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FY2019 Project for Ministry of the Environment Japan

FY2019
City-to-City Collaboration Programme for Low-Carbon Society

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

Report

February 2020

Yokohama Port Corporation

City of Yokohama

Green Pacific Co., Ltd.

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1. Work Overview

1.1 Work 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 decarbonize 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. In addition, the project involves a study of the feasibility of taking advantage of Japan's advanced technology to promote terminal efficiency and further promote a modal shift by introducing low-carbon cargo handling equipment, utilizing JCM at an associated inland container depot.

In providing assistance for PAT's Green Port Project, YPC has taken a phased approach, starting with a project to introduce low-carbon facilities using the JCM at Bangkok Port as Step 1, then expanding the same to other PAT-managed ports including Laem Chabang as Step 2, and then in the medium and long term, seek the development of Thailand's international ports as low-carbon "smart" logistics centers in the ASEAN region. In the previous year, as the beginning of Step 2 in this series of initiatives, a study was conducted regarding the feasibility of a project to introduce advanced Japanese low-carbon technologies and products, etc., to Laem Chabang Port using the JCM.

Specifically, this was a feasibility study for a project to use the JCM to introduce low-carbon cargo handling equipment and utilize renewable energy at the Laem Chabang Port container terminal and multi-purpose terminal, as well as coastal terminal and rail terminal (SRTO) expansions being advanced by PAT.

The aim of this project is to expand the low-carbon efforts not only to Laem Chabang Port but also to logistics networks connected to Laem Chabang Port. In the medium and long term, these efforts could contribute to the development of Thailand's international ports as low-carbon smart logistics hubs in the ASEAN region, taking into consideration the Phase III development plan of Laem Chabang Port.

1.2 Previous Work

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

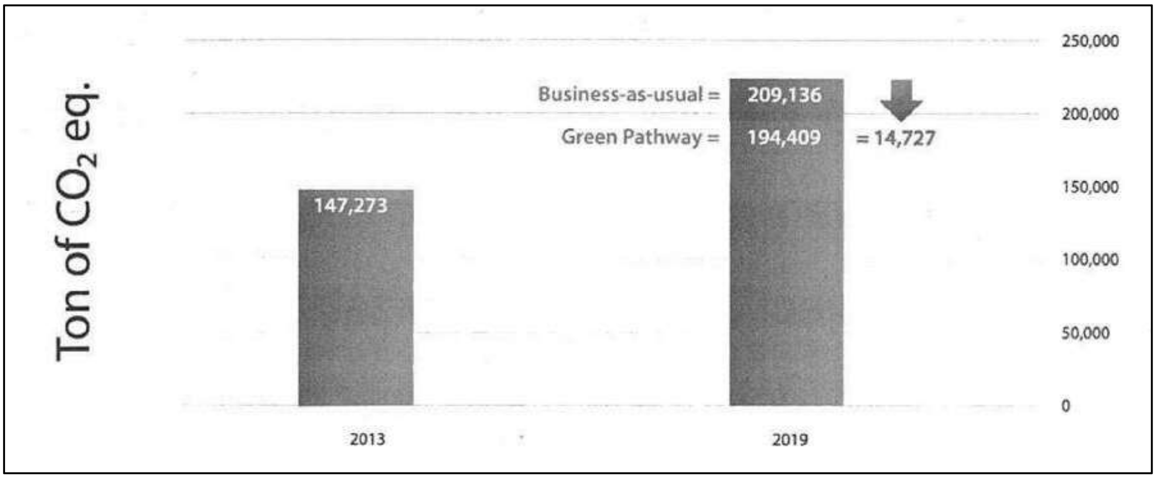
PAT was established in 1951 as a port administrator under the jurisdiction of Thailand's Ministry of Transport. It manages and operates five ports in Thailand (Bangkok Port, Laem Chabang Port, Chiang Saen Commercial Port, Chiang Khong Port, and Ranong Port) (Figure 1).)

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 an environmentally-conscious port under a five-year plan (2015-2019) entitled the "Green Port Project." This plan's target is to reduce projected CO2 emissions from PAT's operations in 2019 by 10% of the 2013 emissions (Figure 2). This target is a sign of very high awareness about environmental protection, and strong interest in introducing low-carbon equipment through use of the JCM.



Source: PAT documents

Figure 2: CO2 emissions reduction target under the PAT "Green Port Project"

Under this feasibility study, with PAT cooperating as a counterpart in Thailand, PAT has coordinated affairs with Thai government authorities and other parties and cooperated for field surveys, and joint discussions have been conducted with implementing bodies such as YPC on the Japanese side concerning appropriate technologies and project feasibility evaluation, etc. PAT also became the local party in the international consortium established for the FY2017 application to become a JCM-funded project.

(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, initially there were plans to merge/integrate the Port of Yokohama, Port of Kawasaki, and Port of Tokyo as a container terminal operation, but the Port of Tokyo later withdrew, and with YPC participating separately, in January 2016, the Yokohama-Kawasaki International Port Co., Ltd. (YKIP) was established, 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, 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.

Unlike the traditional sister port relationship, 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 marking activities to increase port freight handling volume, and promote port use).

Furthermore, a basic agreement on the following concrete action items for implementation 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). 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.

1) From 1986 to 1989, YPC dispatched personnel from the Yokohama Port and Harbor Bureau as JICA experts to the Eastern Seaboard Development Committee of Thailand to support development of Laem Chabang Port.

2) In 2013, the City of Yokohama City cooperated in work to formulate the "Bangkok Master Plan on Climate Change 2013-2023" project implemented by the Japan International Cooperation Agency (JICA). The Yokohama City Action Plan for Global Warming Countermeasures was used as a model for the formulation of the Master Plan, and the City of Yokohama created internal support arrangements consisting of multiple departments to provide extensive cooperation. The City of Yokohama's cooperation is mentioned in the FY2015 White Paper on Development Cooperation published by Japan's Ministry of Foreign Affairs.

3) On October 21, 2013, the City of Yokohama and Bangkok Metropolitan Administration signed a Memorandum of Understanding on Technical Cooperation for Environmentally-Conscious Sustainable Urban Development.

4) 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.

5) 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.

6) Seminar organized by PAT on January 19, 2015. Yokohama City Port and Harbor Bureau Director Itoh joined along with YPC's Director Kanno. A presentation was made on "Efforts of the Port of Yokohama to Become an International Hub Port."

7) On January 20, 2015, the City of Yokohama signed a basic agreement with PAT on concrete actions to fulfill the agreement in the aforementioned memorandum of understanding.

8) In May 2015, YPC received a Port of Yokohama observation tour by professors from Chulalongkorn University in Thailand. Provided information on waterfront development research related to Port Authority of Thailand.

9) 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.

10) 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.

11) 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.

12) 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.

13) In August 2017, Port and Harbor Bureau, City of Yokohama participated as a speaker at

workshop organized by PAT.

14) 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.

15) 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.

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

17) 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 FY2018 City-to-City Collaboration Programme for Low-Carbon Society, and discussions started.

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)

The Port of Yokohama is an example of the move toward low-carbon and “smart” port facilities, and it declares “a safe, secure and environmentally-friendly port” as one of its three pillars for port planning policy. Under that policy, examples of efforts so far by YPC include the installation of photovoltaic panels on the roofs of Container Freight Stations (CFS: facilities for container freight loading) of the container terminals at the Port of Yokohama, and the installation of LED lighting in the yard. In addition, the Yokohama Port and Harbor Bureau has installed photovoltaic panels on the roofs of the public buildings at Daikoku Pier, and installed a stand-alone hydrogen fuel-cell system at the Yokohama Logistics Center at the Daikoku Pier. As an example of efforts by other Yokohama Port stakeholders, operators have started using hybrid tugboats and LNG fuel powered tugboats, and building 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 proposed the “Feasibility Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’ ” (hereinafter referred to as the “previous feasibility study”) and it was selected as a project under a government program entitled “Feasibility Studies for the City-to-City Collaboration Programme for Low-Carbon Society.”

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 Subsidy (Equipment Subsidy Program Under the Joint Crediting Mechanism Subsidy Program)” (hereinafter “JCM equipment subsidy 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 in January 2018, after which implementation began (project name: “Introduction of Energy-Efficient Equipment to Bangkok Port, Thailand”).

In providing assistance for PAT's Green Port Project, YPC has taken a phased approach, starting with a project to introduce low carbon facilities using the JCM at Bangkok Port as Step 1, then expanding the same to other PAT-managed ports including Laem Chabang as Step 2, and then in the medium and long term, seek the development of Thailand's international ports as low-carbon "smart" logistics centers in the ASEAN region.

In 2018, as a first part of Step 2, shifting focus to Laem Chabang Port, discussions were held for low-carbon initiatives using JCM at Laem Chabang Port. Following these discussions, this study aims to proceed with studies to promote low-carbon initiatives in in Thailand supply chains that use Laem Chabang Port, by promoting a modal shift and not being limited only to the JCM.

These kinds of activities also could lead to the possibility of future expansion or roll-out in other ports of other countries in the ASEAN region, which gives this initiative added significance.

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 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”). Subsidy 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)	This study, the “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 “FY2018 City-to-City Collaboration Programme for Low-Carbon Society.”

2. Field Studies

2.1 Overview of Field Studies

(1) First Field Study

1) Laem Chabang Port

This field study involved a kick-off meeting for this fiscal year's City-to-City Collaboration Programme, with an outline explained by YPC regarding the Programme (duration of up to three years starting in fiscal 2019), followed by an exchange of comments regarding this fiscal year's planned study topics (possible consideration of transition to remote operations at the Coastal-A coastal terminal and SRTO rail terminal).

a) Dates and Participants

Meeting dates and participants are shown in Table 1

Table 1: Study Dates and Participants

Date	July 10, 2019 (1) 10:15 to 11:15 (Explanation of development plans for PAT's Laem Chabang Port) (2) 13:30 to 15:30 (Meeting)		
Locations	(1) PAT LCP Hall (2) PAT Laem Chabang SRTO Rail Terminal – Administrative Building		
Local participants	PAT	(1)	Ms.PorntipaTaweenuch
		(2)	Lt.Jg. Yutana Mokekhaow,R.T.N., Managing Director, Laem Chabang Port Ms. Porntipa Taweenuch, Director, General Affair Division, Laem Chabang Port Mr. Ud Tuntivejakal, Chief, Cargo Operation, Laem Chabang Port Ms. Suphattra Phisaisawat, Technical Officer 12, Corporate Strategy Planning Department, Port Authority of Thailand Ms. Mayuree Deeroop, Technical Officer 11, Corporate Strategy Planning Department, Port Authority of Thailand
Participants from Japan	Yokohama Port Corporation (YPC)		Mr. Shinsuke Itoh, President Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department Mr. Takahiro Sakurai, Assistant Manager, Engineering Planning Division, Engineering Department
	City of Yokohama		Mr. Hitoshi Makino, Director of First Construction Division, Port and Harbour Bureau
	Green Pacific Co. (GP)		Ms. Mariko Fujimori,Exective Vice President,Director Mr. Darmp Phadungsri, Consultant

b) Key Findings and Points Confirmed

Development Plans for PAT's Laem Chabang Port

- Participants received explanations by video and PowerPoint presentation regarding development plans for PAT's Laem Chabang Port and the current status of transportation modes, etc.

City-to-City Collaboration Programme Starting in FY2019

- Confirmed details of the necessary research and means of proceeding with discussions under this Programme regarding modal shift from truck to rail and coastal shipping.

Latest Situation at Coastal Terminal (Coastal-A) and Rail Terminal (SRTO)

- Confirmed the service status and operational status of coastal terminal (Coastal-A) and rail terminal (SRTO).
- Confirmed the status of RTG and RMG introduction and procurement plans at rail terminal (SRTO)
- Confirmed the handling capacity and workforce allocation for cargo handling equipment in terms of throughput targets.

Consideration of Automation (Transition to Remote Operations)

- YPC provided an overall explanation of transition to remote operations, and confirmed intentions of PAT to consider the matter under this Programme.

Other Matters

- Confirmed demand projections and related topics regarding rail transport from the coastal terminal (Coastal-A).

2) Lat Krabang ICD

a) Dates and Participants

Meeting dates and participants are shown in Table 2.

Table 2: Study Dates and Participants

Date	July 9, 2019　14:00 to 16:00	
Locations	Lat Krabang　ICD　ESCO office 3F	
Local participants	ESCO	Mr. Narimitsu Kikuno, Vice President
Participants from Japan	Yokohama Port Corporation (YPC)	Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department Mr. Takahiro Sakurai, Assistant Manager, Engineering Planning Division, Engineering Department
	Green Pacific Co. (GP)	Ms. Mariko Fujimori,Exective Vice President,Director Mr. Darmp Phadungsri, Consultant

b) Key Findings and Points Confirmed

An interview was conducted with ESCO (Mr. Kikuno, Vice President), which is the current operator of Lat Krabang ICD and is also a member of ALG consortium that gained preferential negotiation rights as a result of the previous bidding, regarding such information as recent throughput of Lat Krabang, situation after bidding and future contract renewal of Laem Chabang B. Details are shown in 2-4(3).

3) Ocean Network Express (Thailand)Ltd.

a) Dates and Participants

Meeting dates and participants are shown in Table 3.

Table 3: Study Dates and Participants

Date	July 11, 2019　13:30 to 14:00	
Locations	ONE Thailand office	
Local participants	ONE Thailand	Mr. Kiyoshi Tokonami, President Mr. Yasutaka Ikeda, Vice President Mr. Takumi Suzuki, Assitant General Manager
Participants from Japan	Yokohama Port Corporation (YPC)	Mr. Shinsuke Itoh, President Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department Mr. Takahiro Sakurai, Assistant Manager, Engineering Planning Division, Engineering Department
	City of Yokohama	Mr. Hitoshi Makino, Director of First Construction Division, Port and Harbour Bureau

b) Key Findings and Points Confirmed

Interviews were conducted with ONE, which is a container carrier using Laem Chabang Port and Lat Krabang ICD, and a member of ALG consortium that gained preferential negotiation rights as a result of the previous bidding, regarding such information as recent throughput of Laem Chabang, issues to promote modal shift. Details are shown in 2-4(3).

(2) Second Field Study and Local Interim Report

Conducted a briefing regarding a feasibility study about promoting a modal shift at Laem Chabang Port, and went on site visits to coastal terminal (Coastal-A) and rail terminal (SRTO).

1) Dates and Participants

Meeting dates and participants are shown in Table 4.

Table 4: Study Dates and Participants

Dates	(1) November 25, 2019, 13:00 to 16:30 (Briefing) (2) November 26, 2019, 13:00 to 16:00 (Site visits)	
Locations	(1) PAT Offices, 10th Floor, Meeting Room (Briefing) (2) Laem Chabang Port, Coastal Terminal (Coastal-A) and Rail Terminal (SRTO) (Site Visits)	
Local participants	PAT	Mr. Ud Tuntivejakal, Chief, Cargo Operation, Laem Chabang Port Mr. Nattapong,Laem Chabang Port Ms. Suphattra Phisaisawat, Technical Officer 12, Corporate Strategy Planning Department, Port Authority of Thailand Ms. Mayuree Deeroop, Technical Officer 11, Corporate Strategy Planning Department, Port Authority of Thailand Ms. RattikarnChamsap, Scientist10, Corporate Strategy Planning Department, Port Authority of Thailand
Participants from Japan	Yokohama Port Corporation(YPC)	Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department Mr. Naofumi Ito, Chief, Engineering Planning Division, Engineering Department

Note: In addition to the above participants, one representative of a crane manufacturer also attended the briefings and site visits.

2) Key Findings and Points Confirmed

Briefing

- Regarding coastal terminal (Coastal-A) and rail terminal (SRTO), confirmed layouts, equipment flow lines, expected operational methods, and future plans for procurement of cargo handling equipment.
- Discussed general concept of specific steps and outputs for consideration of automation of cargo handling equipment.
- Confirmed possible equipment for automation, levels of automation, etc.
- Confirmed PAT's availability of various data required for discussions.

Site Visits

- By making site visits, confirmed various requirements for consideration of automation.

(3) Third Field Study and Local Final Report

1) Laem Chabang Port

Conducted a detailed briefing regarding promoting a modal shift at Laem Chabang Port, and made a final report for this fiscal year.

a) Dates and Participants

Meeting dates and participants are shown in Table 5.

Table 5: Study Dates and Participants

Dates	February 6, 2020, (1) 10:00 to 12:00 (Meeting with Key Personnel to Prepare for Final Report) (2) 13:30 to 16:00 (Final Report)	
Location	(1) PAT Laem Chabang Port Offices (2) PAT Laem Chabang Port Offices	
Local participants	PAT	Lt.Jg.Yuttana Mokekhaow, RTN.,Managing Director, Laem Chabang Port (afternoon only) Ms. Porntipa Taweenuch, Director, General Affair Division, Laem Chabang Port Mr. Ud Tuntivejakal, Chief, Cargo Operation, Laem Chabang Port Mr. Nattapong, Laem Chabang Port Ms. Natananta Jindapongjaroen, Cargo Operation Officer 12, Laem Chabang Port Ms. Suphattra Phisaisawat, Technical Officer 12, Corporate Strategy Planning Department, Port Authority of Thailand
Participants from Japan	Yokohama Port Corporation(YPC)	Mr. Hidenori Kishimura, Managing Director Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department Mr. Takahiro Sakurai, Assistant Manager, Engineering Planning Division, Engineering Department
	City of Yokohama	Mr. Toshiyuki Sakamoto, Director of Second Property Administration Division, Port and Harbour Bureau
	Green Pacific Co. (GP)	Mr. Kazuhito Yamada, President Mr. Darmp Phadungsri, Consultant

b) Key Findings and Points Confirmed

Preparatory Meeting

At this preparatory meeting, information was shared among key personnel regarding the studies conducted this fiscal year and means of reporting to Managing Director of Laem Chabang Port

Final Report

A report was made on the following points regarding studies conducted this fiscal year.

- Reported on details confirmed by interviews regardings layouts and equipment flow lines at coastal terminal (Coastal-A) and rail terminal (SRTO), as well as the operational methods envisioned by PAT.
- Reported on findings confirmed by simulator on what can be operated efficiently for target throughput based on methods envisioned for the rail terminal (SRTO).
- Explained that it is necessary to discuss previous operational methods in order to consider

automation, and reported on overall discussion results from this fiscal year toward introduction of automation.

・ Reported on overall discussion results of CO_2 emission reduction effect by promoting modal shift, and matters for detailed consideration.

・ In addition, proposed the details of studies to be implemented in cooperation over the next two fiscal years, and reached mutual agreement.

2）Eastern Economic Corridor Office of Thailand (EEC)

a) Dates and Participants

Meeting dates and participants are shown in Table 6.

Table 6: Study Dates and Participants

<table>
<tr><td>Dates</td><td colspan="2">February 7, 2020,　14:00 to 16:00</td></tr>
<tr><td>Location</td><td colspan="2">EEC</td></tr>
<tr><td>Local participants</td><td>EEC
(Eastern Economic Corridor Office of Thailand)</td><td>Muk Sibunruang, Executive Director, Investment Strategy and Promotion Division
Kornvica Pimukmanaskit, Ph.D, Deputy Director, Investment Strategy and Promotion Division
Angsutorn Wasusun, Assistant Director, Investment and International Affairs Group</td></tr>
<tr><td rowspan="3">Participants from Japan</td><td>Yokohama Port Corporation(YPC)</td><td>Mr. Kosuke Shibasaki, Deputy General Manager, Engineering Department
Mr. Katsuyuki Ozaki, Manager, Business Development, Engineering Department
Mr. Takahiro Sakurai, Assistant Manager, Engineering Planning Division, Engineering Department</td></tr>
<tr><td>City of Yokohama</td><td>Mr. Toshiyuki Sakamoto, Director of Second Property Administration Division, Port and Harbour Bureau</td></tr>
<tr><td>Green Pacific Co. (GP)</td><td>Mr. Kazuhito Yamada, President
Mr. Darmp Phadungsri, Consultant</td></tr>
</table>

b) Key Findings and Points Confirmed

Participants from Japan visited Eastern Economic Corridor Office of Thailand (EECO) and conducted interviews regarding infrastructure development (mainly Laem Chabang Port Phase III, double-tracking railway, inland container depot) and confirmed the information gathered by YPC through newspapers and internet.

EECO is not in charge of infrastructure development, but it is expected to continue to exchange information regarding development plan and progress with EECO in the future.

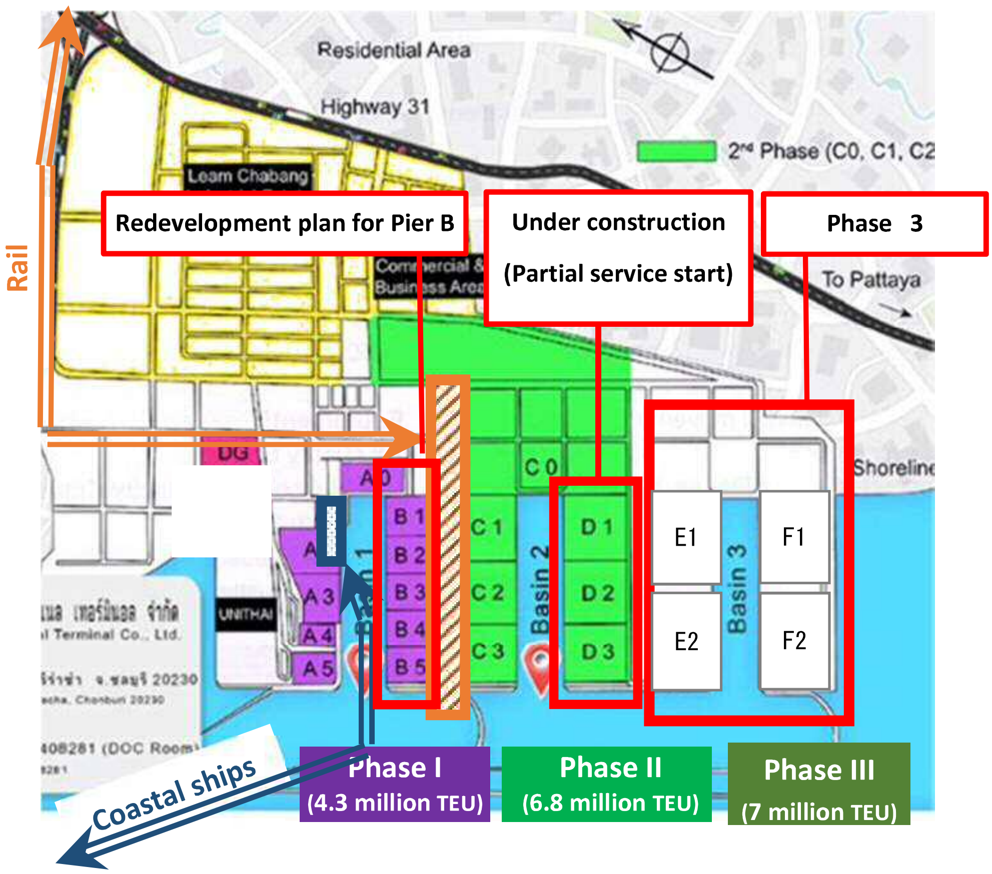
2.2 Laem Chabang Port

(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 3. In addition to the three sections A to C, currently in service, Hutchison Group is progressing on development with the integrated automation of the terminals at section D, and there are also future plans to operate three berths as terminal.

Furthermore, in the future, there are plans to develop the Laem Chabang Port Phase 3 Expansion Plan (sections E and F terminal development), under the Eastern Economic Corridor (EEC) Development Project.



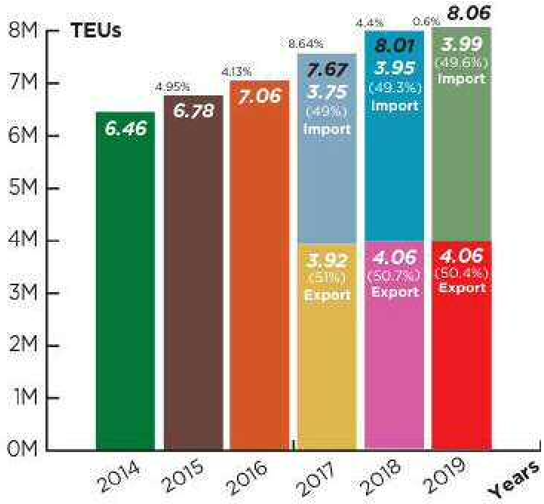
Source: Prepared based on STIC Thailand website

Figure 3: Laem Chabang Port terminal layout

(2) Performance of Laem Chabang Port

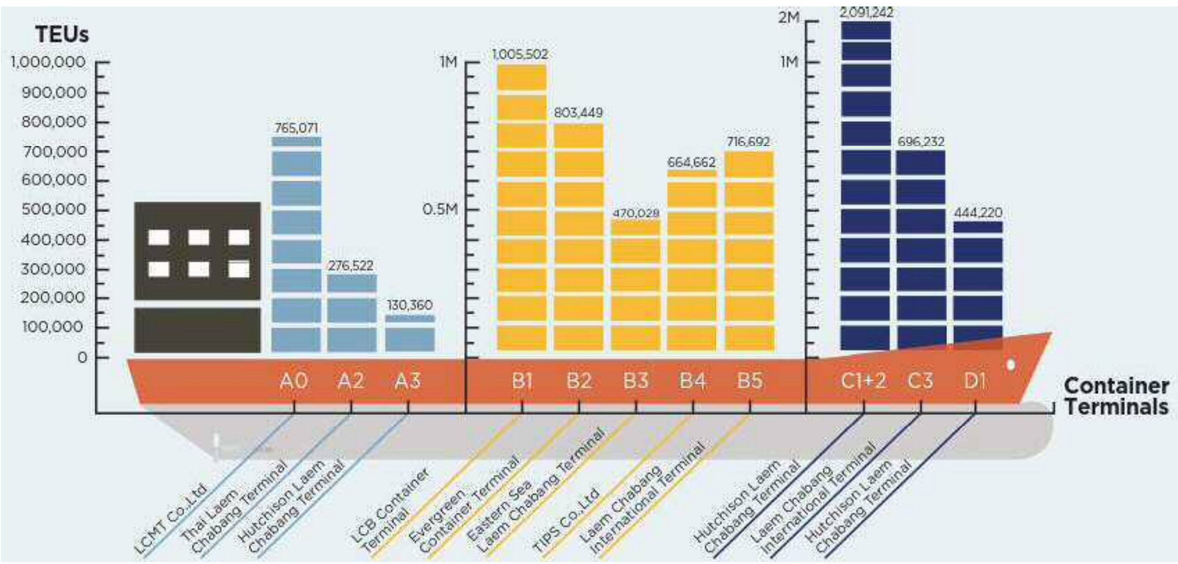
1) Container Throughput

Figure 4 and Figure 5 show the container throughput trends of Laem Chabang Port from 2014 to 2019. The throughput has been increasing year by year, and at 8.06 million TEU in 2019 was 25% greater than in 2014. In FY2019, at 50.4% of volume handled, export throughput was slightly more than import throughput at 49.6%.



