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IMPROVEMENT FOR CONTAINER THROUGHPUT IN CONTAINER TERMINAL BY ANALYSIS OF CONTAINER HANDLING DATABASE

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Background

- Rapid growth in Container transport increases service competitiveness among Container terminals
- Need to measure terminal performance for improving service quality and customer satisfaction

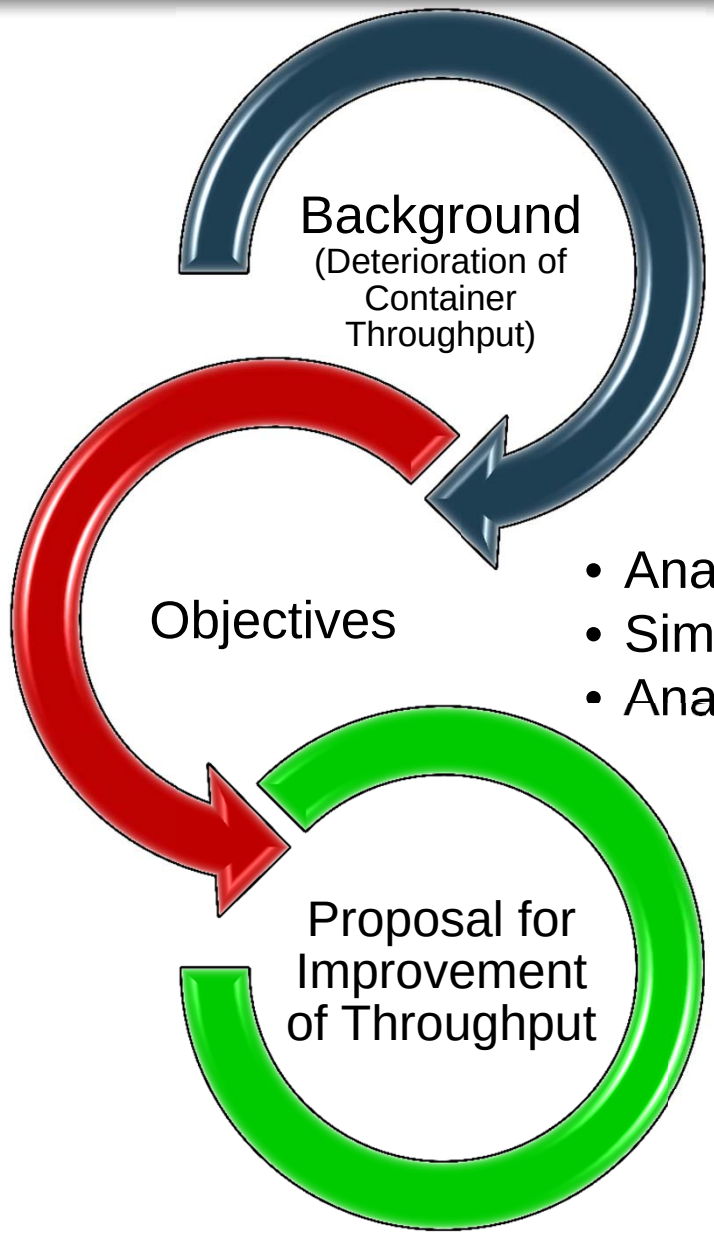
Crucial question :

How to evaluate terminal performance ??

How to improve service quality??

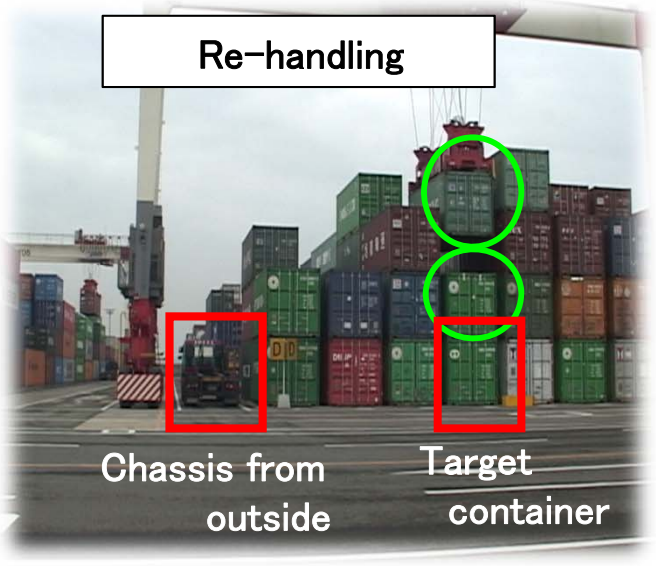
Engineering or Economic Perspective??

Flow of Research



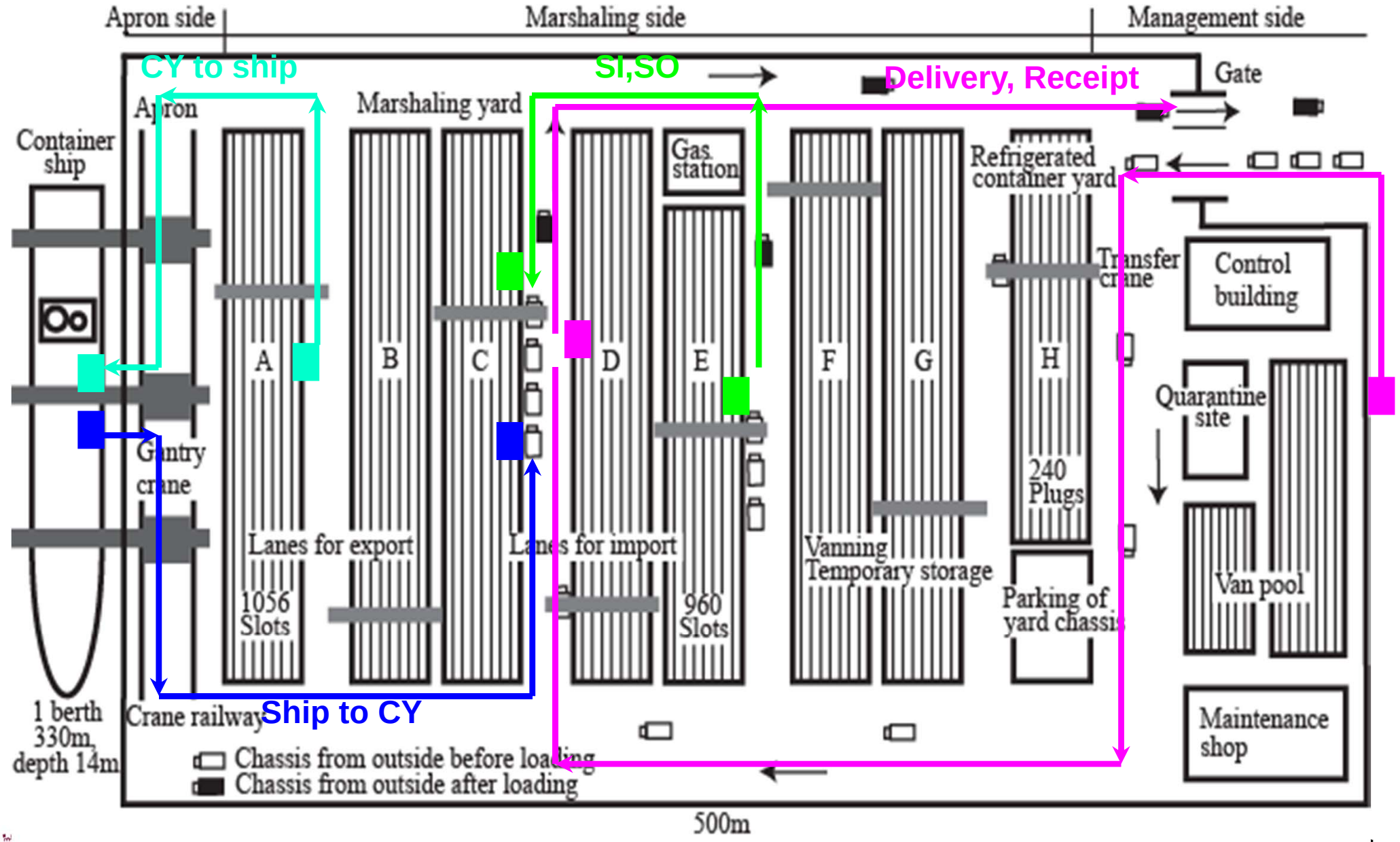
- Container Re-handling
- Queue of Chassis (C/Y) in Yard and In Front of Gate

