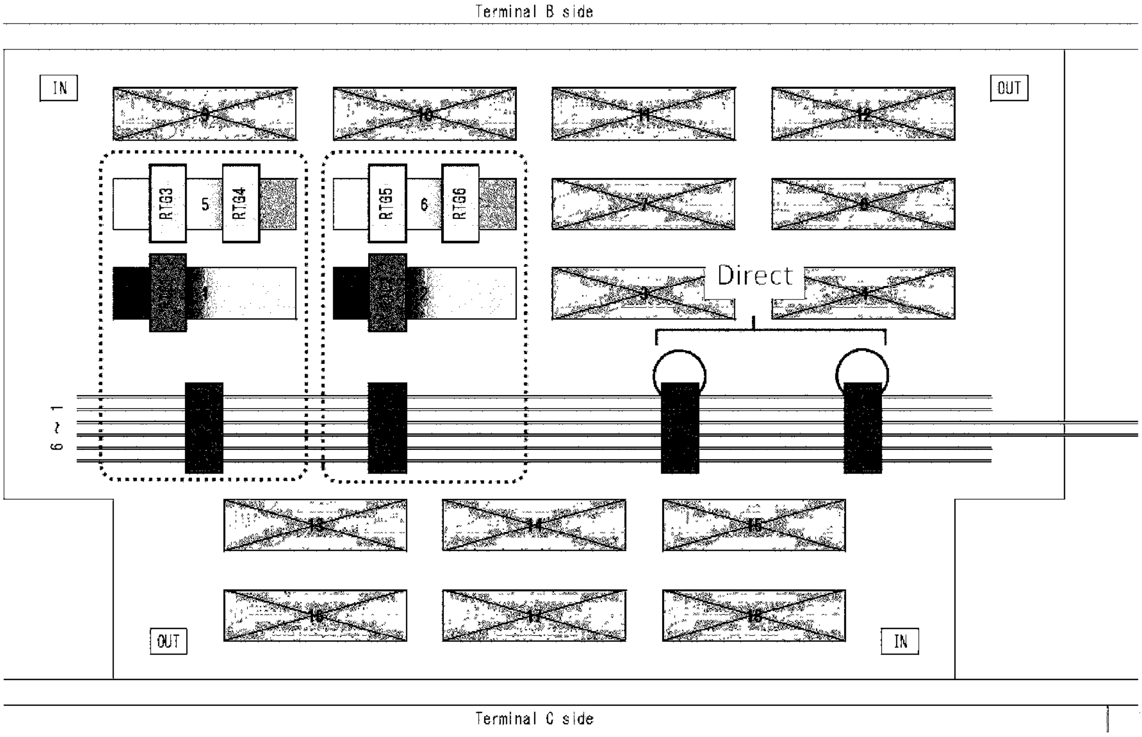
Present) 2 RMGs + 1 RTG

STEP1) 2 RMGs + 4 RTGs

\+ 1 RTG ~0.5M TEU

STEP2) + 6 RTGs ~ 1M TEU

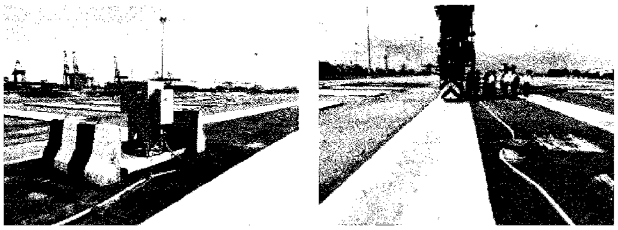
Step1 2 RMGs +6 RTGs :0.5MTEU + 2 RMGs(Direct)



Suitable equipment for changing operation method

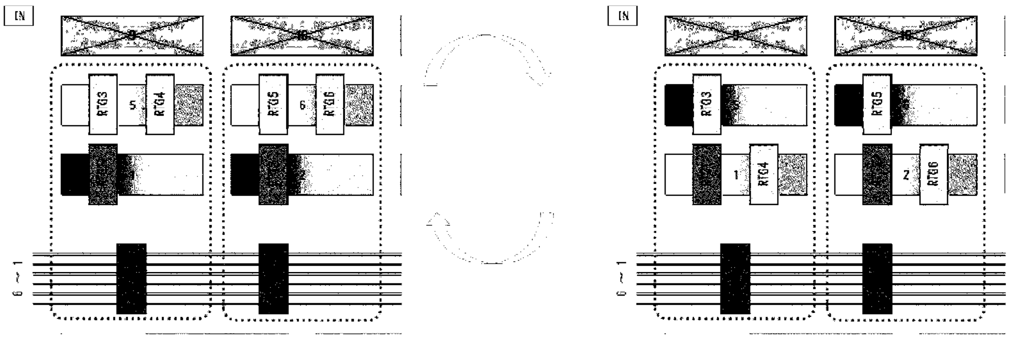
Reference

Cables of RTG must not interfere truck traffic

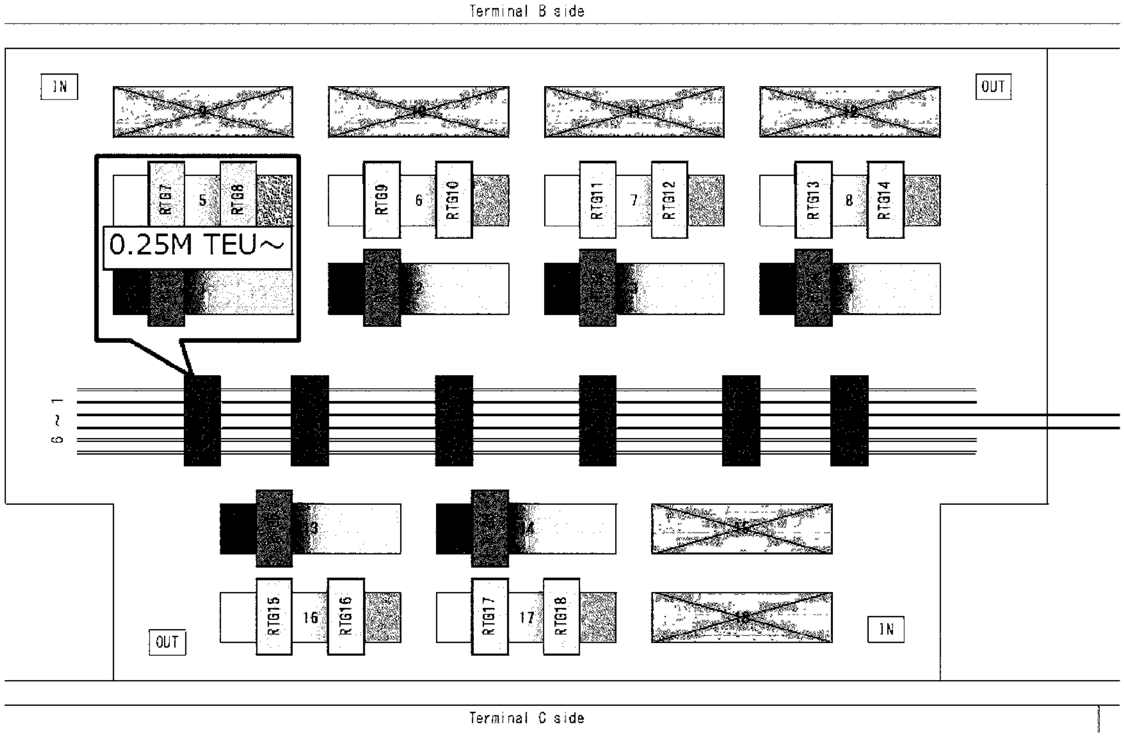


RTG must be able to change lanes

Drive-in type
https://www.youtube.com/watch?v=vJF2nbbRA4k
Auto plug-in type
https://www.youtube.com/watch?v=nYxHHZRXRsA



