

工學碩士 學位論文

A Study on Development Direction of Automated  
Container Terminal in Korea

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2001年 2月

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# A Study on Development Direction of Automated Container Terminal in Korea

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## Abstract

This study is to establish the development direction of automated container terminal in Korea through considering container terminal automation which has been lively discussed in and out of Korea.

This study analyzed current situation of advanced automated terminal and difficulties in development to derive success factors for automated container terminal implementation from case studies, reviewed automation technology status including on-going development status in Korea and suggested the development direction of automated container terminals in Korea by considering productivity, investment cost, integrated technology development, balanced development of H/W and S/W technologies and technology development for operation as success factors for implementation of automated container terminal in Korea.

# 1.

## 1.1

가 , 6,000 TEU , 8,000TEU .

가 , 가 .

25 lifts (AGV, ASC) 가 가 Athens , ECT (Ballis et al. 1997), FAMAS(Mascini, 1997)

가 . ( , 1999), ( ) ECT 가 ( , 1999). ( , 1998; K.C.Nam, 1998, 2000) ( , 1999)가 .

1.2

가



## 2.

.  
ECT, 가 , PSA,  
HHLA ,  
가  
High Quay,  
Dock ,  
AGV

### 2.1

(planning systems) ,  
(operating and monitoring systems) , (handling systems)  
가  
가  
, N/W D/B,

(monitoring)

S/W

가 (DSS) H/W

Quayside Crane, Yard Crane, Yard Tractor

< 2-1>

< 2-1>

	- - Ship Planning - Yard Planning	- -	- ,	-
	- Gate - -	- - -	- ,	- -
	- ,	- -	- -	- ,

: (1998)

가 < 2-2>

< 2-2 >

	-	-
	-        +                    +	-        +                    +
	-        +                    +	-        +

: (1998)

## 2.2

### 2.2.1 ECT AGV/ASC

1)

가 ECT AGV(Automated Guided Vehicle), ASC(Automated Stacking Crane), S/C(Straddle Carrier)

PCS(Process Control System) . AGV

Quayside Crane ASC 20, 40, 45

AGV PCS , PCS

AGV 가 , AGV PCS

. navigation

, 가 ,

ASC RMGC(rail mounted gantry crane)

, oversized container overheight

spreader가 ASC-M lane . ASC

PCS ASC

PCS가

AGV

6 AGV

가 AGV

Marine Terminal

(Ship Planning),

(PAS),

(PCS),

가 PAS(Planning & Administration System)

PCS(Process Control System) . PAS

PCS

## 2) ECT Delta Sea-Land/ Delta Dedicated East

ECT Delta Container

Division(DCD) Home Division , ECT 70%

DCD 1984 Delta Multi-User Terminal(DMU), Delta Sea-

Land Terminal(DSL), Delta Dedicated East Terminal(DDE),

Delta Dedicated West Terminal(DDW) . Delta

DSL DDE 980, 1,030m

, 1997 92 , 48 TEU .

ECT Automated

Guided Vehicle(AGV) (RMGC, RTGC )  
 Automated Stacking Crane(ASC) . AGV  
 Straddle Carrier(S/C)가 .

< 2-3> ECT

	DSL	DDE	
(ha)	67.6	44.1	111.7
(m)	980	1,030	2,010
Q/C	5 + 3	7	12+3
AGV	58	50	108
ASC	27	31	58
MTS train			110
MTS tractor			43
S/C	6	6	12

: DSL Q/C 3 DMU  
 MTS Multi-Trailer System  
 : ECT

ECT

1 ASC가  
 가 1.5 ,  
 AGV, ASC PCS(Process Control System)가 ECT  
 AGV PCS ,  
 PCS AGV 가 , AGV PCS

[ 2-1] ECT



: ECT

navigation

PCS

ASC

ECT

가 . 가 1.5 가 ,

AGV 가

AGV 20m

가

가 . FAMAS

가 .

3)

ECT 가  
 . , 1.5  
 , , AGV 가  
 , AGV 20m ,  
 가 1,000m 가  
 , 가  
 가 .  
 FAMAS 가 .

### 2.2.2 FAMAS(First, All Modes, All Sizes)

1) (Mascini, 1997)

1996 the Centre of Transport Technology

#### FAMAS programme

10,000TEU , ECT, Siemens Netherlands, Nelcon, Cap  
 Gemini 1997 5 .

