

工學碩士 學位論文

海上交通安全性評價 研究

A Study on the assessment of the marine traffic safety
at the Pusan approaching waters

指導教授 朴 鎮 洙

2000年 2月

韓國海洋大學校 大學院

海 事 輸 送 科 學 科

康 英 植

Abstract.....

11

1.11

1.22

2 가3

2.1 가3

2.2 Simulation7

2.2.17

2.2.2 Simulation11

2.3 가(ESA)30

2.3.1 (ESL Value).....31

2.3.2 (ESS Value).....35

2.3.3 가38

3	.....	40
3.1	.....	40
3.1.1	.....	40
3.1.2	.....	41
3.2	.....	43
3.2.1	.....	43
3.2.2	.....	47
3.2.3	.....	49
4	가	51
4.1	.....	51
4.2	.....	54
4.3	.....	54
4.3.1	.....	55
4.3.2	.....	56
4.4	.....	57
4.4.1	.....	58
4.4.2	.....	61
4.4.3	.....	62
4.5	가.....	63
4.5.1	가	64
4.5.2	가	66

5	.....	72
5.1	.....	72
5.2	.....	73

- -

< 3.1 >	.....	42
< 3.2 >	, L L^2	48
< 3.3 >	.....	50
< 4.1 >	.....	52
< 4.2 >	.....	56
< 4.3 >	.....	57
< 4.4 >	.....	62
< 4.5 >	.....	63
< 4.6 >	ESA 가	71

< 1.1 >	.....	2
< 2.1 > 가	.....	5
< 2.2 > 가	.....	6
< 2.3 >	.....	13
< 2.4 >	.....	15
< 2.5 >	.....	17
< 2.6 >	.....	18
< 2.7 >	.....	21
< 2.8 >	.....	25
< 2.9 >	.....	26
< 2.10 >	.....	28
< 2.11 > ESA	.....	39
< 3.1 >	.....	41
< 3.2 >	.....	43
< 3.3 > .	.....	44
< 3.4 > .	.....	45
< 3.5 > OD	.....	46

< 3.6 >	.....	48
< 3.7 >	.....	49
< 3.8 >	.....	50
< 4.1 > 3	gateline	52
< 4.2 > 3	.....	53
< 4.3 >	.....	55
< 4.4 >	.....	58
< 4.5 >	.....	59
< 4.6 >	.....	60
< 4.7 >	.....	61
< 4.8 >	가	65
< 4.9 >	ESA 가	66
< 4.10 >	가 ESA ().....	67
< 4.11 >	가 ESA ().....	68
< 4.12 >	ESA 가 ().....	70
< 4.13 >	ESA 가 ().....	70

**A Study on the assessment of the marine traffic safety
at the Pusan approaching waters**

by kang, young - sic

Department of Marine Transportation Science
The Graduate School of Korea Maritime University
Pusan, Korea

Abstract

Marine traffic engineering is the technical field that observe flows of vessel traffic in accurate and describe the features of ships' movement statistically or analytically, then contribute to the improvement of the traffic flow and safety of traffic.

Recently, marine traffic engineering has been developed until that possible to estimate a changes in traffic flow caused from some transformations of the traffic condition, and to assess the feasibility and validity of the changes by computer simulation.

This paper aims to assess the present traffic safety at the sea area adjacent to Pusan harbour, and the validity of the suggested roundabouts TSS at the Pusan approaching water(by Park in 1998⁽¹⁾) using ESA(Environmental Stress Aggregation) model

There are couple of steps to describe the marine traffic situation and to

assess its safety by computer simulation. The first step is observe the movement of vessel traffic concerned waters and to obtain the relevant data for computer simulation which is described in Chapter 3. A series of traffic surveys were conducted for 4 days and obtained valuable data including the tracks of the vessels, traffic volume, type and size of ships, and etc.

Second step is to carry out computer simulation to assess the simulated traffic flows by using suitable indexes of assessment model - ESA model. Earlier studies and some theoretical backgrounds were examined in Chapter 2, the simulation process and valuable outputs from the simulation were described in Chapter 4.

The last step is to compare the results of assessment on the present traffic situation with the expected one by using suggested changes. The last part of Chapter 4 and Chapter 5 explains the results that ;

- (1) the present traffic condition shows some difficulties in traffic lanes 2 & 8(to and from Japan), and 3 & 9(to and from South coast),
- (2) the comparisons, generally, indicate lower ESA value in suggested roundabouts(TSS) than the present traffic measure, however,
- (3) the roundabouts(TSS) make the traffic lane 1(from Pusan to East coast)and 9(form South coast to Pusan) longer naturally.

Eventually, this paper conclude that the ESA model is a useful technique to assess the traffic safety and the suggested roundabouts(TSS) could make the concerned area safer than present traffic situation

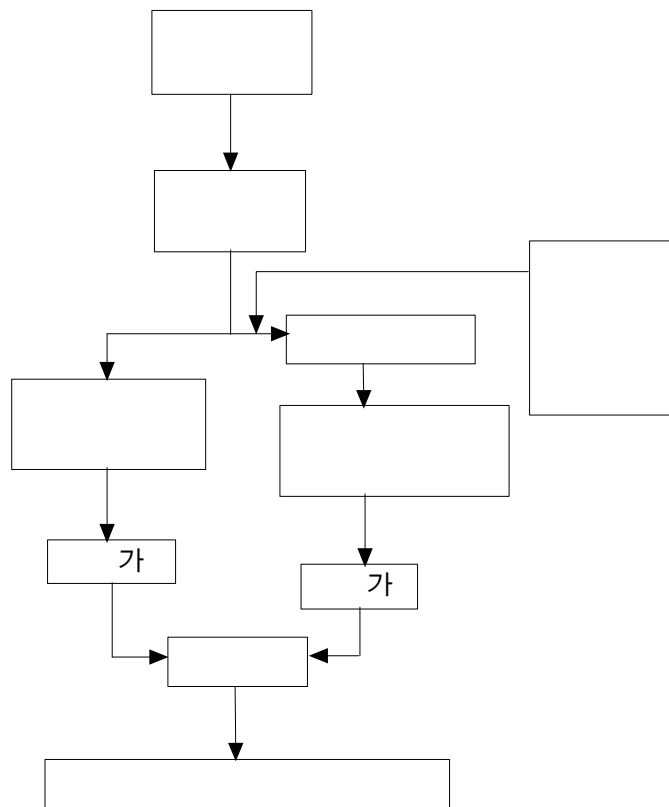
1.2

가

가.

<

1.1 >



< 1.1 >

가 , 2 가 가
가 . , 3 가
, 4 .
5 가 ,
가 ,
가 .