Source: Statistics of Laem Chabang Port 2019 (from Laem Chabang Port website, accessed December 2019)

Figure 4: Laem Chabang Port container throughput

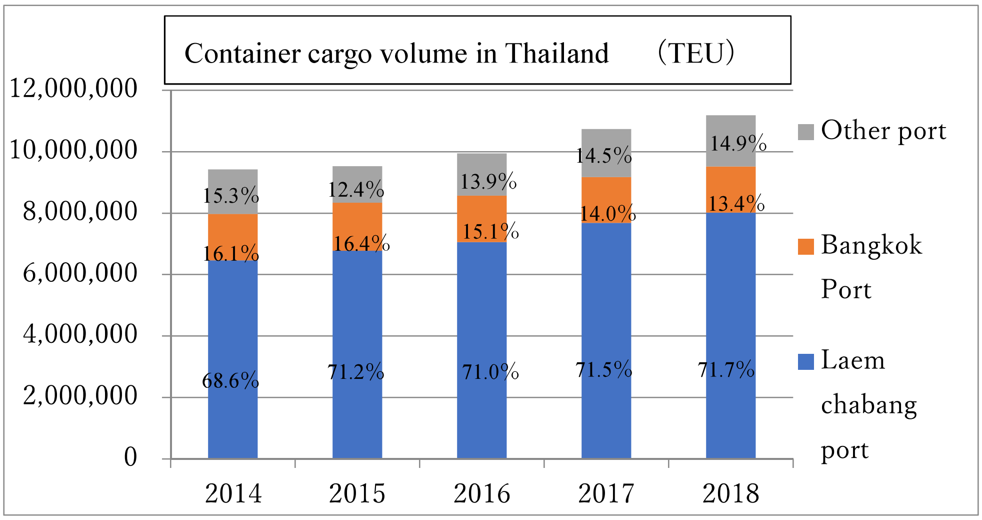


Source: Statistics of Laem Chabang Port 2019 (from Laem Chabang Port website, accessed December 2019)

Figure 5: Containers handled by each terminal (FY 2019)

2) Container Throughput Market Share

With latest data of 2019 not published, the market share of container throughput in 2018 (Figure 6) shows that Laem Chabang Port has about a 71% market share in Thailand and Bangkok Port has a 13.4% market share.



Source: Laem Chabang Port website

Figure 6: Market share of Laem Chabang Port in Thailand

3) Port Arrivals

Table 7 shows port arrivals for Laem Chabang Port from 2013 to 2018. The most arrivals for FY2013 to 2016 are by international container ships, but in FY2017 and FY2018, coastal container ships accounted for the most arrivals. In FY2018 international container ships had a 35.6% share, while coastal container ships had a 43.4% share, so the two together accounted for about 80% of container ship arrivals.

When asked about the reasons for the recent increase in coastal shipping, a PAT official explained that this was likely due to problems with land transportation, and tighter restrictions on heaviest loads (two 20-foot containers can potentially exceed weight limits on roads), Also, regarding coastal ship arrivals at Laem Chabang Port, about 80% are from Bangkok Port and the remaining 20% from southern ports in Thailand (not ports under PAT jurisdiction, such as Surat Thani Port, and throughput is reportedly increasing particularly from southern ports.

Table 7: Trends in port arrivals

(Units: Ships)

Type of vessel \ Fiscal year	2013	2014	2015	2016	2017	2018
Container ships	6,443	9,242	9,889	10,075	10,862	10,521
International container	4,922	4,888	5,153	5,159	4,723	4,738
Coastal container	1,521	4,354	4,736	4,916	6,139	5,783
General cargo	390	382	371	344	352	301
Ro-Ro ships*[1]	670	629	659	665	696	714
Barge	77	68	94	91	60	106
Passenger ship	41	36	42	56	59	80
Bulk carrier	230	320	122	92	86	104
Other	749	1,298	1,301	1,284	1,346	1,484
Total	8,600	11,975	12,478	12,607	13,461	13,310

Source: "Laem Chabang Port full year results" (สรุปผลการดำเนินงานของท่าเรือแหลมฉบัง ปีงบประมาณ)」
(Laem Chabang Port website, accessed December 2019)

(3) 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). Currently, the areas being operated by private sector companies based on concession contracts are three terminal sections A to C and a portion of section D, as listed in Table 8.

Because of the importance of Laem Chabang Port as a logistics center, 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.

*[1] RO/RO ships: Vessels that truck and chassis can drive directly on and off (roll-on/roll-off).

Table 8: 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	Unknown due to maintenance

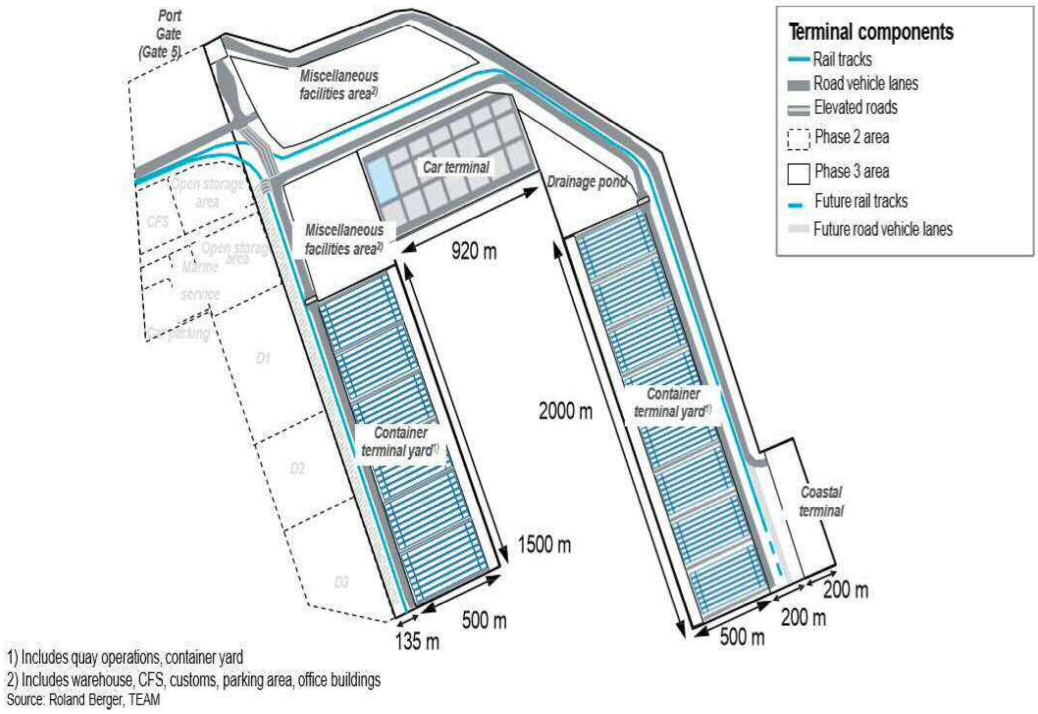
Source: Annual Report 2018, Port Authority of Thailand, 2019
ECT case summary

(4) Future Development Plans at Laem Chabang Port

1) Phase III Development Plan

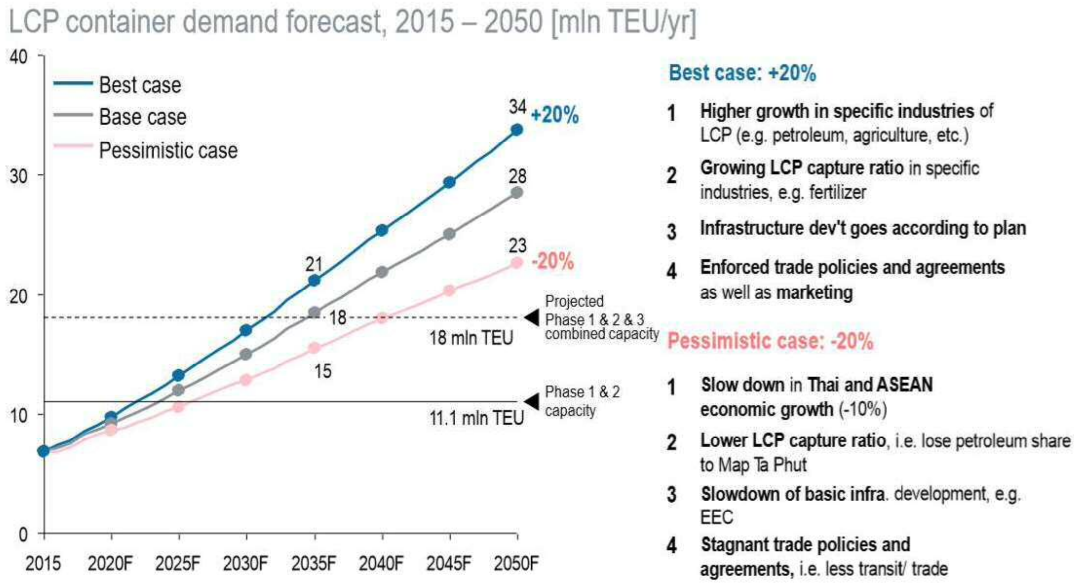
The Thai government adopted "Thailand 4.0" in 2015, as its long-term socioeconomic vision for the country, and is implementing the Eastern Economic Corridor (EEC) Development Project as one of its key actions. The EEC Development Project is an initiative to attract targeted industries through intensive development of transportation infrastructure in the three eastern provinces of Chachoengsao, Chonburi, and Rayong. One of the five large-scale projects is the Phase III Development Plan at 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. If these projects are implemented, the port capacity is expected to increase as shown in Table 8.

For this project, there was bidding process in 2019 for private-sector companies to invest in facilities (equipment and structures) and to operate the terminals, and two consortiums submitted bids, namely, the NPC Joint Venture (Natherine Group, Associate Infiniti, Prima Marine, PHS Organic Healing and CRCC) and the GPC Joint Venture (PTT Tank Terminal, Gulf Energy Development, CHEC). Both consortiums have a Chinese state-run construction company as a member. Contracts are expected to be signed in early 2020after a screening process.



Source: www.laemchabangportphase3.com/

Figure 7: Phase III Development Plan



Source: www.laemchabangportphase3.com/

Figure 8: Future projections of throughput at Laem Chabang Port

Table 9: Capacity of Laem Chabang Port

Units: Million TEUs
RO/RO terminal: Million vehicles

Item	Phase I+II	Phase III
Container terminal	11.1	7.0
RO/RO terminal	1.98	1.0
Rail terminal	2	4.0
Coastal terminal	0.6	1.0

Source: Meeting with PAT, Jan. 2019

Table 10: Current status and planned expansion at Laem Chabang Port

Phase	Throughput capacity (million TEU/yr)	Terminals	Service status	Remarks
Phase I	4.30	A0 to A5, B1 to B5	Started 1991	Lease contracts with PAT end in 2020 for Terminal B. Thereafter, Pier B will be reconfigured.
Phase II	6.80	C0 to C3, D1 to D3	Started 2007	For Berths D1 to D3, construction is in progress, and partial service has started.
Phase III	7.00	E1, E2, F1, F2	Planned for 2025	Discussions underway for environmental impact assessment
Other	—	Rail terminal (SRTO), coastal terminal	Planned for 2019 (tentative)	Being built as part of modal shift for PAT-operated terminals

Source: PAT Annual Report 2018 and interviews with PAT

2) Promoting Modal Shift

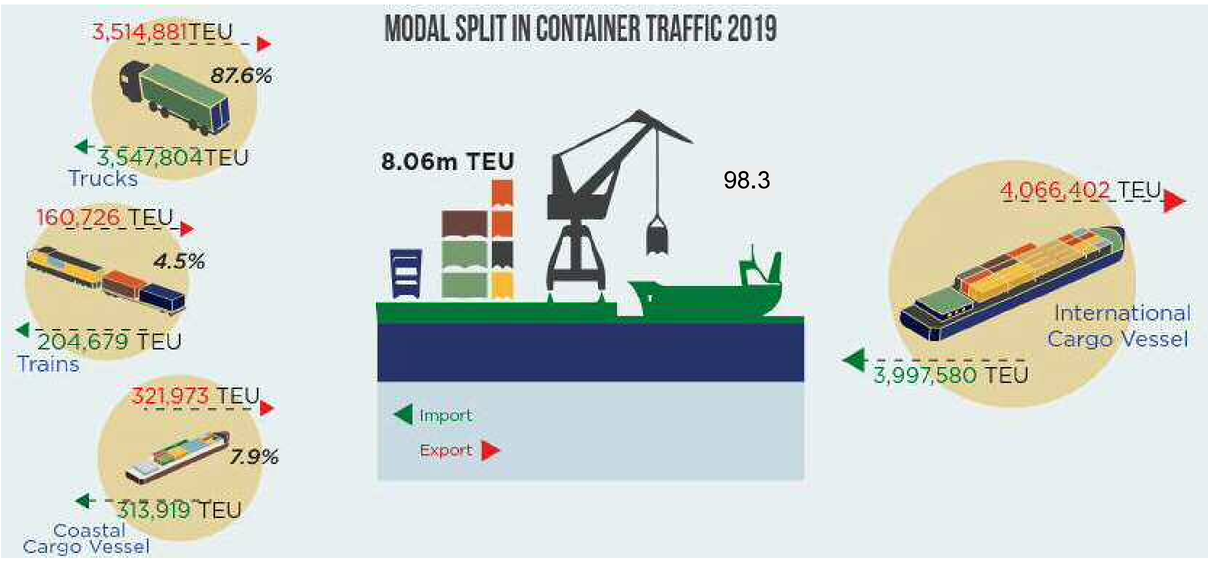
Responding to strong requests from the Thai central government, PAT is undertaking efforts to reduce truck transportation in Areas A to D, the areas currently in operation. Specifically, this includes promoting a modal shift to coastal shipping by building berths and a terminal for coastal ships at both Bangkok Port and Laem Chabang Port, as well as by building a rail terminal at Laem Chabang Port to promote rail transport to a nearby inland container depot and industrial areas.

At Laem Chabang Port, construction underway and progressing toward full scale operation include a rail terminal (SRTO) in the area between Area B and Area C, and a coastal terminal (Coastal-A) at the base of Area A.

Source: Prepared from Google map.

Figure 9: Location of Coastal-A and SRTO

A breakdown of the modal split of container traffic in FY2019 is shown in Figure 10. Trucking accounted for 87.6% of domestic transport, compared to 7.9% for coastal cargo vessels and 4.5% for rail. PAT has a plan to increase the ratio of coastal cargo to 10% and rail to 9% (ultimately 18%) by promoting modal shift.



Source: Laem Chabang Port website, accessed December 2019

Figure 10: Modal split in container traffic (FY 2019)

2.3 Information about Operations at Prospective Terminals for Modal Shift

(1) Terminal Site Visits and Studies

Coastal Terminal (Coastal-A)

A coastal terminal (Photo 1) is being built on available land (about 17.5 acres) between Berths A0 and A1. The berth has a water depth of 10 meters, and with two berths of 120 meters, is capable of docking 3,000 DWT-class coastal vessels. Target annual throughput is 300,000 TEU, and the terminal and quay construction have already been completed in preparation to start operations. In addition to one gantry crane (Photo 2) and two RTGs (Photo 4) procured in 2018, the one harbor crane (Photo 3) was also procured in 2019. Although the original plan was to start operations in May 2019, the start has been delayed as no freight contractor has yet been decided, and terminal operation systems have yet to be developed.

Source: Annual Report 2018

Photo 1: Coastal-A (aerial view)

Photo 2: Gantry cranes at Coastal-A

Photo 3: Mobile harbor crane at Coastal-A

Photo 4: RTGs located at Coastal-A

Photo 5: Berth of Coastal-A Terminal

Rail Terminal (Single Rail Transfer Operator, or SRTO)

A rail terminal has been constructed between Wharf B and Wharf C, and provisional operations started in the autumn of 2018. The terminal storage capacity is approximately 4,000 TEUs of ground slots, but no containers are currently stored here. Instead, containers are loaded directly onto rail from the adjacent container terminal, and containers offloaded from rail are moved directly to the adjacent container terminal.

The annual target throughput is one million TEUs (rising to two million TEUs in the future), but no extensive review appears to have been done yet internally at PAT regarding concrete operational methods to reach those targets. Thus, the current study needs to consider how to design operations for efficiency.

Photo 6: A train entering SRTO

Photo 7: SRTO

Photo 8: RTG located at SRTO

Photo 9: RMG located at SRTO

Photo 10: Container loading at SRTO

(2) Interviews with Terminal Operator (Port Authority of Thailand)

At this point, interviews were first conducted regarding terminal layout, equipment flows within the terminal, and the number and deployment of cargo handling equipment units planned for future introduction, etc.

Coastal Terminal (Coastal-A)

- The terminal layout and equipment flows are as shown in the figure 11.
- Existing equipment includes one container crane, one mobile harbor crane, and two RTG units.
- There are plans to acquire two more RTGs in the future.
- PAT plans to provide trailers, and the plan is to operate 33 trailers at the start of operations.
- In terms of basic operations, the plan is to directly load and unload coastal vessels from/to trucks by STS cranes, and to store them in the yard only if direct unloading cannot be arranged.
- The conversion of current RTG units to hybrid power drive is currently being considering.
- There is a reefer container storage area on sections of the two lanes closest to the quay.

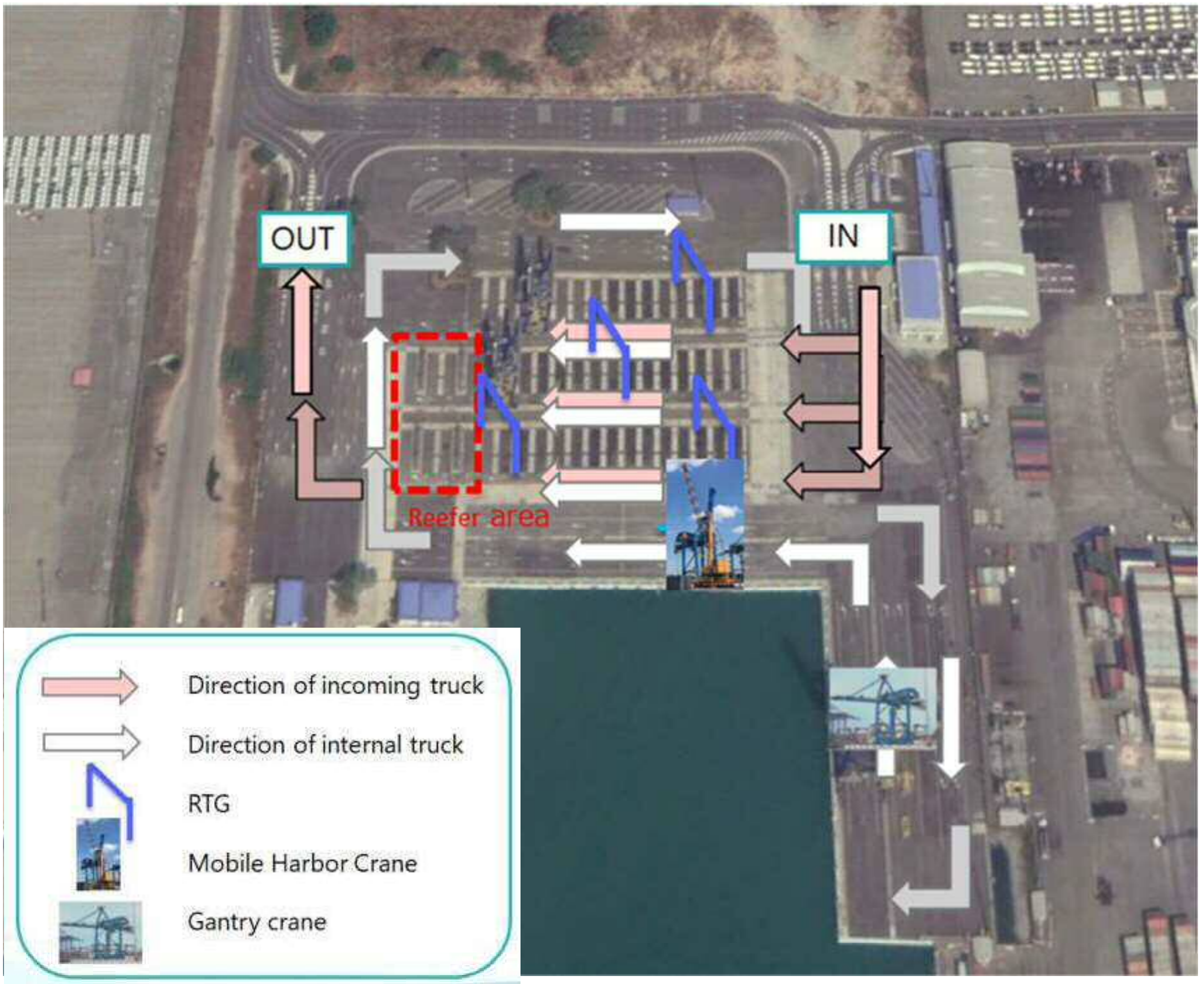


Figure 11: Layout and flow lines of Coastal-A

Photo 11: Reefer area at Coastal-A

Photo 12: Reefer plug at Coastal-A

Rail Terminal (SRTO)

- The terminal layout and equipment flows are as shown in the above figure 12.
- There are six rail tracks in the terminal, of which the center two are for passing, leaving the remaining two on each side for cargo use, totaling four. Total track length is 1.7 km, and two trains can be lined up on each track, so physically, eight trains can be parked at one time.
- There are currently two RMGs and one RTG, but the future plan is to introduce two more RMGs and seven RTGs, bringing the total to four RMGs and eight RTGs. Besides new procurement, there is also discussion about refurbishing three used RTGs temporarily stored at Laem Chabang Port and using them for about five years, and transferring units from Bangkok Port, etc.

Figure 12: Layout and flow lines of SRTO

- One of the existing RTG units is powered by electricity supplied by cable. It is assumed that the next units to be procured will also be electric, all unable to change lanes. There are no gutters to bury the RTG power supply cables, so the cables are laid on top of the pavement. As a result, with the current arrangements, RTGs cannot go past trailers.

Photo 13: RTG cable deployed on road surface

- Currently trains have 32 cars, but if throughput increases in the future, this can be increased to 40 cars. However, in that case, the short RMG cable length will mean that loading will be impossible in some areas, so longer trains will also require cable extensions (or replacement).
- The plan is for PAT to provide the trailers, and to start operations with 50 units.
- When containers are stored in the yard, the plan is not to designate specific areas (e.g., a specific area for containers from terminal B-1), but rather, to decide storage locations based on SRTO operations.
- There is a standby area for trains to wait a few kilometers from the SRTO, and they can wait there to accommodate scheduling. Currently, train movements and timing are being coordinated to accommodate SRTO operations. As a result the train arrivals and departures at Lat Krabang and the SRTO terminal do not necessarily have to be in the same sequence.

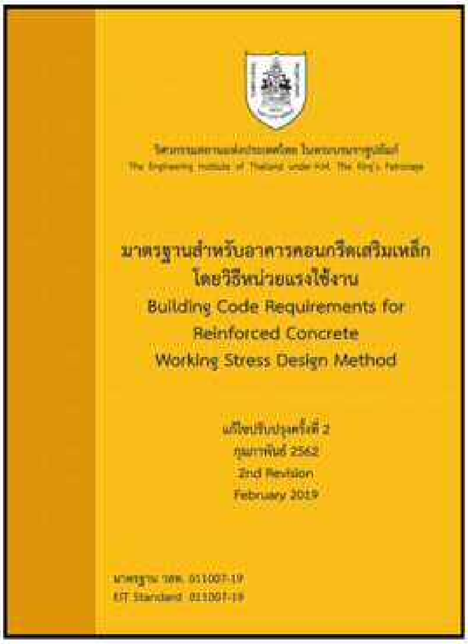
(3) Confirmation of Regulations and Manuals for Construction and Maintenance of Port Facilities in Thailand

Many Thai organizations including PAT use EIT- Thailand Engineering Standards (Figure 13) prepared by Engineering Institute of Thailand (EIT) as standards for designing, planning and cost estimation.

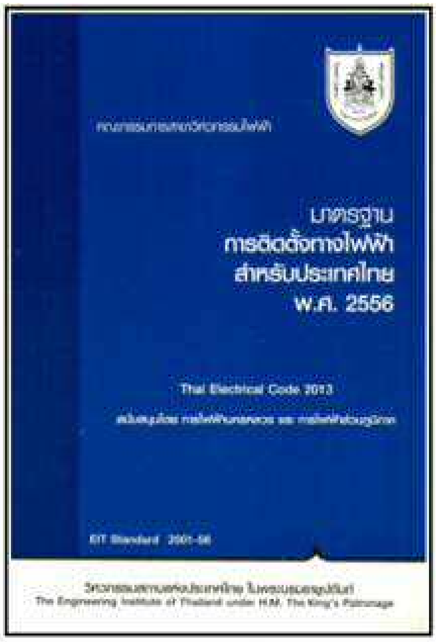
PAT official comments that some of these standards include parts which refer to the Japanese standards.

However, no safety standards have yet been formulated for introducing automation technologies (an equivalent in Japan would be the Industrial Safety and Health Act), so related matters are left for designers to deal with.

For reference, among many EIT-Thailand Engineering Standards, standards for reinforced concrete building and electric equipment are shown in Figure 13.



Standards for reinforced concrete buildings



Electrical Equipment Standards

出典：https://eitstandard.com/

Figure 13 Standards for Reinforced Concrete Building and Electrical Equipment

2.4 Overview of Lat Krabang Container Inland Depot (Lat Krabang ICD)

(1) Site Overview

An Inland Container Depot is a facility for customs clearance and bonded storage of containers, located inland, and it allows shippers to load and unload containers just as they would in a sea port.

Lat Krabang Container Inland Depot is located about 30 km east of Bangkok City and close to Suvarnabhumi International Airport, being connected to Laem Chabang Port by rail, making it an important logistics relay base for inland shippers from areas such as Ayutthaya. It is a particularly important inland depot in terms of shifting the mode of cargo transport using Lat Krabang Port from truck to rail.

The State Railway of Thailand (SRT) developed the basic facilities at Lat Krabang ICD and is in charge of operations. Land area of Lat Krabang ICD covers about 104 hectares in total, of which 60 hectares are occupied by six tenants in 15-year concession contracts with SRT, and they have installed warehousing and cargo handling facilities (Figure 14). In each area (module) operated by each tenant, operators in contract with the tenant have exclusive use of the area. Because of this, gates are installed separately and the roads surrounding the site are congested, apparently resulting in inefficiencies. The remaining 44 hectares not occupied by modules are used as shared offices facilities by related organizations such as customs and quarantine.

Module 1: Siam Shoreside Services

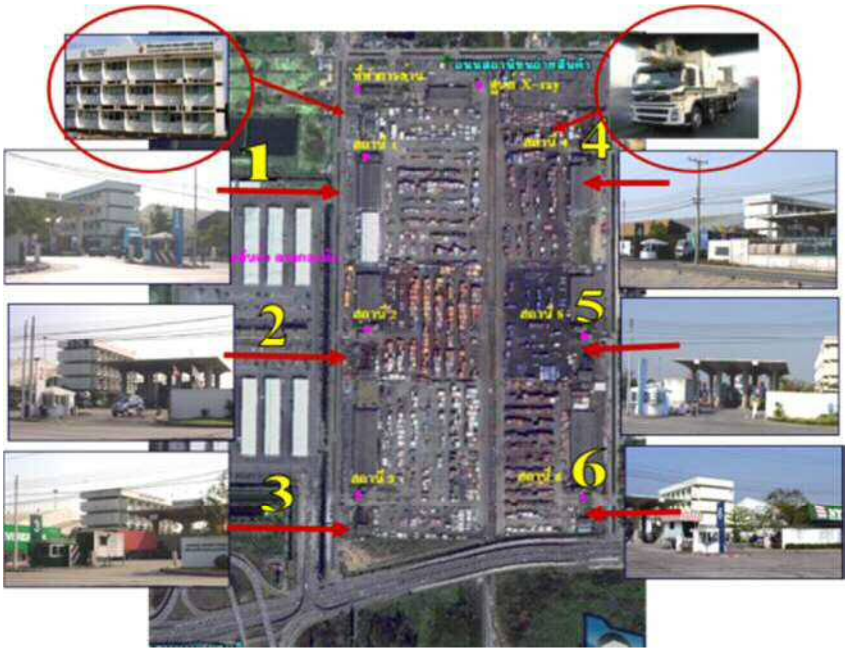
Module2: ESCO (joint venture of Marubeni Corporation, PSA, and Kamigumi Co.)