Near future (1 RMG, 1 RTG, 2 RTGs) × 6 sets



Our view toward Realization of Efficient Cargo Operation

1. Changing operation method and reviewing procurement plan (number of units) is necessary!

2. Introducing remote operation in near future is effective!

1) Preparing cargo handling equipment which is suitable for changing operation method
2) Preparing cargo handling equipment which is modifiable for remote operation

This leads to increase of initial cost, so our suggestion is...

- To introduce suitable technologies with support of Japanese government
- To consider utilizing JCM program

(3) Documents of the 3rd online meeting (Final report)

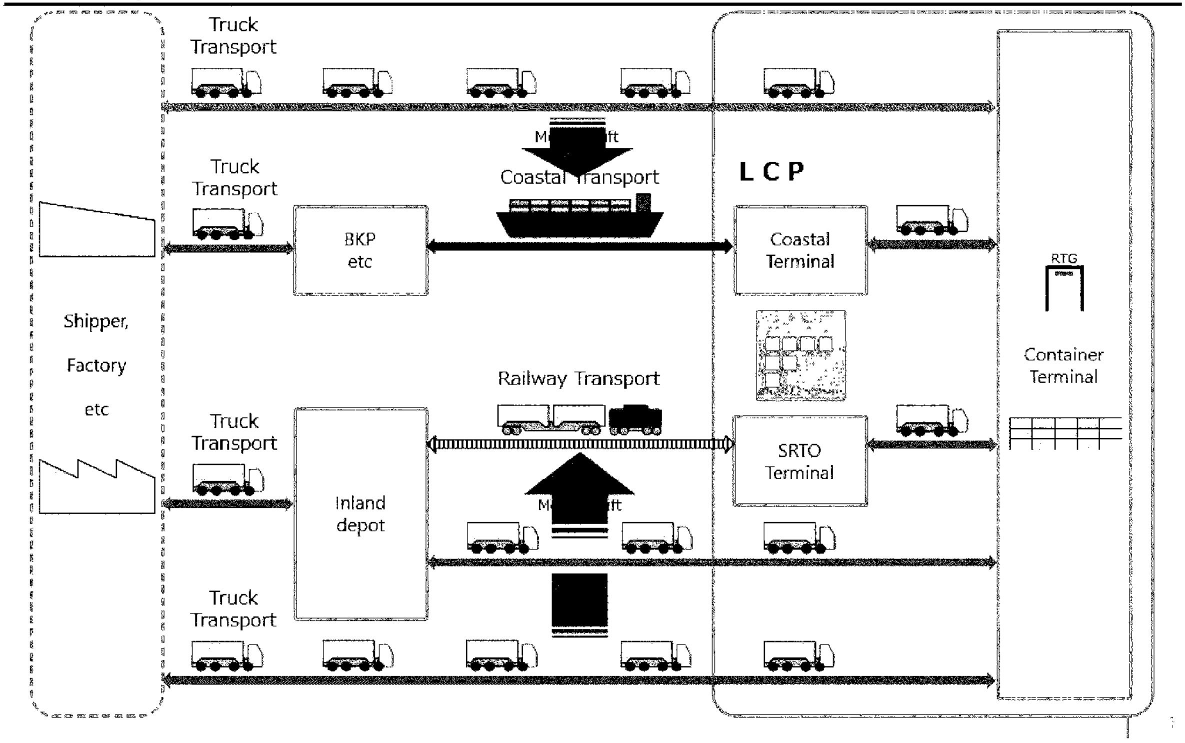
FY2020 Feasibility Study with PAT

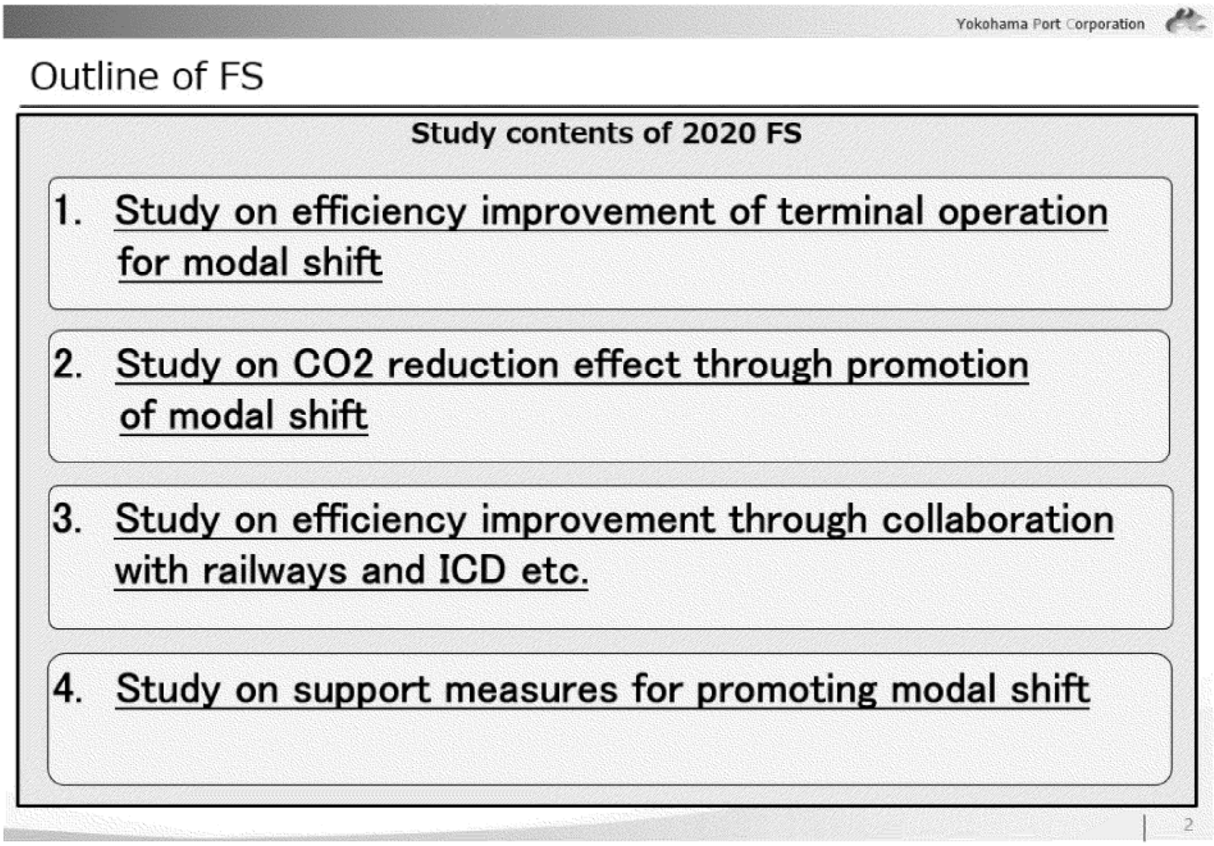
Final report

19th February 2021
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.