2

가

2.1

가

가

가

가

가

가

가

가

가,

< 2.1 >

1970

1980

1990

가

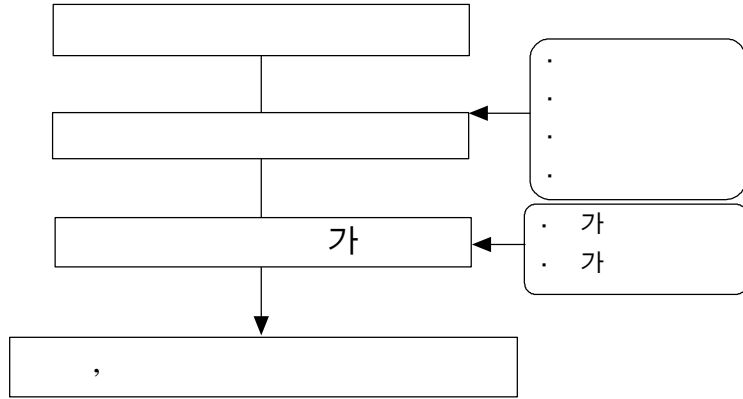
가

, 가

가

가

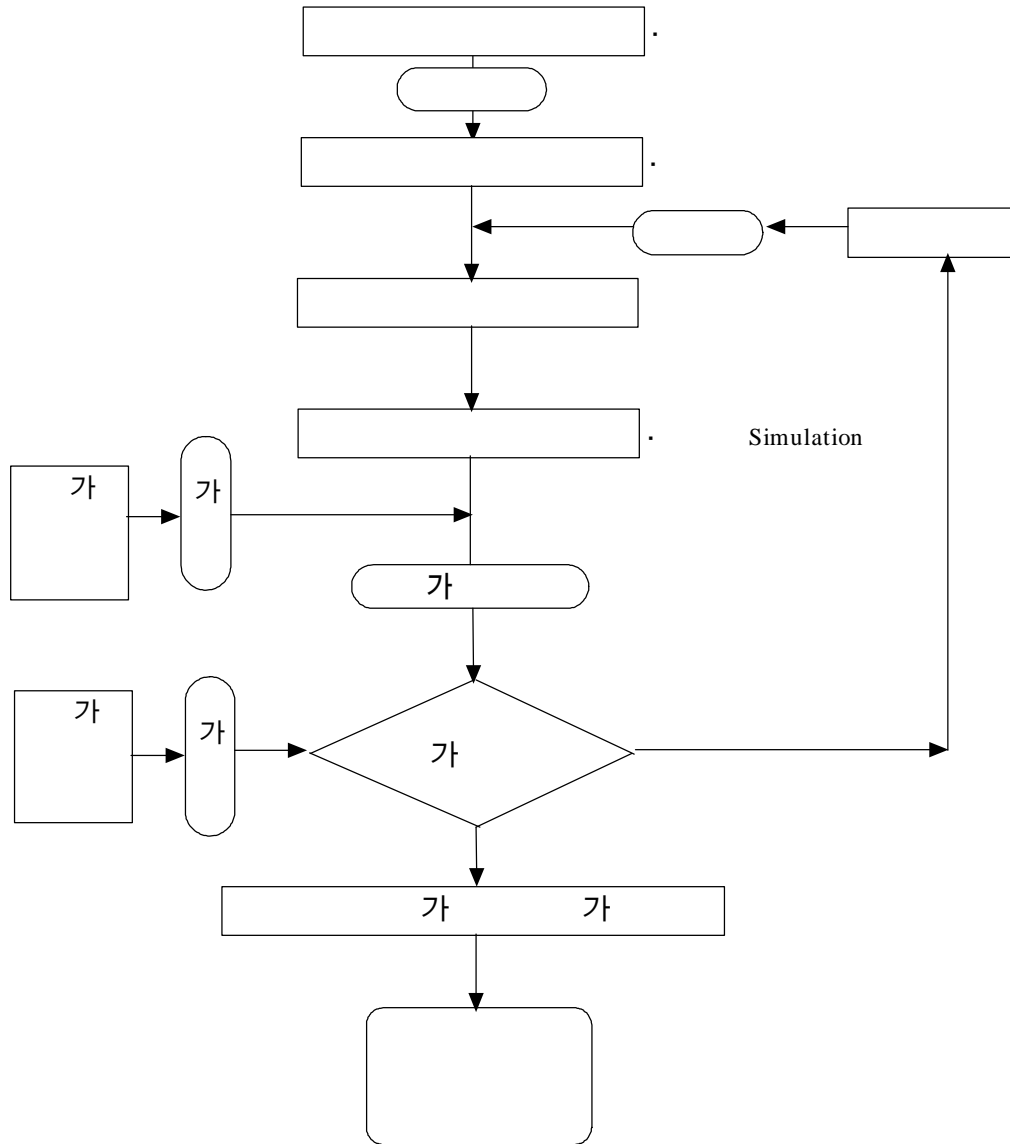
가



< 2.1 > 가

, 가 5 .
 , ' , , 가
 가 , ' , , 가
 , . , ' , , 가
 , ' , ' , ' , 가
 , , ' , , 가
 가 가 가 , , 가
 . , ' 가 , 가'
 가 가 , 가 ,
 , 가 가 , 가가 ,
 가 ,

가 , 가 .
 가 < 2.2 > .



< 2.2 > 가

2.2 Simulation

2.2.1

가 .

가 .

1) 2)

가 .

(山甲)

1Km , 2-3Km ,

가 ,

가 .

가 .

가 .

2 3

, PR
 가 가 . ,
 ,
 .
 가 ,
 ,
 ,
 ARPA ,
 ,
 가
 ,
 Radar ,
 가 ,
 ,
 가
 ,
 OD(-)
 .
 , 가
 .
 0 - , , ,
 0 - , , , , OD(,), ,
 0 - , ,
 0 - , , , , , ,
 0

2)

가 , 가
 가 , A Small(1,2,3),
 Medium(1,2,3), Large(1,2,3) 9 가
 가 VLCC
 L A
 (L²)
 L²
 500 300GT 1 , 3000GT 20,000GT 2, 20,000GT
 4, 100GT 500GT 1/2, 100GT 1/4
 3)

3)

1 , N
 가 , 365 N
 , N 가
 N (井上) 4)

N
 x, k , C m
x

$$(1 - k \cdot C) \cdot m < x < (1 + k \cdot C) \cdot m \dots\dots\dots < 2.1 >$$

$$k = 2(75\%) \cdot 7$$

x .

$$0.76 \cdot m < x < 1.24 \cdot m \quad (N = 7)$$

(明石海峡)

$$C = 0.25 \cdot N^{-0.39}$$

N 1 N 7 C 0.12가 .
C = 0.25가 x

$$0.5 \cdot m < x < 1.5 \cdot m \quad (N = 1)$$

, N 2 3 , 2 3
C = 0.19, C = 0.16 x .

$$0.62 \cdot m < x < 1.38 \cdot m \quad (N = 2)$$

$$0.68 \cdot m < x < 1.32 \cdot m \quad (N = 3)$$

7 ± 25% 가 , 3 ± 30%
가 가 .