- Analysis of re-handling operation
- Simulation of delivery operation
- Analysis of the reason for deterioration of throughput



Layout & Operation In HICCT

HICCT : Hakata Island City Container Terminal

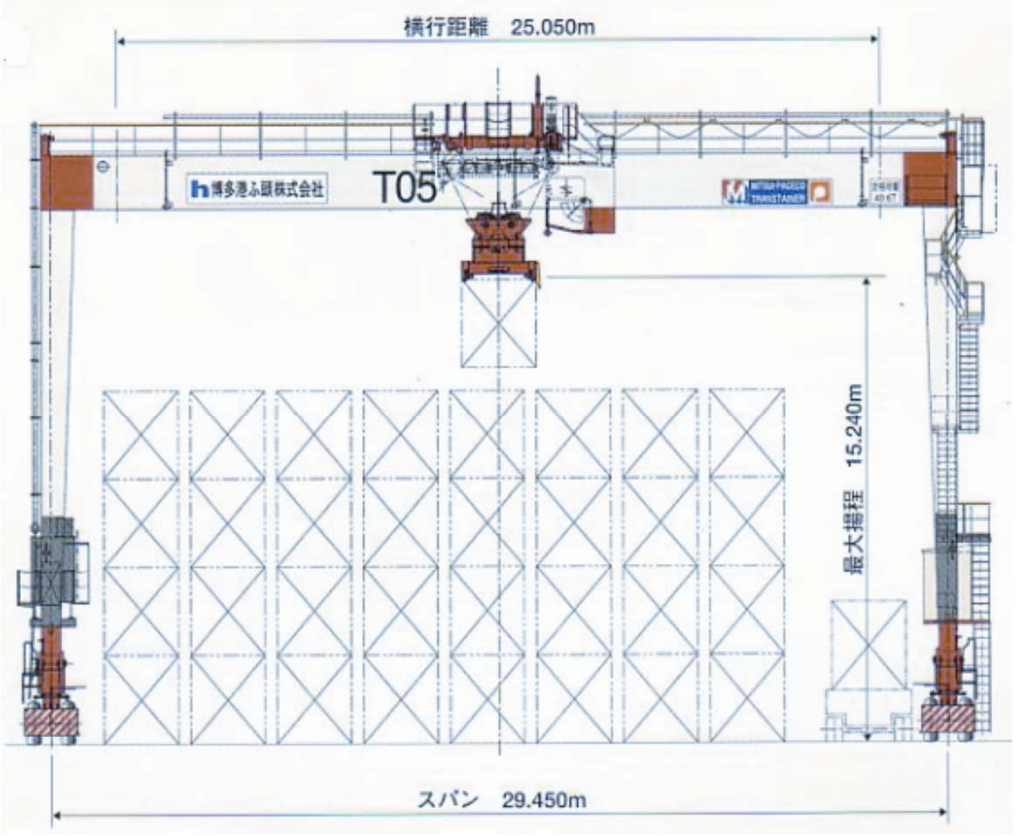


PART I : ANALYSIS OF REHANDLING OPERATION

Target for Improvement (Handling Gear)

- RTG　(Rubber Tired Gantry Crane)-able to move between lanes
- High stack capability vs Re-handling operation vulnerability

Regular load：40．6 tons
Hoist/wind speed 52-54m/min.（no container)23m/min.(with container）
Traveling 70m/min., Driving 135m/min.



Analysis of Re-handling operation

- Based on Daily Work Report Information extracted from HICCT database

Daily work report of Hakata Island City Container Terminal

[Transfer crane No.7] [Completed work data on 19:07, 13 / July / 2004 (Tue.)]

No.	Operation	G/C	Container No.	Size	From	To	Stock address	Acceptance work time	Completed work time	Wait time	Comments By HiTS	Flag
37	Ship to stock	I3	TRLU6698051	40	CY013	C115-4-4	C115-2-3	8:57	9:11	14		Ordinaty completed
38	Rehandling		UGMU8050570	40	C121-1-2	C121-4-2		9:06	9:13	7		O/C
39	Delivery		EISU1316020	40	C121-1-1	TM004		9:06	9:14	8	Reserved	O/C
40	Rehandling		NYKU6057208	40	C113-5-2	C113-4-2		9:09	9:16	7		O/C
41	Delivery		TCKU9410917	40	C113-5-1	IW005		9:09	9:24	15	Reserved	O/C
42	Delivery		EMCU9190948	40	C121-3-2	KM009		9:16	9:28	12		O/C
43	Rehandling		DJLU5201770	40	C119-6-2	C119-5-1		9:14	9:29	15		O/C
44	Delivery		UGMU8991246	40	C119-6-1	IT001	C119-7-3	9:14	9:31	17	Reserved	O/C
45	Delivery		NYKU6112239	40	C127-1-3	MI001		9:26	9:34	8	Reserved	O/C
46	Rehandling		TGHU2538224	20	C130-8-3	C130-7-1		9:16	9:35	19		O/C
47	Delivery		FSCU3157245	20	C130-8-2	HE001		9:16	9:37	21		O/C

Remark ; The abbreviation of O/C means Ordinaty completed.