横浜港埠頭株式会社
Yokohama Port orporation

Concept of Modal Shift in Ports in Thailand

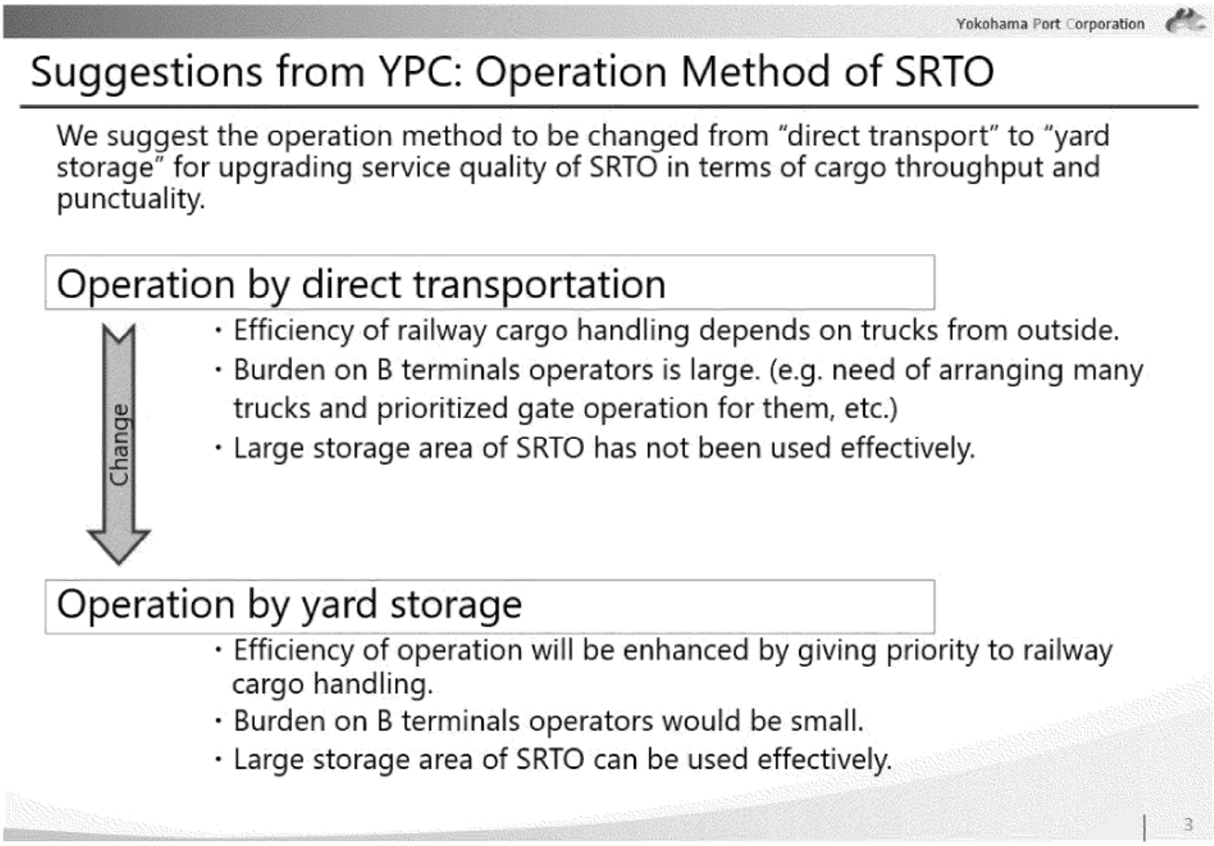




Outline of FS

Study contents of 2020 FS

1. **Study on efficiency improvement of terminal operation for modal shift**
2. **Study on CO2 reduction effect through promotion of modal shift**
3. **Study on efficiency improvement through collaboration with railways and ICD etc.**
4. **Study on support measures for promoting modal shift**



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We suggest the operation method to be changed from “direct transport” to “yard storage” for upgrading service quality of SRTO in terms of cargo throughput and punctuality.