2.2.2

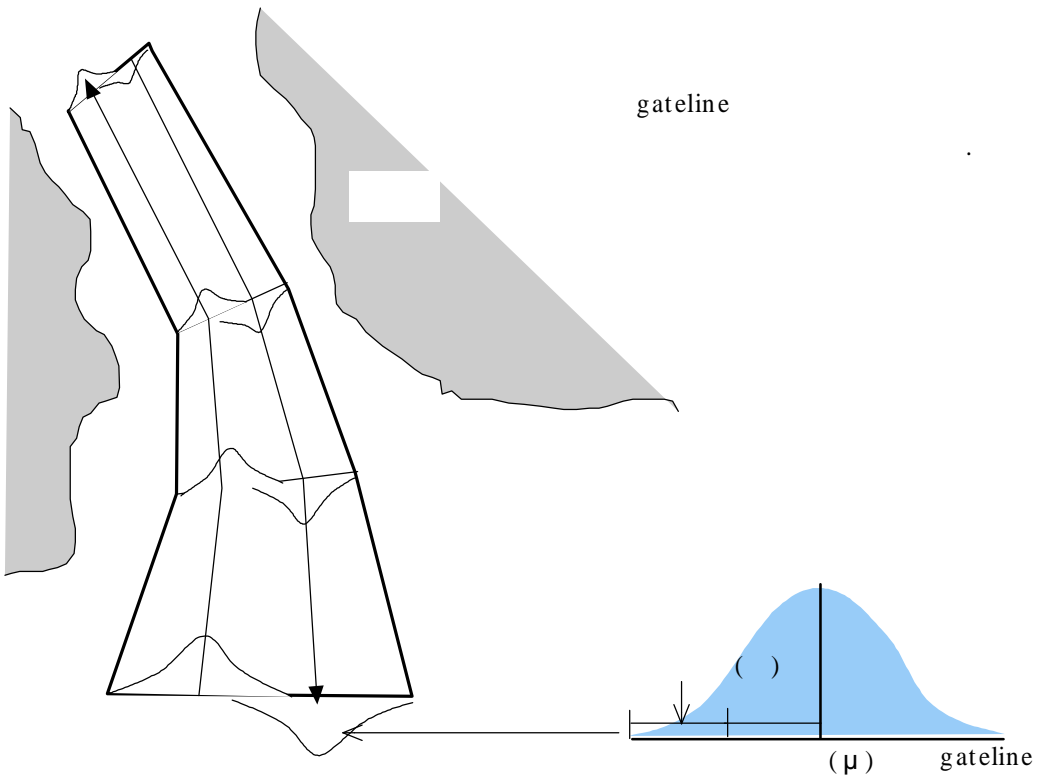
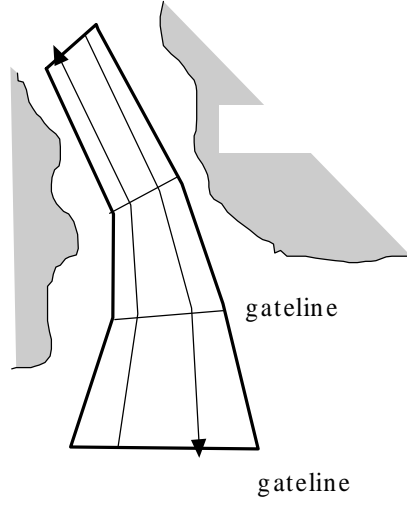
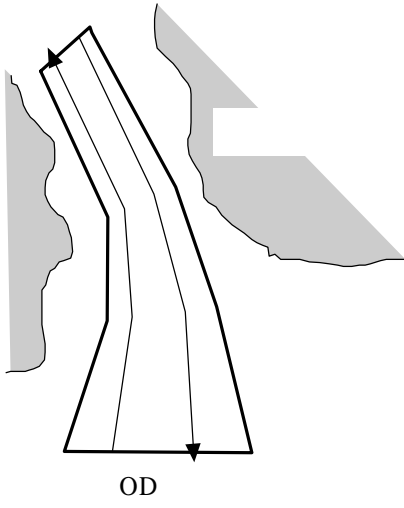
가 , , 가
 가 . 가
 가 . 가
 , 가가 .
 가 가
 , 가 2
 , 가 .
 가 .
 가 .
 , , (), , , , , , , .
 1)
 OD
 , (Origin) (Destination)가 .
 OD , 가
 , ,
 , gateline . gateline
 , gateline ()

() gateline
gateline
gateline
gateline
. < 2.3 >
가
가 2
, Q(/) 가
w(m) (m)
5)

$$= -9.49 + 0.016 \cdot w + 3.33 \cdot Q \dots\dots\dots < 2.2 >$$

(, w : 180 1400m, Q : 2.1 12.0 /)

OD



< 2.3 >

2)

gateline

, 10 gateline 10

(), (),

(1)

가 , 가

가 L , L²

L , L²

가 가

()

(2)

gateline

gateline 가

가

(Poisson) 가

가

T

n $P_{(n)}$.

$$P_{(n)} = \frac{(Q \cdot T)^n}{n!} \cdot e^{-Q \cdot T} \dots\dots\dots < 2.3 >$$

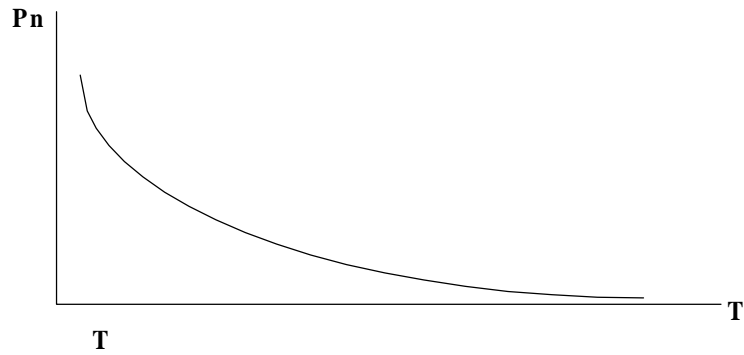
> , T X $P_{(0)}$ < 2.4
 가 .

$$P_{(0)} = \frac{(Q \cdot T)^0}{0!} \cdot e^{-Q \cdot T}$$

$$= e^{-Q \cdot T} \dots\dots\dots < 2.4 >$$

T

.
 T , T
 , < 2.4 > .



< 2.4 >

,
 $F(x) = 1 - \exp(- \quad *x) \dots\dots\dots < 2.5 >$

, $\lambda : 1/M(\quad)$
 $M : (\quad / \quad)$

, (x)
 .

$x = - M \cdot \text{LOG}(1.0 - (\text{double})(\text{rand}()) / 32767.1) \dots\dots\dots < 2.6 >$

, rand : (C)

M ,

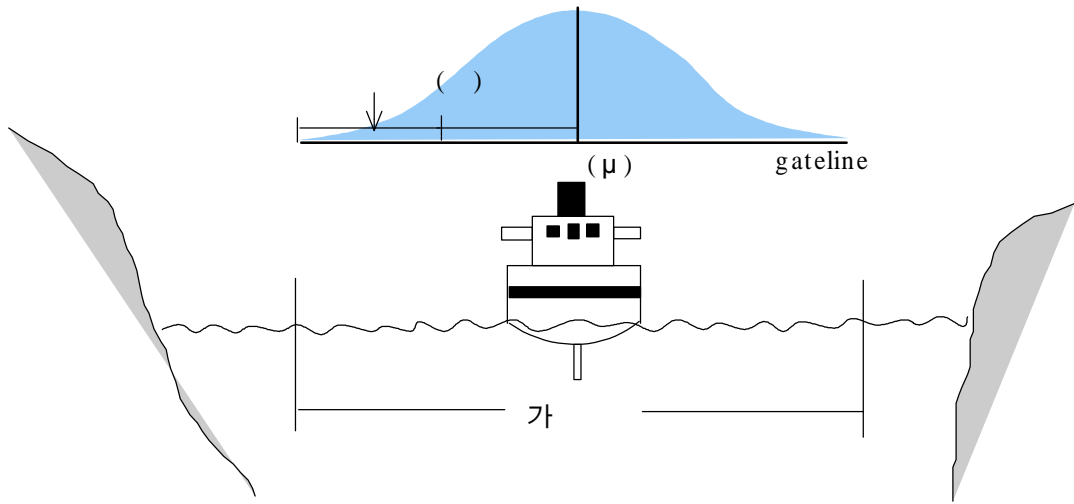
가 (Erlang)

(3)

가 가 가

가

가



< 2.5 > ()

가 가 ,

,

N

가 1/12

가 .