ECT New Terminal  
 Control(NewCon), Jumbo Container Crane(JCC), Automated Guided  
 Vehicles(AGV) , anti-  
 sway anti-skew , , AGV ,

#### FAMAS

ECT  
 (Jumbo Vessel), (Standard Vessel),

, Junbo Service Center

2) Jumbo Service Centre

Jumbo Vessel 24

2-3 가

8,000TEU

4,000TEU

120-150 moves

high quay low quay 가

. High quay

Crafe

. High quay

Crane Feeding

System 1

< 2-4> High Quay

	High Quay	Low Quay
	Deck 20m	300
	-High quay 1 -AGV -Crane Feeding System	- -
	- 가 가 - , positioning handling -	

layout,

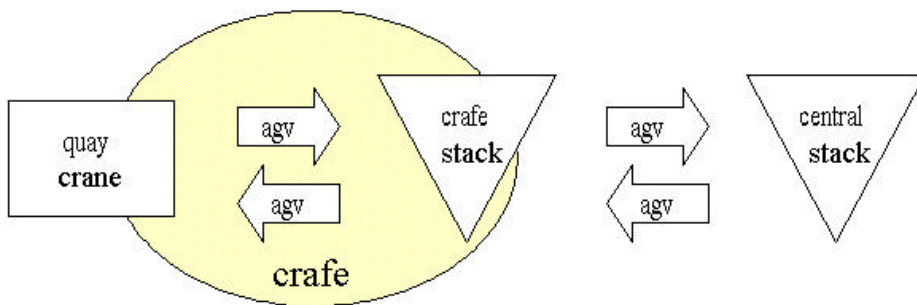


mounted AGV , rail or rubber

[ 2-2] High Quay



[ 2-3] High Quay



3)

① Jumbo Container Crane

high quay low quay

Second Trolley option

②

가 ,  
ECT 가 ASC

③

, SMAGIC(SMarter Automated

Guidance of AGV's to Increase Capacity)

ECT

AGV

AGV

AGV

AGV

3가

④ AGV

AGV

AGV

가

AGV

가

AGV

20m

⑤ AGV

AGV

⑥

AGV

AGV

AGV 가 . S/C Inter  
 Terminal Hoist Vehicle(ITH)

2.2.3 가

1) Thams Port (奥村 猛, 1998)

가 1996 350m KC1 berth가  
 14m , 2 , RMG 8 가  
 가 , KC2 berth가 1999  
 , KC3 berth

KCT RMG AGV Thames port

RMG AGV . RMG 가  
 가 , berth

350m KC2 berth가 2001

Thames port “ (Kiosk) ”

stacking area buffer area

stacking area

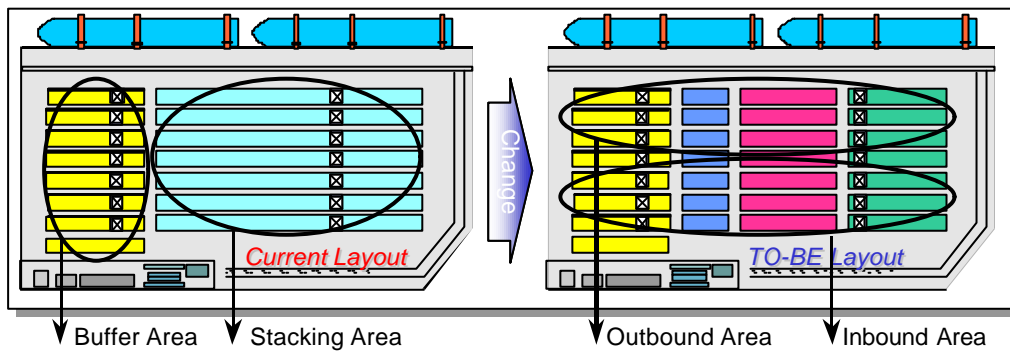
Kiosk -> Stacking area -> Relay point ->

Buffer area -> Y/C [ 2-6 ], layout

2) Layout

KCT 가 가 RMG  
 Kiosk RMG 가 700m  
 RMG 가 8 가 Kiosk  
 Kiosk ,  
 Dual trolley 2  
 20 van

[ 2-4] Layout



: ( ) (1997)