Queuing time of C/Y ＋ Working time of T/C
（except queuing time in front of gate）

- This database is re-constructed to be able to extract more useful information
- **Operation work codes** list are determined
- Term of **processes in T/C operation** are defined

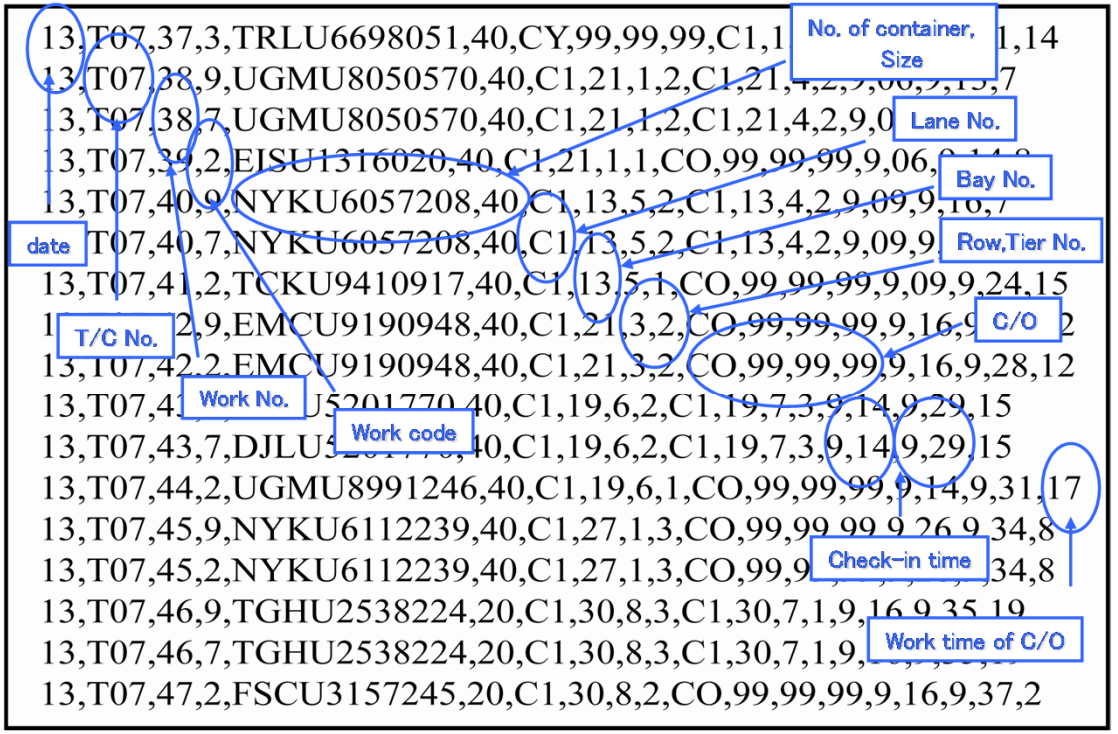
Work Codes & Reconstructed Database-1

Operation Work Code

Code	Denomi-nation	Operation	Carried device from/to T/C
1	Receipt	Stack of received container	C/O
2	Delivery	Un-stack for delivery container	C/O
3	Ship-to-Stock	Stack of unloaded container	Y/C
4	Stock-to-Ship	Un-stack for loading container to ship	Y/C
5	Shift-In	Stack from other lane/slot	Y/C
6	Shift-Out	Un-stack to other lane/slot,	Y/C
7	Re-handling	Remove the obstacle containers above the target container in the same bay	None
8	Spacing	Remove the containers to make space in bay	None
9	Moving	Moving T/C between bays to catch the target container	None
10	Halt	Halt the operation of T/C	None
11	Temporary-In	Temporary stack for loading to ship	Y/C
12	Temporary-Out	Un-stack of Temporary-In container	Y/C