6,

1 .

가 1/2,

(N) 12

6

가 0

()

X gateline

$$X = \mu + \dots < 2.7 >$$

, : (m), : (-2 < < 2), μ : (m)

< 2.7 > -2 2

가

가 ,

< 2.7 >

gateline (m) , 0m

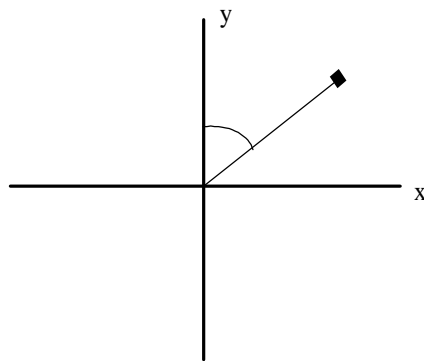
gateline

gateline

gateline

가

(m) ()



< 2.6 >

(4) ()

가 ()

3)

, gateline

(1)

< 2.7 >

$$b/a = b'/a'$$

x, y

$$(x', y') \quad x' = x + r \cdot \sin \theta', \quad y' = y +$$

$$r \cdot \cos \theta'$$

x, y

, gateline

gateline

< 2.8 >

< 2.7 >

< 2.7 > 1

(Co)가 , 2 · 3

가 . 4 2

가 .

$$Course = \tan^{-1} \left(\frac{x' - x}{y' - y} \right)$$

=< 2.8 >

(2)

Check line

0

가

가

OD

가 .

$$Y = a + b \cdot \log X \quad \text{.....< 2.9 >}$$

$$V = Y * V_0 \quad \text{.....< 2.10 >}$$

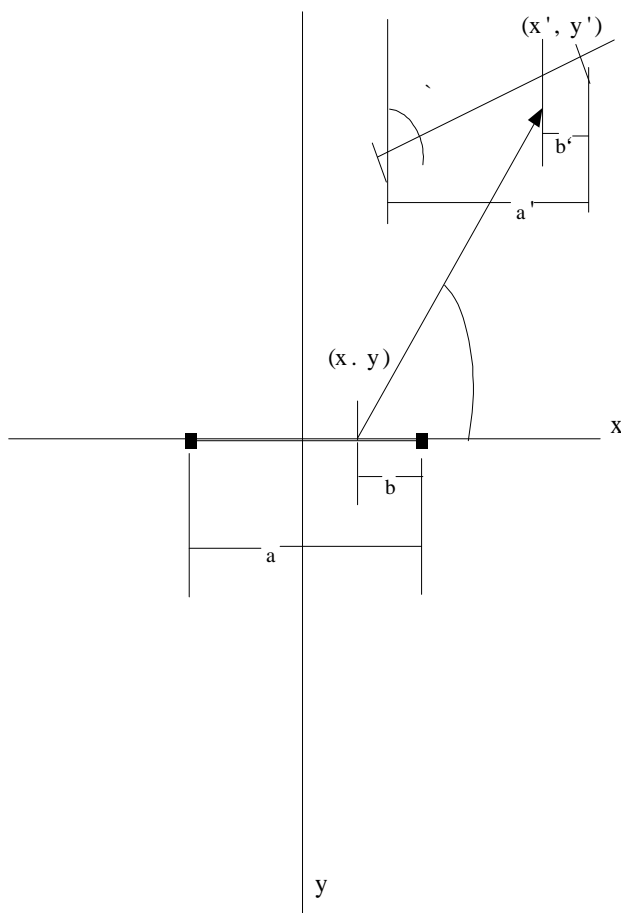
, X ; (m)

Y ; X /

Y 1

V < 2.10 >

가



$$b/a = b'/a'$$

1 $Co = Course$

2 · 3 $Co = Course +$

4 $Co = Course + 2$

< 2.7 >

4)

. 가 가 ,
,
, 가 .

(1) First match

First match ,
가 . ,
,
(,)
.

(2)

가
, 1991 原
SJ (subjective judgement) < 2.11 > < 2.12 >
> .⁶⁾

$$* = + * \times (SJ^* - SJ) - * \times \frac{dSJ}{dt} \dots\dots\dots < 2.11 >$$

, * : * :
: SJ :
SJ* : 가

$$= a \times (\dots) - b \times \dots \times \frac{L}{V_R} \dots \dots \dots < 2.12 >$$

, $a = +2.0$ $b = -2.5$

:

V_R :

L : (LOA)

, < 2.11 >

, < 2.12 >

, 가

(3)

今幸

가

가

?)

()

(1)

(2)

(a)

(a₁)

(a₂)

2 × 2

,

$u(a,)$

,

$U(a|)$

$$U(a_1|) = U(a_1) = u_{11} \cdot u_{11} + u_{21} \cdot u_{21}$$

$$U(a_2|) = U(a_2) = u_{12} \cdot u_{12} + u_{22} \cdot u_{22}$$

· , u_{11} $u_{12} \dots$ $a_{1, 1}$ $a_{1, 2} \dots$ $u(a,$

)

a

,

$U(a_1)$ $U(a_2)$

가
， 今聿

1993 長澤

8)9)