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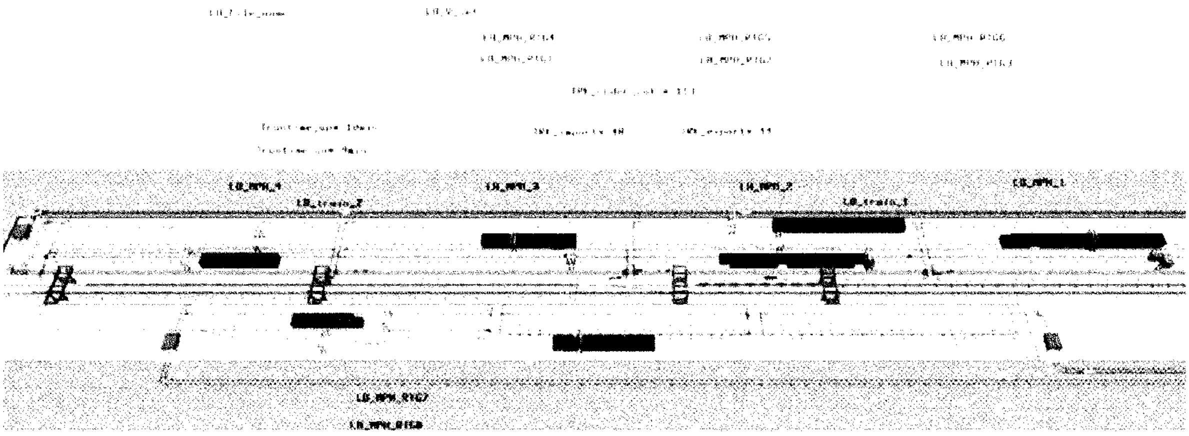
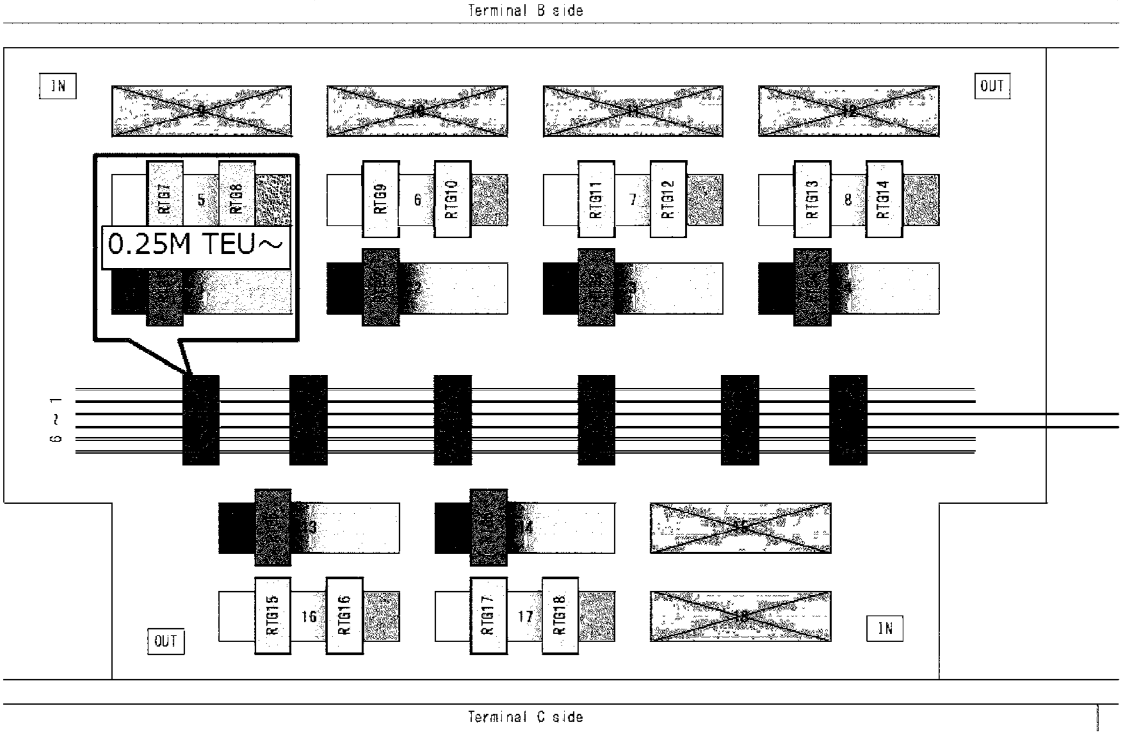
- Large storage area of SRTO can be used effectively.

Simulation Model



Near future (1 RMG, 3RTGs) × 6 sets = 1.5M TEU



Proposal on Arrangement of Cargo Handling Equipment

Optimal combination : 1 RMG + 3 RTGs 0.25M TEU/set

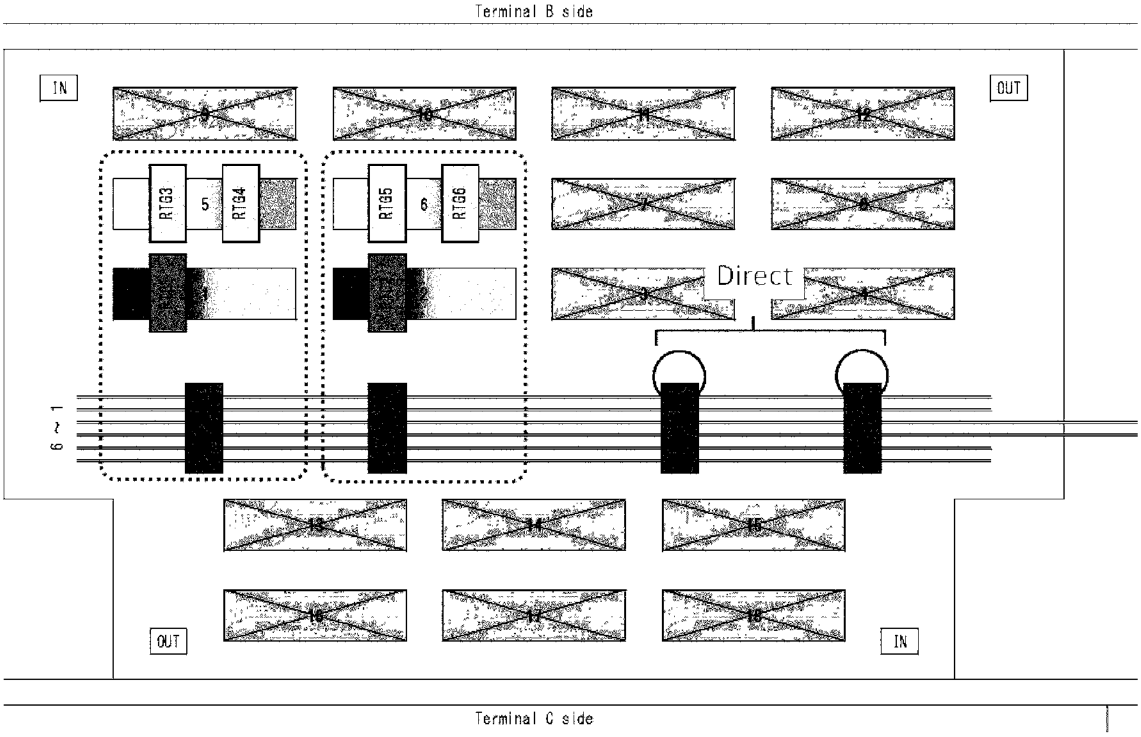
Present) 2 RMGs + 1 RTG

STEP1) 2 RMGs + 4 RTGs

+ 1 RTG ~0.5M TEU
STEP2)
+ 6 RTGs ~ 1M TEU

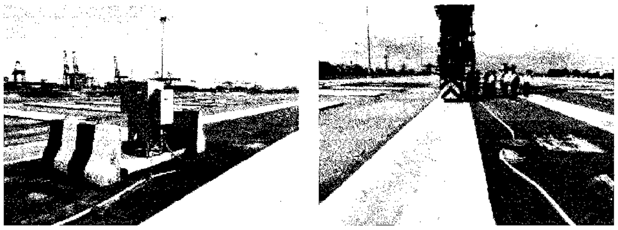
STEP3) 2 RMGs + 6 RTGs ~1.5M TEU

Step1 2 RMGs +6 RTGs :0.5MTEU + 2 RMGs(Direct)