Module3: Evergreen

Module4: TIFFA (Thai company)

Module5: Thai Hanjin

Module6: NYK Distribution Service



Source: Prepared based on LICD photo

Figure 14: Aerial photograph of Lat Krabang ICD (LICD)

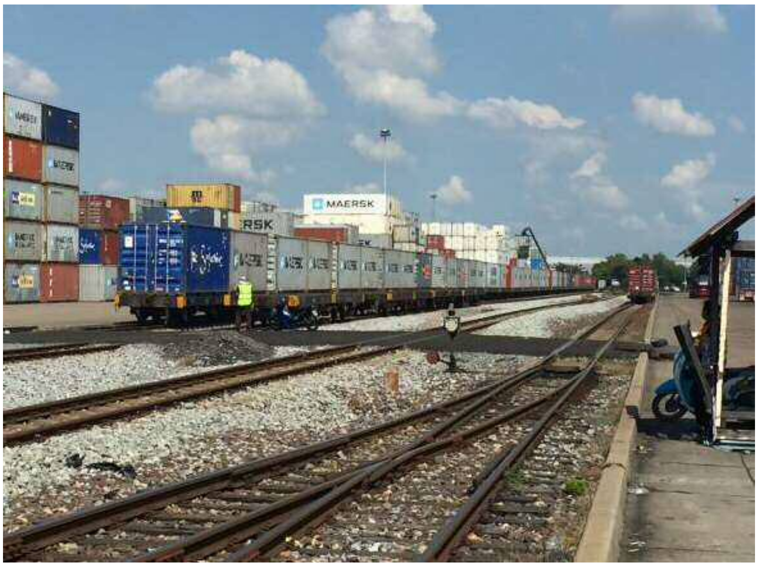


Photo 14: Cargo handling operation at Lat Krabang ICD (1)

Photo 15: Cargo handling operation at Lat Krabang ICD（2）

(2) Moves toward Efficiency Improvement

The main contracts between SRT and the current six tenants have expired and operations are currently continuing based on temporary contracts. SRT's plan is to consolidate six modules and operate them as one unit, with the aim of improving efficiency. To do so, SRT conducted a bidding process for integrated operations early in 2019, resulting in preferential negotiation rights being granted to the Asia Logistics Group (ALG), a consortium consisting of ESCO (a joint venture of Marubeni Corporation, PSA and Kamigumi Co.) and Japanese container carrier Ocean Network Express (ONE). SRT and ALG had not yet concluded an official contract as of January 2020, but the conditions for bidding included the use of rail to transport at least 50% of the terminal handling capacity (current handling capacity is 1.4 million TEUs, so this would mean 700,000 TEUs) and the introduction of at least two gantry cranes. Thus, it is likely that efforts will be made to increase container depot efficiency once a contract is signed.

(3) Interviews with Operators, etc.

Interviews were conducted with ESCO, which is the current operator and is also a member of ALG consortium that gained preferential negotiation rights as a result of the bidding mentioned above, and with ONE, which is a new participant of ALG. Interview findings are as follows;

Lat Krabang ICD is connected to each container terminal in Area B of the Laem Chabang Port, with the SRTO rail terminal as the connection point, and most of the companies in ALG are tenants of Area B of at Laem Chabang Port.

The contract has not yet been concluded, but after it has been concluded, the six operational zones will be unified into one. At first, fences will be removed, but there are also eventual plans to discuss both physical and organizational reconfigurations to boost operational efficiency.

However, because the contract has not yet been concluded one year after the bidding process, it has not been possible to have discussions about specific capital investments.

Furthermore, each terminal in Area B of Laem Chabang Port is either in temporary use now that the contract has ended, or currently approaching the time for contract renewal. However, since it is not known when contracts will be renewed and reconfiguration plans for the five terminals are not yet clear (the five terminals are likely to be consolidated into just two or three), it is difficult to make decisions on capital investments in Lat Krabang until it becomes clear that there is a chance to continue using Terminal B.

Achieving a goal of transporting 50% of cargo by rail depends not only on terminal operations but on train operations as well, and this would require a review by the State Railway of Thailand of timetables and services.

In many cases, shipping companies can only charge shippers the same to receive containers at Lat Krabang Port as in Laem Chabang, so there is a need to keep costs down for transportation modes using rail.

(4) Information Gathering and Analysis regarding Railways in Thailand

Railways in Thailand are managed and operated by the State Railway of Thailand under the jurisdiction of Thailand’s Ministry of Transport. The total rail length is about 4,000 km, the largest rail network in Southeast Asia. Major routes include four lines shown below:

(http://www.thairailways.com/train-and-travel.map.html)

Figure 15: Major railway network in Thailan

1 Northern Line

High-speed rail between Bangkok and Chiang Mai is planned with Japan, but the plan has been postponed due to profitability and other concerns.

2 Southern Line

Plans for high-speed rail between Bangkok and Nakhon Ratchasima are underway, to be developed as a PPP, with the potential to connect to Malayan Railways.

3 Northeastern Line

Plans for high-speed rail between Nong Khai / Ubon Ratchathani are underway with China, expected to start operating in 2023, with the potential to connect to Lao Railway.

4 Eastern Line

Plans for high-speed rail between Bangkok and Hua Hin are underway, to be developed as a PPP, with the potential to connect to Cambodian Railway.

At present, 90% of Thailand’s railway network is single track, which makes it inefficient due to the need for trains to wait every time another train passes, so utilization rates are low for both freight and passenger rail. As for rail transport for container freight, Lat Krabang ICD, located about 30 km east of central Bangkok, is connected to Laem Chabang Port by about 100 km of rail, and service status shows 10 round trips a day with 32 cars (capable of carrying 64 TEUs at a time) operating irregularly. The rail usage rate is low, at about 20% (about 270,000 TEUs annually).

In Thailand, there is a plan for large-scale infrastructure development to promote rail usage, including a plan for dual track railways (67 billion baht) to extend about 350 km from Khon Kaen Province in the northeast to Nakhon Phanom Province near the Laos border, aiming to start operation in 2024. Besides the existing Lat Krabang ICD, there are also plans for construction of four new ICDs (Chachoengsao Province in the east, Khon Kaen Province in the northeast, Nakhon Ratchasima Province in the northeast, Nakhon Sawan Province in the north).

Dual track railways initiative

Project	Distance (KM.)	Budget (Million Baht)	Duration
1) Jira Station, Nakhon Ratchasima - Khon Kaen	185	26,007	2015 - 2018
2) Prachuap Khiri Khan - Chumporn	167	17,293	2015 - 2018
3) Nakhon Pathom - Hua Hin	165	20,038	2015 - 2018
4) Map Ka Bao - Nakhon Ratchasima	132	29,855	2016 - 2020
5) Lop Buri - Pak Nam Pho, Nakhon Sawan	148	24,842	2016 - 2020
6) Hua Hin - Prachuap Khiri Khan	90	9,437	2016 - 2020
Total	887	127,472	

出典：タイ投資委員会（Thai board investment） HP より

Figure 16: Future development plan of railways in Thailand

When completed, average train speed will be between 30 km/h and 60 km/h, and the number of trains (including passenger cars) in service will significantly increase, from about 230 to about 800 trains/day, so rail usage rates are expected to grow. Furthermore, Lat Krabang ICD is being connected to Malayan Railways via the Eastern Line and Southern Main Line of the State Railway of Thailand, and with international container service heading to Port Klang (Kuala Lumpur), rail will become a very efficient transportation mode as an alternative to truck transport, amid a strengthening rail transport network through the Thailand's conversion to dual track railways and the development of ICDs.

3. Study Results

3.1 Consideration of efficiency improvements of terminal operation for modal shift

An outline of the modal shift at Laem Chabang Port is provided in Figure 17.

One feature of this model is that both the coastal terminal (Coastal-A) and the rail terminal (SRTO) built by PAT at Laem Chabang Port are located separate from the container terminal.

As a result, if there is a shift from trucks to coastal vessels, the target for comparison of CO2 emissions from truck transport would be the sum of CO2 emissions from coastal vessels plus the CO2 emissions from coastal terminal operations plus CO2 emissions from truck transport between the coastal terminal and each container terminal. Similarly, if there is a shift from trucks to rail transport, the target for comparison of CO2 emissions from truck transport would be the sum of CO2 emissions from rail plus CO2 emissions from rail terminal operations plus CO2 emissions from truck transport between the rail terminal and each container terminal.

Effectively, increased efficiency of operations at the coastal terminal and rail terminal, plus reduced time and costs required per container, will obviously help promote the modal shift. But one could also say that operational efficiency improvements themselves will also contribute to a reduction of CO2 emission from the terminals.

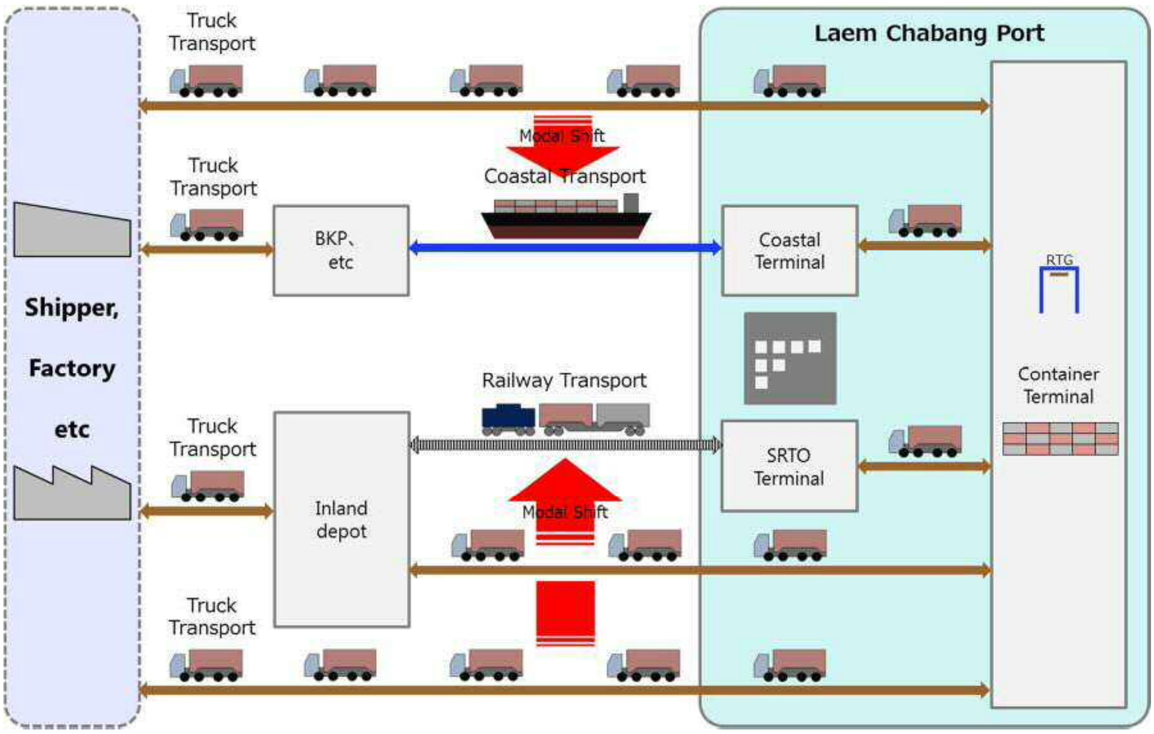


Figure 17: Overall concept of modal shift

(1) Confirmation of Operational Methods Envisioned

At this point, based on the circumstances confirmed in Chapter 2 (Section 2-3) plus the results of interviews with PAT, this study verified the operational methods needed to handle the target throughput.

Coastal Terminal (Coastal-A)

Assuming an annual throughput target of 300,000 TEU, 24-hour operations 365 days per year would mean daily throughput of 822 TEU (300,000 TEU ÷ 365 days = 822 TEU/day), and hourly throughput of 34 TEU (822 TEU ÷ 24 hours = 34 TEU/hour).

There are two berths at the terminal, and each has one crane (one container crane, one mobile harbor crane), so this means that the expected capacity of each crane per hour is 17 TEU (if all containers are 20 feet, this means 17 moves, and if 40 feet, 8.5 moves).

Also, there are four RTGs within the yard, and each container involves two moves (one to remove and one to load the container on a trailer). Therefore, the expected performance of each RTG is 18 TEU per hour (34 TEU x 2 moves / 4 RTGs =18 TEU/hour/unit).

The Port of Yokohama cargo handling speed ranges from 40 to 60 moves per container crane, which is among the highest performance in the world, so this is not a suitable comparison for the current study, but generally-speaking, for cargo handling with ships the average speed ranges from 20 to 30 moves per hour. In the above calculations, the numbers are lower for both the container crane and mobile harbor crane. For RTGs, the average generally ranges from 15 to 25 moves, but the above numbers are lower. In addition, at this terminal, the plan is to remove containers from coastal vessels and move them directly to each container terminal without being stored in the yard, or to move containers from each container terminal directly to the coastal vessel to be loaded. Thus, if one assumes strategy of only storing containers in the yard if the timing does not match, the expected performance of RTGs is significantly reduced. Based on the above points, a throughput of 300,000 TEU annually is likely to be possible with the cargo handling equipment being envisioned.

Rail Terminal (SRTO)

The ultimate annual throughput target is two million TEU, but the verification below will proceed based on a volume of one million TEU as the target for the foreseeable future.

The configuration of freight trains is 32 cars (64 TEU) per train, so to handle one million TEU per year, this means handling 43 trains per day (1 million TEU / 365 days = 2,740 TEU/day, 2,740 TEU/day / 64 TEU/train = 43 trains/day), and this means a pace of approx. one train arriving and one train departing per hour.

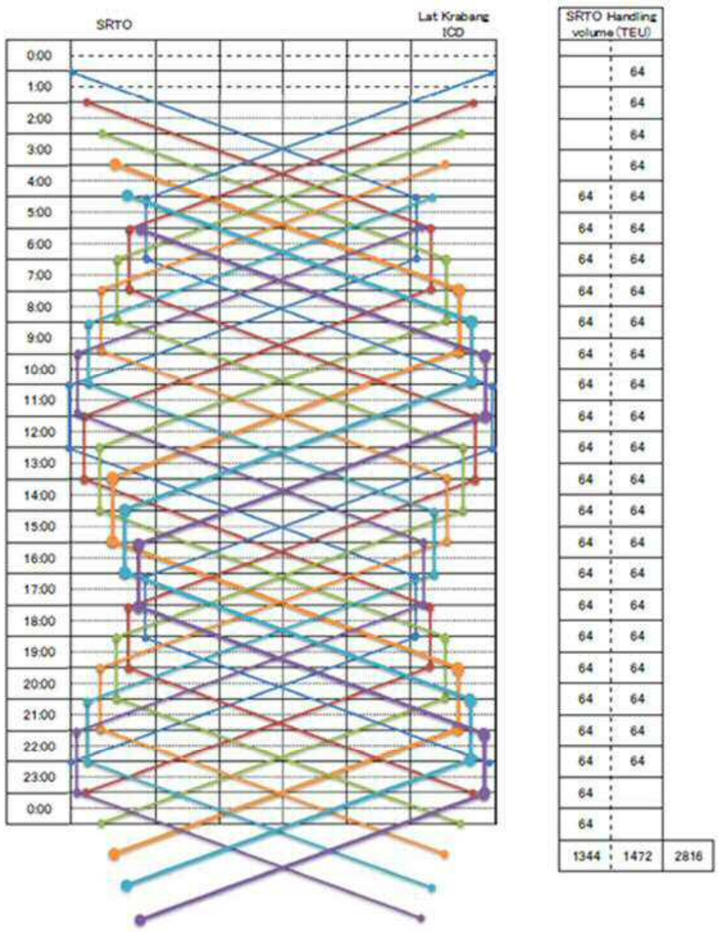


Figure 18: Operational diagram and throughput volumes

Now, considering the corresponding capacity for RMGs and RTGs, when calculated, it would appear to be sufficient for RMGs to handle 29 TEU/hour and RTGs 15 TEU/hour, but it is uncertain whether or not these numbers could be achieved. The reason is that this rail terminal (SRTO) differs from the typical layout, being extremely long, as it was planned to accommodate the rail tracks. This design increases the distance the RTGs must travel and reduces efficiency, and results in concerns about a shortage of RTGs. Also, as a consequence, the waiting time of trailers is longer, and there are concerns about a further drop in efficiency due to congestion within the terminal.

(2) Verification by Simulation

As a result, for the rail terminal (SRTO), calculations do not tell the whole story so it was deemed necessary to use simulations to verify the operational plans. Thus, this study used a simulation to confirm whether operations could be done efficiently with the target throughput, using the numbers and deployment of cargo handling equipment being envisioned by PAT.

Incidentally, in Japan to date, there are not many cases of simulators being used at the stage of considering container terminal layout, but it is common to use simulators overseas as automation becomes more common. In the case of an automated terminal, it is extremely difficult to make changes after the start of operations, due to the need, for example, for much more of the infrastructure to be installed in the ground than for analog systems. This fact makes it even more important to verify the situation by simulator in advance.

The simulation parameters are provided below.

Table 11: Simulation parameters (SRTO)

Equipment, etc.	Parameters
Rail terminal	Layout: See Figure 20 IN gate: 2 locations OUT gate: 2 locations Rail: 6 tracks
Rail	Per train: 32 cars (64 TEU) Scheduled operations, 1 arrival and 1 departure per hour 2 RMGs handling cargo for each train
Cargo handling equipment	4 RMGs (60 seconds per loading and unloading) 8 RTGs (90 seconds per loading & unloading, including rehandling) * No lane changes by RTGs * 1 team = 1 RMG + 2 RTGs + 4 trailers
Trailers	100 units available in fleet Of which, trailers within terminal: 4 per RMG = 16 trailers total Remaining 84 trailers: Assigned for terminal connections
Throughput	Container throughput: 1 million TEU/year (all 40 foot) Assumed import/export ratio: 50:50
Zoning	Areas are zoned separately: Cargo handling for rail, and cargo handling for each container terminal. No movement of containers between the zones is assumed. (See Figure 19)

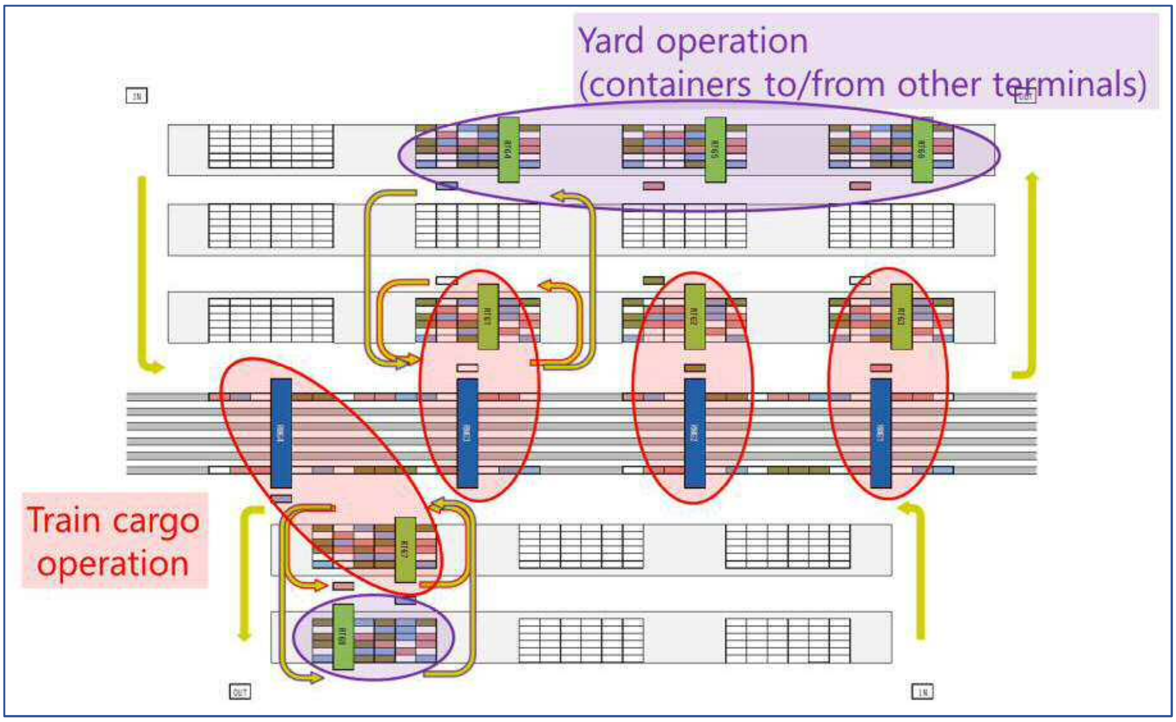


Figure 19: Zoning in the simulation

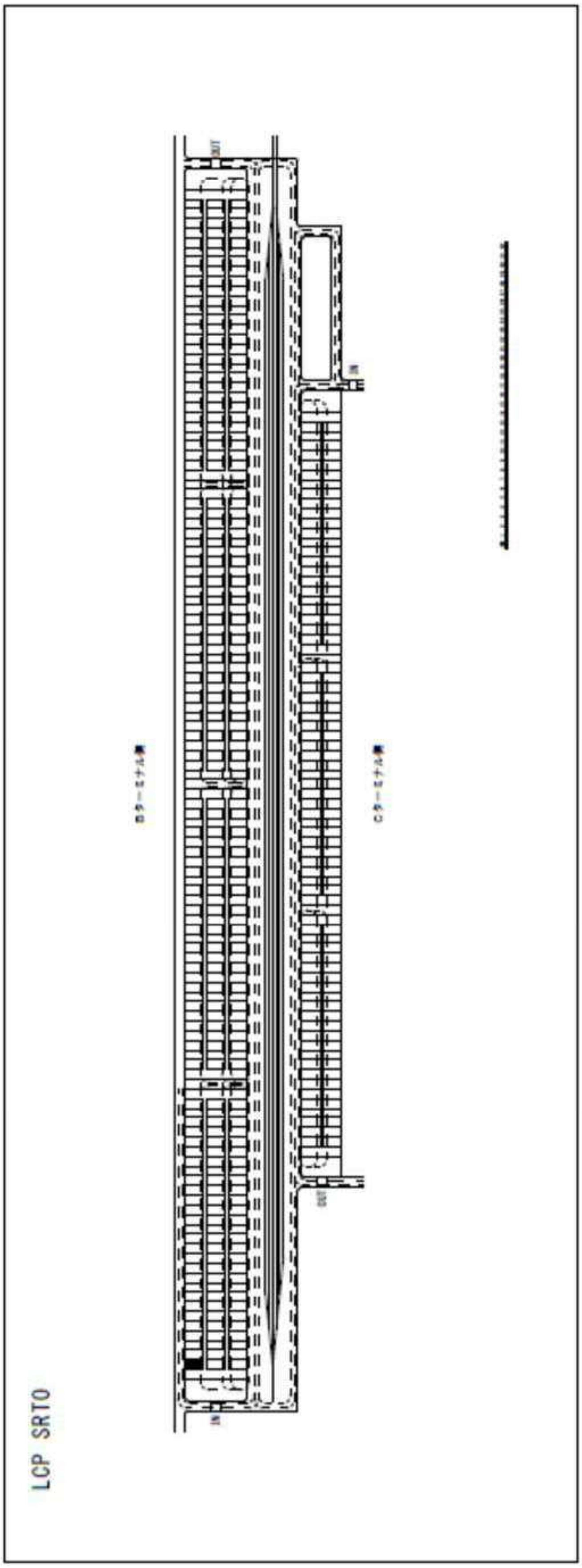


Figure 20: Rail terminal layout as recreated by simulator

Simulation results are summarized in the following Table 12

Table 12: Simulation results (SRTO)

Equipment, etc.	Results and notes
Rail	Wait times: 89–110 minutes/train (unloading and loading)
Cargo handling equipment	【RMG】Work productivity: 18-22 moves/hour
	【RTG】 <Cargo handling for rail> Productivity: 35-39 moves/hr Travel distance: 252 to 3,062 m/hr <Cargo handling for each container terminal> Productivity: 14 to 15 moves/hr Travel distance：37,069 to 41,076 m/hr Note: No movement of containers between the zones is assumed
Trailers	1,396 units inbound and outbound per 24 hours Turn-around time: Ave. 85 minutes (max. 300 minutes)
Throughput	Based on 1,396 trailers inbound and outbound, 2,792 TEU/day 2,792TEU x 365 days = 1,019,080 TEU (1 million TEU)

At the container terminal, time is required for work to check containers at the gates, and congestion can arise when errors arise that demand more time. Thus, gates can often become a bottleneck.

However for this study, the number of items to check at gates is reduced, eliminating bottlenecks at the gates. Meanwhile, there are problems with the long length of the rail terminal (SRTO), a special feature of the terminal layout. The resulting daily travel distance of 40 km for RTGs is unrealistic. It reduces work efficiency, and also one could expect to see more equipment damage and more frequent breakdowns.

Also, low RTG work efficiency can trigger trailer congestion, requiring up to 300 minutes as the turn-around time for trailers carrying containers to the adjacent container terminal (time elapsed between the time a trailer passes the IN gate, completes container loading and receiving from the RTG, and arrives back at the OUT gate).

This has additional impacts on other flows due to terminal congestion, further exacerbating a decline in efficiency.

The result is one train arrival per hour and one departure per hour, which more than satisfies the 24 hour throughput target of 2,740 TEU. However, it is clear that this would be difficult to achieve in reality, because it would be necessary to have full operations 24 hours a day, which permits absolutely no time for equipment maintenance or human error. Also, this simulation does not reflect any movement of containers between lanes (rehandling), so one could surmise that the real outcomes would be significantly less efficient than these simulation results suggest.