가  
 , 가 가  
 가 maker

( ) 1998 ( ) 가

< 2-5 > 가

	1997	2001
	1	2
(m)	350	700
Q/C	2	5
RMG	8	14
	6	0
AGV	0	20
(TEU)	285,000	500,000

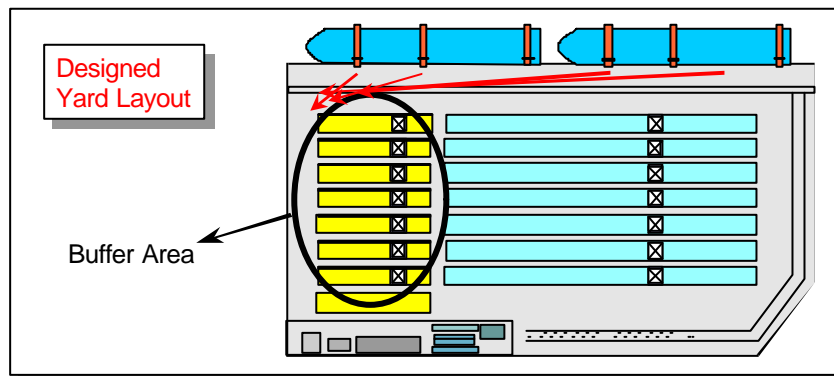
: ( ) , 1997

KCT ECT

가 , 가

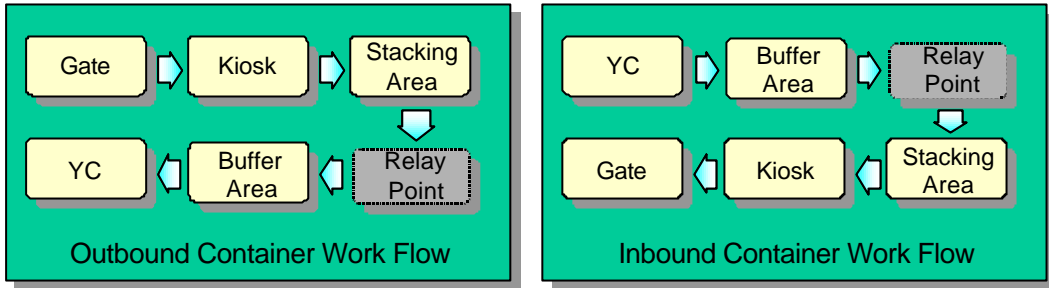
layout

[ 2-5 ] 가 Layout



: , 1997.

[ 2-6]



: ( ) , 1997.

#### 2.2.4 HHLA

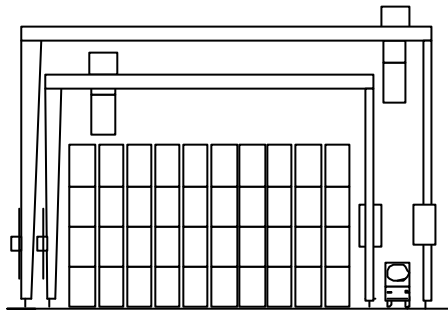
HHLA 가 , Hamburg Burchardkai(Straddle Carrier ), Tollerort(Straddle Carrier ), Unikai(RTG ) 3 . 2001 10 1 120 TEU ( 150 van/ ), , , , , , , .

VCT(Van Carrier Terminal), ASC(Automatic Straddle Carrier), CTRMG (Cantilever Rail Mounted Gantry Crane), RMG AGV DRMG (Doppel Rail Mounted Gantry Crane), AGV OHBC (Overhead Bridge Cranes) . RMG AGV DRMG 가 , 가 RMG RMG RMG

가 1 . [ 2-7]  
 RMG . HHLA Altenwerder  
 < 2-6> AGV  
 6 가 .

RMG AGV  
 DRMG(Doppel Rail Mounted Gantry Crane) .

[ 2-7] RMG







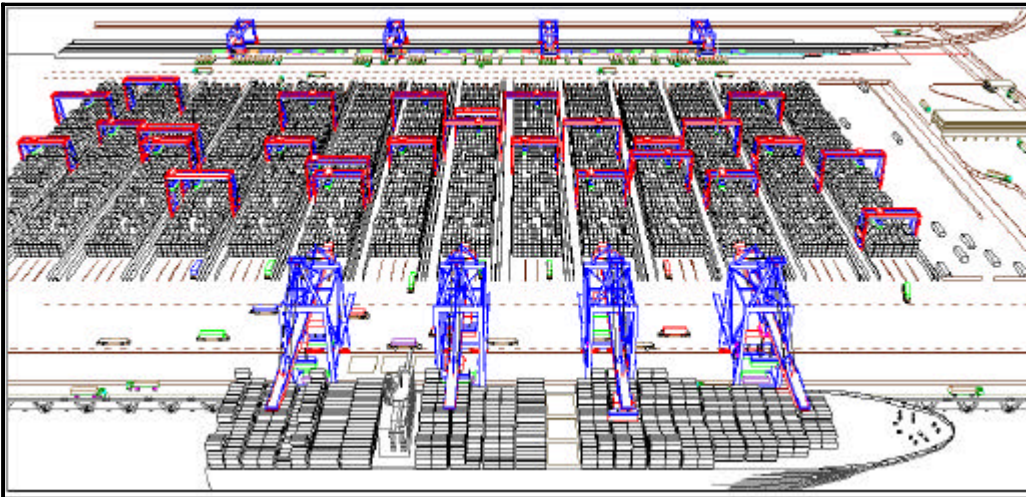
< 2-7> HHLA 가

Conventional straddle terminal	-	
Driverless straddle carrier	-	
Cantilevered RMG and trucks	-	
Overhead Bridge Cranes and AGV	- 가 RMG	
RMG with trucks	-	
RMG with AGV	-	

: HHLA

1 810m 2001 4 ,  
590m 2 2003 . 2001 4

[ 2-8] HHLA Altenwerder



: HHLA

HHLA Altenwerder

ECT 가 , ECT

1

가

< 2-8> HHLA Altenwerder

	1	2	
(m)	810	590	1,400
(m <sup>2</sup> )	530,000	230,000	760,000
(Van/ )	700,000	500,000	1,200,000
(TEU)	15,000	15,000	30,000
	2001. 4.	2003. 4.	

: HHLA

### 2.2.5 PSA

PSA Tanjung Pagar Terminal, Keppel Terminal, Brani Terminal, Pasir Panjang Terminal 4 < 2-9>.