Remark; T/C: Transfer Crane, C/O: Chassis from outside,
Y/C: Yard chassis

Reconstructed Database

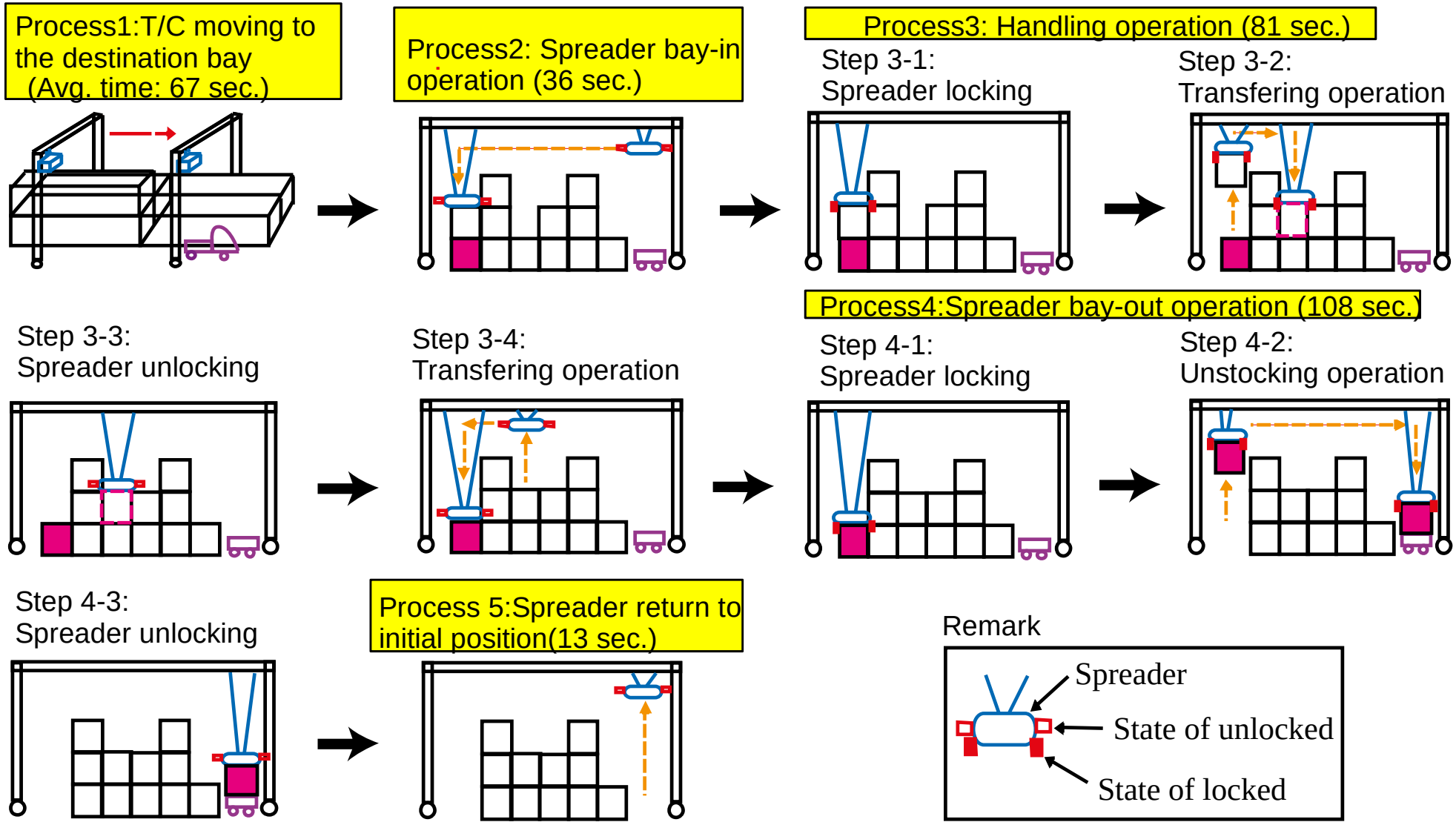


Database file by analyzing on daily work report and work code of T/C

Based on this database, we can determine work state transition of T/C

Term of Process in T/C Operation

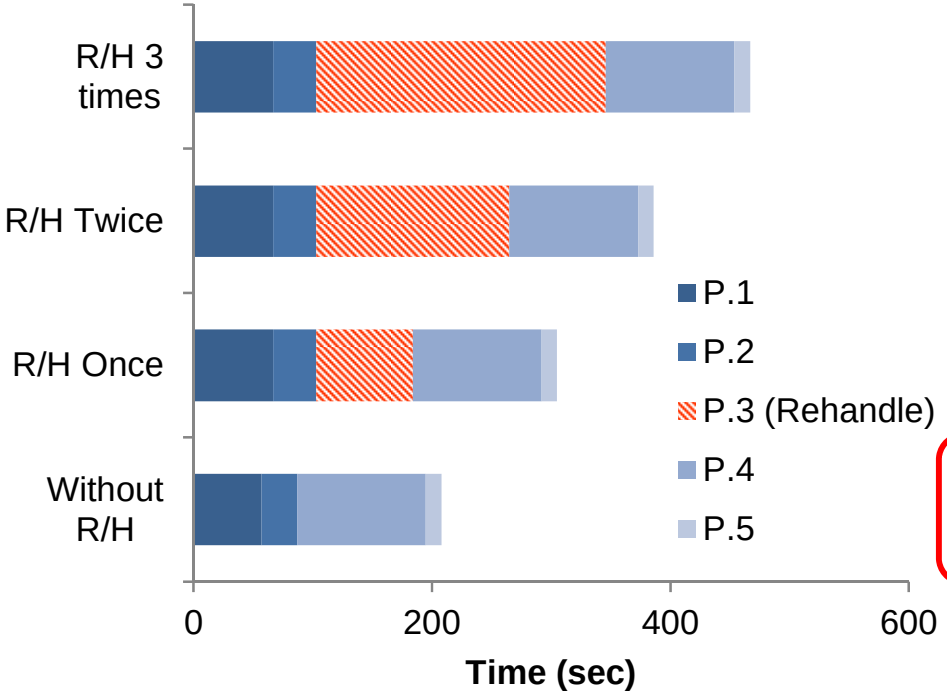
- To provide more detail analysis, step-by-step operation process is defined



Analysis of Reconstructed Database

How big is Re-handling problem??

→ **55%** from total handling

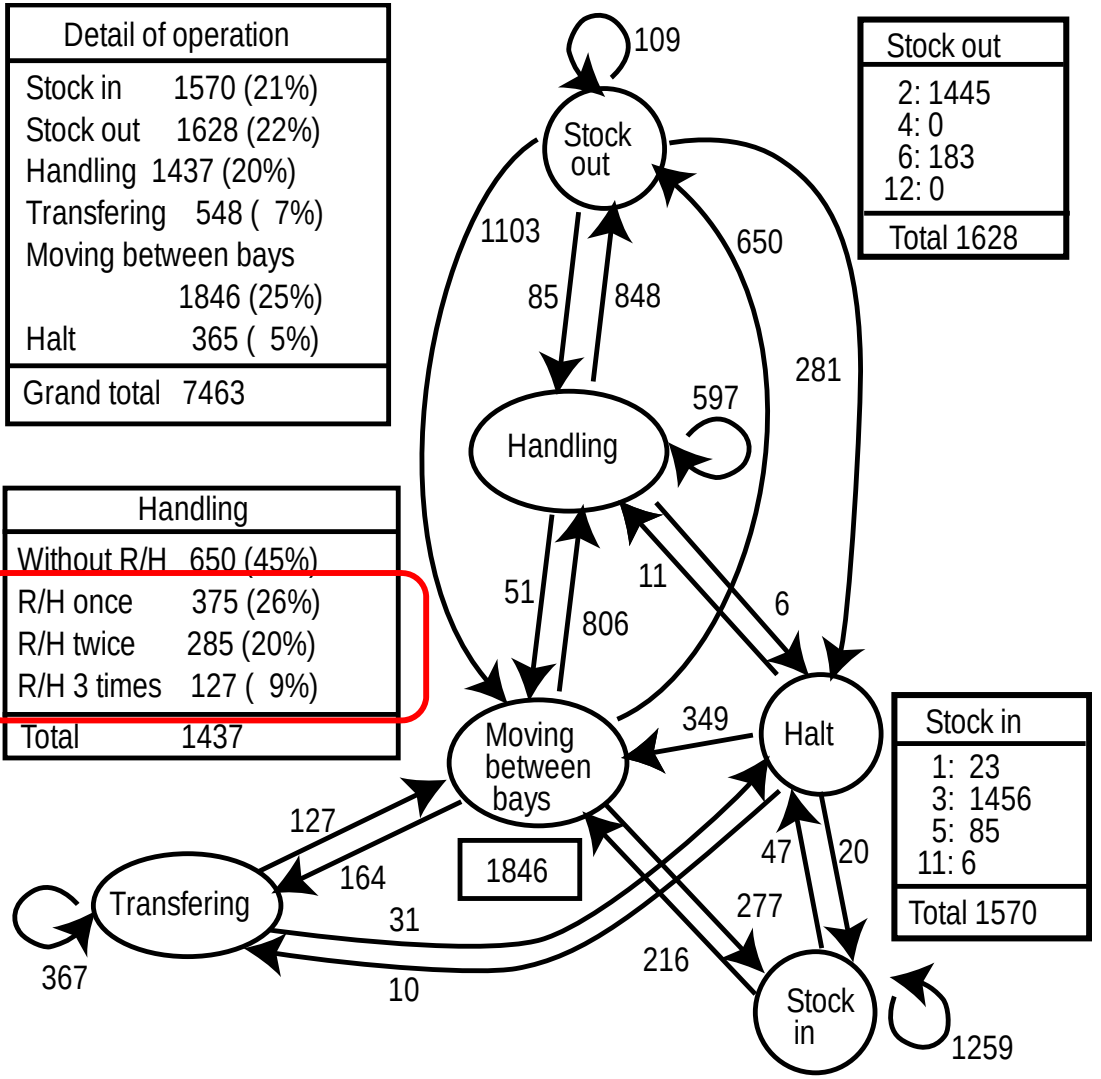


P1: T/C moving to designated bay
P2: Spreader bay-in operation
P3: Rehandling
P4: Spreader bay-out operation
P5: Spreader return to initial position

Markov Chain Model of T/C Work State Transition

Detail of operation	
Stock in	1570 (21%)
Stock out	1628 (22%)
Handling	1437 (20%)
Transfering	548 (7%)
Moving between bays	1846 (25%)
Halt	365 (5%)
Grand total	7463

Handling	
Without R/H	650 (45%)
R/H once	375 (26%)
R/H twice	285 (20%)
R/H 3 times	127 (9%)
Total	1437



PART II : SIMULATION BY PETRI NET

Micro Simulation Approach for Detailed Operation

1. **Examine the Standard Performance Specification of T/C**
2. **Comparing Standard Time & Real Process Time**
3. **Construction of Petri Net Simulation Modul**