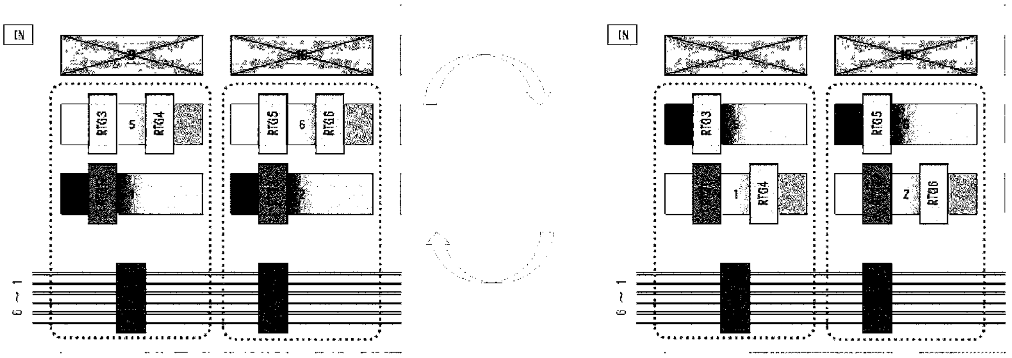
Suitable equipment for changing operation method

Cables of RTG must not interfere truck traffic



Drive-in type
https://www.youtube.com/watch?v=vJF2nbbRA4k
Auto plug-in type
https://www.youtube.com/watch?v=nYxHHZRXRsA

RTG must be able to change lanes



Roadmap

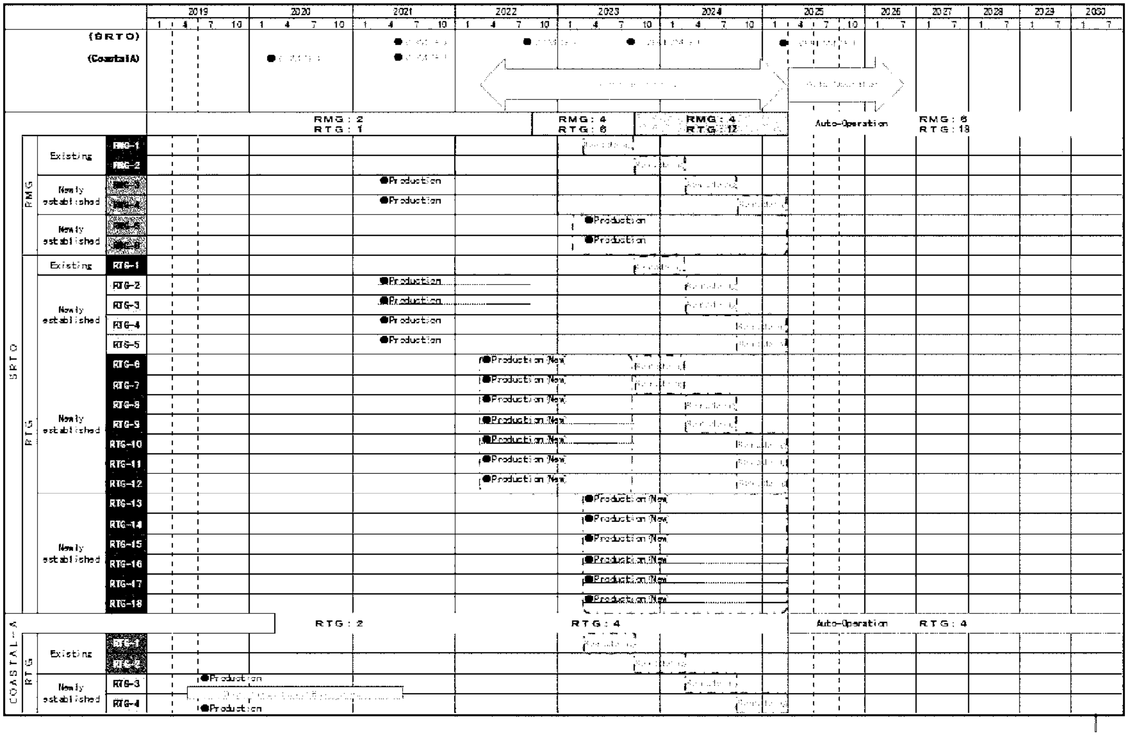
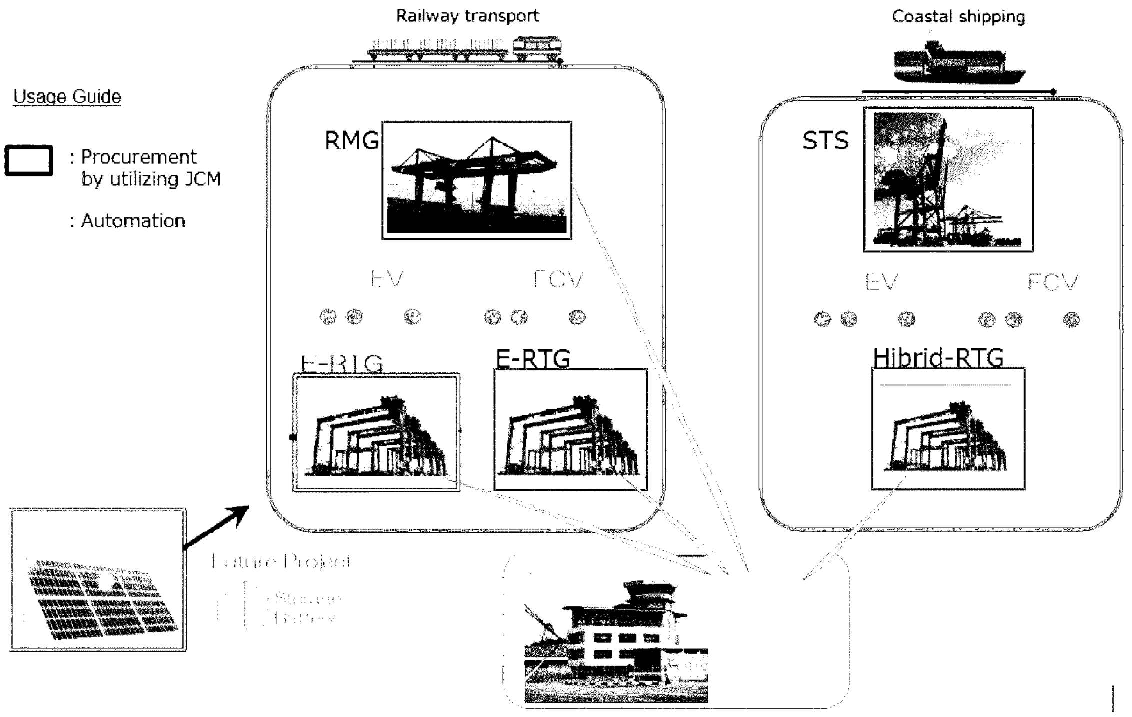