(hub port)

PSA

(mega transshipment hub)

(port time)

12

"Flow-Through"

Container Gate System

, EDI

Electronic Data

Communication System (PORTNETR)

Computer Integrated Terminal Operations System(CITOS)

CITOS

Pasir Panjang Terminal

3

< 2-9> PSA

	Tanjong Pagar Terminal	Keppel Terminal	Brani Terminal	Pasir Panjang Terminal
(ha)	80	96	79	84
(m)	11-14.8	9.6-14.6	12-15	15
	6 main 2 feeder	3 main 11 feeder	5 main 4 feeder	6 main
Quay Crane	29	36	30	24
Yard Crane	95	117	98	44(bridge cranes) 15(RMGC)
Ground Slots	15,940	19,428	15,590	14,443
	840	936	1,344	588

: PSA , 1997

PSA 가 가

PSA 4 Pasir Panjang Terminal(PPT)

3 PPT AGV

가 (bridge crane)

가

[ 2-9] Pasir Panjang Terminal



: PSA ,1997

	ECT		ASC	
. PPT	44	15	RMGC	.
가		AGV		
,	AGV	.	ECT	PCS
			ECT	
가 1.5		가	PSA	5

## 2.3

### 2.3.1

1)

415 TEU

1978

5 4 1 1 가 100 TEU

1991 ( )

128 TEU 1998

5 5 4

120 TEU 1996

가 ( ) 2 1 5

2 가 .

97 11 5 2 가

37 TEU . 825m 5 2 , 5

1 2001

가 2000

가 가 (Hub -

Port) 가 .

< 2-10> ('99 )

	(1, 2 )	(3 )	(4 )		
		( )	, ,	( )	
(m)	1,447	1,200	1,400	500	600
(m)	-12.5	-14 -15	-15	-11	-13
(TEU)	100	128	120	30	36
	5 4 1 1	5 4	5 4	2 1 5 2	5 2
	648 m <sup>2</sup> (196 )	1,039 m <sup>2</sup> (314 )	750 m <sup>2</sup> (227 )	180 m <sup>2</sup> (54 )	148 m <sup>2</sup> (45 )
	980m	925m	950m	-	-

: 2000. 5. 1.

:

2)

'99 < 2-11> .

1998 2000 300

(C/C) 5 가 .

< 2-11> ('99 )

	(1, 2 )	(3 )	(4 )		
	C/C 13 T/C 31 S/C 14 Y/T 56 F/L 27 252	C/C 11 T/C 32 Y/T 61 F/L 27 230	C/C 12 T/C 34 Y/T 73 F/L 9 R/S 11 196	C/C 4 T/C 10 Y/T 17 F/L 2 R/S 1 28	C/C 4 T/C 10 Y/T 19 R/S 1 38

:

2.3.2

(Auto -  
Swag)  
가  
RTGC Transponder ,  
, Auto Steering Gear , Touch Screen, Weighing ,  
(RF Identity Tag) . Transponder T/C  
T/C  
, T/C  
(spreader) , X, Y  
. Auto Steering Gear  
. Weighing  
. Auto Steering Gear (Bay)  
가  
가  
Encoder 가  
, Weighing 가

< 2-12>

		HBC T						PEC T	UTC
Q/C	Auto-Swag								
RTGC	TRANSPONDER	-						-	
		x		x				x	x
	AUTO STEERING GEAR	x						x	
	T/C TOUCH SCREEN								
	T/C WEIGHING	x	x			x	x	x	x
	RF IDENTITY TAG								
	BAR CODE								

: , x

:

### 2.3.3

Planning ( ) HBCT, PECT,  
 , Ship Planning 가  
 ( , 1999). ( )  
 C3IT(Command Control Communication and Intelligence for Terminal)  
 가 . 4 ,  
 process  
 H/W  
 가 ,



### 3.

#### 3.1

##### 3.1.1

가

가

ECT HHLA

Thamsport 가 PSA가 Thamsport Kiosk

가

가

Terminal RMG PSA Pasir Panjang

가

##### 3.1.2

1) Jumbo Service Centre

Jumbo Service Centre ECT  
 FAMAS .  
 8,000TEU Jumbo Vessel 24  
 .  
 Deck 20m  
 High Quay .  
 , positioning handling ,  
 , , . High  
 quay Q/C 1 (Crafe) , AGV  
 Crafe  
 layout, ,  
 가 , rail rubber mounted AGV가

2) Ship-in-Slip/ Docking System

Ship-in-Slip Docking System  
 ,  
 가 . Dock 10 Q/C  
 . JWD  
 Cres Paragon Terminal  
 (www.jwdliftech.com). JWD

Ship-in-Slip

가

[ 3-1] Ship-in-Slip



! **CERES PARAGON TERMINAL**  
*Amsterdam, The Netherlands*

: JWD

4-5

(POD)