Standard Performance of T/C

- Standard performance is measured by shop test standard container delivery operation
- Standard Process time (T_{si}) defined by

$$Ts_i = \sum_{k \in i} Tc_{ik}(a_k, d_k) + Te_{ik}$$

T_{Cik}= sub-process time by spreader of T/C in i-th process

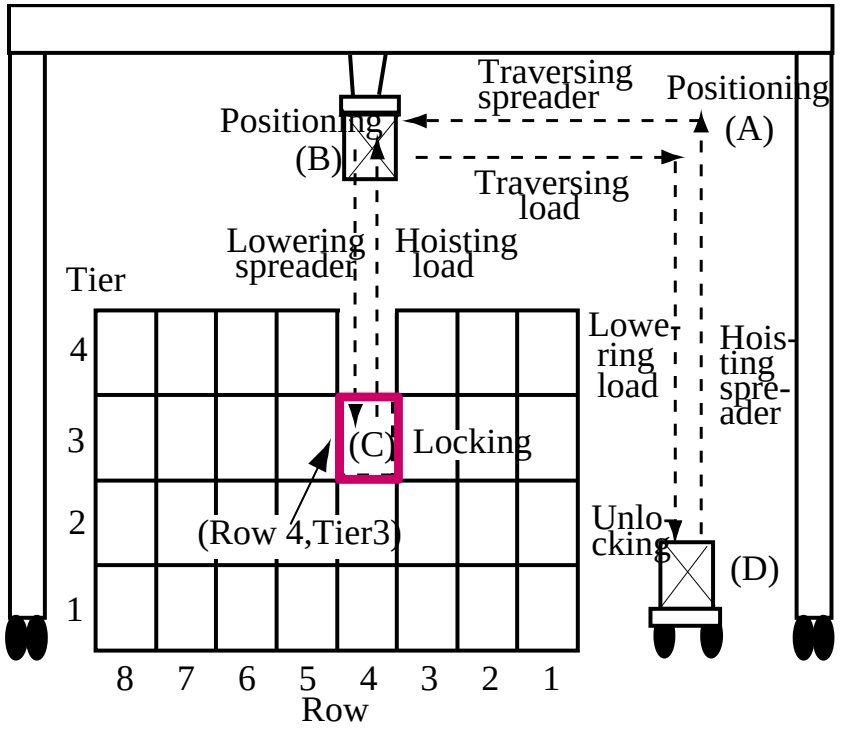
Te_{ik} = container adjusting time in i-th process

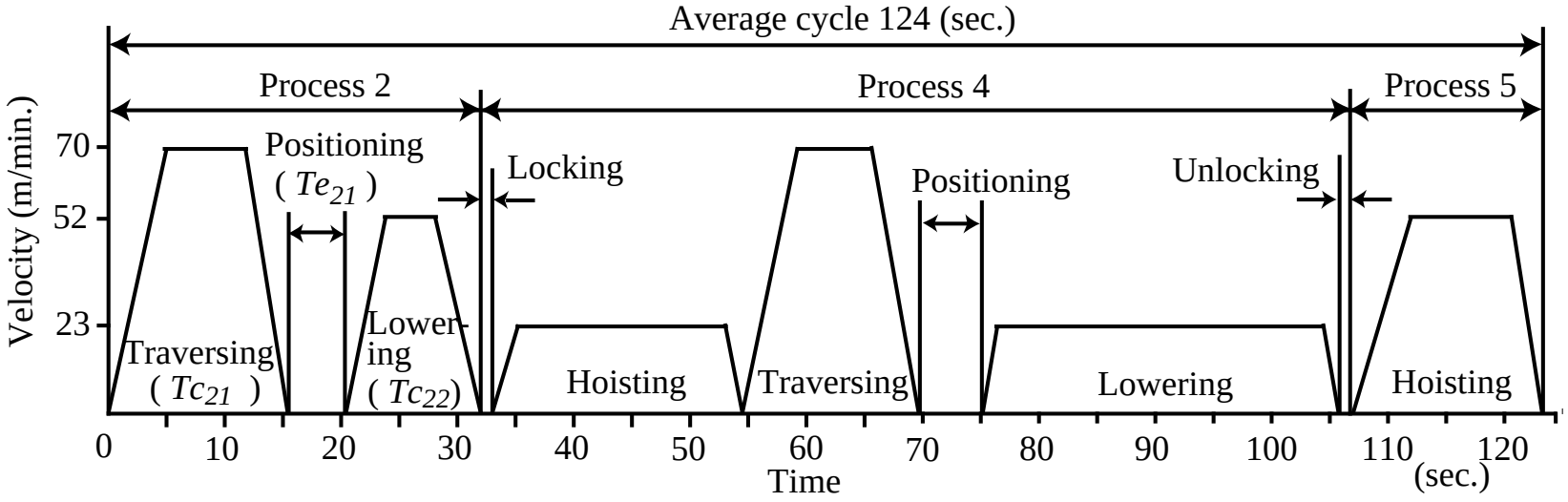
d_k = distance between present position and target position

i = process num.

k = sub process num.

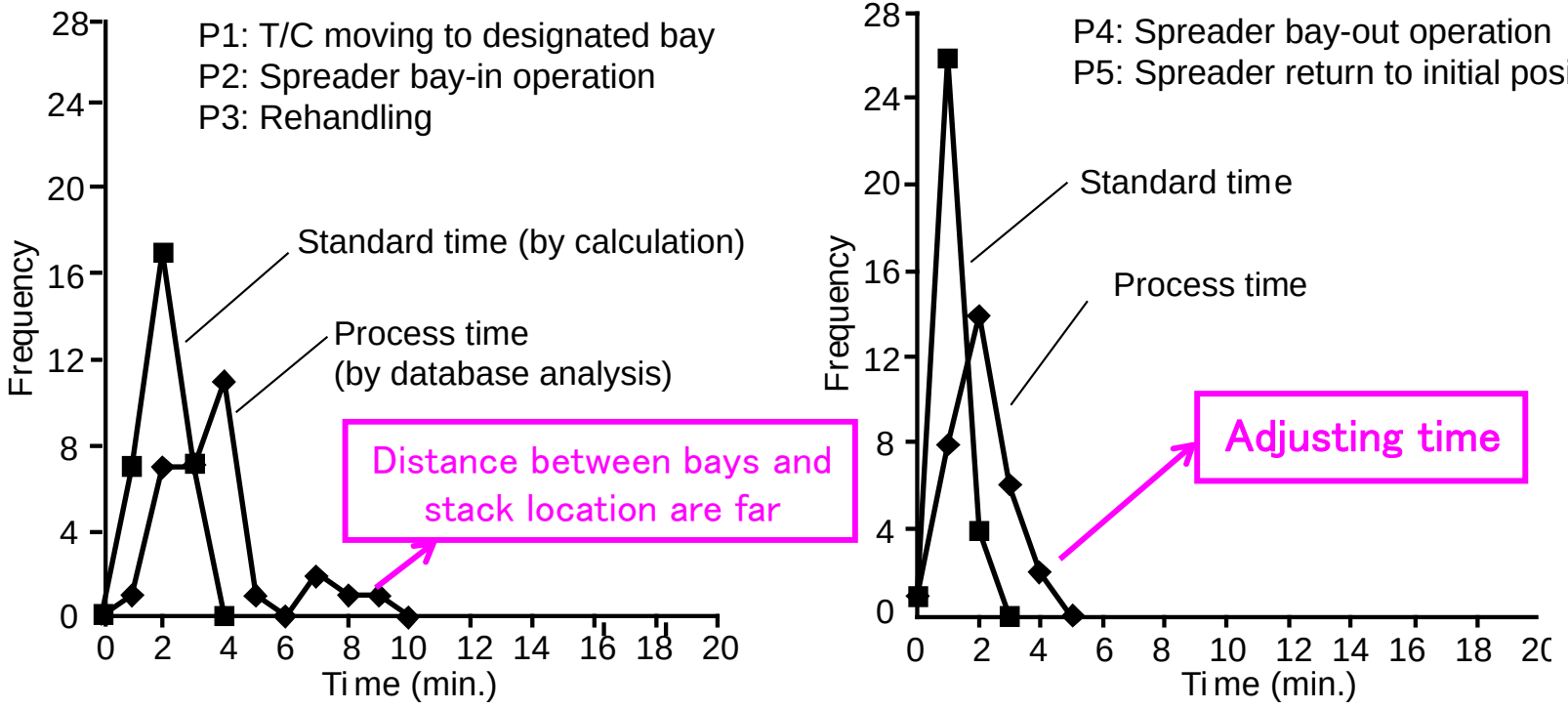
a_k= acceleration





Comparison of working time (Standard. vs Real Process)