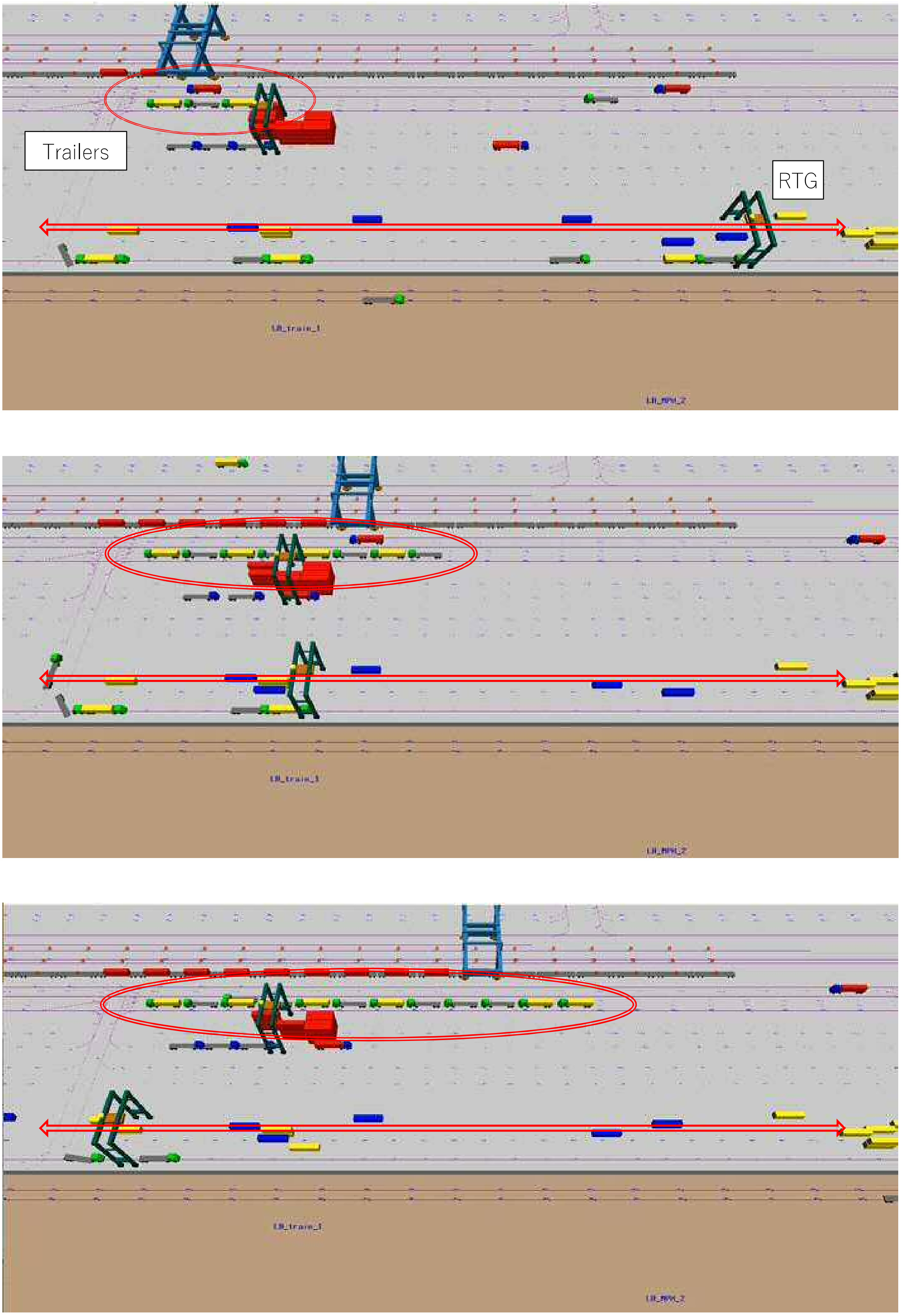


Figure 21: Screen shots from simulation software

(Image of RTG showing significant travel distances, and image of trailers lining up on standby within the terminal)

(3) Consideration of Introduction of Automation (and Remote Control) of Cargo Handling Equipment

As is evident from the simulation results, before beginning to consider introducing automation, it is necessary to further consider the optimal operational methods. This study assumed the addition of four RTGs for the equipment deployment plan of the rail terminal (SRTO) to have optimal operations, and then conducted a summary review of the automation scenario.

1) Scope of Use of Automation

Based on a series of discussions with PAT, it was decided to focus the automation only on four RTGs at the coast terminal (Coastal-A), plus four RMGs and twelve RTGs (adding the above-mentioned four units to PAT's plan of eight units) at the rail terminal (SRTO), and to exclude trailers within the terminal from consideration. Also, the scope of the use of automation for cargo handling equipment was set as depicted in Figure **, so that when containers are being loaded or unloaded from human-operated trailers, the process is not automated but rather human-controlled by remote operation, as is done in countries like Japan and Hong Kong. Nevertheless, interviews with PAT suggest that there are no particular constraints in terms of Thailand's domestic regulations, so the potential exists to fully automate, subject to future consideration.

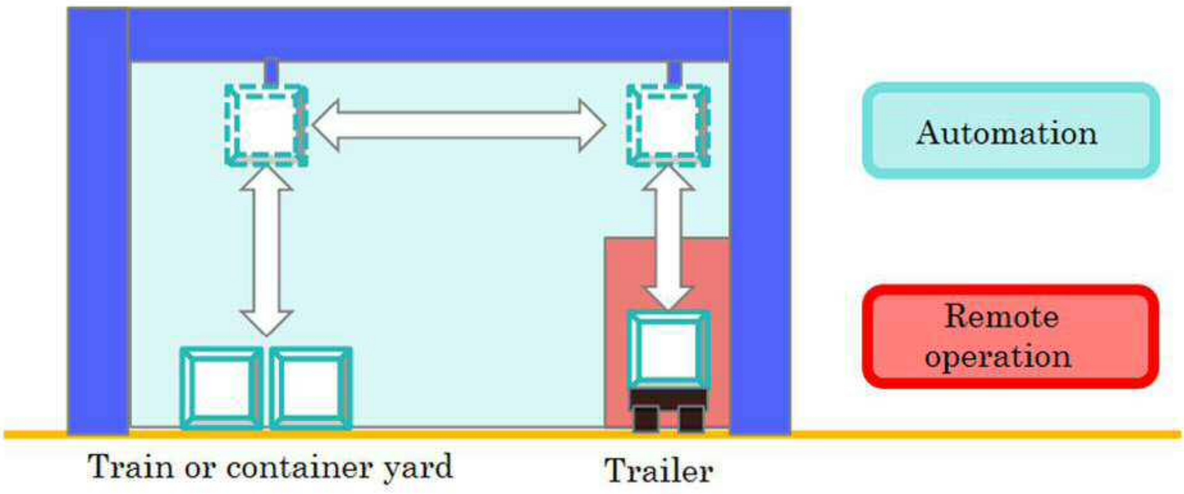


Figure 22: Scope of use of automation

2) Introduction of Automation Technologies

For introduction of automation technologies based on domestic manufacturers, besides the basic management control systems, it is also necessary to install a variety of equipment control systems (sensors, cameras, etc.) on the crane bodies, foundation work to bury equipment in the yard, remote control panels in the administrative buildings, and communication systems to connect all of these system components. A typical automation setup is shown in Figure 23 and Figure 24.

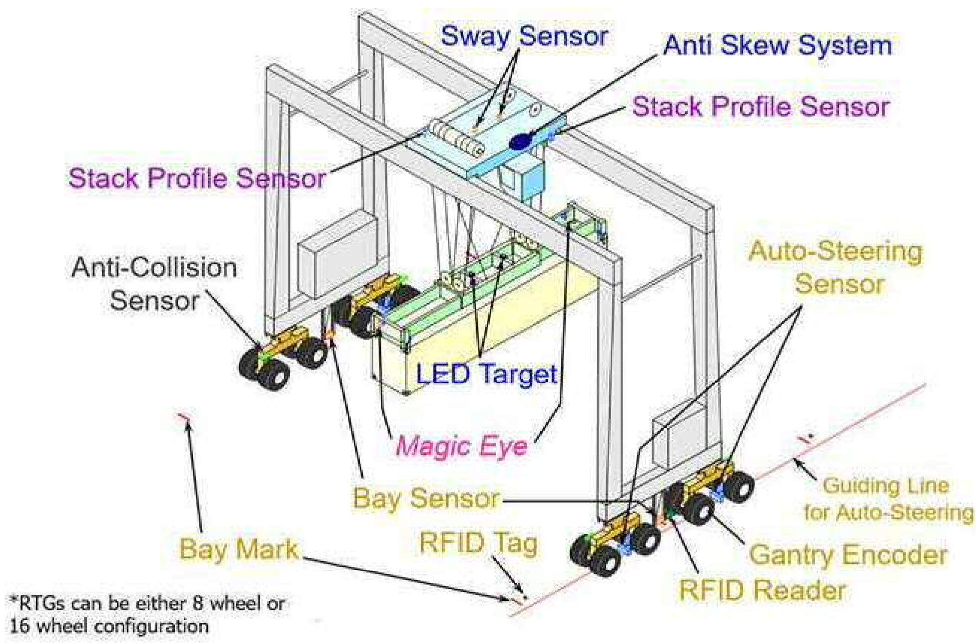


Figure 23: Examples of equipment required for automation

Figure 24: Remote control panel

3) Key Topics for Introduction of Automation, and Expected Benefits

When it comes to introducing automation technologies, this study identified the following key topics.

Rail terminal (SRTO)

- It is necessary to review efficient operational methods before considering automation.

Coastal terminal (Coastal-A)

- From the perspective of ensuring safety, it is necessary to have physical zoning, with a reefer area (manned area) and automation area (unmanned area). It might be necessary to modify the layout in some cases.
- With the coastal terminal (Coastal-A) alone, the scale of the yard is too small, which reduces the cost benefits of automation. However, benefits can be expected by monitoring RTGs jointly with the rail terminal (SRTO).

Meanwhile, the expected benefits of introducing automation technologies are 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 natural environment)
- Improved labor environment (shift from outdoor crane work to indoor work)
- Reduced environmental burden, reduced CO_2 emissions

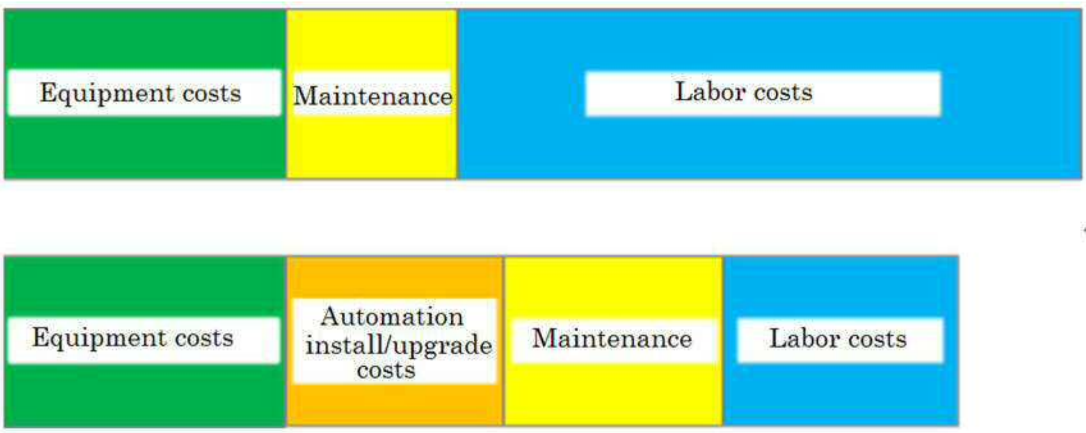


Figure 25: Image of cost and benefits

This study estimated the costs required to introduce automation equipment, but did not go as far as adequately determining the benefits of terminal cost control, due to being unable to verify the required equipment deployment for optimal operations, and therefore not being able to adequately calculate the actual labor costs.
Also, as for the separation of the manned and unmanned areas mentioned above, depending on how this zoning is handled, additional physical modifications may be necessary in the area, and this would all require further consideration going forward.

4) Consideration of Introduction Schedule

PAT plans to introduce two more RTGs at the coastal terminal (Coastal-A) to bring the total to four. Also, at the rail terminal (SRTO), in addition to adding two RMGs and four RTGs, PAT planned to refurbish three used RTGs currently stored at Laem Chabang Port to bring the total in operation to eight. However, for this study, it was assumed that there is a need to add four RTGs for optimal operations. In summary, this study assumed that installation work would be done to automate four RMGs and 16 RTGs, and considered a schedule for introduction that would also allow for uninterrupted terminal services.

A detailed schedule proposed for introduction of automation is presented in Figure 26.

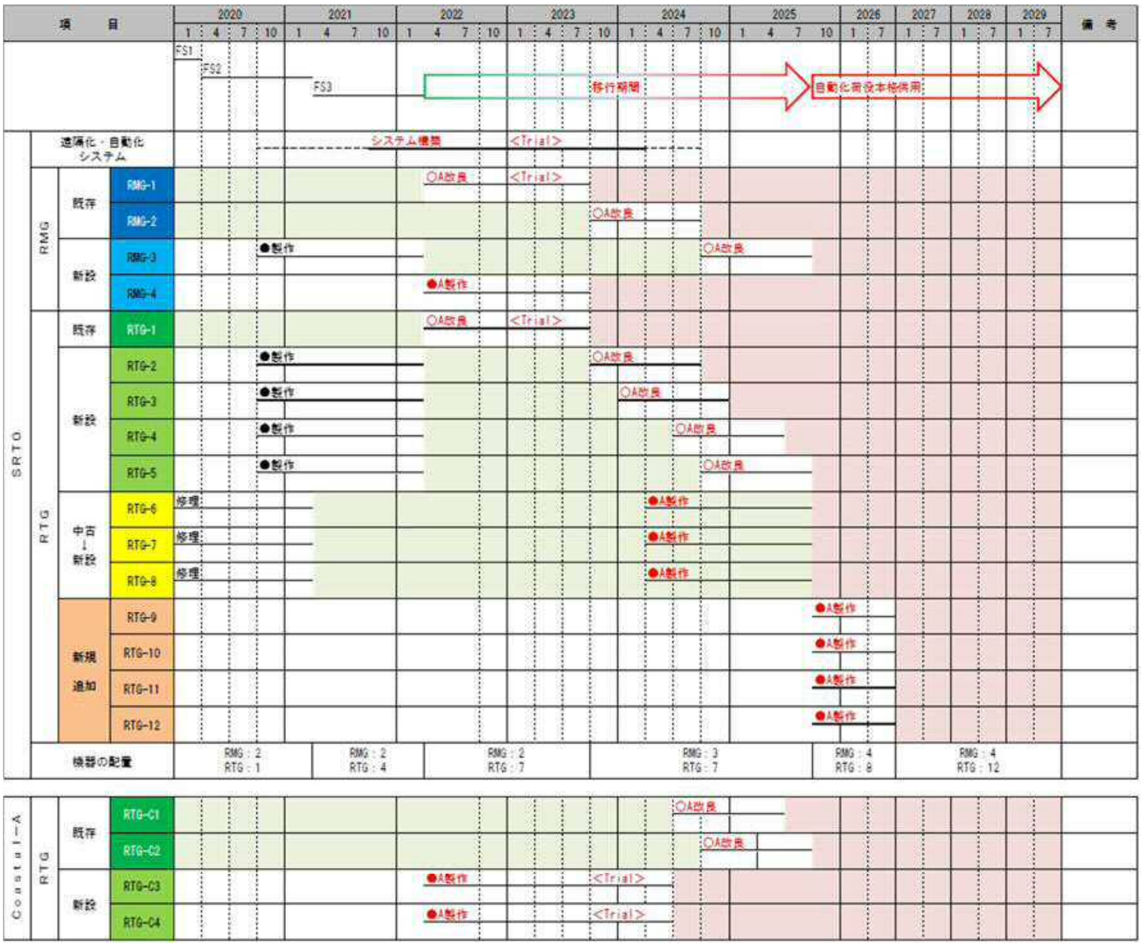


Figure 26: Proposed schedule for introduction

3-2 Consideration of Possible Efficiency Increases by Coordinating Rail Transport by State Railway of Thailand and Private Operators at Lat Krabang ICD

(1) Consideration of Low-Carbon Equipment for the Lat Krabang ICD

A bidding process was implemented in 2019 to select operators at Lat Krabang ICD and to integrate six modules into one to make operations more efficient, but as of February 2020, there were no reports that contracts had been signed yet.

This study originally assumed that the terminal would be configured to accommodate the change of operations from six to one module, and interviews were conducted with corporate members of ALG, a consortium that was given special negotiating rights, but the current situation is not yet conducive to detailed considerations of the reconfiguration plans. Considering this situation, we executed a basic study for this year.

1) Target facilities and freight handling equipment, etc.

In the future, Lat Krabang ICD will change operations from six modules to one, and equipment that might be considered for introduction compatible with that reconfiguration includes procurement and remote operation of cargo handling equipment, replacement of structures such as the administrative building(s), gatehouse(s), storage structure(s), etc., and introduction of terminal communications equipment (including the introduction of 5G networks). Examples of facilities and equipment that could be procured using the JCM Model Project include rooftop photovoltaic systems, LED lighting in storage areas, and energy-efficient air conditioning equipment in offices and warehouses. However, under the current conditions with the operators not yet being decided, it is unknown whether existing facilities and equipment will remain or be replaced. This makes consideration of these options difficult to do at the moment. Thus, this study has examined the use of the JCM Model Project for low-carbon equipment—specifically, gantry cranes, which according to stakeholder interviews were among the bid requirements.

Two types of gantry cranes (RMG and RTG) could be introduced at Lat Krabang ICD, but because there must be some challenges for introduction of RMGs such as research of the ground strength around the rails, at this point the study looks at scenarios for changing from diesel-powered RTGs to hybrid or electric.

Figure 27: Potential for introducing low-carbon facilities at Lat Kraban ICD

2) Evaluation results

RTGs were the subject of consideration and the analysis assumed a scenario of two units, with the standard specifications of 40.6 tons as the rated load, and the capacity to stack containers in six rows, six high.

The evaluation results are shown in Table 13.

Table 13: Evaluation results for RTG

		Hybrid RTG	Electric RTG
Specs, quantity	Quantity	2 units	2 units
	Rated load	40.6 t	40.6 t
	Containers	Rows 6+1 rows, stacked 1 over 6	Rows 6+1, stacked 1 over 6
	Depreciation period	12 years	12 years
Return on investment	Initial cost (A)	84,265,908 THB (296,615,996 JPY)	92,692,500 THB (326,277,600 JPY)
	CO2 reduction (B)	5,771 t-CO2/12yr (480.9t-CO2/yr)	8,971 t-CO2/12yr (747.5 t-CO2/yr)
	JCM subsidy (C)	6,488,474 THB (22,839,428 JPY)	10,196,175 THB (35,890,536 JPY)
	JCM cost/benefit (C)/(B)	1,124 THB (3,956 JPY) /t-CO2	1,136 THB (3,998 JPY) /t-CO2
	JCM subsidy ratio	7.7%	11.0%
	Running cost savings (reduced fuel cost)	61,809,454 THB/12yr (217,569,278 JPY)	20,073,454 THB /12yr (70,658,558 JPY)
	Evaluation	○	○

Note: The exchange rate used for this study is 1 THB = 3.52 JPY.

In the case of introducing hybrid RTGs, the initial cost is approx. 84 million THB, CO2 emission reduction approx. 5,771 t-CO2/12 years, JCM subsidy approx. 6.5 million THB, JCM cost/benefit approx. 1,124 THB (approx. 3,956 JPY)/t-CO2, JCM subsidy ratio 7.7%, and running cost savings approx. 61 million THB/12 years.

Meanwhile, for electric RTGs, the initial cost is approx. 92 million THB, CO2 emission reduction approx. 8,971 t-CO2/12 years, JCM subsidy approx. 10.1 million THB, JCM cost/benefit approx. 1,136 THB (approx. 3,998 JPY)/t-CO2, JCM subsidy ratio 11.0%, and running cost savings approx. 20 million THB/12 years.

Comparing the above points, the initial cost of introducing electric RTGs is higher, but fuel efficiency is better and the environmental burden is lower, so considering the long term, one could say the benefits are greater.

However, when introducing electric RTGs, additional infrastructure is also required to supply electricity to the RTGs (transformers and cables, buried conduits, and special equipment to connect to RTGs, etc.). Also, in some cases, at Lat Krabang ICD it might be necessary to do a fundamental reconfiguration of electrical equipment, so when it comes to implementation, it will be crucial to evaluate the options with a more detailed review once the operators have been decided.

(2) Identifying challenges to improve coordination

To promote a modal shift between Laem Chabang Port and Lat Krabang ICD, it is important to enhance facilities and improve the efficiency of operations at both the Laem Chabang Port rail terminal (SRTO) and the Lat Krabang ICD terminal.

In addition, it is important to improve coordination, including the following points.

(a) Improving rail operations

The rail schedule for Lat Krabang ICD and Laem Chabang Port is irregular and this needs to be improved. The current operations do not have regularly scheduled departures, and there is no regularly scheduled service at Lat Krabang ICD, because trains depart only after all train cars are loaded with containers. As a result, for containers that cannot wait the only option is to be transported by truck.

This situation it presumably not easy to change as that will require the cooperation of the railway operator (State Railway of Thailand) to change the current operational rules. If improvements of punctuality of the service can be made, it may be possible to attract shippers who are currently choosing truck transport due to the unpredictability of rail arrival times. In the future, it will also be necessary to consider the increased cargo projections and cost comparisons in a situation with regular train operations.

(b) Improving the coordination of operations

It is important for all parties involved in operations at Lat Krabang ICD, rail operations, the Laem Chabang rail terminal (SRTO), and also the container terminal at Laem Chabang Port, to share information about containers and work together to achieve smooth and efficient coordination of operations.

The Laem Chabang Port rail terminal (SRTO) currently does not receive trains and handle cargo in the same sequence that the trains departed from Lat Krabang. The operational method adopted is to make trains wait in a standby area outside Laem Chabang Port, and then pull trains into the SRTO terminal area to start cargo handling in the sequence of trains that have got clearance for cargo handling. Meanwhile, the Laem Chabang Port rail terminal (SRTO) and Lat Krabang ICD each have their own separate cargo handling rules and operations schedules.

Going forward, to promote a modal shift and achieve throughput volume targets, enhancement of overall efficiency of railway transportation by mutual coordination will clearly be a crucial factor. The key points will be to modify the cargo loading rules and operational rules that are currently being handled independently and work to share information about containers being handled. Possible approaches are to create methods to adopt common systems, create systems that have platform functions, and coordinate the respective systems. It will cost money to introduce the systems, but it is important to evaluate the option comprehensively 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.

Among the members of the consortium that obtained priority negotiation rights through the Lat Krabang ICD bidding process, many are operators at the container terminal at Wharf B of Laem Chabang Port. This fact could help facilitate the coordination of operations, because many of the containers handled at the rail terminal (SRTO) are destined to connect to the container terminal at Wharf B. However, the contracts for each container terminal at Wharf B come up for renewal in a number of years, so some time may be required to address the fact that the current situation is not conducive to immediate capital investments.

3.3 Identification of Issues and Consideration of Solutions for Methods to Quantify Modal Shift

Transportation and logistics in Thailand, examined by mode of transport, are heavily dependent on road transport (road 92.6%, water 6.4%, rail 1%).[2] Perceiving Thailand's rail infrastructure development to be lagging countries such as Singapore and Malaysia, the national government in 2015 adopted the "Thailand Transport Infrastructure Development Plan 2015-2022" and has since then been pursuing the modernization of rail transport in the country.[2] The modal shift from cars to rail is one of the priority strategies in the OTP(The Office of Transport and Traffic Policy and Planning) that was prepared in accordance with the above Plan. Regarding ship transport, although there are challenges such as the lack funds for aging port infrastructure and for dredging, the "Master Plan for Development of Transportation System (2017-2036)" includes plans to increase water transport's share to 19%.[3]

The current study, aiming for a modal shift of container freight between Laem Chabang Port and Lak Krabang ICD (rail), and between Laem Chabang Port and Bangkok Port (coastal vessel), had the aim of identifying the issues relating to methods to quantify the CO_2 emission reductions that would result from a modal shift specifically adapted to conditions in Thailand, and also aimed to consider how to resolve those issues.

(1) Determination of monitoring parameters

In Thailand, there have been many academic papers regarding the benefits of modal shift, with case studies on rail transport for sugar from the north, and rail transport of rubber from the south of the country, but there has been little consideration of the resulting CO2 emission reductions. For enhancing water transport as well (modal shift from road to water transport), there have been various initiatives, but there has been only limited consideration of the resulting CO2 emission reductions.[3] It should be noted that estimates of CO2 emission reductions have been done at the national level in Thailand, but initiatives at the case study level have not been done.

Thus, the present study referred to examples from the UN's Clean Development Mechanism (CDM) and Japan's Joint Crediting Mechanism (JCM) to develop a basic formula for estimating the CO2 emission reductions that could result from a modal shift, and also determined the monitoring parameters.

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[2] Railway development and long term plan in Thailand (OTP, 2017).
[3] Integrating Inland Waterways and Coastal Shipping as Part of Logistics Network: Experience of Thailand (TIFFA, 2018).

1) Basic formula for calculating CO2 emission reductions from a modal shift

The basic formula for calculating CO_2 emission reductions from a modal shift is described below.

CO2 emission reduction = A – B

A: CO2 emissions from truck transport

= CEF of truck transport (t-CO2/ton-km) x transport distance of truck transport (ton-km/year)

B: CO2 emissions from rail (R) or coastal ship (CS) transport

= CEF of R or CS (t-CO2/ton-km) x transport distance of R or CS (ton-km/year)

*CEF = Carbon Emission Factor

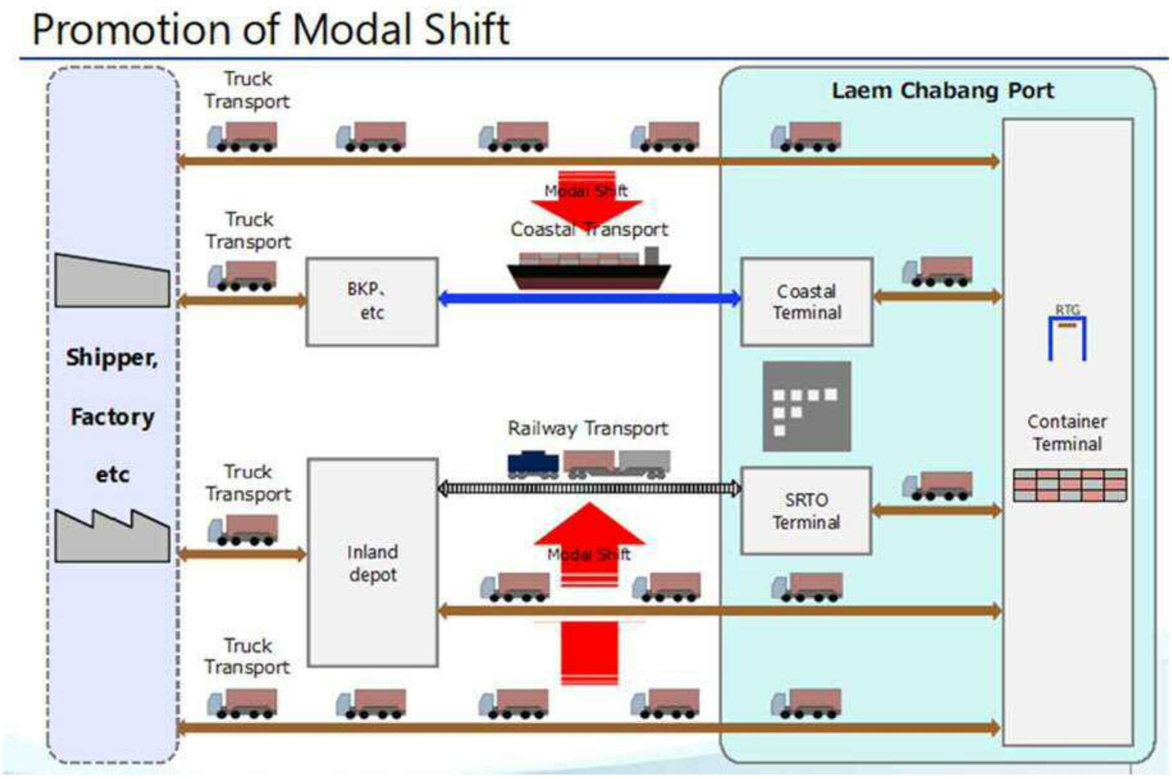


Figure 28: Concept of modal shift from truck to rail and coastal vessel

In the case of a modal shift to coastal transport, "CO2 emissions from operations within the Coastal-A terminal" and "CO2 emissions from truck transport from Coastal-A to each terminal" newly emerge in the consideration. In the case of a modal shift to rail, "CO2 emissions from operations within the SRTO" and "CO2 emissions from truck transport from SRTO to each terminal" newly emerge. Generally, if these CO2 emissions are about 5% (maximum) of total emissions, they are not counted in the emissions, as they are considered to be "negligible." Thus, the above basic formula does not include these CO2 emissions in the calculations, but going forward, if there is the potential for these CO2 emissions to exceed 5% of total emissions, it will become necessary to revise the above formula.