가

가

, 5000TEU

가

6

가

2-3

가

가

Ship-in-Slip

3) GRAIL

GRAIL

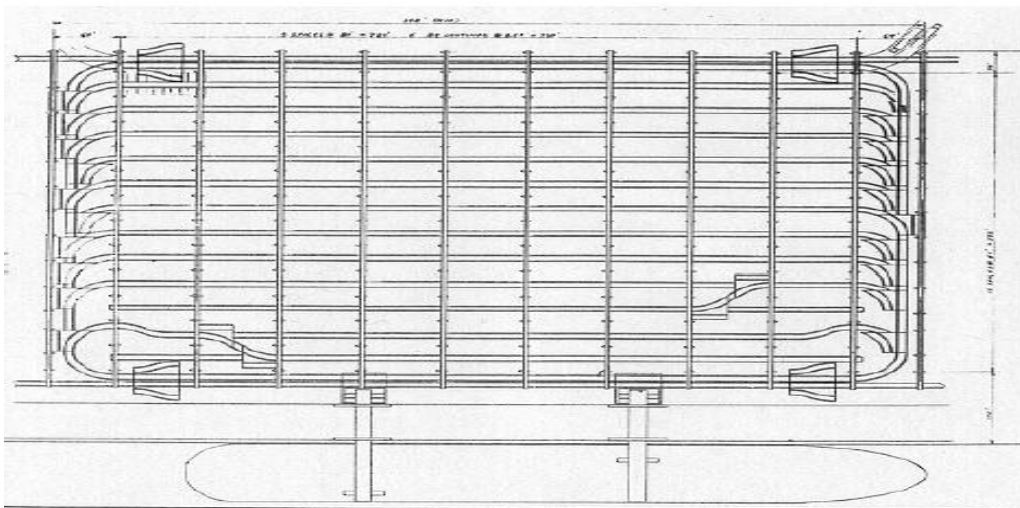
Sea-Land

August

Design 가 (Edmond, 2000).

AGV 가 (overhead grid system of rails) (Shuttle)

[ 3-2] GRAIL



: August Design

4)

bar Earl 가

Earl's Computainer

rehandling Handling System 가 (Edmond, 2000). Kropp Kropp Fast 30

### 3.2

#### 3.2.1

RMG (ASC) 1 가 230m 230m AGV 1 가

Quay Crane HHLA 가

#### 3.2.2 Cell Elevator

Cell Elevator August

Design

가

August Design

Cell Elevator [ 3-3].

Quay Crane 가 가

Cell Elevator [ 3-3] 가

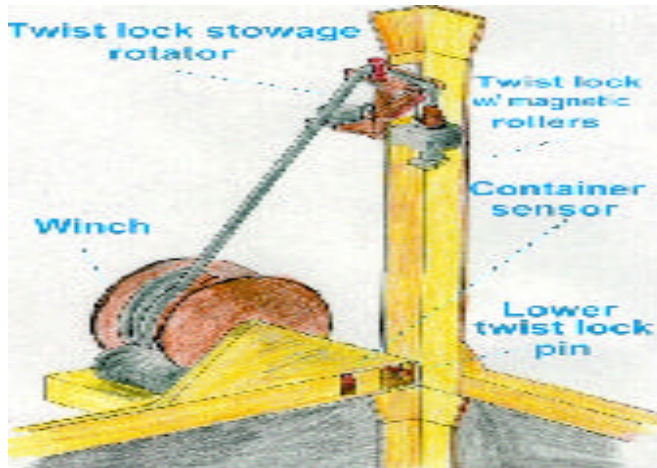
Winch, Twist Lock Stowage Rotator, Magnetic Rollers, Container  
Censor, Lower Twist Lock Pin , Quay Crane

가

가

4 가 4 Twist Lock

[ 3-3] Cell Elevator



: August Design

4 Twist Lock

coner casting

. Twist Lock

Magnetic Roller

가

Container Sensor

가

Lower Twist Lock Pin

coner

casting

coner casting

Twist Lock

Quay Crane

가

3.2.3 DARTS(Direct Acquisition Rail to Ship) Spreader

DARTS Spreader

가

. August Design

Bromma

1998

Bromma 가

가

가 , 20'

, Q/C

가

20' 2

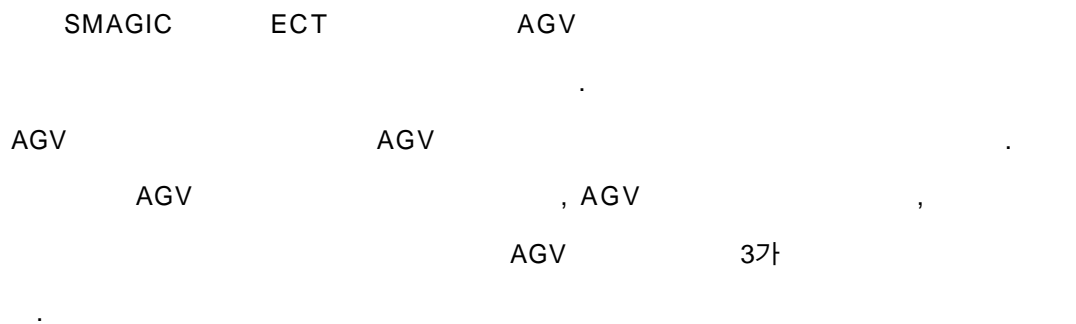
Q/C

[ 3-4] DART Spreader



: August Design

### 3.2.4 SMAGIC(SMarter Automated Guidance of AGV's to Increase Capacity)



### 3.2.5



가 .  
가  
가 . Expert Intermodal Container Handling System  
, ECT PCS(Process  
Control System), PSA CITOS  
( ) 가 CATOS(Computer Automated Terminal  
Operation System) , 가

, rehandling

가

(POD), ,  
가 .