Image of the project

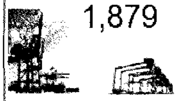


Estimation of procurement by utilizing JCM

	RTG	PV
Legal durable years	12	17
Quantity	7 unit	1set (2.73MW)
Initial cost (A)	331,011,492 THB	115,065,000 THB
JCM subsidy (B)	36,080,247 THB	27,615,000 THB
Percentage of subsidy (C)	10.9%	24.0%
CO2 reduction (D)	31,603 t-CO2/12year (2,633.6 t-CO2/year)	35,370 t-CO2/17year (2,080.6 t-CO2/year)
JCM cost effectiveness (B)/(D)	1,142 THB/t-CO2	781 THB/t-CO2
Cost saving	346,500,000 THB	112,484,496 THB
Total JCM subsidy	63,695,247 THB (221,659,460 JPY)	
Total Percentage of subsidy	14.3%	

CO2 reduction effort through promotion of Modal shift

t-CO2e/year

	Project Scenario (Modal shift)			Reference Scenario (Truck)	GHG Emission Reduction
Coastal-A (0.3M TEU/y)	Ship	Others	Total	34,080 	17,037
	15,164 	1,879 	17,043		
SRTO (1.0M TEU/y)	Train	Others	Total	104,614 	81,826 ~ 69,385
	15,834 ~28,275 	6,954 	22,788 ~35,229		

Source of emission factor by train: Locomotive Emissions Monitoring Program 2016, Railway Association of Canada 0.025 t-CO2e in 1990 and 0.014 t-CO2e in 2016.

Conclusion

1. Terminal Operation

- ✓ It is efficient to gradually increase a set of "1 RMG +3 RTGs" depending on the handling volume.
- ✓ Introduction of automation is desirable when handling volume reaches 1.5M TEU/year.

2. CO2 reduction

- ✓ It is important to make the best mix of mode of transportation while promoting zero emissions for ships, railroads, and trucks.

3. Collaboration

- ✓ Cooperation between PAT, Lat Krabang ICD, SRT and B Terminals would be important. A round-table meeting by these parties may facilitate good coordination.

4. Support measures

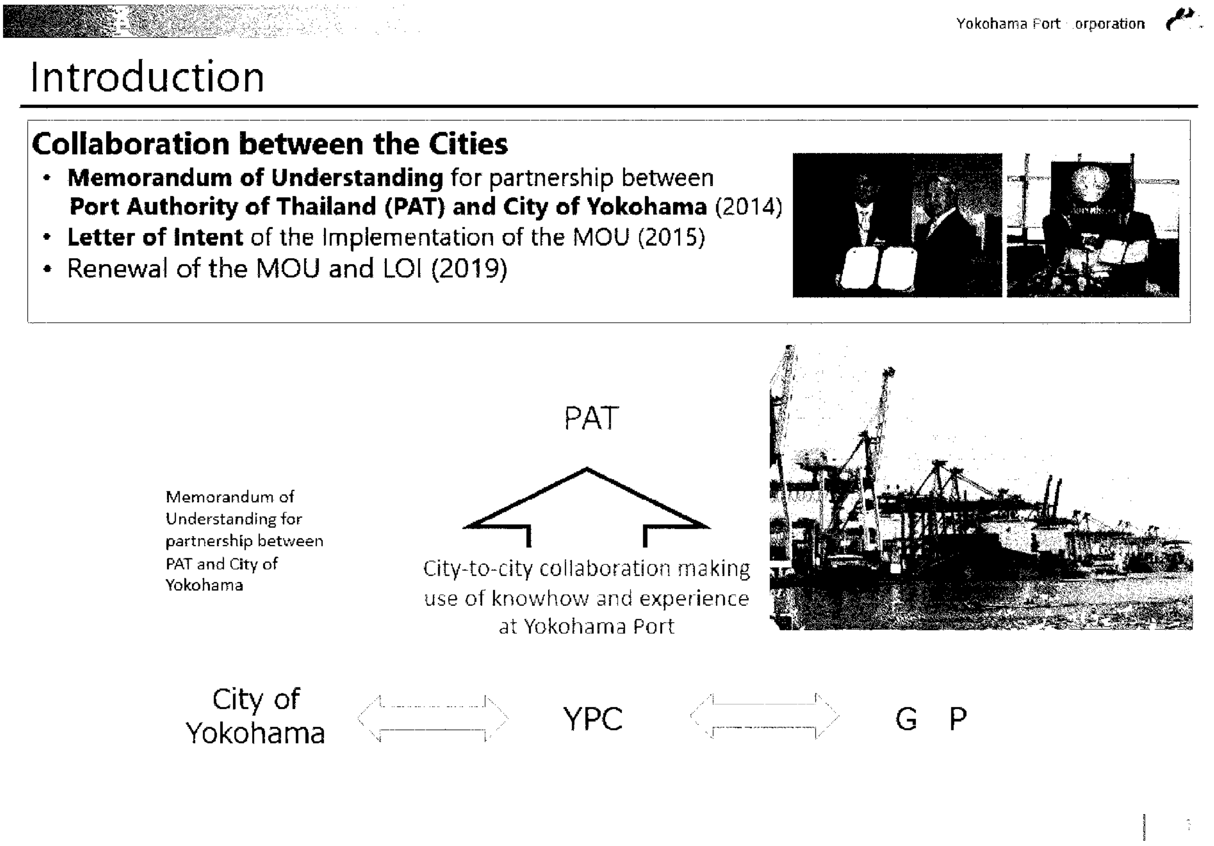
- ✓ There is a possibility to start a project for introducing automation, which may incorporate JCM in some areas.

Attachment 3: Presentation at the City to City Collaboration Seminar

Promotion of Modal Shift and Enhancement of Terminal Efficiency of Ports in Thailand

Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.

横浜港埠頭株式会社
Yokohama Port Corporation



Yokohama Port Corporation

Introduction

Collaboration between the Cities

- **Memorandum of Understanding** for partnership between **Port Authority of Thailand (PAT) and City of Yokohama** (2014)
- **Letter of Intent** of the Implementation of the MOU (2015)
- Renewal of the MOU and LOI (2019)