The data required to quantify the CO_2 emission reductions from a modal shift (from truck to rail or coastal transport) is the carbon emission factor (kg-CO_2/TEU/km) for truck, rail, and coastal vessel transport. These carbon emission factors can be determined by the following methods.

(a) Highest confidence method:

<Modal shift to rail>

For container freight transport from Laem Chabang Port to Lat Krabang ICD, obtain data by interviews or by actual measurement of the actual truck travel distance and fuel consumption, as well as rail travel distance and fuel consumption.

<Modal shift to coastal vessels>

For container freight transport from Laem Chabang Port to Bangkok Port, obtain data by interviews or by actual measurement of the actual truck travel distance and fuel consumption, as well as coastal vessel travel distance and fuel consumption.

(b) Alternative A:

From existing documentation in Thailand, obtain data on truck travel distance and fuel consumption for container transport for a segment similar to the route from Laem Chabang Port to Lat Krabang ICD, as well as rail travel distance and fuel consumption.

<Modal shift to coastal vessels>

From existing documentation in Thailand, obtain data on the truck travel distance and fuel consumption for container transport for a segment similar to the route from Laem Chabang Port to Bangkok Port, as well as coastal vessel travel distance and fuel consumption.

(c) Alternative B:

<Modal shift to rail>

From existing documentation from other countries (including Japan), obtain data on truck travel distance and fuel consumption for container transport for a segment similar to the route from Laem Chabang Port to Lat Krabang ICD, as well as rail travel distance and fuel consumption.

<Modal shift to coastal vessels>

From existing documentation from other countries (including Japan), obtain data on the truck travel distance and fuel consumption for container transport for a segment similar to the route from Laem Chabang Port to Bangkok Port, as well as coastal vessel travel distance and fuel consumption.

For methods (a) to (c) above, if the carbon emission factors (kg-CO2/TEU/km) can be determined for truck, rail, and coastal vessel, the monitoring parameters will be the annual distances travelled (km) by truck, rail, and coastal vessel.

(2) Analysis of data availability

Option (a) will require a request for cooperation from container freight transport truck owners, and the State Railway of Thailand (SRT). For options (b) and (c) challenges will include data availability, and determining how to identify travel segments for container transport that are similar to the segment from Laem Chabang Port to Lat Krabang ICD (and for coastal vessels, to Bangkok Port). In interviews Dr. Jakapong PONGTHANAISAWAN (associate professor at Chulalongkorn University), an expert in climate actions in the Thailand's transport sector, explained that identifying similar transport segments mentioned in option (b) would be difficult.

1) Data availability from SRT

To obtain rail transport data (travel distance, fuel consumption), it was learned including through telephone interviews with SRT that the following procedures are required.

○ Prepare and submit request letter to SRT

Prepare and send a formal letter (in Thai and English) to the SRT department responsible (Director of Freight Service Department of SRT) requesting information, and if possible, include letters from the related organizations in Thailand (PAT headquarters, LCP office, etc.) explaining the nature of this study. Send to the following address.

Director of Freight Service Department of State Railway of Thailand (SRT)
1 Rongmuang Road, Rongmuang, Pathumwan, Bangkok 10330
Tel: 02-220-4272 or 02-220-4255 (direct line)
Fax: 02-220-4255
email: blackman353@gmail.com (to contact for this project, attention to K. Raneechon)

○ Interviews with SRT

After sending the request letter, related organizations in Thailand (PAT headquarters, LCP office, etc.) and from Japan (YPC, GP) visit SRT and hold meetings. These meetings are to deepen mutual understanding between SRT and data requesters.

○ Review by SRT

High level personnel at SRT will decide whether or not to provide cooperation for this study including the provision of data. Some of the data may be highly confidential, and it is possible that the data request will be denied.

2) Data availability from container freight truck owners

Telephone interviews produced comments that as private sector companies, truck transport companies may not wish to provide information on fuel consumption and travel distance (including routes) as potentially confidential information. Dr. Jakapong PONGTHANAISAWAN (associate professor at Chulalongkorn University) advised that some data from studies implemented by state agencies may be available regarding fuel consumption and travel distances (including routes) for container freight transport trucks.

(3) Consideration of issues and solutions

The most important issue for quantification methods for CO2 emission reductions from a modal shift applicable in Thailand is how to obtain data to establish the carbon emission factors (kg-CO2/TEU/km) for transport by container freight trucks, rail, and coastal vessel. Modal shift is clearly described as an important action, not only for each type of transportation plan but also for NDCs and other climate action plans, so the lack of various types of data that is crucial for quantifying CO2 emission reductions in individual businesses could become an important topic for promoting modal shift in the future.

As one solution for these data challenges, it was suggested that since SRT and PAT are government bodies in the position of being able to promote modal shift, an important first step could be that through this project they come to understand the importance of quantifying CO2 emission reductions from a modal shift, actively engage in exchanges of perspectives, and create a platform to obtain and share the necessary data.

Also, the establishment of calculation methods for new CO2 emissions generated associated could be mentioned as a technical issue arising from this study. As stated above, for case of modal shift to coastal transport, "CO2 emissions from operations within the Coastal-A terminal" and "CO2 emissions from truck transport from Coastal-A to each terminal" are new emissions. And in the case of a modal shift to rail, "CO2 emissions from operations within the SRTO" and "CO2 emissions from truck transport from SRTO to each terminal" are new emissions. If assumptions can be made on the state of each operation and the state of truck transport to each terminal, it becomes possible to generally determine CO2 emissions from these activities. It is desirable to establish multiple scenarios for realistic operation and truck transport, and to develop methods to calculate the CO2 emissions from these activities.

(4) Estimation of CO_2 emission reduction from modal shift

When attempting to quantify the CO2 emission reductions from a modal shift in a way that is relevant for Thailand, developing a general grasp of the magnitude of the CO2 emission reduction effects of a modal shift could be an important step to help address the issues mentioned above when explaining the benefits to SRT and PAT

The modal split of container transport at Laem Chabang Port in 2018 is shown in figure 29, at 7.14 million TEU by truck (89.1%), followed by 600,000 TEU by coastal vessel (7.5%), and 270,000 TEU by rail (3.4%).

Notably, PAT aims to achieve 11.00 million TEU of annual throughput in Phase II.

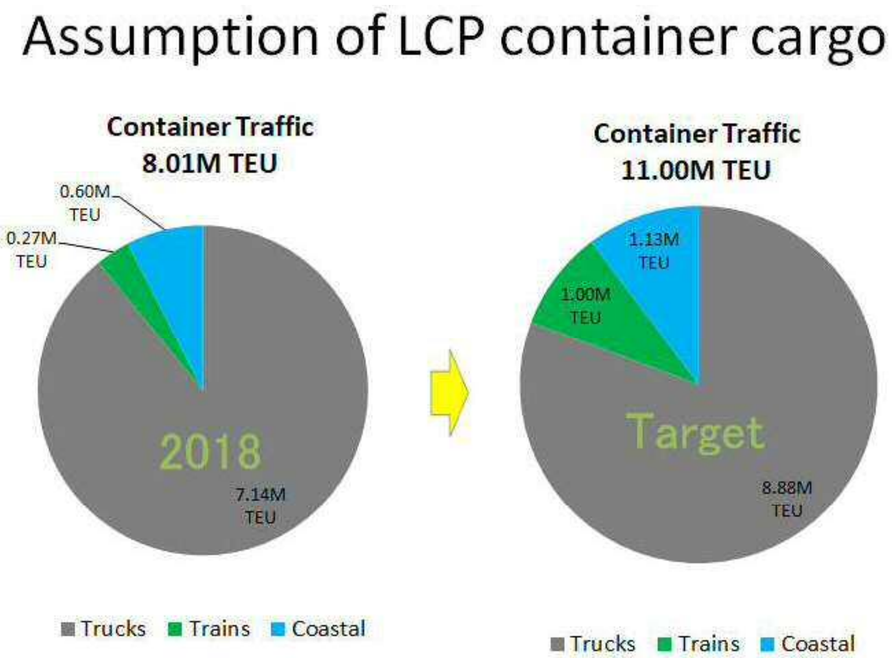


Figure 29: Modal split for container transport

The goal for the rail terminal (SRTO) is one million TEU, of which the share of rail in 2018 (3.4%) equivalent (370,000 TEU) is set as the natural increase, so the increase in rail transport volume from this study is set at 630,000 TEU. Also, for this study the coastal vessel transport volume is set only at 300,000 TEU, which is the target for coastal vessel transport volume for the coastal terminal (Coastal-A). Based on this CO2 emission reductions were estimated. The methodology and results of estimation are shown below.

1) Modal shift to rail transport

<Estimation method for CO2 emission reductions>

Assumptions:

・Transport distance:	100 km (truck, rail)
・Emission factor (truck;):[4]	173 g-CO2/ton/km
・Emission factor (rail):[5]	25 g-CO2/ton/km
・Increase in rail transport volume:	630,000 TEU/year
・Container weight (2 TEU):	24.4 ton

<Estimation results>

・CO2 emissions from rail transport	19,215 ton-CO2/year
・CO2 emissions from truck transport	132,968 ton-CO2/year
・CO2 emission reduction	113,753 ton-CO2/year

2）Modal shift to coastal vessel transport

<Estimation method for CO2 emission reductions>

Assumptions

・Transport distance (truck):	130 km
・Transport distance (coastal vessel):	100 km
・Emission factor (truck):[4]	173 g-CO2/ton/km
・Emission factor (coastal vessel):[6]	48.9 g-CO2/ton/km
・Increase in coastal transport volume:	300,000 TEU/yr
・Container weight (2 TEU):	24.4 ton

<Estimation results>

・CO2 emissions from coastal vessel transport	17,897 ton-CO2/yr
・CO2 emissions from truck transport	82,313 ton-CO2/yr
・CO2 emission reduction	64,416 ton-CO_2/yr

[4] "Joint guidelines for estimating CO_2 emissions in the logistics sector (Ver. 3.1)" (March 2016, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism) (in Japanese).
[5] Locomotive Emissions Monitoring Program 2016 (Railway Association of Canada).
[6] Documents from National Institute for Land and Infrastructure Management (2019) (in Japanese).

Table 14: Summary of estimation results of CO2 emission reductions by modal shift

	2018		Target		Increase of TEU		CO2 emission reduction (t-CO2/year)
Trucks	7.14M TEU	89.1%	8.87M TEU	80.6%			
Coastal	0.60M TEU	7.5%	1.13M TEU	10.3%	0.83M TEU	7.5%	
					0.30M TEU	2.7%	64,416
Trains	0.27M TEU	3.4%	1.00M TEU	9.1%	0.37M TEU	3.4%	
					0.63M TEU	5.7%	113,753
Total	8.01M TEU		11.00M TEU				178,169

3.4 Summary of Study Findings and Future Prospects

This study has examined ways to boost the efficiency of terminal operations that would be needed to promote a modal shift at Thailand's ports, with a focus on container freight flowing through Laem Chabang Port, and also looked at related matters.

Regarding a modal shift at the rail terminal (SRTO) and coastal terminal (Coastal-A) at Laem Chabang Port, this study used a simulator and other means to examine the effectiveness of operations being planned by PAT, the port administrator, identified key issues, and shared the findings with PAT. The study also identified general topics and issues associated with the possible introduction of Japanese manufacturers' automation technologies, which could be expected to provide significant boosts to efficiency.

Regarding the Lat Krabang ICD, the renewal procedures for concession contracts is on hold due to circumstances on the Thai side, so the next operators have not yet been decided. Thus, this study did not consider that matter in detail, but interviewed Japanese companies that are potential future operators to gather information, and with a view to the terminal reconfiguration that will probably be implemented after contracts are signed, this study confirmed that the potential exists to utilize a JCM Model Project for the introduction of certain cargo handling equipment.

Regarding CO2 emission reductions that are possible by promoting modal shift, this study calculated the potential reductions and showed that modal shifting can produce significantly greater emission reductions than decarbonizing terminal equipment and facilities. Looking forward, future work should include gathering the information needed for a more detailed assessment of potential emission reductions (i.e., detailed data specifically relating to truck transport of containers, coastal ship transport, and rail transport in Thailand).

Going forward, considering the issues that were clarified by the study this fiscal year, the plan is to conduct a more detailed examination of strategies to boost efficiency by introducing automation technologies, and to share the findings with PAT—regarding operational methods to effectively and safely utilize the modal shift terminals at Laem Chabang Port and to realize a modal shift.

Regarding the Lat Krabang ICD, the study will endeavor to continue with information gathering, and consider concrete strategies for collaboration to introduce low carbon equipment and facilities in the reconfiguration plans and promote modal shift. Regarding the verification of possible CO2 emission reductions, the plan is to proceed with studies to calculate emission intensity and increase the accuracy of calculations of emission reductions possible with modal shift, and also to make progress with the verification of direct CO_2 emission reductions that could be realized by increasing the efficiency of operations at each terminal.

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
(signature)	平原 敏英
DIRECTOR GENERAL PORT AUTHORITY OF THAILAND	DEPUTY MAYOR CITY OF YOKOHAMA

(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,

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

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 31st MARCH, 2019

Following the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama dated 31st 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,

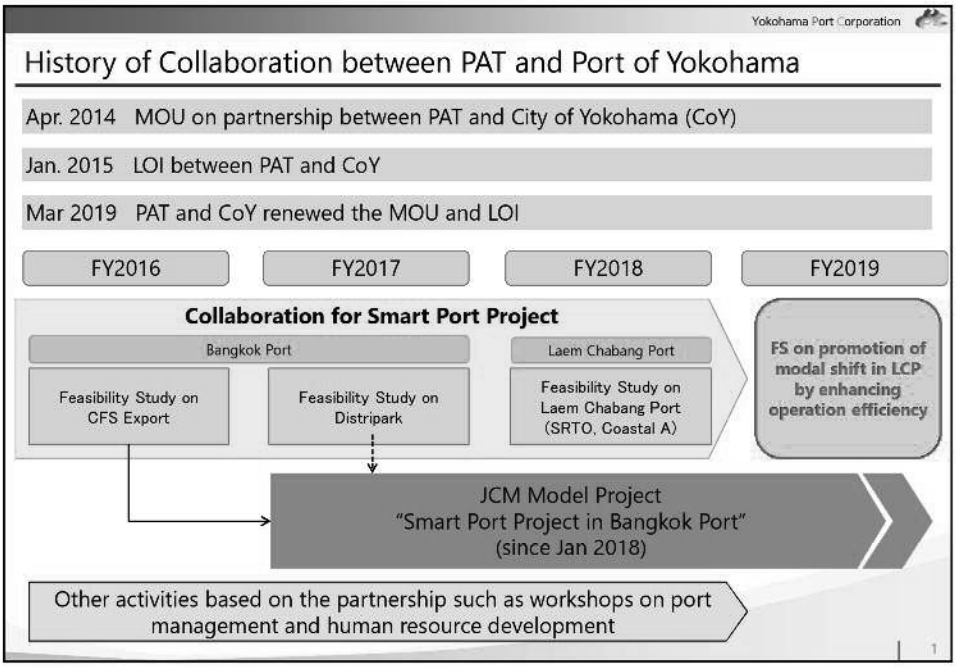
Director General
Port Authority of Thailand

For and on behalf of
the Port of Yokohama,

Director General
Port and Harbor Bureau,
City of Yokohama

Attachment 2: ：Documents of the meetings with PAT

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



Feasibility Study (F/S) for LCP in FY 2019

Points of the study

1. Possibilities of enhancing operational efficiency of **SRTO and Coastal A** terminal by utilizing **automation technology**
2. Effect of **CO2 emission reduction** by modal shift in LCP
3. Effective way of **promoting modal shift in LCP** in line with the re-development of Lat Krabang ICD

Participants
- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)

Period
- From Jul 2019 to Feb 2020

* May be extended until Feb 2022 subject to contract with MOEJ

Cost
- Funded by MOEJ (and YPC & GP)

➢ There is no obligation to form any actual project based on this F/S.

Yokohama Port Corporation

Details of the study points with Laem Chabang Port

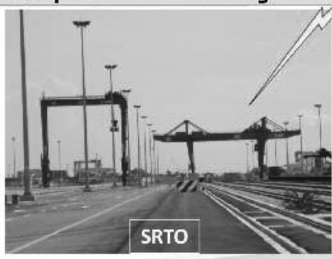
1. Enhancing operational efficiency of SRTO and Coastal A terminal

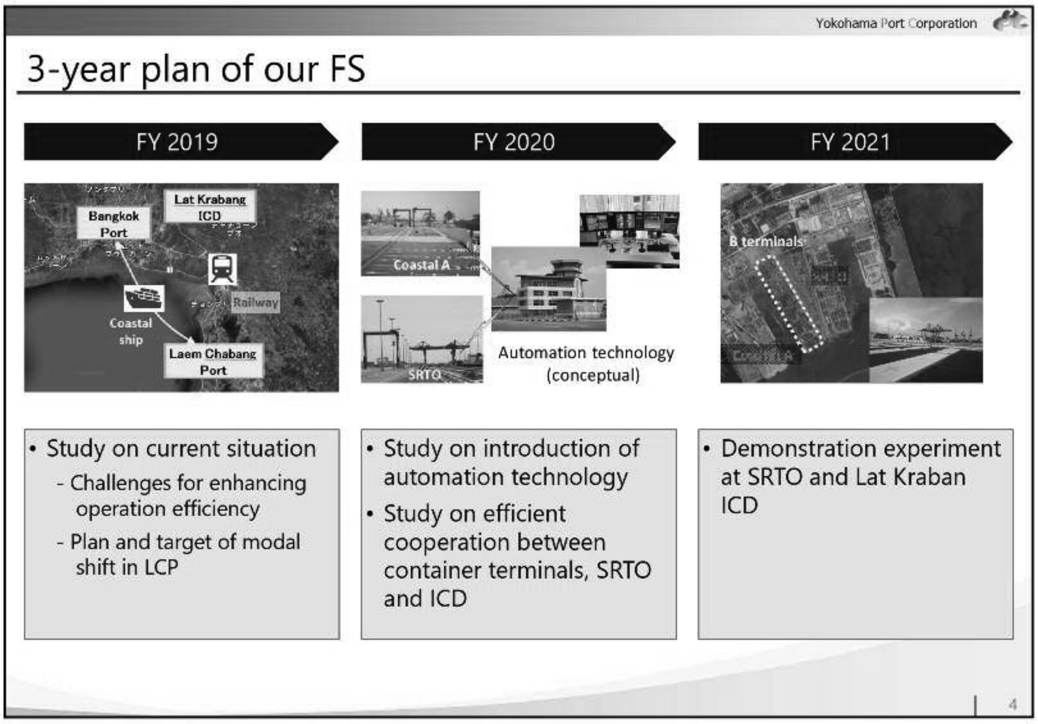
- Study on remote control system for RMG and RTG for promoting modal shift

Example of necessary infrastructure
- positioning and communication system for RMG and RTG
- cameras and sensors on RMG and RTG
- control room equipped with remote control system

2. Calculation of CO2 emission reduction by modal shift

3. Possible collaboration with operators in Lat Krabang ICD





Attachment 9

(2) Documents of the 2nd meeting (Interim WS)

FY2019 Feasibility Study with PAT

25th Nov. 2019
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.

横浜港埠頭株式会社
Yokohama Port Corporation

Feasibility Study (F/S) for LCP in FY 2019

Points of the study

1. Possibilities of enhancing operational efficiency of **SRTO and Coastal A** terminal by utilizing **automation technology**
2. Effect of **CO_2 emission reduction** by modal shift in LCP
3. Effective way of **promoting modal shift in LCP** in line with the re-development of Lat Krabang ICD

Participants
- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)

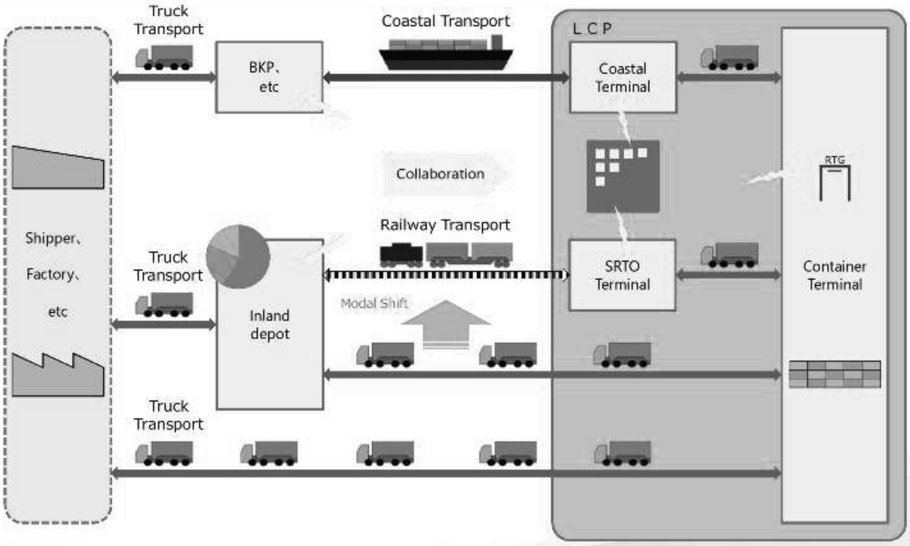
Period
- From Jul 2019 to Feb 2020

* May be extended until Feb 2022 subject to contract with MOEJ

Cost
- Funded by MOEJ (and YPC & GP)

➢ There is no obligation to form any actual project based on this F/S.

Promotion of Modal Shift



Details of the study points with Laem Chabang Port

1. Enhancing operational efficiency of SRTO and Coastal A terminal

- Study on remote control system for RMG and RTG for promoting modal shift

Example of necessary infrastructure

- positioning and communication system for RMG and RTG
- cameras and sensors on RMG and RTG
- control room equipped with remote control system

2. Calculation of CO_2 emission reduction by modal shift

Study on automation

<Decision at the last meeting in July>

- Conduct study on introduction of automation technology (remote control) for cargo handling machines in this year's FS. (Start with Coastal A terminal.)

YPC's proposal ->Extend the scope of the study to both Coastal A and SRTO

<Steps>

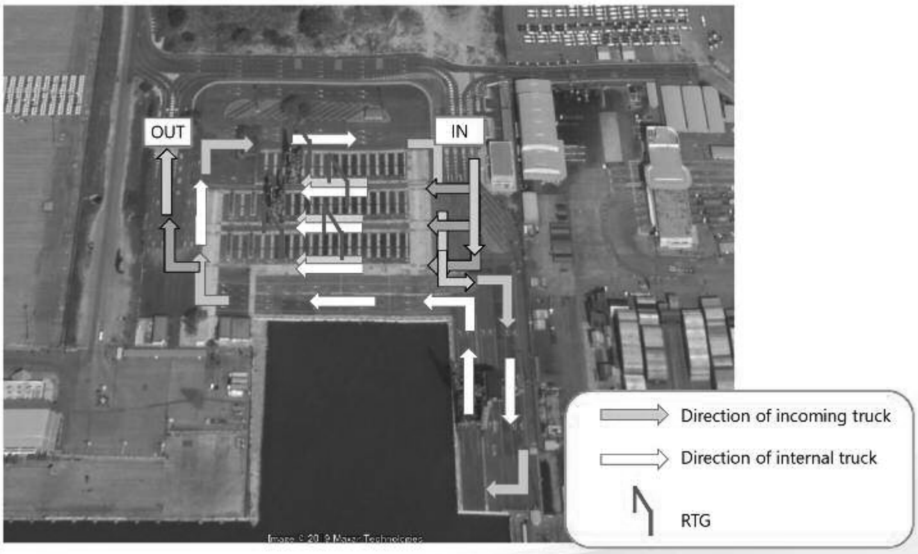
- Confirmation of the terminal layout of SRTO and Coastal A at present
- Confirmation of the necessary number of units of cargo handling machines
- Study on automation (remote control)
- Check of the advantages of automation

Confirmation of the terminal layout of SRTO and Coastal A at present

<Points>

- Location of the gates (in/out)
- Traffic lines of trucks incoming and internal
- Whether incoming trucks directly receive container from the ship (and the ratio of such operation if any)

Confirmation of the terminal layout (Coastal A)



Confirmation of the terminal layout (SRTO)

<Points>

- Location of the gates (in/out)
- Traffic lines of trucks incoming and internal
- Location of cargo storage area for B terminals and C terminals
- Rules to decide the location of the storage area for loaded containers and empty containers
- Operation rule for 6 lanes of the train rail
- Whether incoming trucks directly receive container from the train (and the ratio of such operation if any)

Confirmation of the terminal layout (SRTO)

Confirmation of necessary number of cargo handling machines (Coastal A)

To handle 300,000 TEU containers/year (target)

1) 300,000TEU / 365 days ≒ 822 TEU / day

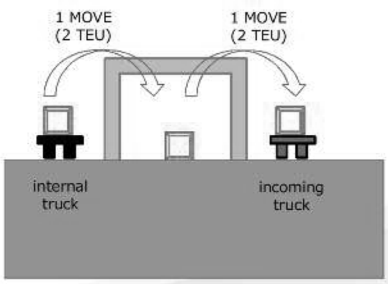
2) 822TEU / 4 units ≒ 206 TEU / unit

3) 206TEU / 16 hours ≒ 13 TEU / hour

・Per 1 unit of RTG ≒ 13 TEU / hour

->13 moves / hour

2 moves of RTG will be necessary to carry 1 container



Attachment 14

Confirmation of necessary number of cargo handling machines (SRTO)

To handle 1,000,000 TEU containers/year (target)

1) 1,000,000TEU / 365 days ≒ 2,740TEU / day

2)-1 RMG : 2,740TEU / 4 units ≒ 685TEU / unit

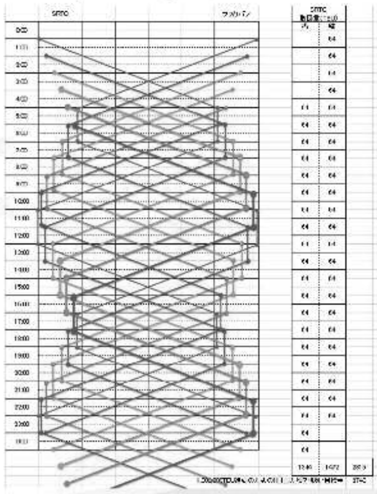
2)-2 RTG : 2,740TEU / 8 units ≒ 343TEU / unit

- Per RMG
  685TEU / 24 hours ≒ 29TEU / hour
  →14.5 moves / hour

- Per RTG
  343TEU / 24 hours ≒ 14.5TEU / hour
  →14.5 moves / hour

Seems difficult to achieve...