### 3.3

가

. S/W ,  
, H/W , Q/C, ,

21 , SOC 가

HBCT, PECT, ,

Quayside Crane ,

Transponder , , Auto Steering Gear

CCTV 가

, 1998

“ ” ( “

” ) 가

( , 1999). 1998 12

2 3

, AGV, ATC , 3

가 .

( , 1999).

### 3.3.1

가

. '98 12 2003 10 5 169 ( 1

34 , 35 ) , , AGV(Automated Guided Vehicle), ATC(Automated Transfer Crane) .

( ) , , ( )

Automated Guided Vehicle) , ① (AGV:  
Automated Transfer Crane) , ② (ATC:  
, ③  
, ④ 3  
('2000.11 - 2001.10) , 4-5 (2001.11 -  
2003.10)

< 3-1>

(AGV)	- , (Navigation System)
(ATC)	-AGV AGV (Automatic Landing System)
	- (Simulator)
	- ,

3.3.2 (Automated Guided Vehicle: AGV)

1)

AGV ( ) - (T/T)  
ECT가 AGV  
ECT, PSA, Thamsport  
[ 3-5].  
AGV , Positioning  
AGV Kamag,  
Gottwald, MES 가  
< 3-2>.

[ 3-5] AGV



: ( ) (1999)

< 3-2> AGV

	KAMAG	GOTTWALD	MES	
( )	50	40	50	50
(Box)	2x20 ,1x4 0/45	1x20 ,1x4 0/45	2x20 ,1x4 0/45	2x20 ,1x4 0/45
(m/sec)	5.5	4.5	6.9	5.0
(m/sec)	5.0	4.0	5.0	4.0
(m)	11.5	9.0	9.0	11.5
Positioning (mm)	± 20	± 20	± 20	± 20

: , 1999.

2)

AGV Axle Assembly Module, Power Pack Module, Energy Pack  
Module, Frame, Safety System Control System

AGV

[ 3-6] Supervisor Communication  
Controller, Navigation System

AGV

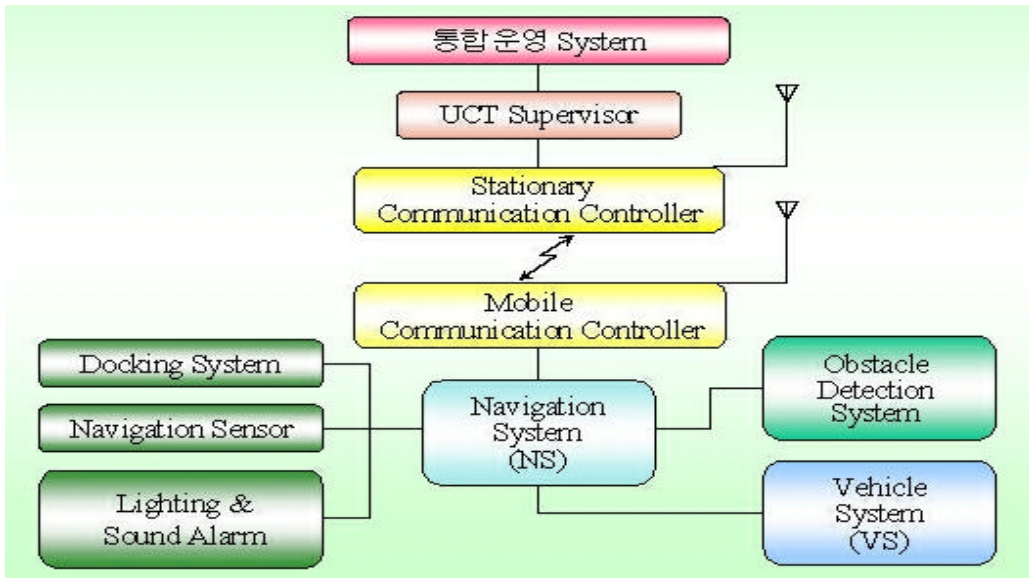
AGV

Navigation System,

AGV

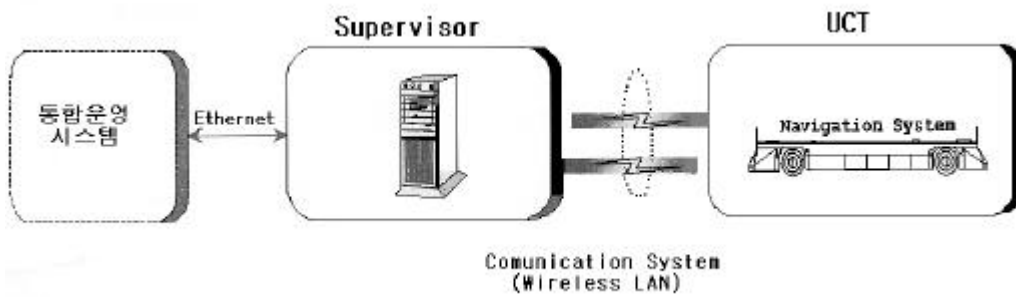
Supervisor, Supervisor AGV

[ 3-6] AGV



: ( ) (1999)

[ 3-7] Supervisor, Navigation System Communication System



: ( ), 1999.10.