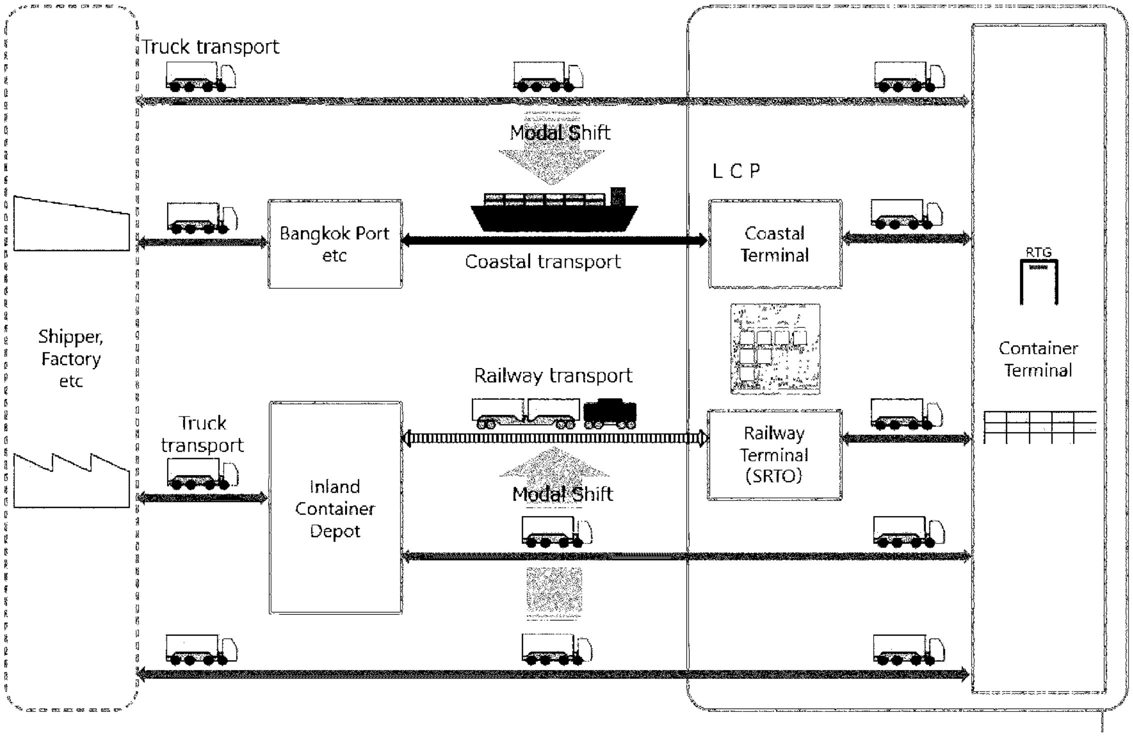
PAT

Memorandum of Understanding for partnership between PAT and City of Yokohama

City-to-city collaboration making use of knowhow and experience at Yokohama Port

City of Yokohama ⟷ YPC ⟷ G P

Concept of Modal Shift in Ports in Thailand



Truck transport

Modal Shift

LCP

Bangkok Port etc

Coastal transport

Coastal Terminal

RTG

Container Terminal

Shipper, Factory etc

Railway transport

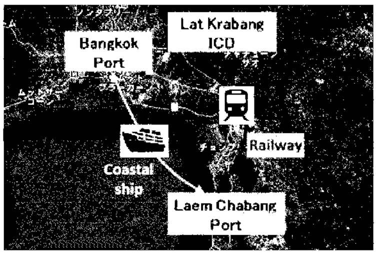
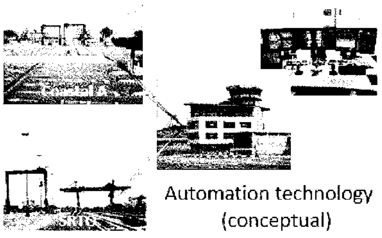
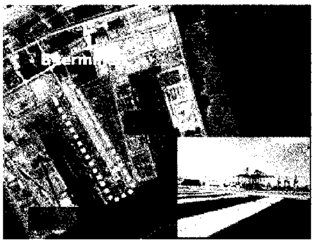
Truck transport

Inland Container Depot

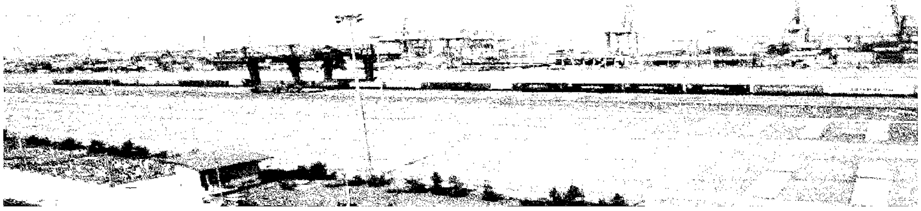
Railway Terminal (SRTO)

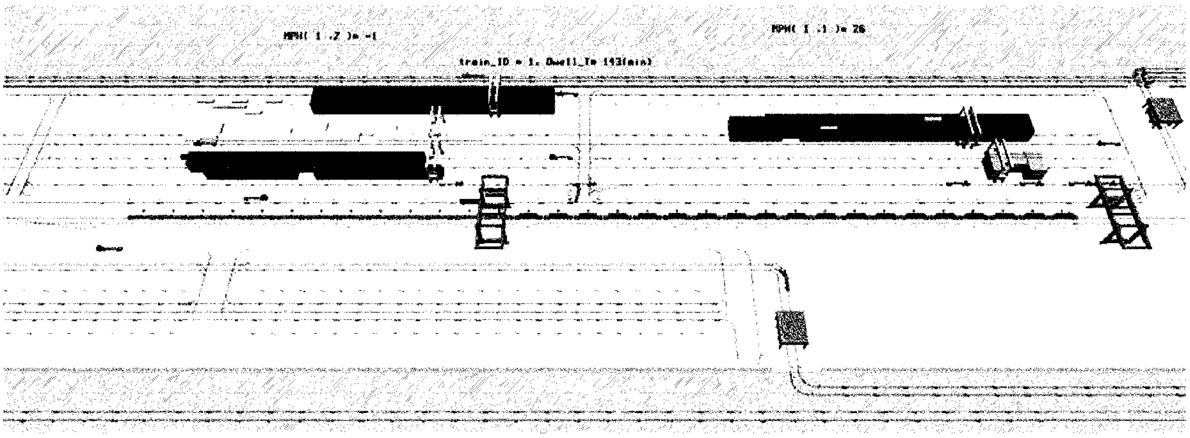
Modal Shift

Three-year Project Plan FY2019 to FY2021

FY 2019	FY 2020	FY 2021
		
	Automation technology (conceptual)	
•Study on current situation - Challenges for enhancing operation efficiency - Plan and target of modal shift in LCP **Completed**	• Study on enhancing efficiency of terminal operation through modal shift • Study on enhancing efficiency by cooperation between container terminals, SRTO and ICD • Study on CO2 reduction effect by promoting modal shift • Study on introduction of support measures for promoting modal shift	• Demonstration experiment at SRTO • Study introduction of Japanese technologies (both infrastructure and system) for the railway terminals and coastal terminal to be built in the Phase3 Development plan of LCP under the EEC

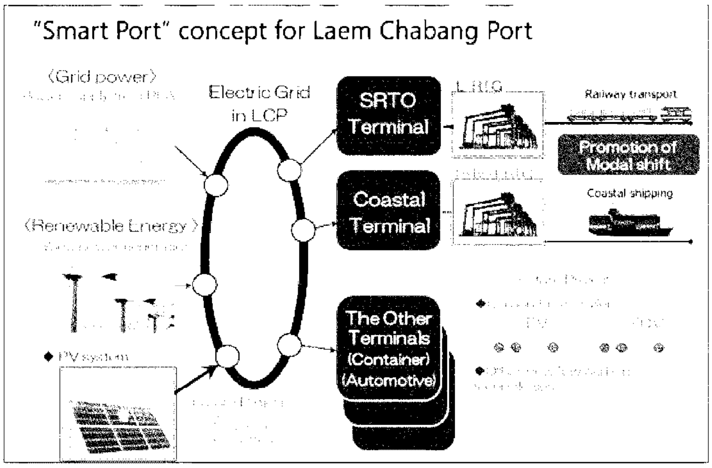
Study on Efficiency Improvement of Terminal Operation by using Simulator