Train operation diagram (YPC's calculation)



Calculation of necessary number of the machines by computer simulation

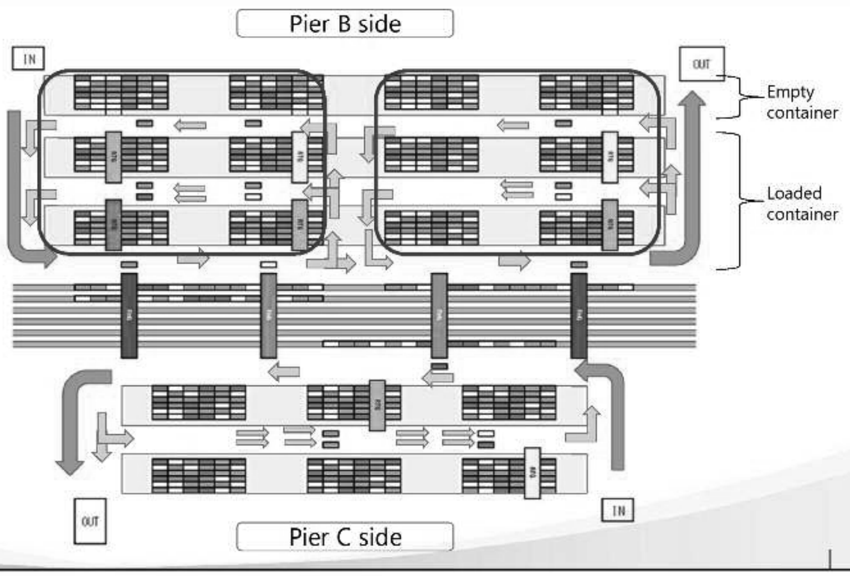
Movie clip

Temporary conditions for the computer simulation

< Temporary conditions >

- Speed of the trucks in the terminal will be 30 km/hour
- Cargo handling machines (RMG and RTG) can achieve 16 moves/hour
- Storage areas are decided according to the type of cargo
- RTGs do not change the lane
- Operation on pier B side will be done by 2 groups of machines
- Some of the truck traffic lanes are changed
- RTG can move 2 TEU containers at once
- Gate processing times are set based on actual data of other ports

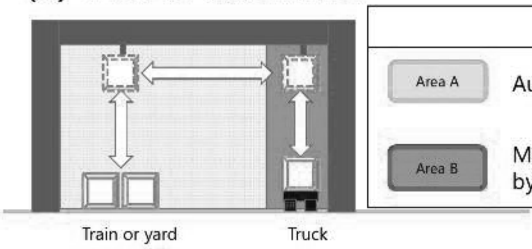
Confirmation of the conditions of operation (SRTO)



Confirmation on automation (remote control)

(1) Coverage of automation
-> RMG/RTG will be automated (remotely controlled)
-> Internal trucks are manned

(2) Level of automation



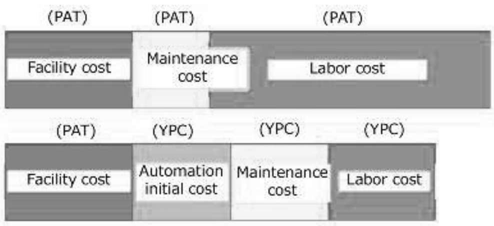
RMG and RTG	
Area A	Automated (program-controlled)
Area B	Manually operated (remote control by an operator)

Check of the advantage of automation

(1) Cost calculation

1) Manual operation

2) Automation (remote control)

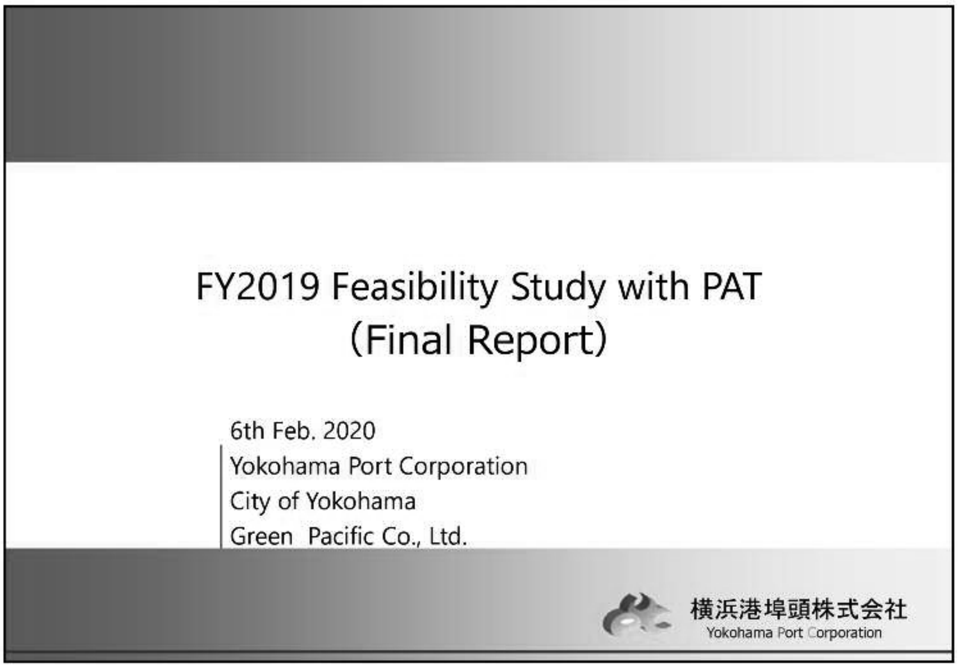


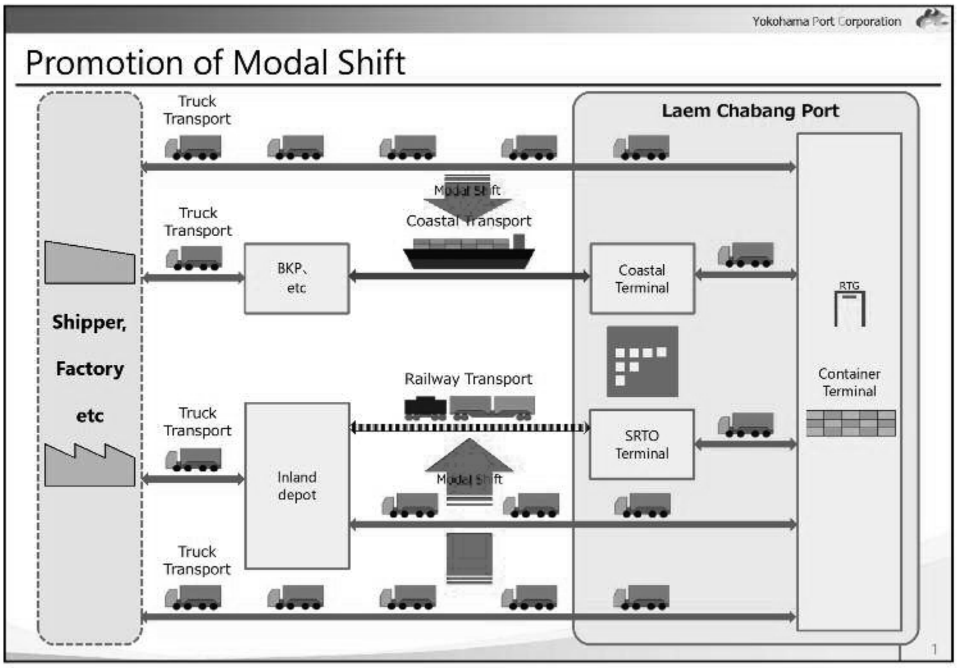
Please provide information for the expected cost of manual operation

(2) Amount of CO2 reduction

To be estimated

(3) Documents of the 3rd meeting





Yokohama Port Corporation

Feasibility Study (F/S) for LCP in FY 2019

Points of the study

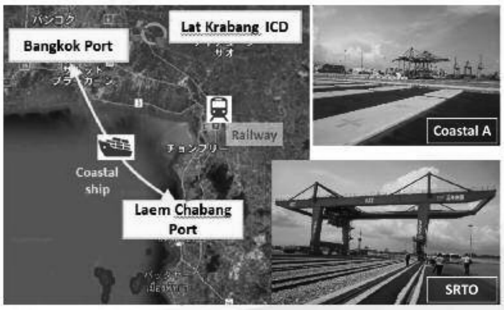
1. Possibilities of enhancing operational efficiency of **SRTO and Coastal A** terminal by utilizing **automation technology**
2. Effect of **CO2 emission reduction** by modal shift in LCP
3. Effective way of **promoting modal shift in LCP** in line with the re-development of Lat Krabang ICD

Participants
- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)

Period
- From Jul 2019 to Feb 2020

* May be extended until Feb 2022 subject to contract with MOEJ

Cost
- Funded by MOEJ (and YPC & GP)



➢ There is no obligation to form any actual project based on this F/S.

2

Yokohama Port Corporation

Study on automation for enhancing terminal efficiency

<Decision at the meeting in July>
- Conduct study on introduction of automation technology (remote control) for cargo handling machines in this year's FS. (Start with Coastal A terminal.)

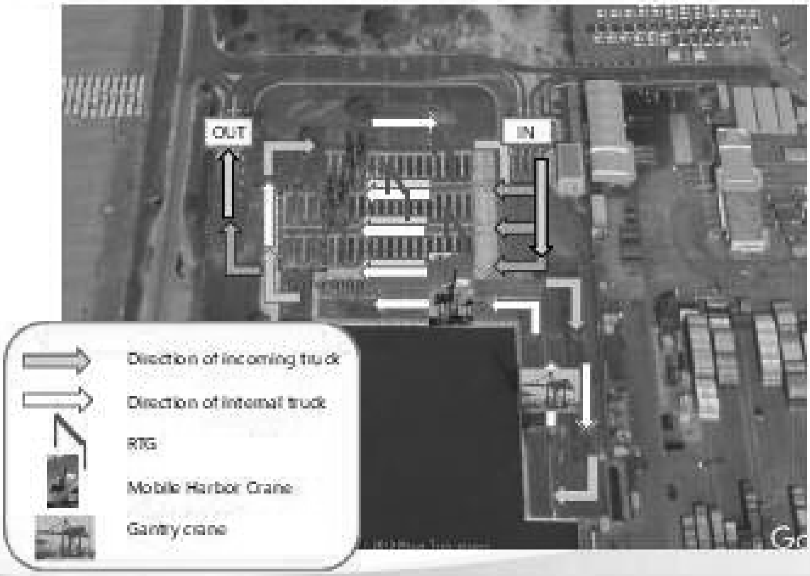
<YPC's proposal at the meeting in November>
- Extend the scope of the study to both Coastal A and SRTO

<Steps>
- Confirmation of the terminal layout of SRTO and Coastal A at present
- Confirmation of the necessary number of units of cargo handling machines
- Study on automation
- Check of the advantages of automation

3

Yokohama Port Corporation

Confirmation of the terminal layout (Coastal A)



Yokohama Port Corporation

Confirmation of necessary number of cargo handling machines (Coastal A)

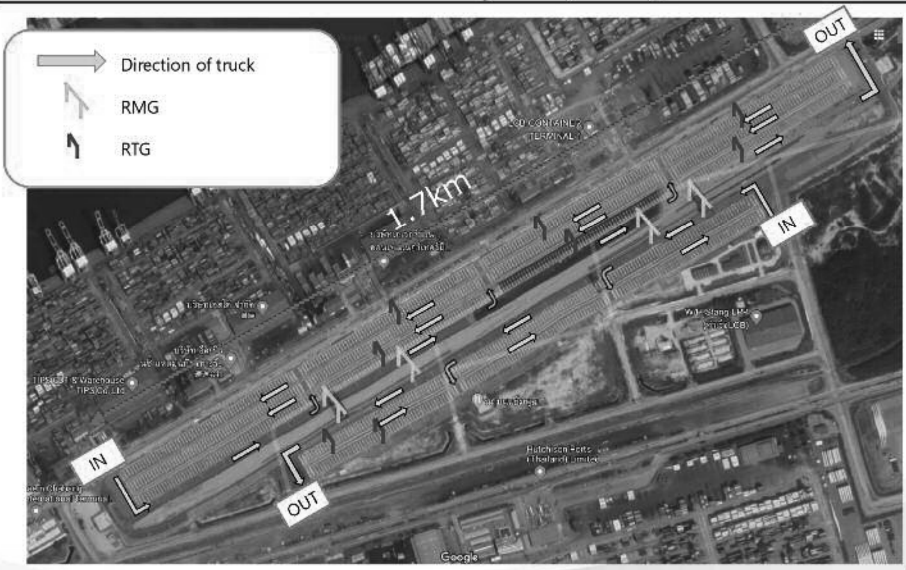
- Target container throughput : 300,000 TEU / year

  1) 300,000TEU / 365 days ≒ 822 TEU / day
  2) 822TEU / 24 hours ≒ 34 TEU / hour
  3)-1 STS Crane: 34TEU / 2 units ≒ 17 TEU / hour・unit
  3)-2 RTG: 34TEU×2 / 4 units ≒ 18 TEU / hour・unit

- It is expected most containers are directly loaded to trucks from vessels by the STS cranes. Therefore cargo handling by RTG will be less than usual container terminal

- Considering above, it is considered that 300,000 TEU can be handled with the existing facilities

Confirmation of the terminal layout (SRTO)



Confirmation of necessary number of cargo handling machines (SRTO)

- Target container throughput : 1,000,000 TEU /year

- Gate processing time will be short
- The yard is horizontally long and moving distance of RTG will become long accordingly. So additional RTGs may be required
- Travelling distance of truck seems long and the number of RTGs may be insufficient as mentioned above. So congestion of truck may occur in the yard, which will decrease terminal efficiency

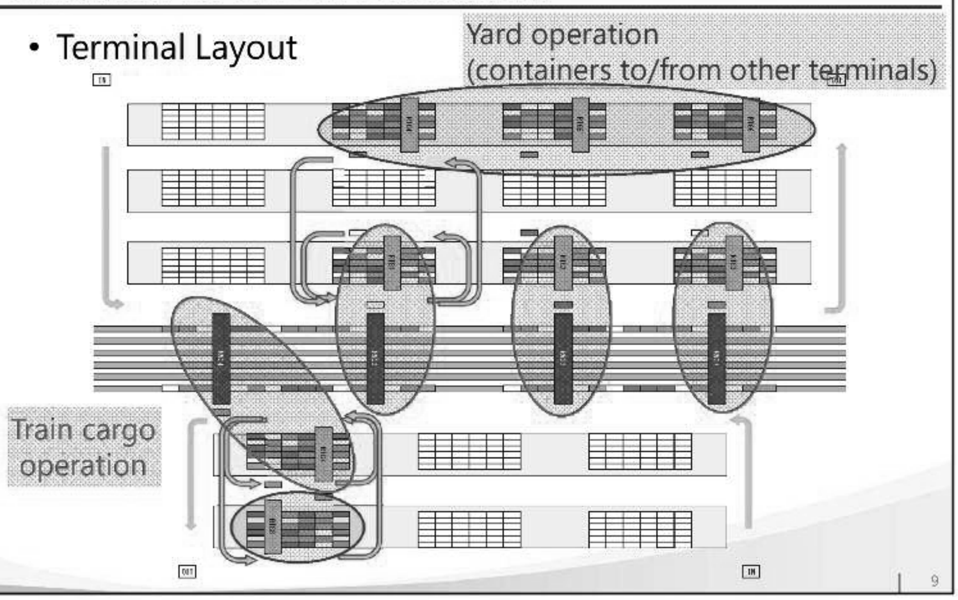
We did computer simulation to check the moves and operations of cargo handling machines and trucks

Simulation for SRTO : Preconditions

Facilities	Numbers etc
Terminal (SRTO)	• Gates: 2 for IN, 2 for OUT • Rail lanes: 6
Cargo train	• 32 cars (64TEU) per train • Arrive 1 train / Depart 1 train every hour • 2 RMG work on 1 train
Cargo handling machines	• 4 units of RMG: velocity 7.2km/h (2m/s) • 8 units of RTG: velocity 3.6km/h (1m/s) *RTGs will not change the lanes
Truck	• 100 units in total • 4 trucks serve for 1 RMG = 16 units for 4 RMG • The other 84 units work for carrying containers to/from B or C terminals
Cargo throughput	• 1 million TEU (all 40f container) • Import/Export = 50-50

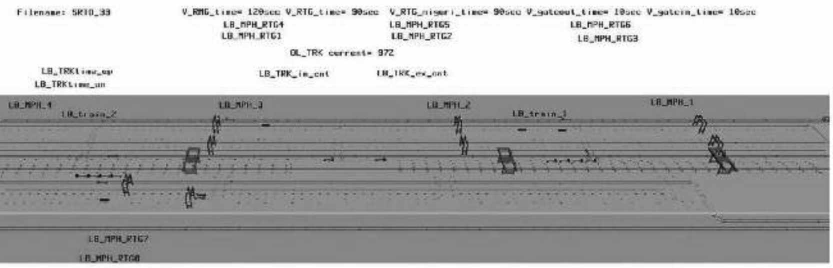
Simulation for SRTO : Preconditions

- Terminal Layout



Result of the simulation

24-hour operation



Movie clip

Summary of the simulation result

Facilities	Results
Train	Turnaround time : 89 - 110 min / unit
RMG	Operation efficiency : ☆☆☆
RTG	Train cargo operation efficiency : ☆☆☆☆ Moving distance : 252 - 3,062 m / day
	Yard operation efficiency : ☆ Moving distance : 37,069 - 41,076 m / day
Truck	1,396 units in/out in 24 hours (2,792TEU / day) *2,792TEU × 365day = 1,019,080TEU (1 million TEU) Turnaround time : average 85min (300min at maximum)

- Moving distance of RTG for yard operation is as long as 40 km/day, which decrease terminal operation efficiency
- Heavy congestion of truck occurred in the yard and turnaround time was 300 minutes at maximum
- 24 hour-operation is necessary to cover the low efficiency of the operation. This means any loss of time can not be allowed such as maintenance or human error
- There will be no time for cargo relocation, so operation must be reviewed

Proposal on Further study for enhancing operation efficiency

We propose that we conduct further study in next year on following items.

1. Study on continuous operation with efficiency and safety
    - Terminal operation
    - Necessary number and location of cargo handling machines
    - Possibilities of introduction of automation

2. Study on ways to reduce CO2 emission
    - Confirmation of the emission reduction effect by modal shift
    - Emission reduction by enhancing terminal operation efficiency
    - Emission reduction by introduction of e-truck

Details of the study points with Laem Chabang Port

1. Enhancing operational efficiency of SRTO and Coastal A terminal

- Study on remote control system for RMG and RTG for promoting modal shift

Example of necessary infrastructure

- positioning and communication system for RMG and RTG
- cameras and sensors on RMG and RTG
- control room equipped with remote control system

2. Calculation of CO2 emission reduction by modal shift

SRTO

Coastal A

Challenges for automation (remote control)

●SRTO

・Efficient operation method must be established prior to introduction of automation

●Coastal-A

・Reefer area (manned) and automation area (unmanned) must be separated due to safety reasons

・The size of Coastal-A is relatively small, so cost advantage will not be gained by Coastal-A only

➔ Need to study on introduction of common system with SRTO to monitor RTGs

Study for enhancing terminal efficiency by automation

Expected advantages by automation (remote control)

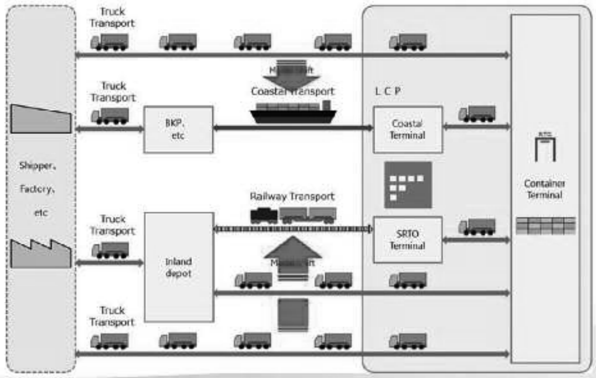
- Reduction of terminal operation cost
- Enhancement of terminal efficiency (improved cargo handling capability and labor-saving)
- More stable operation (not influenced by nature conditions)
- More safety (reduction of fatal accidents)
- Better labor conditions
- Lower GHG emission (with low-carbon facilities and efficient terminal operation)

CO2 Emission Reduction by Promoting Modal Shift

Simplified Formula of CO_2 Emission Reduction by Modal Shift

CO_2 Emission Reduction = A − B

A: CO_2 emission by Truck	B: CO_2 emission by Railway or Coastal ship
CEF of Truck (t-CO_2/ton-km)	CEF of T/S (t-CO_2/ton-km)
× Transport Distance of Truck (ton-km/year)	× Transport Distance of R or CS (ton-km/year)



CO_2 Emission Reduction by Promoting Modal Shift

Modal shift from truck to railway/coastal ship

The data required to quantify the CO_2 reduction effect by modal shift (from truck to railway or coastal ship) is the CO_2 emission factor (kg-CO_2/TEU/km) of trucks, railways and coastal ships. These data can be set by the following methods:

(1) Regarding container freight transportation from Laem Chabang Port to Ladkrabang ICD (or to Bangkok Port in case of coastal ship), actual measurements or interviews will be conducted on truck mileage and fuel consumption, and railway/ship mileage and fuel consumption (electricity consumption in the case of electric trains). Based on the data, we can calculate the most plausible CO_2 emission factors (kg-CO_2 /TEU/km).

(2) In case the method (1) is difficult, try to collect the data about truck mileage and fuel consumption, railway/ship mileage and fuel consumption (electricity consumption in the case of electric trains) in a section similar to container transport from Laem Chabang Port to Ladkrabang ICD (Bangkok Port in case of coastal ship) from existing data in Thailand. Based on the data, we can estimate the second best CO_2 emission factors (kg-CO_2/TEU/km).

(3) In case the method (2) is difficult, try to collect the data about truck mileage and fuel consumption, railway/ship mileage and fuel consumption (electricity consumption in the case of trains) in a section similar to container transport from Laem Chabang Port to Ladkrabang ICD (Bangkok Port in case of coastal ship) from existing data in other countries (including Japan). Based on the data, we can estimate an alternative CO_2 emission factors (kg-CO_2 / TEU / km).

Regarding the method (1), which provides the most accurate CO_2 emission factors (kg-CO_2/TEU/km), the cooperation of the container freight truck owner and the State Railway of Thailand (SRT) is necessary.

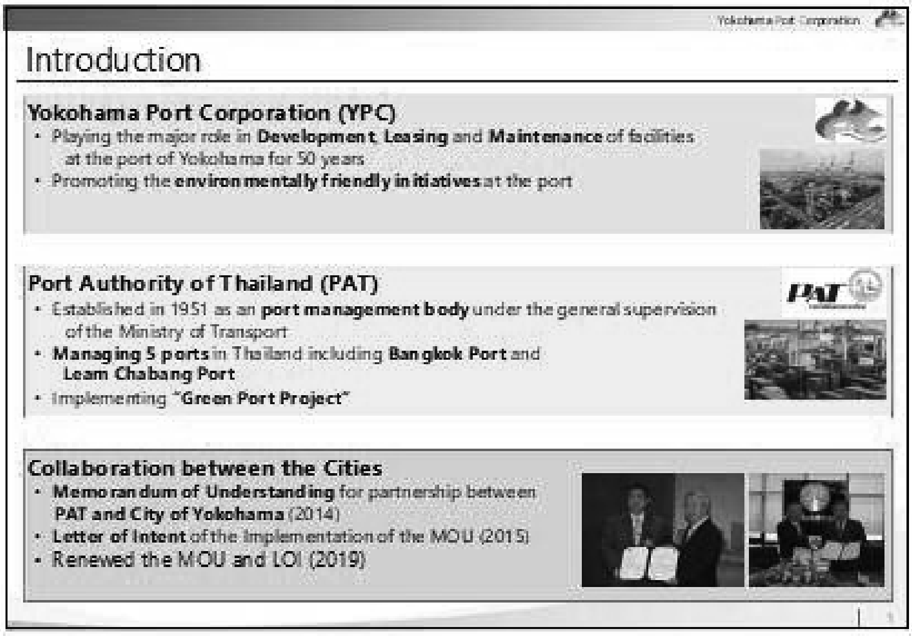
CO2 Emission Reduction by Promoting Modal Shift

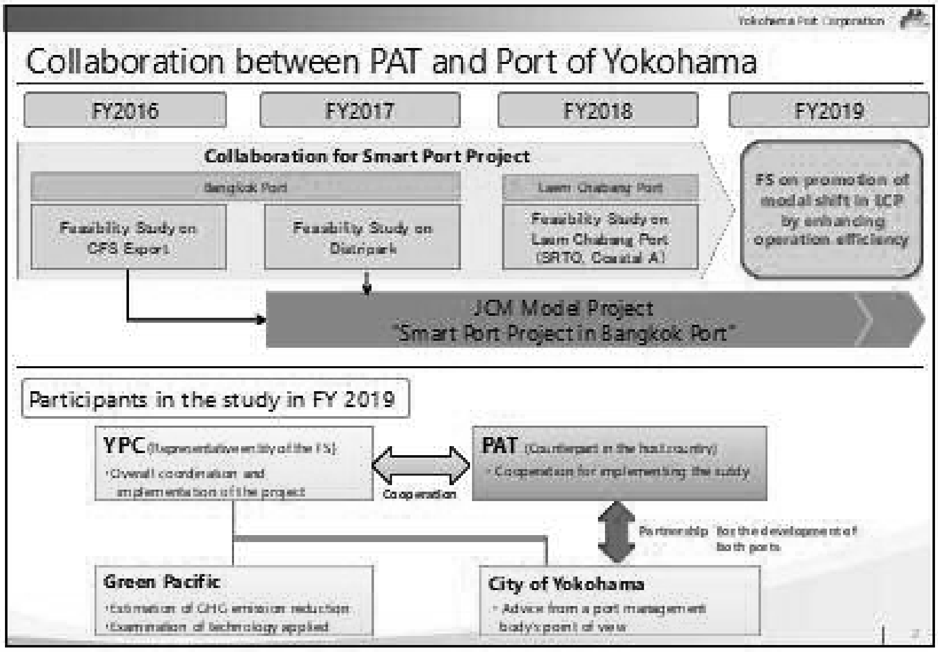
Result of Estimation of CO_2 Emission Reduction (tentative)