Supervisor System

Supervisor ECT PCS(Process Control System)

AGV

AGV

AGV

Navigation System

Navigation

AGV

Supervisor

Obstacle Detection System,  
System

Docking

Communication System

AGV

Supervisor

AGV

Wireless LAN

### 3.3.3

(Automated Transfer Crane: ATC)

1)

ATC

RMGC(Rail Mounted Gantry Crane)

2

ATC

(block) 5 12 4 6 가

[ 3-8] ATC



: ( ) (1999)

## 2) ATC

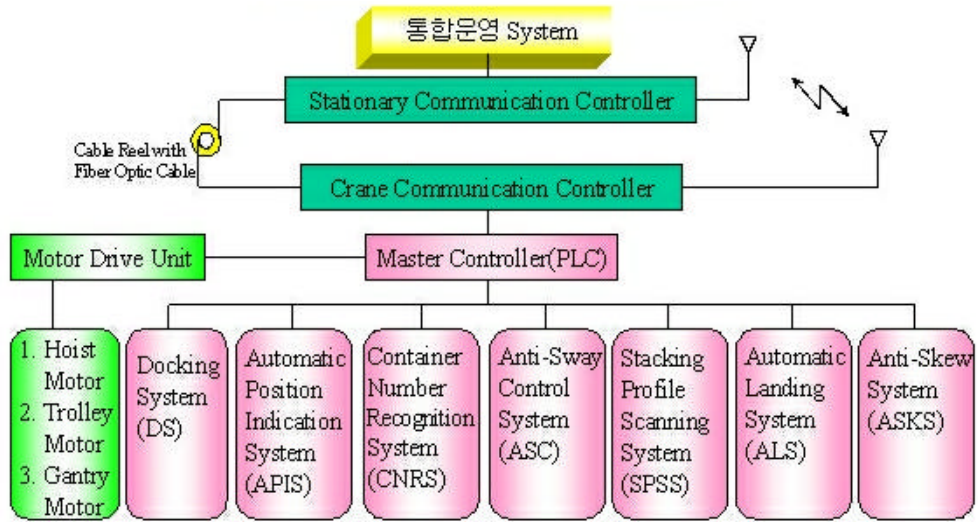
ATC Trolley Assembly, Gantry Assembly, Steel Structure, Safety System, Crane Control System

Crane Control System, Communication Controller Master Controller(PLC) . Master Controller

Docking System, Automatic Positioning Indication System, Container Number Recognition System, Anti-Sway Control System, Stacking Profile Scanning System, Automatic Landing System, Anti-Skew System



[ 3-9] Crane Control System



: ( ) (1999)

### 3.3.4

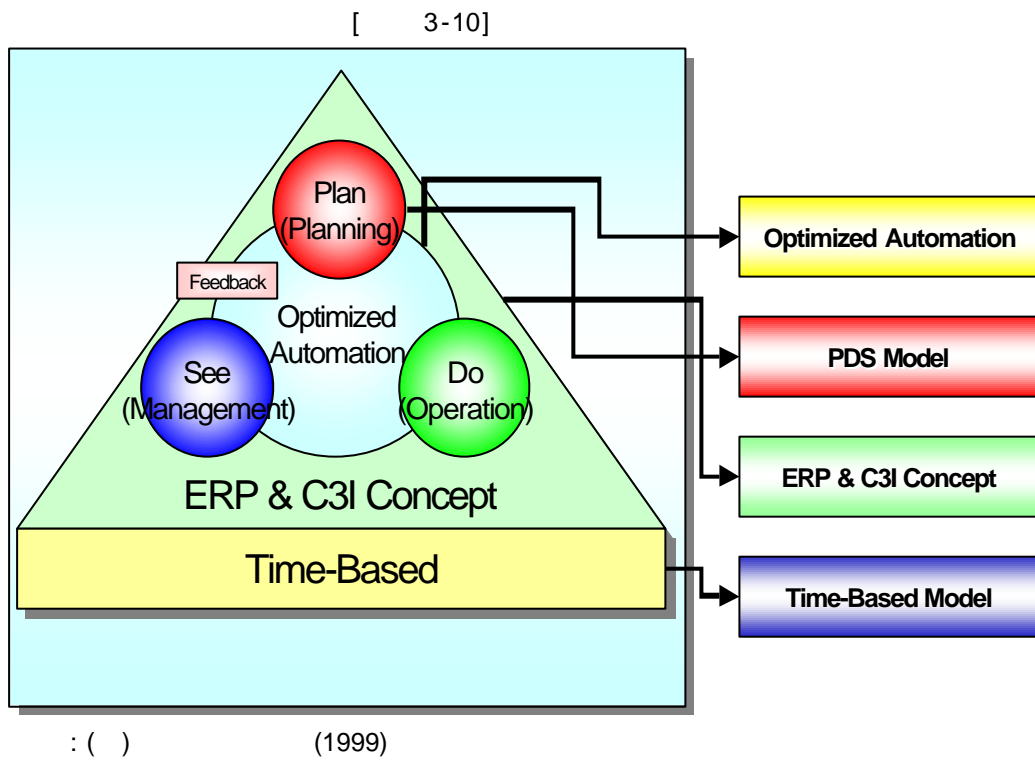
Time-based

integrated command, control and communication

based [ 3-10 ].