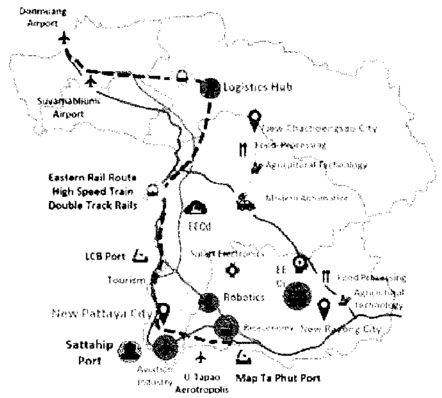


Future Prospect

"Smart Port" concept for Laem Chabang Port



Eastern Economic Corridor (EEC)



Source: Royal Thai Embassy, U.S.
https://thaiembdc.org/eastern-economic-corridor-eec/

Attachment 4: Preconditions and results of the simulation

< CASE-1>

Train dwelltime

	train_dwell_time (min)	RMG_no
1	146.74	RMG1
2	148.76	RMG3
3	148.10	RMG2
4	159.53	RMG4
5	150.79	RMG1
6	152.34	RMG3
7	152.96	RMG2
8	158.71	RMG4
9	155.81	RMG1
10	154.02	RMG3
11	157.63	RMG2
12	159.78	RMG4
13	159.46	RMG1
14	155.68	RMG3
15	160.85	RMG2
16	161.10	RMG4
17	160.52	RMG1
18	157.32	RMG3
19	164.15	RMG2
20	158.23	RMG4
21	166.93	RMG1
22	161.06	RMG3
23	168.20	RMG2

AVE= 157.33

MAX= 168.20

MIN= 146.74

RMG MPH

RMG1_MPH	RMG2_MPH	RMG3_MPH	RMG4_MPH
25.68	25.45	25.07	23.43
25.00	24.65	24.50	23.54
24.21	23.93	24.24	23.39
23.66	23.46	23.99	23.20
23.51	23.00	23.75	23.61
22.62	22.46	23.21	

RTG MPH

RTG_no	RTG_handling_cnt	MPH	Total_distance_traveled
1	384	17.06	1,864.8
2	384	16.94	1,864.8
3	384	16.97	1,864.8
4	320	17.40	1,386.0
5	136	5.24	15,472.8
6	139	5.20	14,250.6
7	135	5.16	14,112.0
8	145	5.85	14,515.2
9	129	4.93	13,986.0
10	127	4.95	14,364.0
11	142	5.39	14,566.6
12	138	5.26	15,850.8
13	115	4.49	13,154.4
14	78	3.00	6,438.6
15	87	3.42	7,988.4
16	83	3.23	8,706.6
17	81	3.09	7,106.4
18	93	3.54	9,046.8
AVE=	172	7.28	9,807.8
MAX=	384	17.40	15,850.8
MIN=	78	3.00	1,386.0

<CASE-2>

Train dwelltime

	train_dwell_time (min)	RMG_no
1	146.74	RMG1
2	148.76	RMG3
3	148.10	RMG2
4	159.49	RMG4
5	150.79	RMG1
6	152.34	RMG3
7	152.96	RMG2
8	158.68	RMG4
9	155.81	RMG1
10	154.02	RMG3
11	157.63	RMG2
12	159.86	RMG4
13	159.46	RMG1
14	155.68	RMG3
15	160.85	RMG2
16	161.06	RMG4
17	160.52	RMG1
18	157.32	RMG3
19	164.15	RMG2
20	158.25	RMG4
21	166.93	RMG1
22	161.06	RMG3
23	168.20	RMG2

AVE= 157.33

MAX= 168.20

MIN= 146.74

RMG MPH

RMG1_MPH	RMG2_MPH	RMG3_MPH	RMG4_MPH
25.68	25.45	25.07	23.43
25.00	24.65	24.50	23.55
24.21	23.93	24.24	23.38
23.66	23.46	23.99	23.21
23.51	23.00	23.75	23.61
22.62	22.46	23.21	

RTG MPH

RTG_no	RTG_handling_cnt	MPH	Total_distance_traveled
1	384	17.06	1,864.8
2	384	16.94	1,864.8
3	384	16.97	1,864.8
4	320	17.40	1,386.0
5	131	5.34	16,014.6
6	273	10.36	82,391.4
7	242	9.29	71,265.6
8	278	10.41	91,737.3
9	269	10.08	82,958.4
10	122	4.77	20,298.7
11	121	4.71	20,865.6
12	182	6.85	39,375.0
AVE=	258	10.85	35,990.6
MAX=	384	17.40	91,737.3
MIN=	121	4.71	1,386.0

< CASE-3>

Train dwelltime

train_no	train_dwell_time (min)	RMG_no
1	143.2337	RMG1
2	143.6231	RMG3
3	143.8887	RMG2
4	158.2445	RMG4
5	145.9030	RMG1
6	145.3933	RMG3
7	146.0832	RMG2
8	159.4155	RMG4
9	151.4705	RMG1
10	148.2647	RMG3
11	147.5496	RMG2
12	163.1473	RMG4
13	152.6036	RMG1
14	146.7808	RMG3
15	149.7335	RMG2
16	161.3745	RMG4
17	154.4184	RMG1
18	149.5319	RMG3
19	154.6738	RMG2
20	163.9755	RMG4
21	155.2282	RMG1
22	152.5500	RMG3
23	154.8323	RMG2

MAX=	163.9755	min
MIN=	143.2337	min
AVE=	151.8226	min

RMG MPH

RMG1_MPH	RMG2_MPH	RMG3_MPH	RMG4_MPH
26.2943	26.1772	25.9441	23.6116
25.8223	25.7913	25.6374	23.4428
24.8904	25.5398	25.1552	22.9206
24.7090	25.1741	25.4021	23.1658
24.4238	24.3844	24.9481	22.8079
24.2986	24.3599	24.4683	

RTG MPH

RTG_no	RTG_handling_cnt	MPH	distance(m)
1	192	9.0059	201.6000
2	192	9.1359	201.6000
3	384	16.4176	302.4000
4	384	16.7031	302.4000
5	320	17.2979	3,364.2000
6	236	9.2103	8,341.2000
7	232	8.6752	9,185.4000
8	442	17.1830	31,235.4000
9	376	14.6169	25,993.8000
10	221	8.5781	9,051.4651
11	207	8.1570	9,172.8000
	MAX=	17.2979	31,235.4000
	MIN=	8.1570	201.6000
	AVE=	12.2710	8,850.2059

CASE3 Result