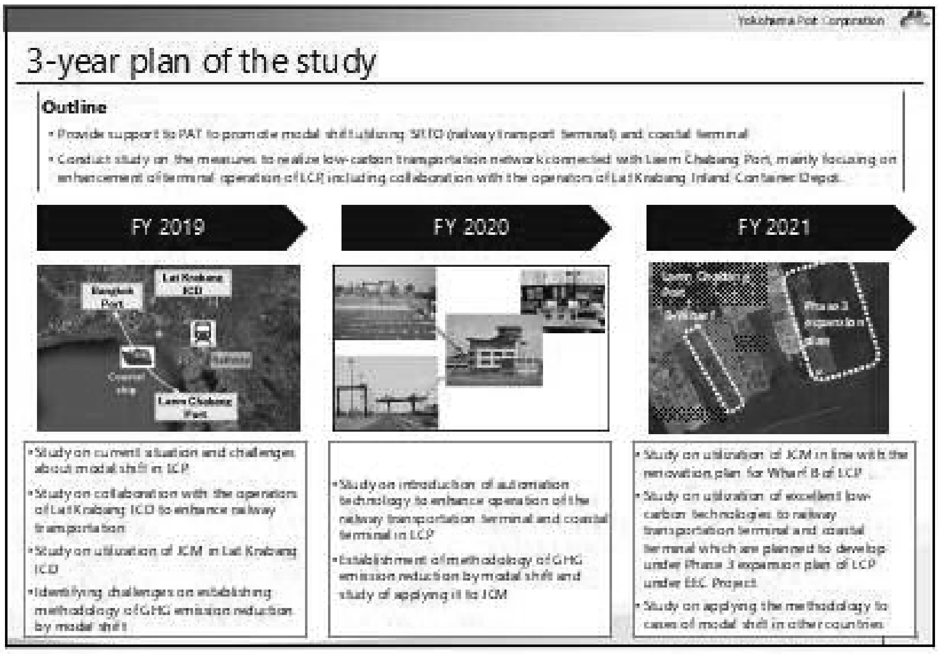
Target of Modal Shift in Leam Chabang Port and Effect of CO_2 Emission Reduction

	2018		Target		Increase of TEU		CO2 emission reduction (t-CO2/year)
Trucks	7.14M TEU	89.1%	8.87M TEU	80.6%			
Coastal	0.60M TEU	7.5%	1.13M TEU	10.3%	0.83M TEU	7.5%	
					0.30M TEU	2.7%	64,416
Trains	0.27M TEU	3.4%	1.00M TEU	9.1%	0.37M TEU	3.4%	
					0.63M TEU	5.7%	113,753
Total	8.01M TEU		11.00M TEU				178,169

Attachment 3: : Presentation at the City to City Collaboration Seminar




Yokohama Port Corporation
Collaboration between PAT and Port of Yokohama
FY2016
FY2017
FY2018
FY2019
Collaboration for Smart Port Project
Bangkok Port
Laem Chabang Port
Feasibility Study on CFS Export
Feasibility Study on Distripark
Feasibility Study on Laem Chabang Port (SRTO, Coastal A)
FS on promotion of modal shift in LCP by enhancing operation efficiency
JCM Model Project "Smart Port Project in Bangkok Port"
Participants in the study in FY 2019
YPC (Representative entity of the FS)
・Overall coordination and implementation of the project
Cooperation
PAT (Counterpart in the host country)
・Cooperation for implementing the study
Partnership for the development of both ports
Green Pacific
・Estimation of GHG emission reduction
・Examination of technology applied
City of Yokohama
・Advice from a port management body's point of view

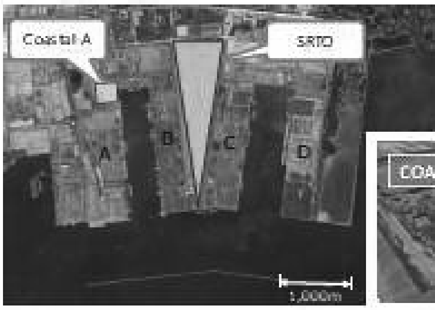

Yokohama Port Corporation
3-year plan of the study
Outline
・Provide support to PAT to promote modal shift utilizing SRTO (railway transport terminal) and coastal terminal
・Conduct study on the measures to realize low-carbon transportation network connected with Laem Chabang Port, mainly focusing on enhancement of terminal operation of LCP, including collaboration with the operators of Lat Krabang Inland Container Depot.
FY 2019
FY 2020
FY 2021
Lat Krabang ICD
Bangkok Port
Laem Chabang Port
Phase 3 expansion plan
・Study on current situation and challenges about modal shift in LCP
・Study on collaboration with the operators of Lat Krabang ICD to enhance railway transportation
・Study on utilization of JCM in Lat Krabang ICD
・Identifying challenges on establishing methodology of GHG emission reduction by modal shift
・Study on introduction of automation technology to enhance operation of the railway transportation terminal and coastal terminal in LCP
・Establishment of methodology of GHG emission reduction by modal shift and study of applying it to JCM
・Study on utilization of JCM in line with the renovation plan for Wharf B of LCP
・Study on utilization of excellent low-carbon technologies to railway transportation terminal and coastal terminal which are planned to develop under Phase 3 expansion plan of LCP under EEC Project
・Study on applying the methodology to cases of modal shift in other countries

Yokohama Port Corporation

Activity in FY 2019

Points of the study

1. Possibilities of enhancing operational efficiency of **SRTO and Coastal A** terminal by utilizing **automation technology**
2. Effect of **CO2 emission reduction** by modal shift in LCP
3. Effective way of **promoting modal shift in LCP** in line with the re-development of Lat Krabang ICD



About Laem Chabang Port

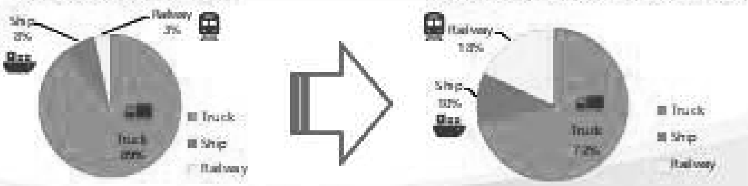
Area	:1,014ha(2,505ac)
Location	:130km south of Bangkok
Handling volume	:8,016,000 TEU (2018)
	:8,649,000 Ton (2018)

Yokohama Port Corporation

Modal Shift and Reduction CO2 emission

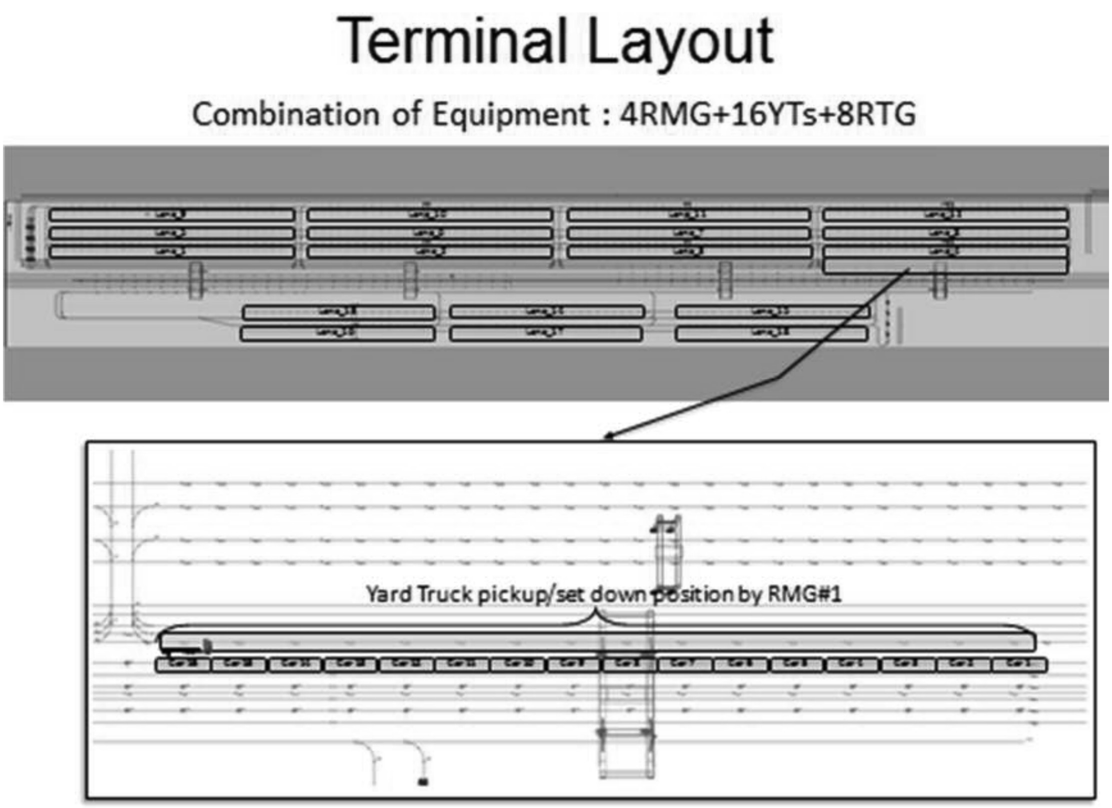
Modal Split of Laem Chabang Port

2018(8.02mil TEU) **Near future (11.0mil TEU)**



Attachment 4: Preconditions and results of the simulation

(1) Preconditions



Settings of Terminal Equipment

- RMG velocity 7.2km/h(2m/s)
- RMG pickup time 60 sec
- RMG set down time 60 sec
- Truck velocity 30km/h (8.333m/s)
- RTG traveling velocity 3.6km/h (1m/s)
- RTG pickup time 45 sec
- RTG set down time 45 sec
- RTG re-handling time 90 sec
  (Only for cargo pickup external truck)

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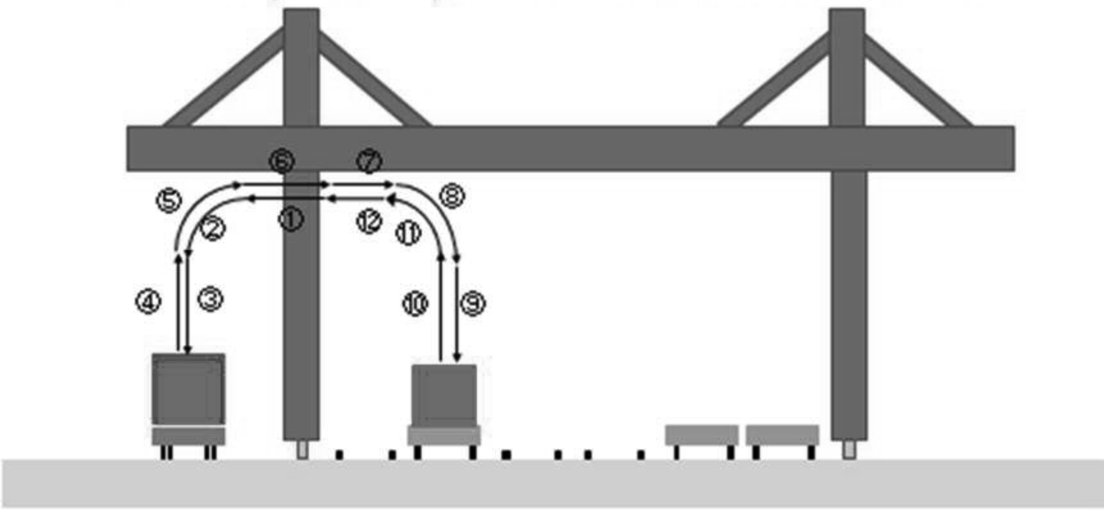
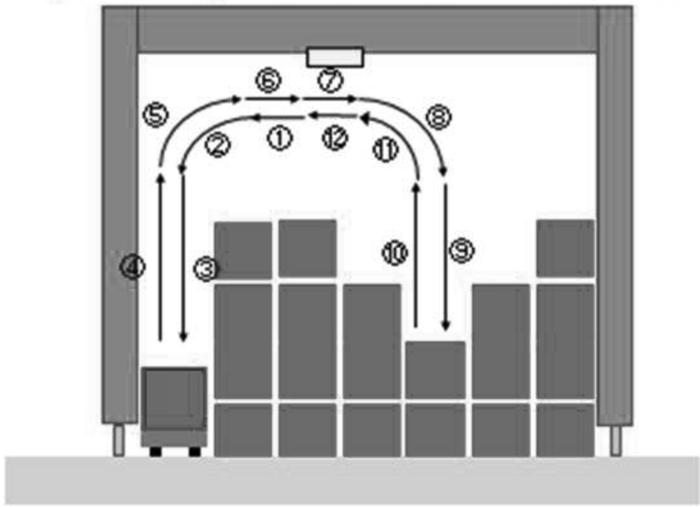
RMG pick up and set down time



Automod RMG pickup time = ① + ② + ③ + ④ + ⑤ + ⑥ = 60sec

Automod RMG set down time = ⑦ + ⑧ + ⑨ + ⑩ + ⑪ + ⑫ = 60sec

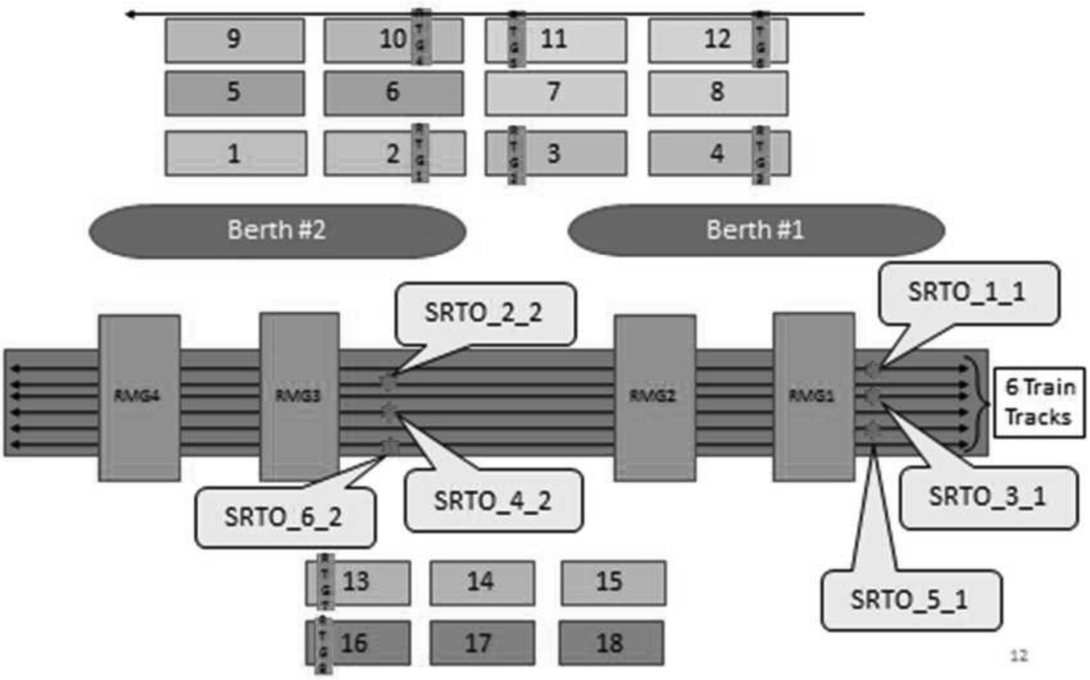
RTG pick up and set down time



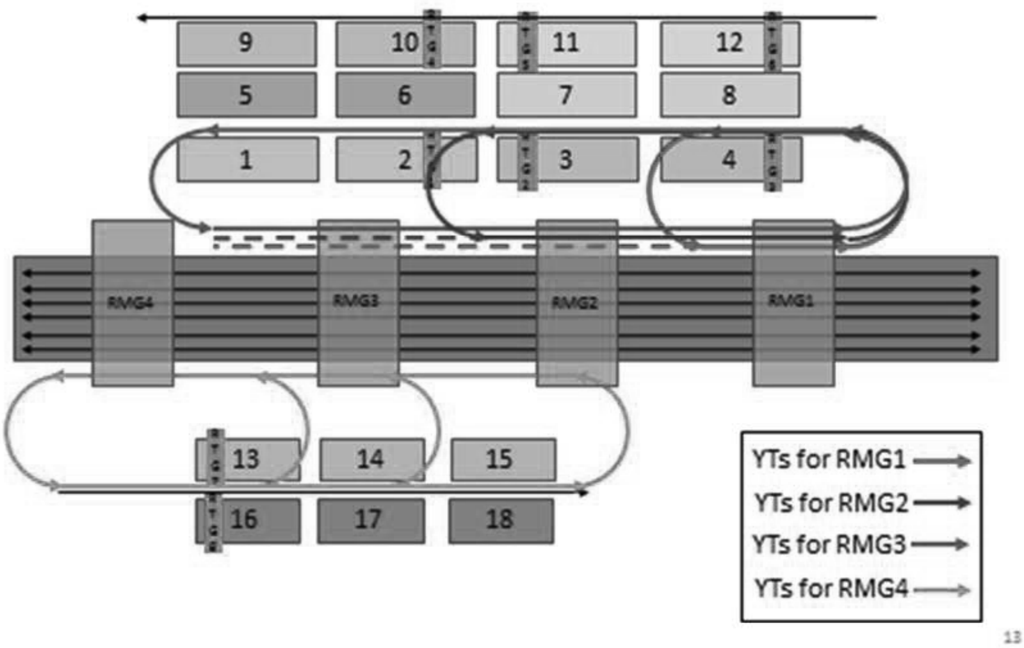
Automod RTG pickup time = ① + ② + ③ + ④ + ⑤ + ⑥ = 90sec

Automod RTG set down time = ⑦ + ⑧ + ⑨ + ⑩ + ⑪ + ⑫ = 90sec

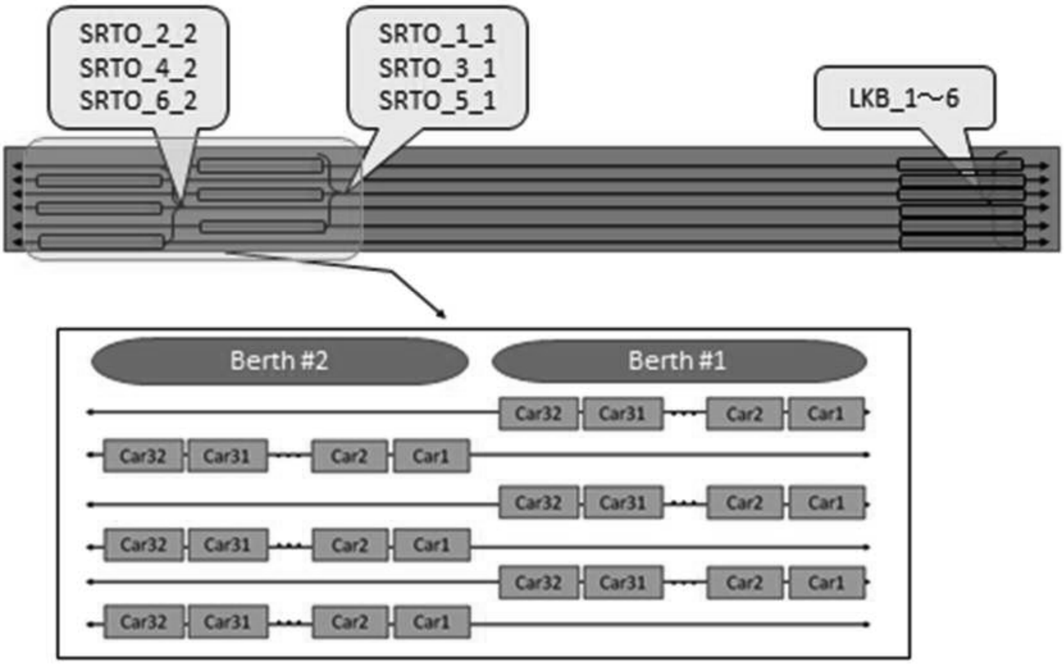
Terminal Layout



YT path mover layout



Train path mover layout



Attachment 35

(2) Results

・SRTO RMG MPH

RMG1 train_ID	MPH
1	18.86
3	18.45
5	18.69
7	18.71
9	18.77
11	18.80
13	18.68
15	18.81
17	18.61
19	18.77
21	18.65
23	18.63

RMG2 train_ID	MPH
1	18.23
3	17.60
5	17.80
7	17.82
9	17.88
11	17.90
13	17.80
15	17.92
17	17.72
19	17.86
21	17.76
23	17.74

RMG3 train_ID	MPH
2	21.36
4	21.69
6	21.65
8	21.72
10	21.73
12	21.58
14	21.72
16	21.49
18	21.68
20	21.59
22	21.59

RMG4 train_ID	MPH
2	20.68
4	20.64
6	20.81
8	20.98
10	21.16
12	21.26
14	20.79
16	21.53
18	21.69
20	21.78
22	20.25

・SRTO RTG MPH

RTG	MPH
1	39
2	35
3	39
4	14
5	14
6	14
7	35
8	15

※24h平均

・SRTO TRAIN Dwell Time

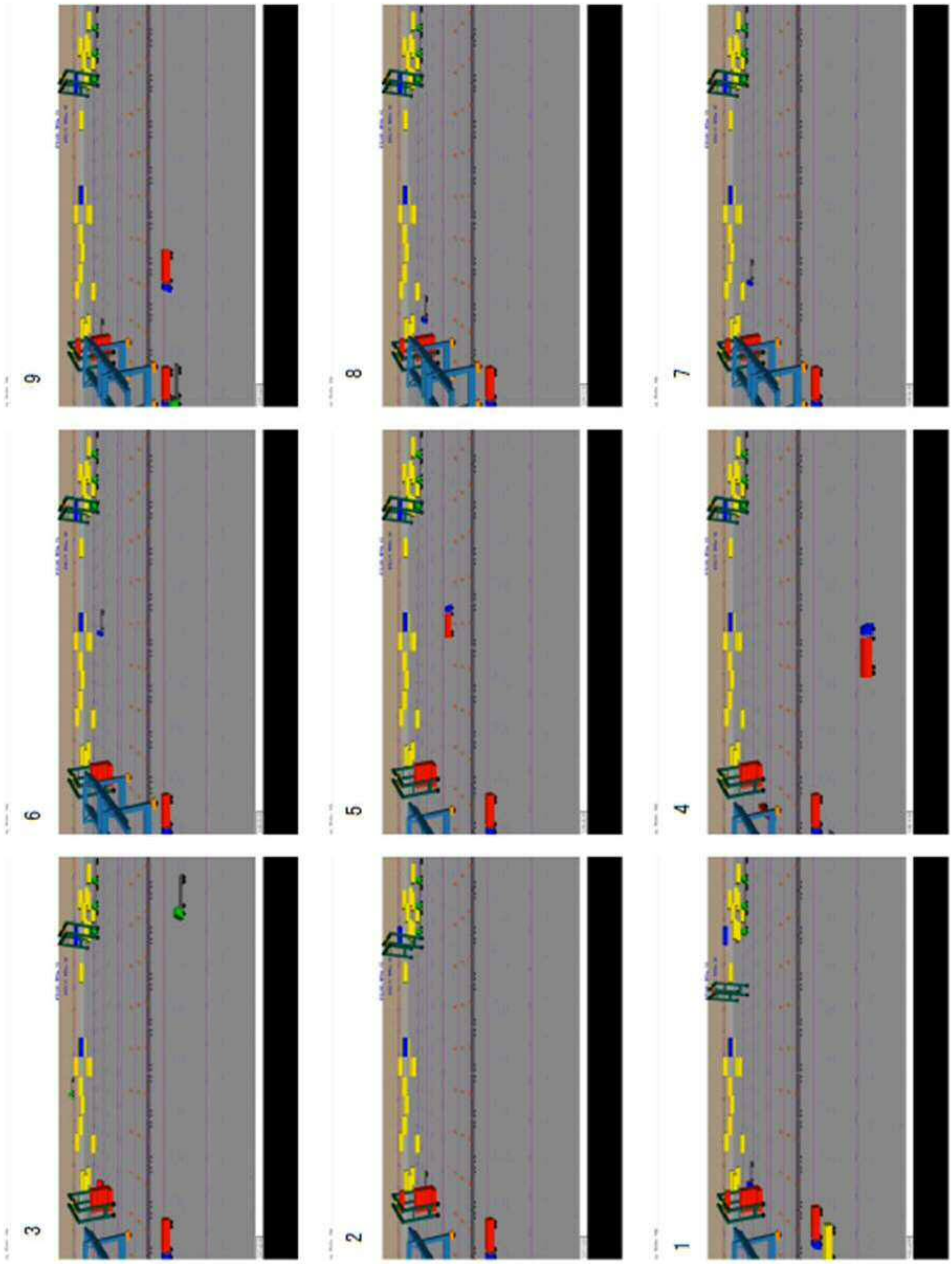
	(min)
MAX=	109.07
MIN=	88.55
AVE=	99.85
train_ID	V_train_dwell_time
1	105.32
2	92.82
3	109.07
4	93.02
5	107.85
6	92.27
7	107.74
8	91.52
9	107.39
10	90.76
11	107.24
12	90.31
13	107.86
14	92.34
15	107.12
16	89.36
17	108.35
18	88.55
19	107.49
20	88.94
21	108.10
22	94.80
23	108.22

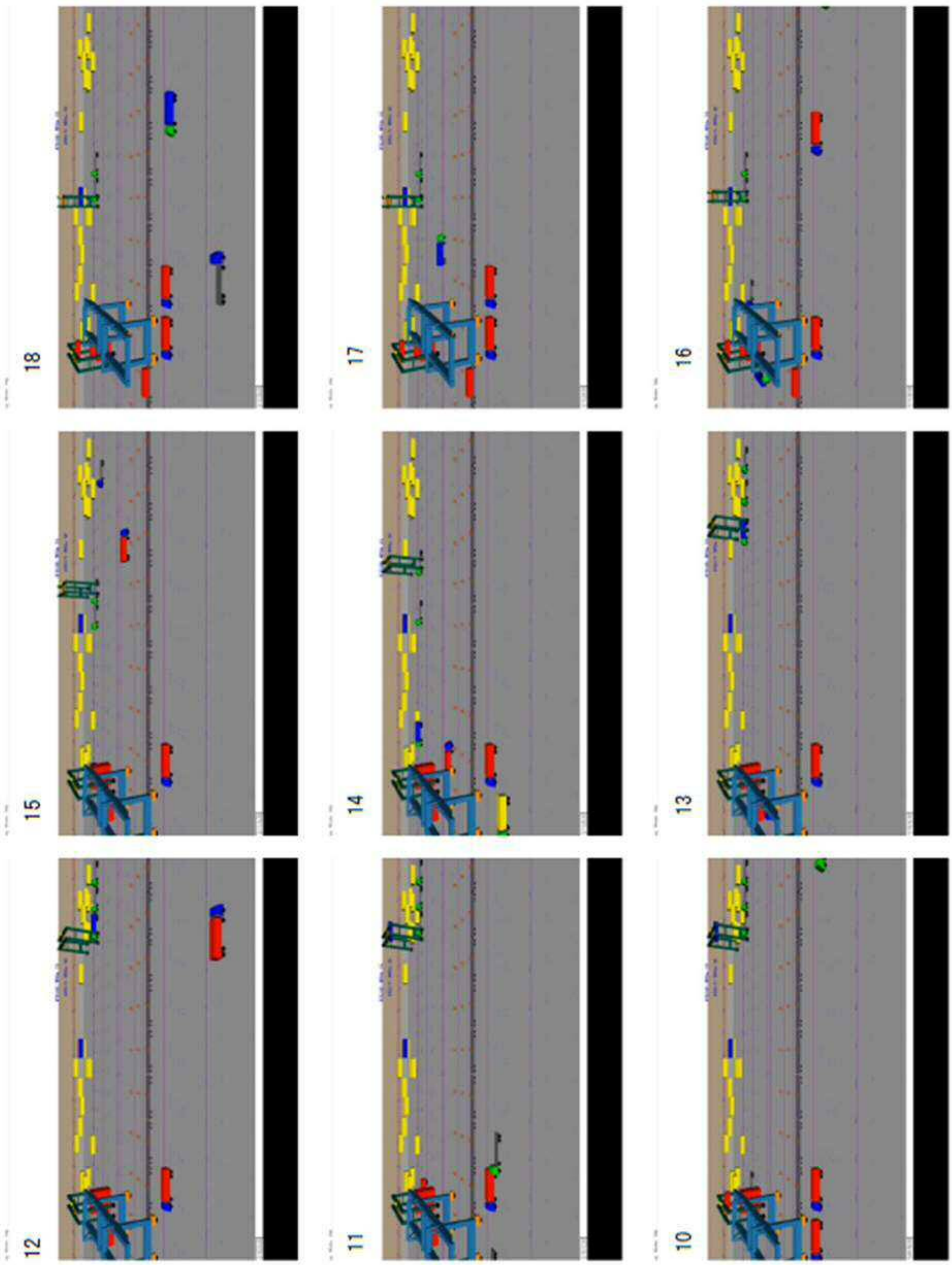
・SRTO TRACK Turne Time date(Excerpt)