- Both diagram shapes shows good agreement and the delay of operation can be known since real process time graph is mostly behind the standard times
- The reason of this delay is mainly driver's skill which did not able to reached sufficient crane performance speeds.
- Some delay time has been appeared remarkably in the occasion of moving comparably long distance between and in the occasion of adjusting container with crane spreader to chassis (C/Y)



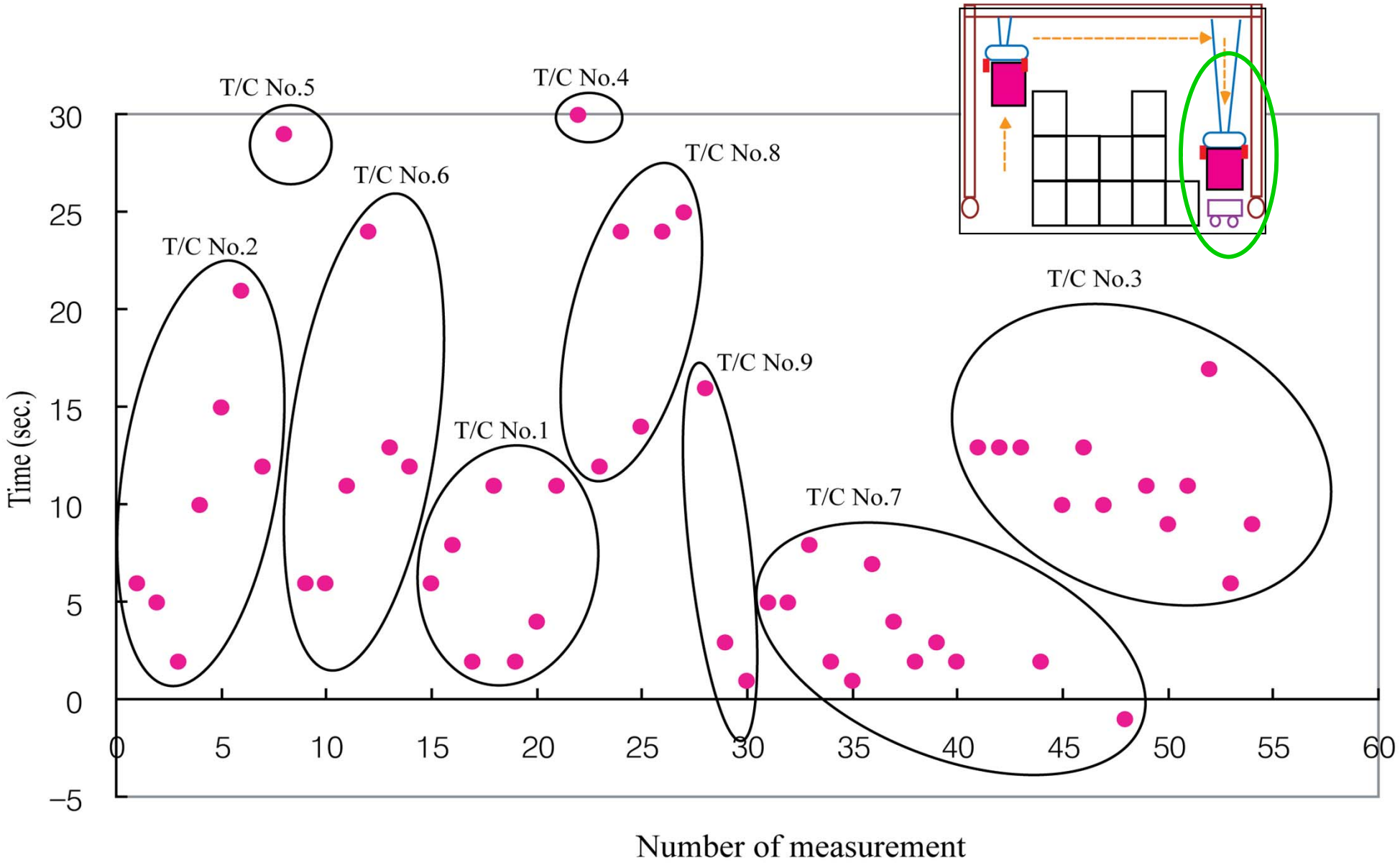
(a) Cummulated time of process 1, 2 and 3

(b) Cummulated time of process 4 and 5

Remarks: Standard time : standard time which is gained by calculation
Process time : real process time which is gained by analysis of constructed database

How far adjustment time vary by frequency

Result of adjusting time that it is calculated by specification and measurement



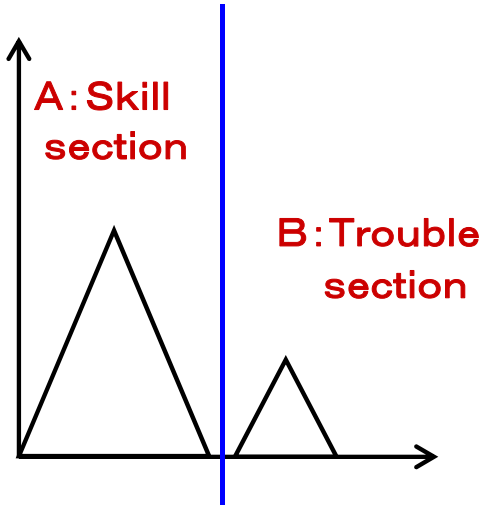
Impact of T/C Operator's Skill

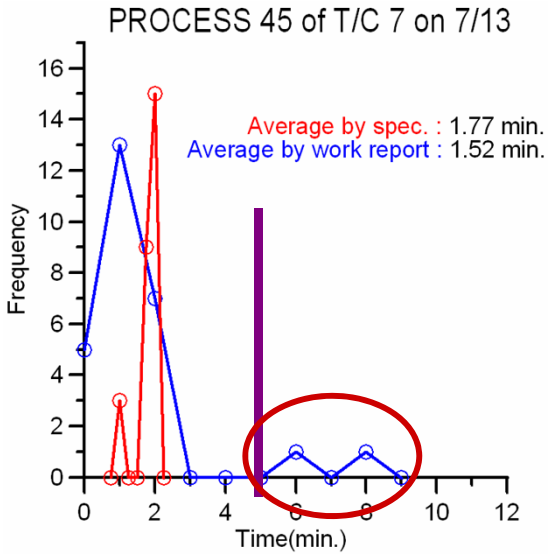
- How driver's skill influenced T/C performance in real operation