가

가

가

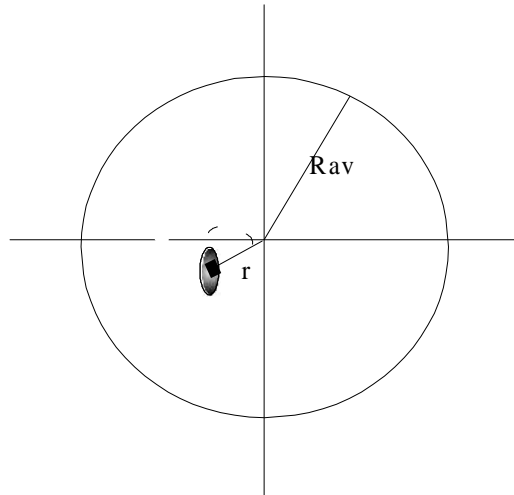
가

가

가

< 2.13 >

가



< 2.8 >

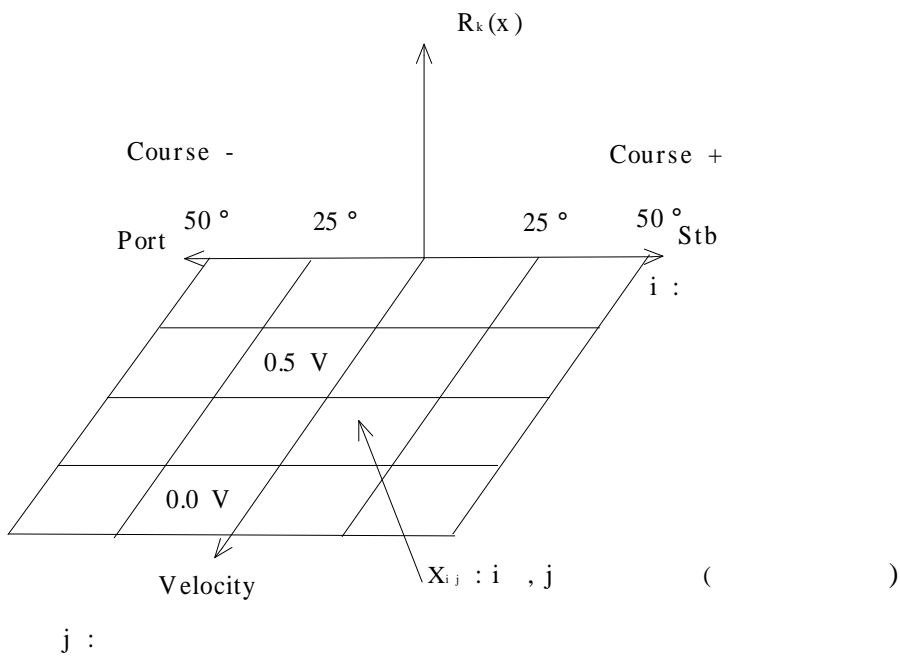
$$R_{av} = (3.3 \cdot V_R + 6) \cdot \left(\frac{L_0^2 + L_t^2}{2} \right)^{1/2} \dots\dots\dots < 2.13 >$$

- | | | | |
|--------------|---------|---------|------------|
| , R_{av} : | (m) | L_t : | LOA(m) |
| V_R : | (m/sec) | | : 45° |
| L_0 : | LOA(m) | r : | $R_{av}/3$ |

10)

가
 < 2.9 >

가



< 2.9 >

가 $u(X_{i,j})$
 ,
 가 $u(X_{i,j})$
 ,
 가 $u(X_{i,j})$

$$u(x_{i,j}) = p_b(X_{i,j}) - \times \text{Max } R_k(X_{i,j}) \dots\dots\dots < 2.14 >$$

, $u(X)$: 가

$P_b(X)$:
()

$R_k(X)$:

$X_{i,j}$: , $i = 1 - p$:

$j = 1 - q$:

: 가

n : (가)

가

,

가

$P_b(X_{ij})$,

$$P_b(X_{ij}) = \exp(- a_c \cdot C_o)$$

$$P_b(X_{ij}) = \exp(- a_v \cdot V)$$

$$P_b(X_{ij}) = P_b(X_{i,0}) \times P_b(X_{0,j}) \dots\dots\dots < 2.15 >$$

, $P_b(X)$:

C_o : (: deg)

V : (: %)

$a_c = 0.0190$ (), $a_c = 0.0260$ ()

$a_v = 0.0456$

, 가

가

, < 2.10 >

(長徑)

(短徑)

가

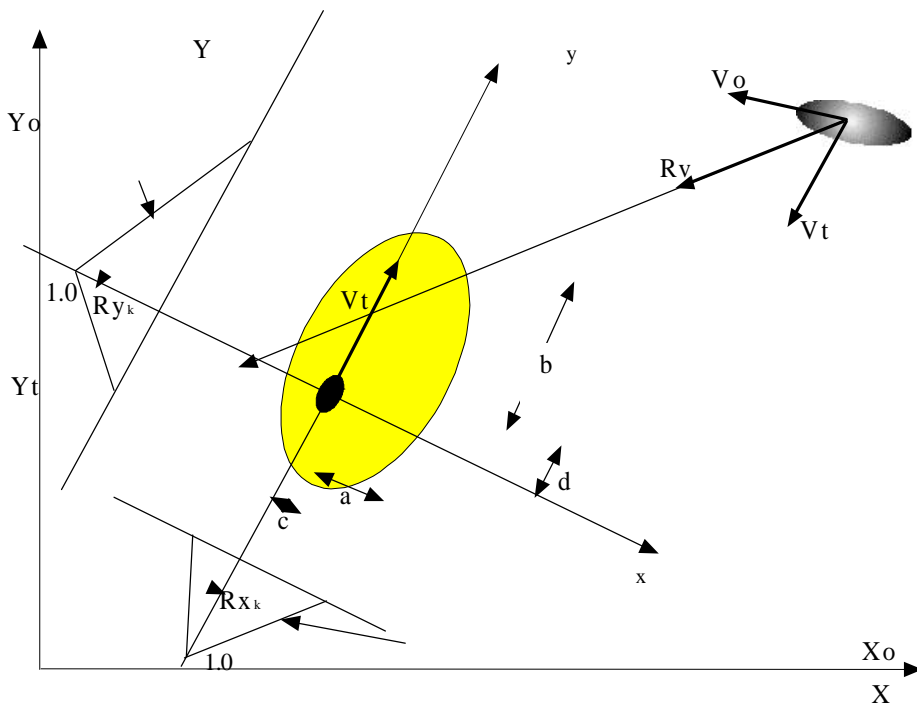
長澤

가

, < 2.10 >

<

2.16 >



< 2.10 >

$$R_k(X_{i,j}) = \text{Max}(R_{x_k}, R_k) \times \left(1 - \frac{T_{cpa}}{W_{tcpa}}\right) \dots \dots \dots < 2.16 >$$

$$a = 75 \cdot V_o \underline{\underline{\geq}} 1.5 \cdot Lg$$

$$b = \{3 - 2 \cdot \exp(-0.18 \cdot V_R)\} \cdot Lg$$

$$c = 0.2 \cdot a$$

$$d = 0.2 \cdot b \dots \dots \dots 0.02 \cdot Lg \underline{\underline{\leq}} Vt$$

$$= \frac{10 \cdot Vt \cdot b}{Lg} \dots \dots \dots 0.02 \cdot Lg > Vt$$

$$Lg = \left(\frac{L_o^2 + L_t^2}{2}\right)^{1/2}$$

, $R_k(X)$:

R_{x_k} : ()

R_{y_k} :

T_{cpa} :

W_{tcpa} : 가

V_R : (m/sec)

V_o : (m/sec)

Vt : (m/sec)

L_o : (m)

L_t : (m)

Lg : ()

X_{ij} :

i, j :

$P_b(X)$ 가 가 가 $R_k(X)$ i, j $u(X)$
 .
 . , 가
 ,

2.3 가(ESA)

가 가 가 가 가
 , , 가 ,
 SJ(Subjective judgement) , BC(Blocking coefficient) , ES(Environmental Stress) 가
 .
 ES 가 .
 ,
 Stress (가)
 Stress(가)
 , 가 Stress Stress .