. Time - x, y, z 3

4



### 3.3.5

1) ( , 1999 )

( )

2) ( , 1999)

가

가

6-9

가

가

가

가

6-9

가 가

4.

가

## 4.1

가 ,  
가 ,

### 4.1.1

(Customer), (Competition), (Change)  
가  
, one-stop  
(Change)  
(IT)  
가  
(planner)  
가

Q/C

가

#### 4.1.2

1)

ECT

(islands of automation)

가

, ECT

가

120 TEU ,

1000m .

1.5

, 3

. AGV

가 ,

AGV

20m

AGV

가

가

가 .

RMGC 5-6

, AGV

20-25km/h

. AGV

Navigation

AGV

,

AGV

. 8,000TEU

Q/C

port time

. , 4,000-5,000TEU

port time 24

Q/C

170TEU-200TEU가 ,

Q/C

Dual Trolley

2)

가 . . , 75% , 가  
 (AGV) 25km/h , 40 20

4-2].

process

EDI/IP

3)

(RMGC)

가 .

가 . . ,

가

가 .

ECT

HHLA

Thamsport 가

PSA . Thamsport 가

Kiosk

. PSA Pasir Panjang Terminal

RMGC

#### 4.1.1.3

가

가

가

가가

1)

가 . ECT

ASC

1.5 ,

AGV

FAMAS

가

가 . ,

2)

가 .(4.3 ) .

가, AGV

가, ASC

3)

ECT

(islands of automation)

가

4.2

4.2.1

[ 1].

가



가 , 가  
 가 , ,

< 4-1>

	- - - -
	- 가 - 가 가
	- - - ( )

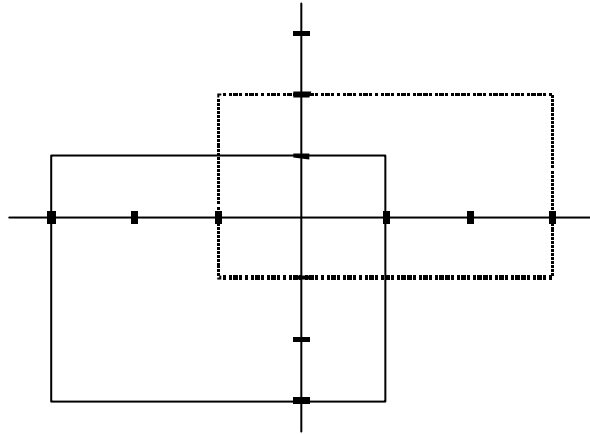
4.2.2

[ 4-1].  
 3 , 1  
 ,  
 , 가  
 2 , , ,  
 , 가  
 3  
 가  
 ,  
 가



[ 4-1]

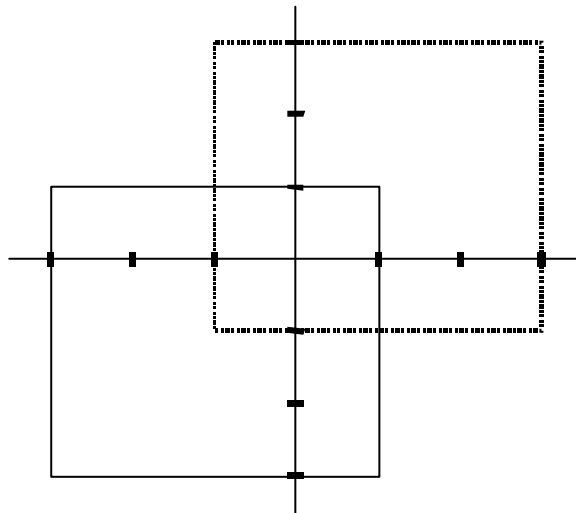
가



: (1998)

[ 4-2]

가



가

: (1998)

ECT

< 4-3>

(1998 )

		A	B	D					
		49	46.2	62.6	52.6	30.7	26.6	25.7	27.7
		38	22	21.2	27.1	65	68	63.4	65.5
		4.9	5.3	6	5.4	3.4	5.1	2.4	3.6
		8.1	26.5	10.2	14.9	0.9	0.3	8.5	3.2
		100	100	100	100	100	100	100	100

:

# 5.

가 . ECT  
ASC 1.5 , AGV  
FAMAS 가 가 .  
가, AGV  
가, ASC  
(islands of  
automation)

가

, H/W S/W

가

Thames Port

가

. ECT

FAMAS

가

( )

가

가

가

가

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