$$Tp_i = Fs_i \times Ts_i + Tt_i$$

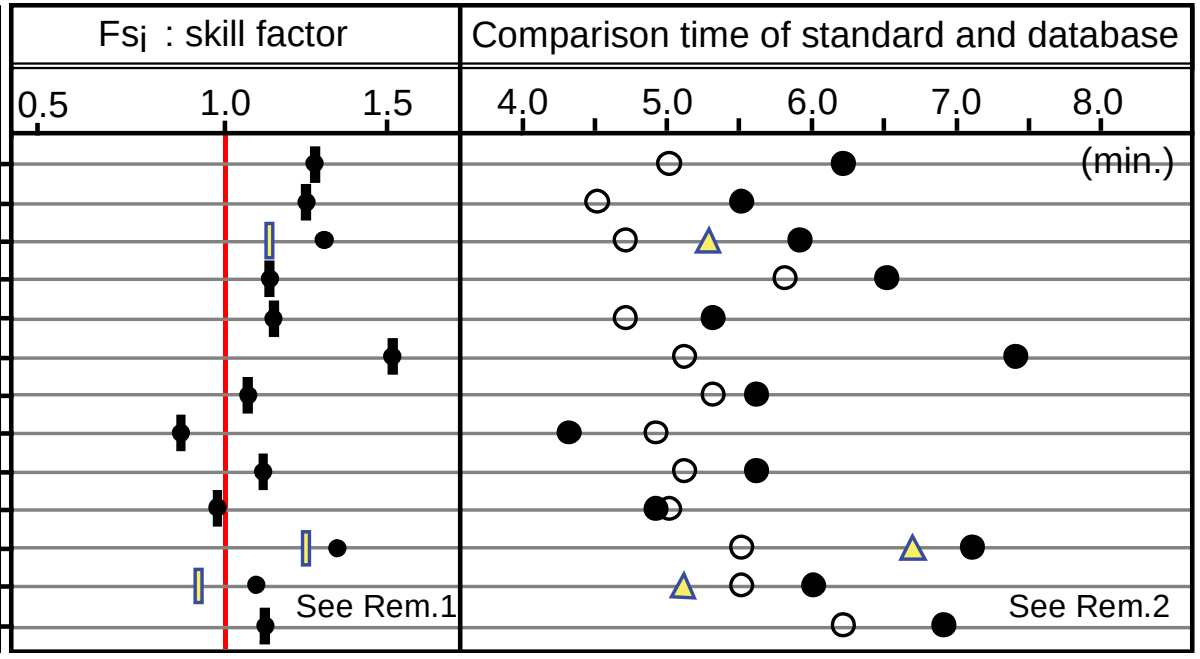
Fs_i : i-th process's Skill factor
Ts_i : i-th process's Standard time
Tt_i : i-th process's Trouble

Skill factor (Fs_i) :
0.5 : Good 1.5 : Poor
1 : Standard





Date	T/C No.
1st	8
1st	9
2nd	2
2nd	8
3rd	6
5th	2
6th	8
7th	5
7th	8
8th	4
9th	4
10th	1
10th	5



Remark 1

Driver's skill factor without trouble (driving skill of operator only)

Driver's skill factor with trouble

Remark 2

average standard time of average by calculation

Average process time of with trouble by database analysis

Average process time without trouble by database analysis

Petri Net Simulation

Petri net is a discrete model that provided constraint such as sequence of event, frequency

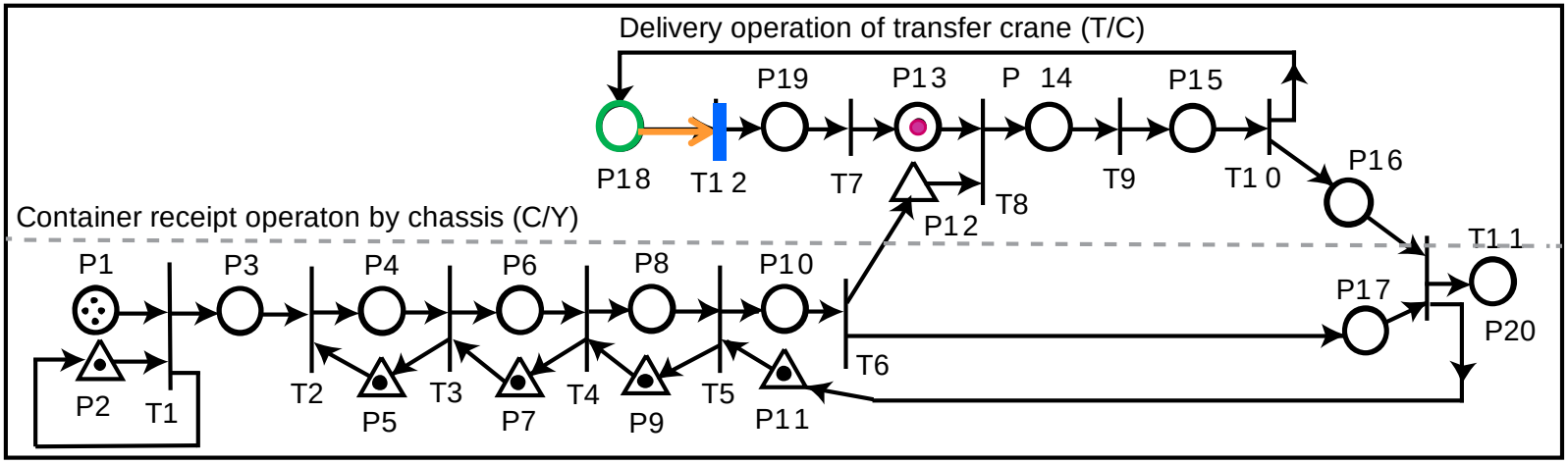
Elements of the PN

Place...State, location, information and conditions

Transition...State transitions, determine the conditions

Arc...State change flow direction arrows

Token... State / activity.



Place No.	State of C/O
P1	Presence of C/O in front of gate
P3	Queue of C/O after pass gate
P4,P6,P8,P10	Queue of C/O in yard
P17	End of queueing to load container
P20	End of loading container

Place No.	State of T/C
P13	End of moving to the bay for operation
P14	End of moving the spreader to target container
P15	End of rehandling operation
P16	End of loading the container to C/O
P18	End of lowering the spreader to C/O
P19	End of hoisting the spreader from C/O