2.3.1 Stress (ESL value)

가

,
 . ,
 , ,
 , , , 井上
 가
 , 가
 ,
 “ Stress ”(Environmantal stress for
 land) .¹¹⁾ , Stress , ,

1)

Stress

(1)

$\pm 90^\circ$

가

가

90°

가

$\pm 90^\circ$

(2)

가

$\pm 90^\circ$

Stress

(V)

(R)

가 0
 0, 가 0
 (3) 가 (R/V)
 가 가 SJL
 SJL

$$SJL = \alpha \times \frac{V}{R} + \beta \dots\dots\dots < 2.17 >$$

,
 $\alpha = - 0.00092 \times \log_{10}(GT) + 0.0099$, $GT \leq 10,000$
 $\alpha = - 0.006671 \times \exp \{ - 7 \times 10^{-6}(GT) \}$, $GT > 10,000$
 $\beta = - 3.82$

SJL : 가 가

R :

V :

GT :

, :

SJL 가

- +3 :
- +2 :
- +1 :
- 0 :
- 1 :
- 2 :
- 3 :

, SJL 230m ()
 가
 ,
 가 가 .

(Length)
(Blind Zone)
(Short Stopping Distance)

, SJL 가 R
 , 가 가 ,
 (R)
 , SJL 가 가
 R'

$$R' = R \times \left(\frac{Length}{Length} + \frac{Blind\ Zone}{Blind\ Zone} + \frac{Short\ stopping\ Distance}{Short\ stopping\ Distance} \right) \times \frac{1}{3}$$

R'(m) ; 가

R(m) ; 가

(4)

가 . ES
cos(/2) .
가

,
. , 가
가 1 . ,
가 0

,
. ES 가
1, . 110° 0 cos
. , 가 0 가

(5) SJL ±3

, +3 0 0 6 . ,
1° , (1) (4) SJL 가
() SJL ±90° .
Sress , 180×0 = 0 180×6 1000 .

(6) Stress

"Negligible" (ES 500)

"Marginal" (ES 500 750)

"Critical" (ES 750 900)

"Catastrophic"(ES 900 1000)

, "Negligible", "Marginal" 가

2)

, , .
ES ± 90°

가

가

SJL

가

가

가

2.3.2 Stress (ESS value)

Stress 가
 “ Stress ” 가 Stress 가
 가 가 가

(1)

가 가 가

(2)

$\pm 90^\circ$

(3)

$\pm 90^\circ$

()

(1)

(4)

가 가 가
 가 가 가

12)

$$\begin{aligned}
SJS &= \alpha \times (\quad \cdot \quad / \quad) + \beta \\
&= \alpha \times (R / V \cdot V / Lm) + \beta \\
&= \alpha \times (R / Lm) + \beta \\
&= \alpha \times (R') + \beta \\
\alpha &= 0.00192 \times Lm \quad \dots\dots\dots < \quad 2.18 \quad >
\end{aligned}$$

- : = - 0.65 × ln(Lm) - 2.07
- : = - 0.65 × ln(Lm) - 2.35
- : = - 0.65 × ln(Lm) - 2.07
- : = - 0.65 × ln(Lm) - 0.85

- ,
- SJS :
- R :
- V :
- Lm :
- R' : (Lm)
- , :

, SJS 가 .

- +3 :
- +2 :
- +1 :
- 0 :
- 1 :

-2 :

-3 :

, (1) (4)

.

가

() 1°

- 3 + 3

+ 3 0, - 3 6

0 6

, ± 90°

,

0 × 180 = 0

6 ×

180 = 1000

. SJS 0

, - 1

, - 2

, - 3

,

, 0 1000

0 500

Negligible, 500 750

Marginal, 750 900

Critical, 900 1000

Catastrophic

.

2.3.3

가

가

. ± 90°

,

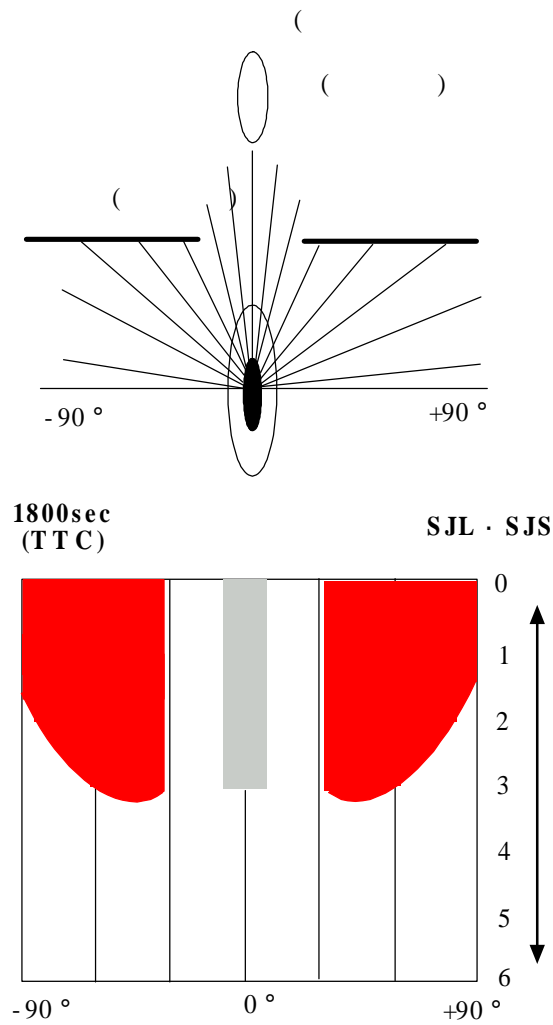
,

.

,

± 90°

< 2.11 > ES



SJ	ES		
0		NEGLI GIA BLE	가
1			
2			
3	500	MAR GINAL	
4	750	CRITI CAL	
5	900	CATA STRO PHIC	가
6	1000		

$$ESL = \sum_{\phi} \{ w_{\phi} (R / V)_{land} \rightarrow SJL \}$$

$$ESS = \sum_{\phi} \{ w_{\phi} (R / V)_{ship} \rightarrow SJS \}$$

$$ESA = \sum_{\phi} \max \{ SJL, SJS \}$$

< 2.11 > ESA

3

3.1

PTMS

Workstation 2

3.1.1

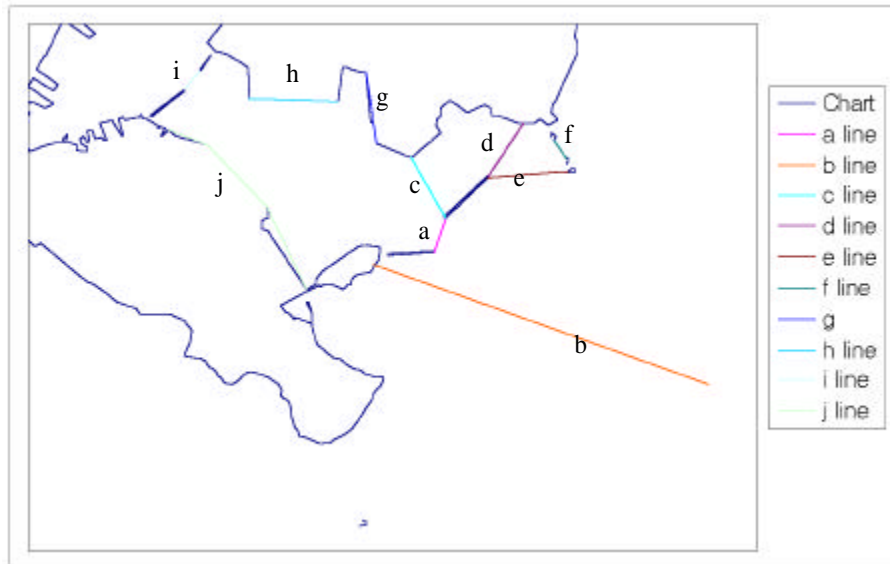
2000 3 28 31 1 7 4
28 . 가
06 : 00 13 : 00 ,
10
28
3 , 4 , 3
2 ,