				(min)
			MAX=	300.61
			MIN=	8.05
			AVE=	84.74
	TRK_ID	Ue	export_num	turntime
1	2	2	1	10.79
2	1	1	1	13.17
3	5	2	1	13.91
4	4	1	1	12.64
5	10	2	2	10.88
781	670	1	1	209.72
782	842	2	2	52.87
783	674	1	2	209.00
784	810	1	2	83.64
785	844	2	1	54.96
786	807	1	2	87.06
787	812	1	2	85.92
788	851	2	1	52.74
789	677	1	1	212.78
790	809	1	1	90.23
791	819	1	2	82.24
792	811	1	1	91.07
793	815	1	2	88.39
794	679	1	2	217.04
795	823	1	2	83.31
796	856	2	1	55.36
797	818	1	1	90.93
798	688	1	1	213.75
799	863	2	1	54.04
991	1,018	1	2	103.56
992	870	1	2	242.52
993	874	1	2	240.07
994	1,100	2	1	31.94
995	1,007	1	2	117.47
996	1,026	1	1	100.25
997	1,013	1	1	115.71
998	1,109	2	1	29.12
999	881	1	1	240.62
1,251	1,086	1	2	295.60
1,252	1,379	2	1	41.34
1,253	1,298	1	1	48.34
1,254	1,277	1	2	23.13
1,255	1,382	2	2	40.75
1,256	1,281	1	2	12.49
1,257	1,253	1	2	51.76
1,258	1,383	2	2	42.01
1,259	1,098	1	1	300.61
1,260	1,254	1	2	53.69
1,261	1,087	1	2	296.39
1,262	1,333	1	1	15.23
1,263	1,385	2	1	45.40
1,264	1,260	1	2	37.53
1,265	1,107	1	1	292.65
1,266	1,092	1	2	292.76
1,267	1,261	1	2	39.76
1,268	1,387	2	1	48.90
1,269	1,108	1	1	295.62
1,270	1,308	1	1	44.05
1,386	1,439	1	2	19.42
1,387	1,420	1	1	36.00
1,388	1,237	1	1	270.25
1,389	1,527	2	1	60.83
1,390	1,404	1	2	36.02
1,391	1,535	2	2	54.60
1,392	1,443	1	2	22.21
1,393	1,193	1	2	273.31
1,394	1,414	1	2	32.77
1,395	1,430	1	2	28.52
1,396	1,544	2	1	35.85

The highlighted line shows the train whose turn around time was the longest

< Example of the simulation>

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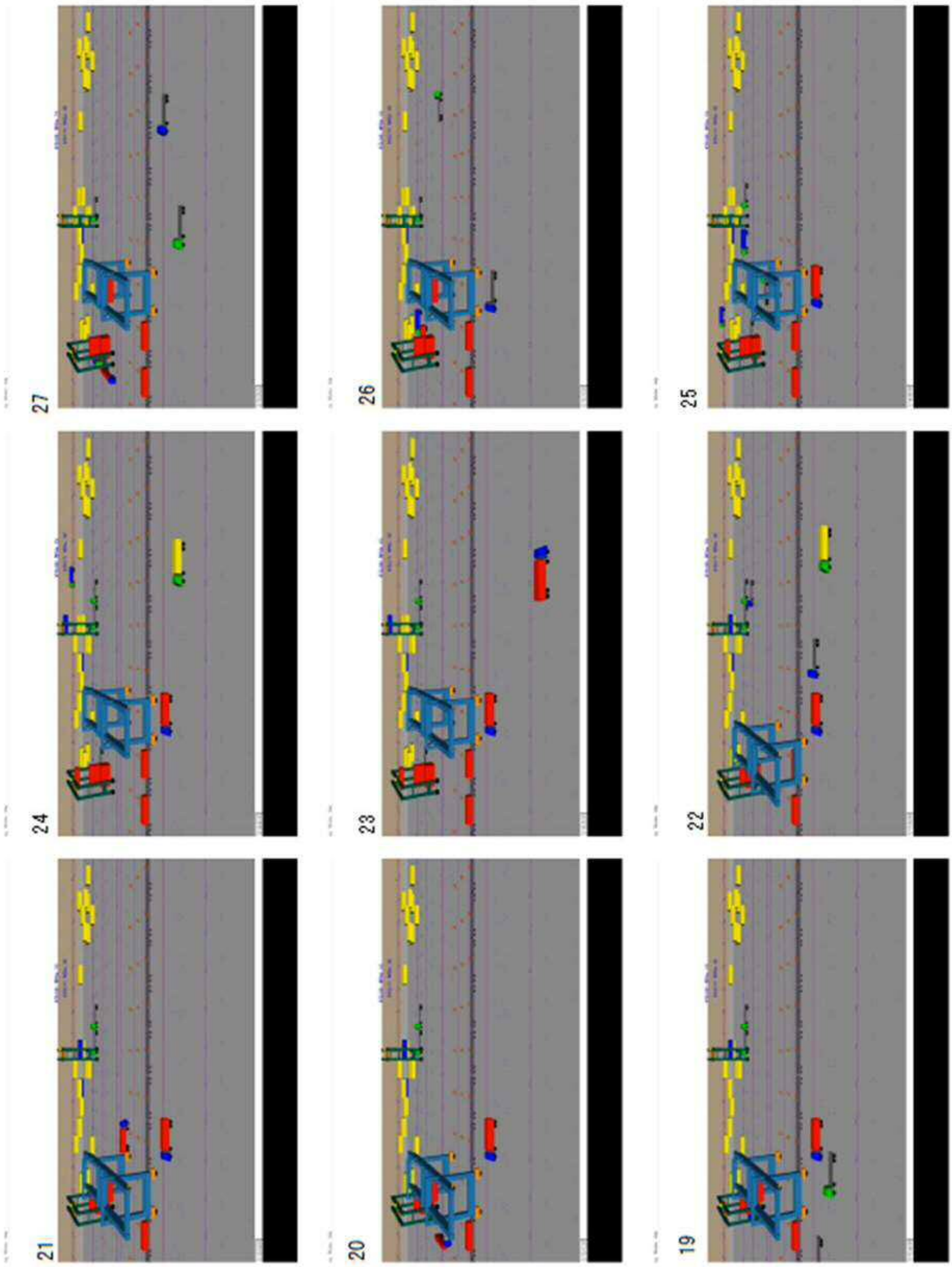
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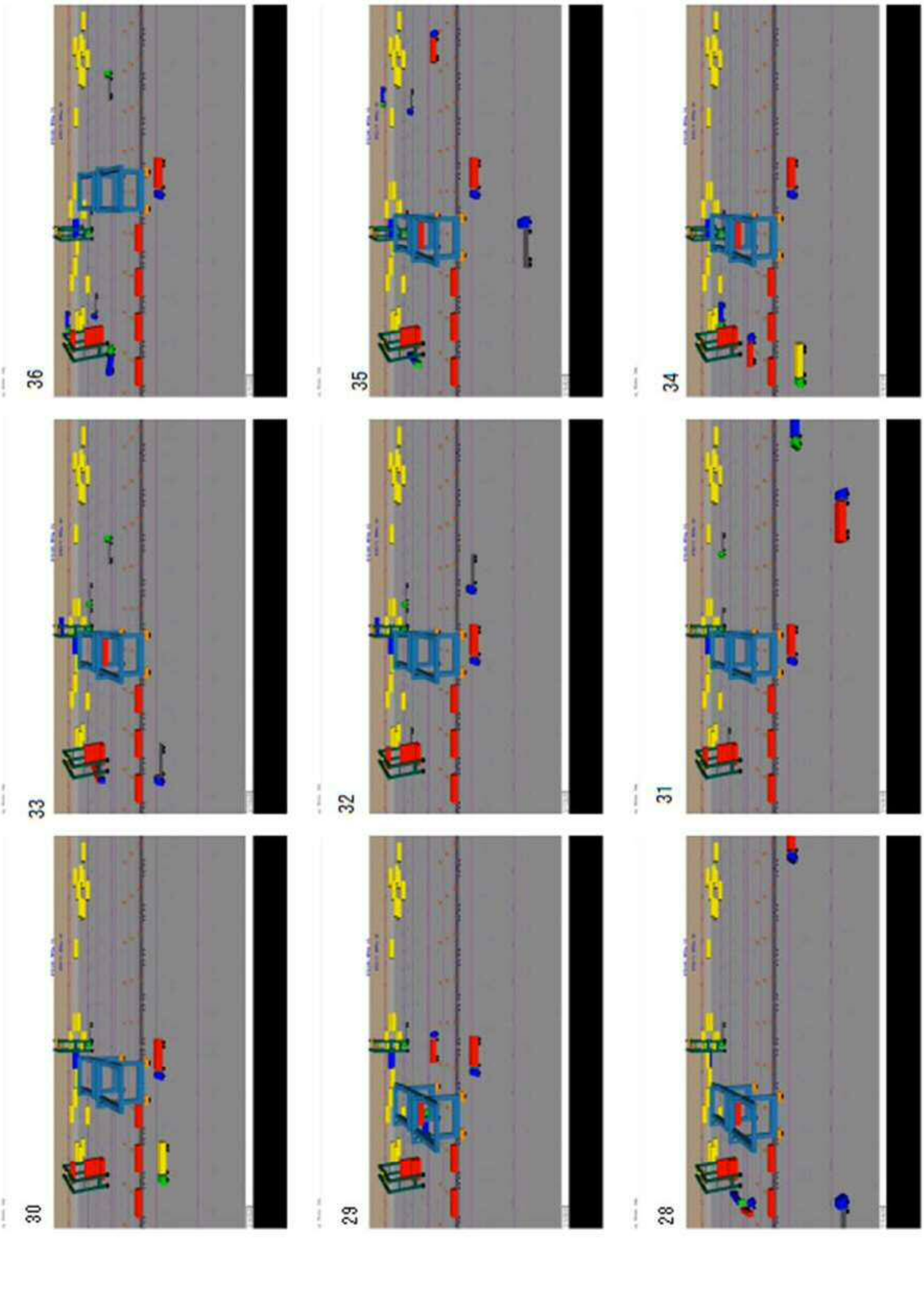
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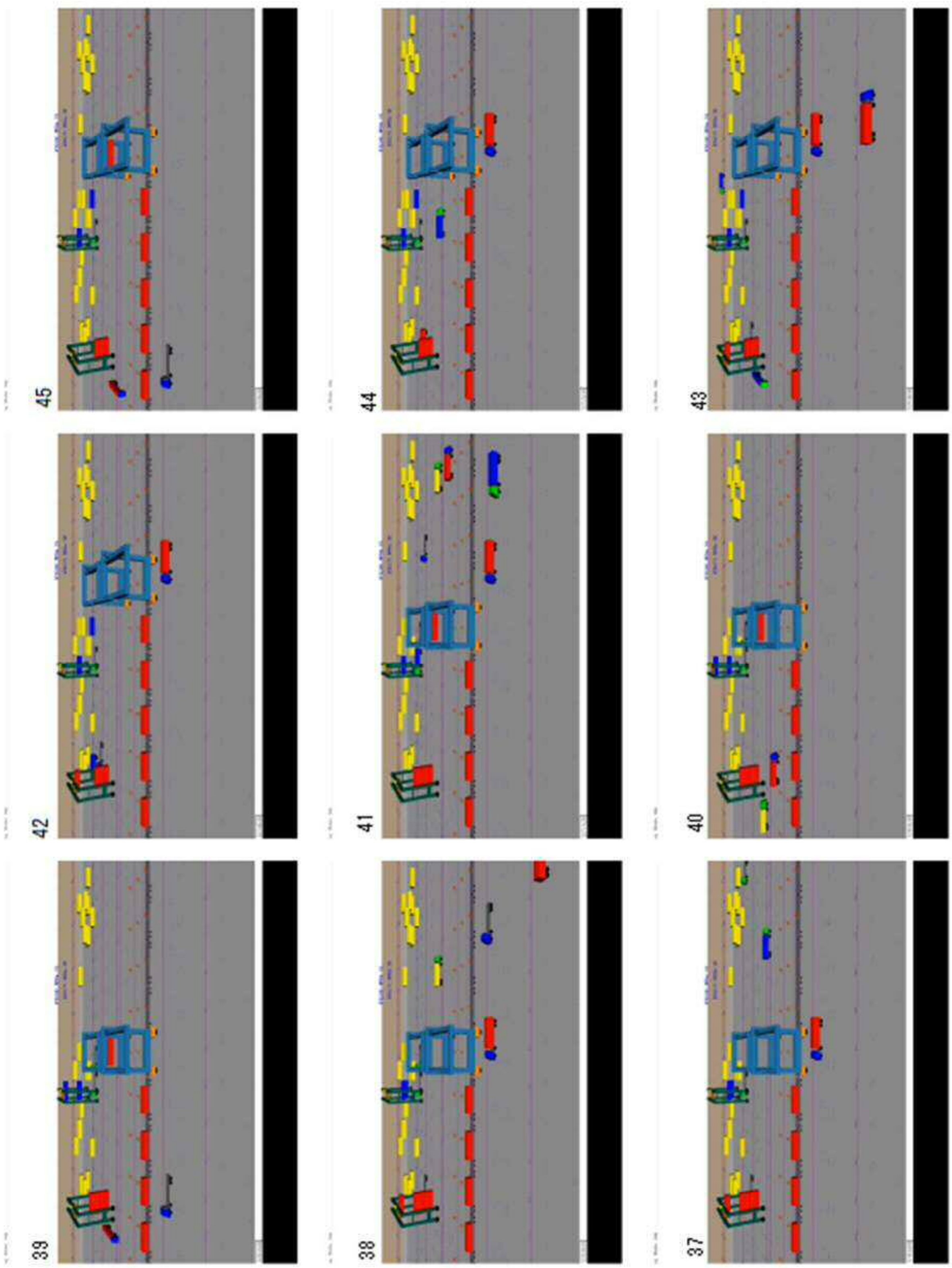
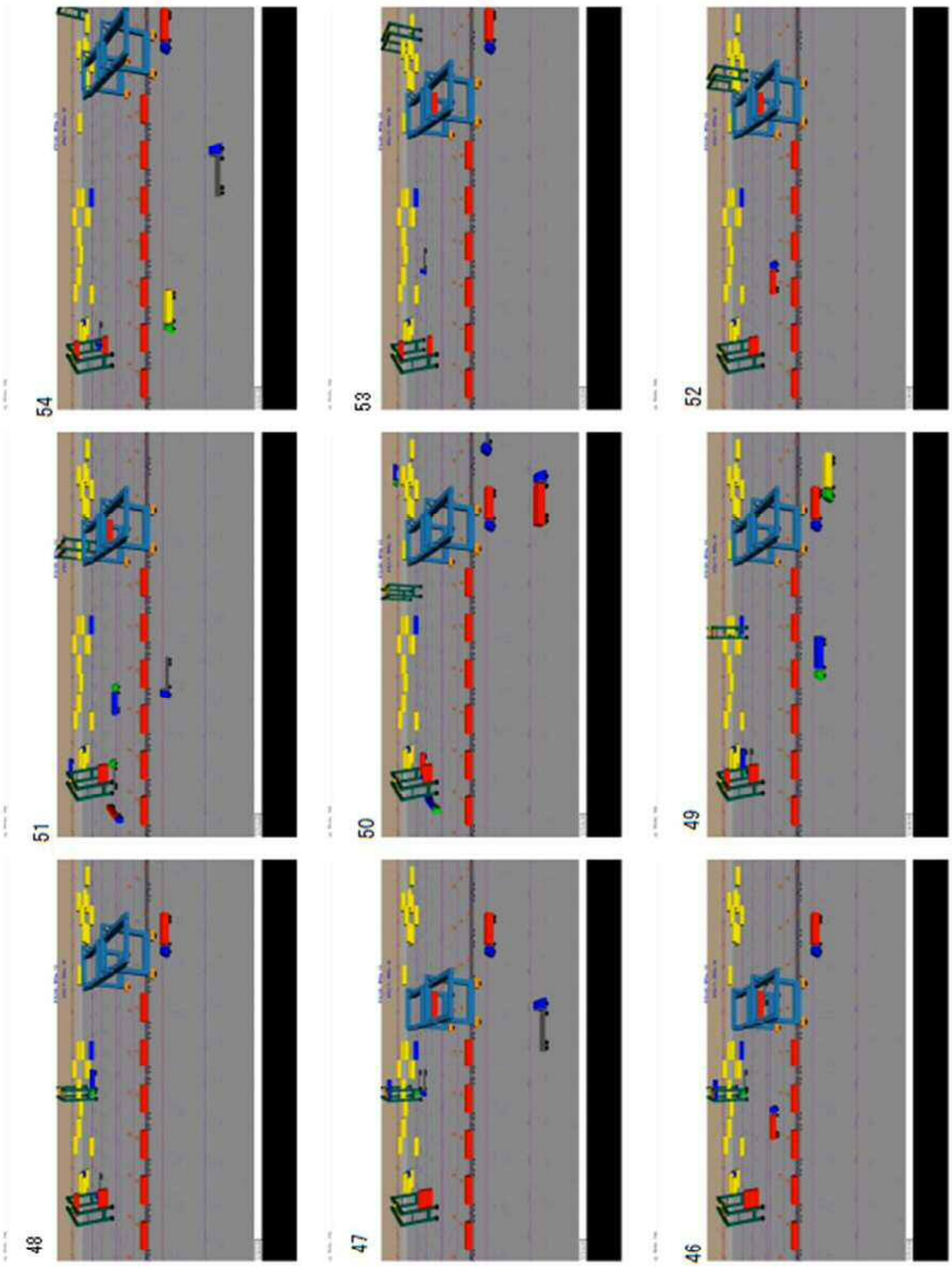


Attachment 44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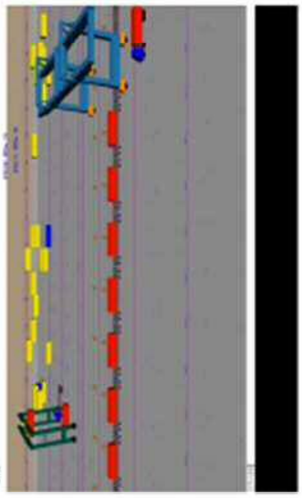

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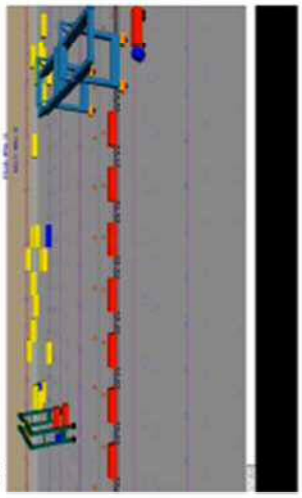

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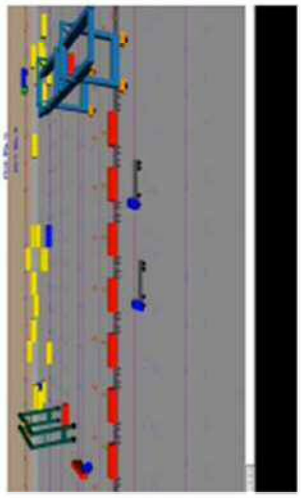

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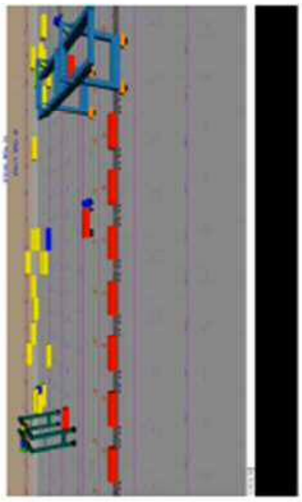

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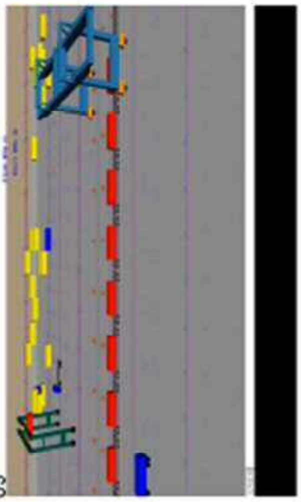

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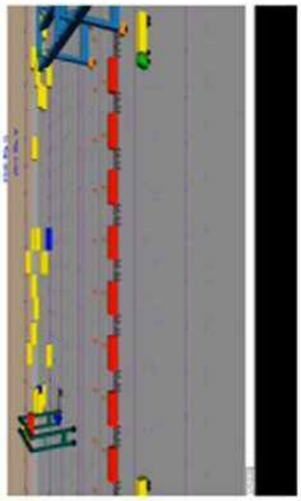

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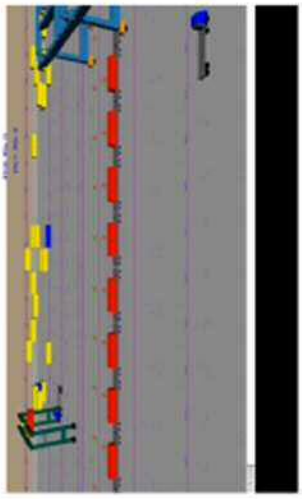

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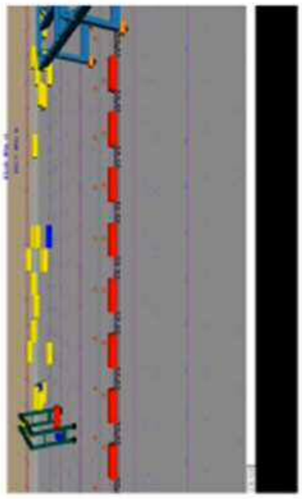

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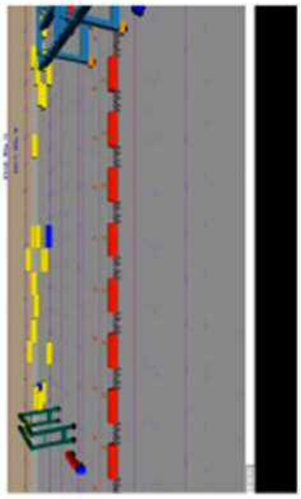

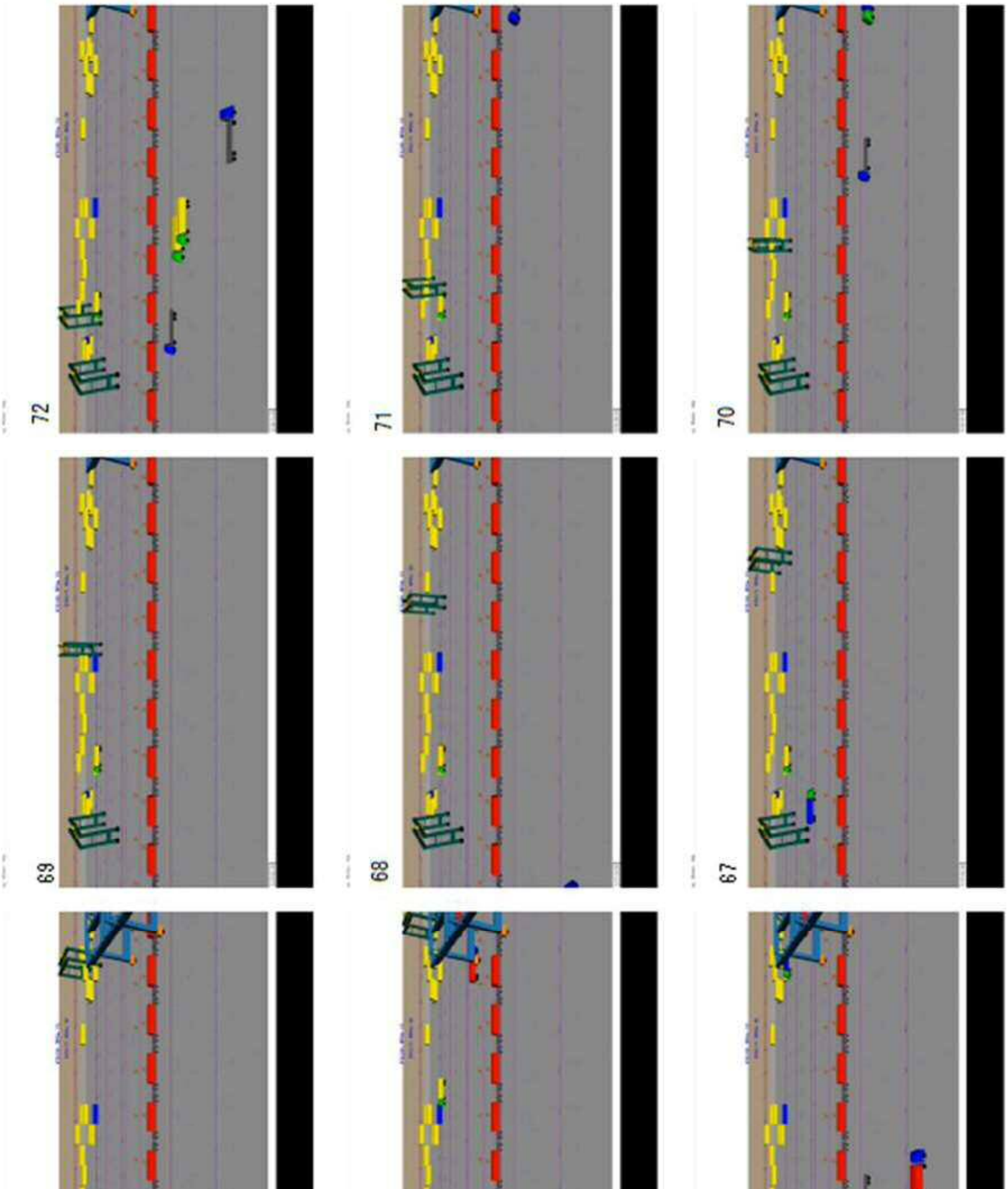

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