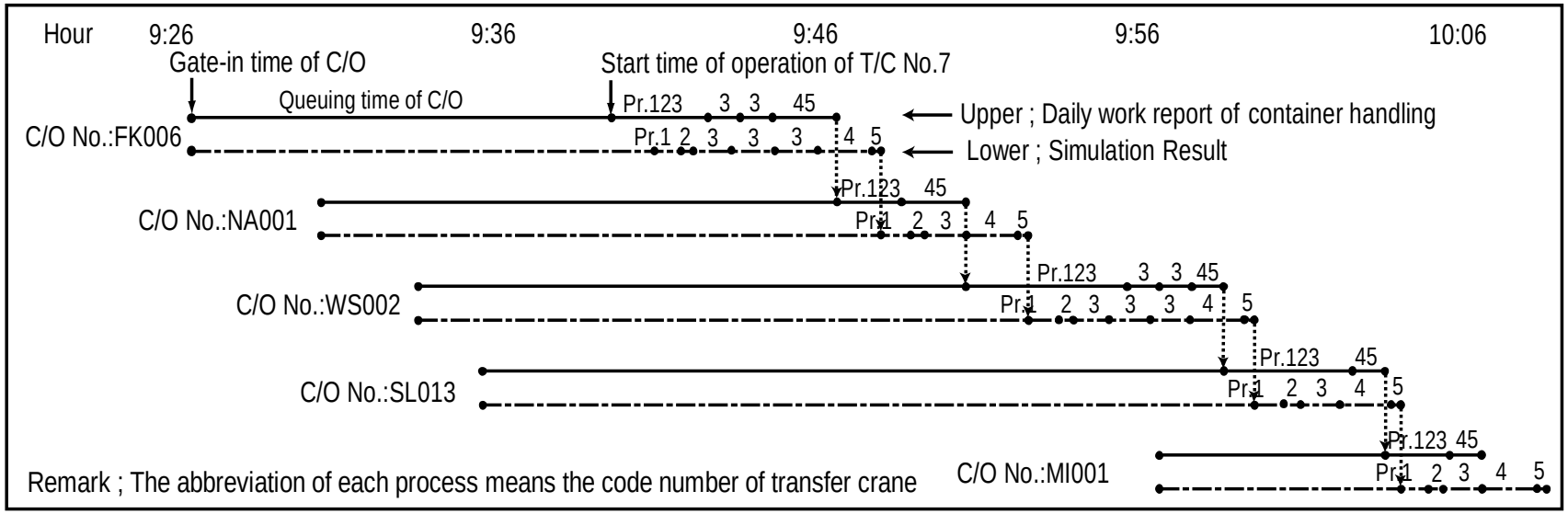
Place. No.	Operation of transfer crane
P2	Arrival of C/O
P5,P7,P9,P11	Possibility of queue of C/O in yard
P12	Ready for working of C/O

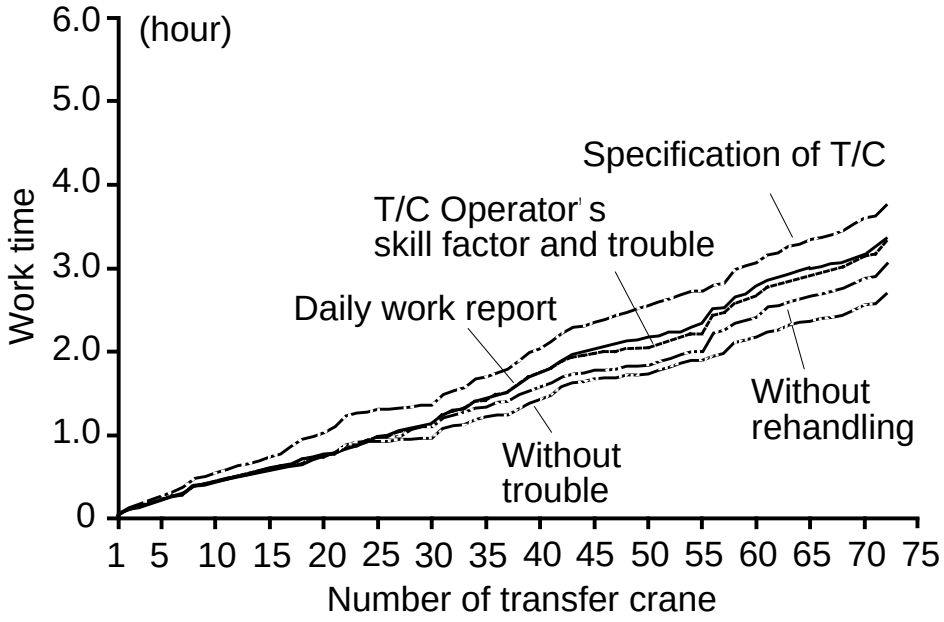
Trans. No.	Operation of C/O
T1	Moving to yard from gate
T2,T3,T4,T5	Moving to the queue place
T6	Moving to the bay for operation
T12	Completion the operation

Trans. No.	Operation of T/C
T7	Moving to the bay for operation
T8	Moving the spreader to target container
T9	Carrying out the rehandling operation
T10	Lowering the spreader to C/O
T11	Hoisting the spreader from C/O

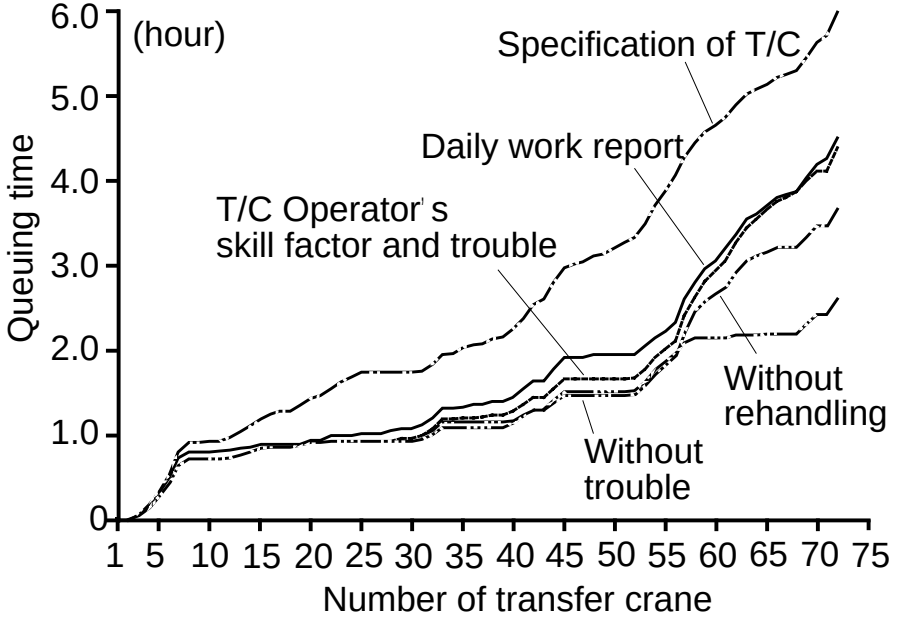
Simulation Result

Comparison of actual time and a simulation result of transfering process of transfer crane to chassis from outside





(a) Cumulative work time of transfer crane (T/C)



(b) Cumulative wait time of chassis (C/Y)

Conclusion

- It is possible and convenient to evaluate port performance, particularly in measuring micro operation inside the terminal.
- In this research, RTG/Transfer Crane (T/S) performance were successfully evaluated by means of operation database analysis based on the following procedure
  - Extracting data from daily work DB
  - Reconstructing new DB and extract real process time
  - Analyze the result and determine delay cause (Operator Skill factor in this case)
    - Define skill factor influence by comparing standard and real process time
  - Construct delivery operation model by Petri net
  - Carry out simulation by constructed model and examined the efficiency with real data

- Constructed model is confirmed to be demonstrated the actual operation process appropriately and can be employed to improve efficiency especially for operation evaluation and in planning stage to decide equipment deployment in container terminal.