3.1.2

< 3.1 > a j 10
 , 1 , 2
 , 3

Radar

,
 , OD
 < 3.1 > ,
 가
 PTMS



< 3.1 >

< 3.1 >

			no							
001	3/28	0617	J	In	Ct	L1	5.914	Kyung hae		

【	】	【	】
CG :		SS :	20
PC :		S1 :	20 100
CT :		S2 :	100 300
CC :		S3 :	100 300
GS :		MM :	100 300
TK :	(,)	LL :	100 300
LP :	LPG	L1 :	100 300
LN :	LNG	L2 :	100 300
CF :		L3 :	100 300
PS :		HH :	100 300
JF :		H1 :	100 300
TB :		H2 :	100 300
PB :		XX :	
SG :			
PL :			
SB :	(, ,)		
FB :			
LB :			
AN :			
XX :			

3.2

511

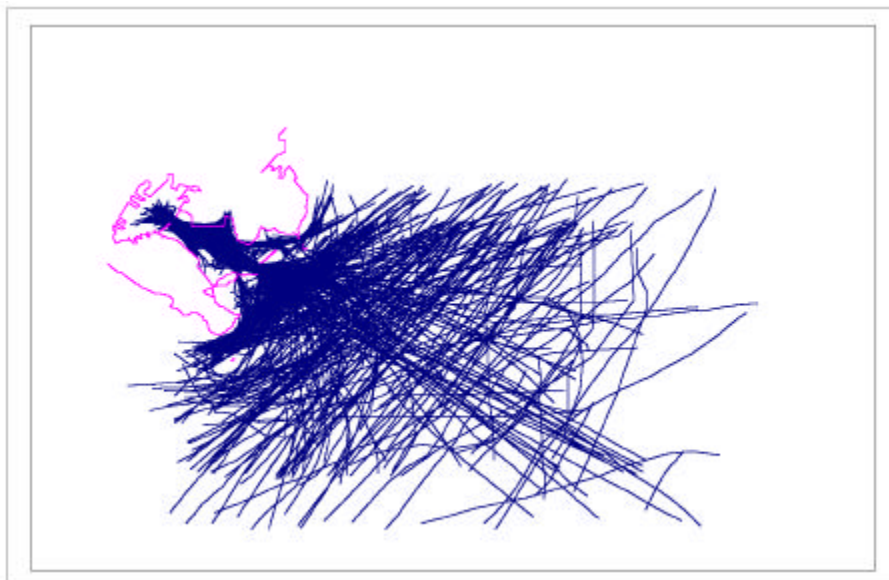
가

277

3.2.1

< 3.2 >

OD



< 3.2 >

OD

, <

3.3 >

<

3.4 >

OD



< 3.3 >

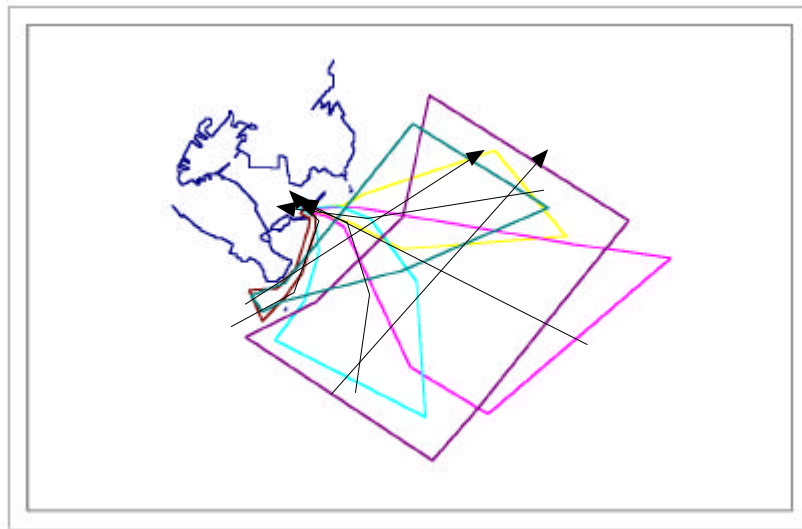
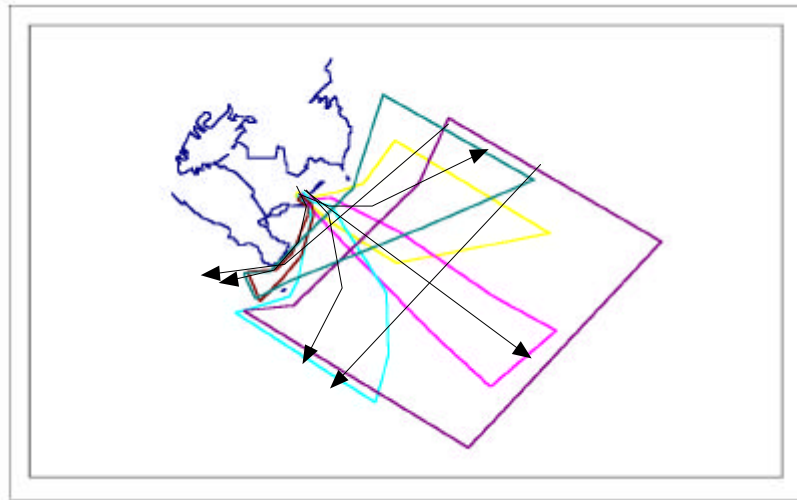


< 3.4 > .

OD

< 3.5 >

12



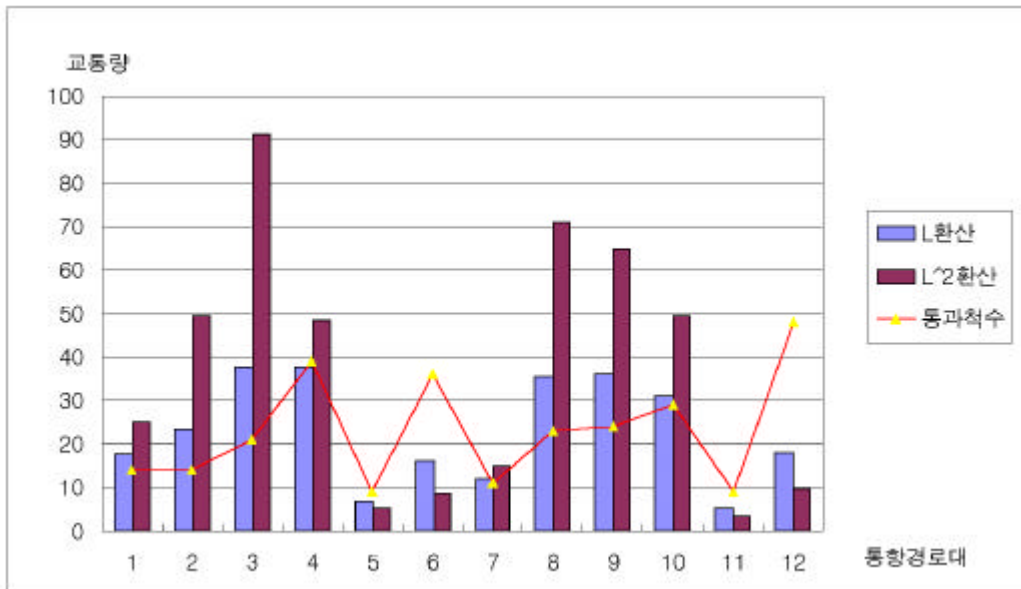
< 3.5 > OD

. < 3.6 >

, L L²

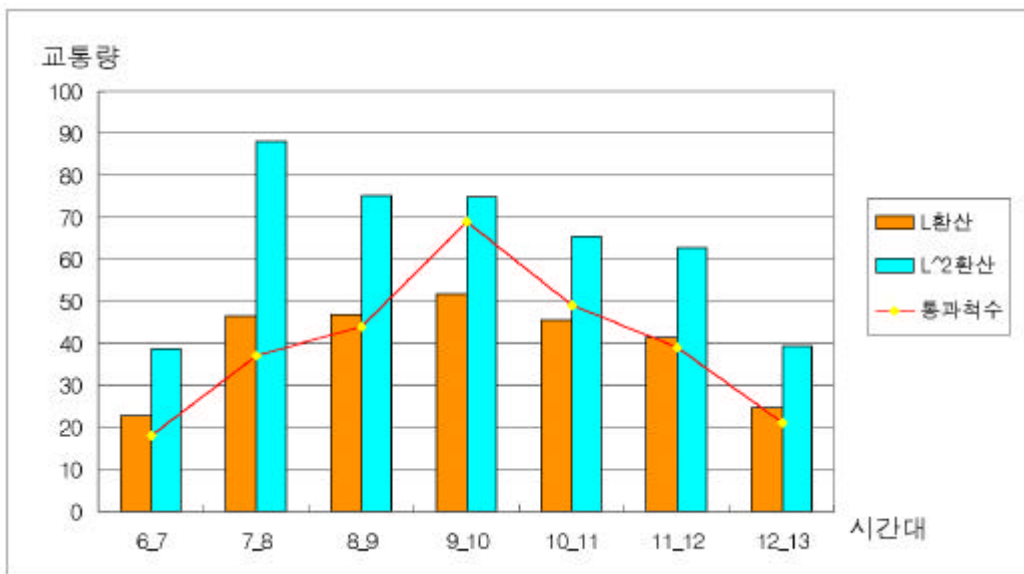
< 3.2 > , L, L² (70m, 21)

	1	2	3	4	5	6	7	8	9	10	11	12	
	14	14	21	39	9	36	11	23	24	29	9	48	277
L	17.62	23.34	37.63	37.63	6.82	15.93	12.15	35.40	35.94	30.89	5.48	18.15	276.98
L ²	25.05	49.20	90.84	48.36	5.38	8.73	14.97	71.4	64.70	49.45	3.43	9.63	441.14



< 3.6 >

1, 06 13
 1 7
 . < 3.7 > . 9
 10 L 가 .



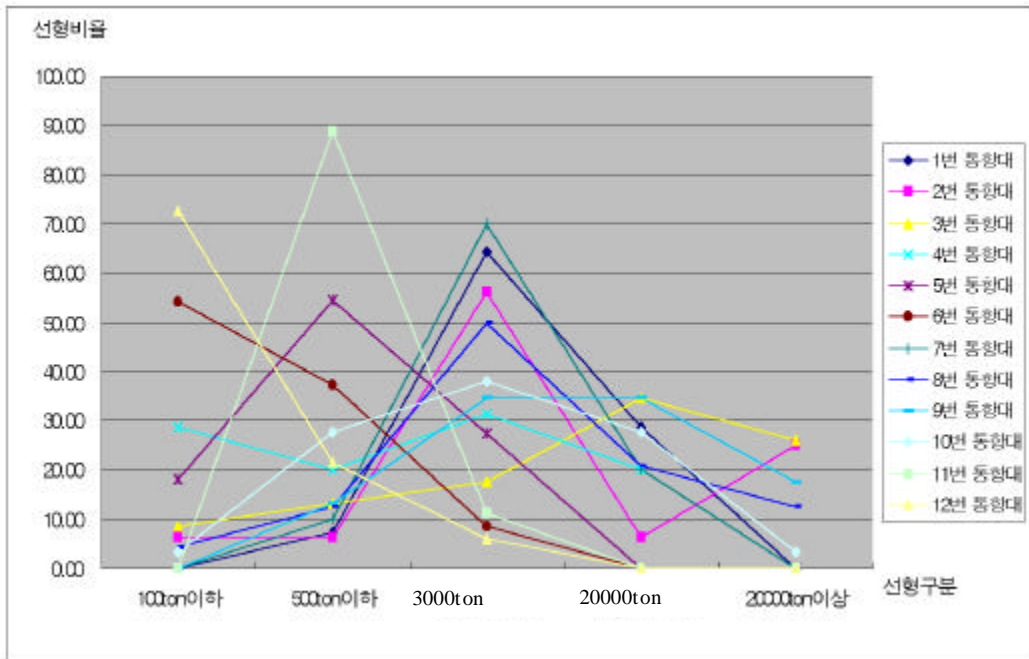
< 3.7 >

3.2.3

3000 , 3000 20,000 , 20,000 100 , 100 500 , 500
 . 5
 . < 3.3 > < 3.8 >
 . 500 3000 가

< 3.3 >

	1	2	3	4	5	6	7	8	9	10	11	12	(%)
100ton	0.0	6.2	8.7	28.5	18.1	54.2	0.0	4.1	0.0	3.4	0.0	72.5	16.3
500ton	7.1	6.2	13.0	20.0	54.5	37.1	10.0	12.5	13.0	27.5	88.8	21.5	25.9
3000ton	64.2	56.2	17.3	31.4	27.2	8.5	70.0	50.0	34.7	37.9	11.1	5.8	34.5
20000ton	28.5	6.2	34.7	20.0	0.0	0.0	20.0	20.8	34.7	27.5	0.0	0.0	16.1
20000ton	0.0	25.0	26.0	0.0	0.0	0.0	0.0	12.5	17.3	3.4	0.0	0.0	7.0



< 3.8 >

4

가

2

< 3.5 >

4.1

gateline

2

3.2.2

가

L

가

3

가

28

9

10 , 29

10

11 , 30

10

11

L

가

< 4.1 >

. 11

0.1

0.1

< 4.3 >

	1	2	3	4	5	6	7	8	9	10	11	12	
	1	1	3	2	0.66	2.33	0.33	2	1.33	2	0.1	1.33	17.08

gate line

< 4.1 >

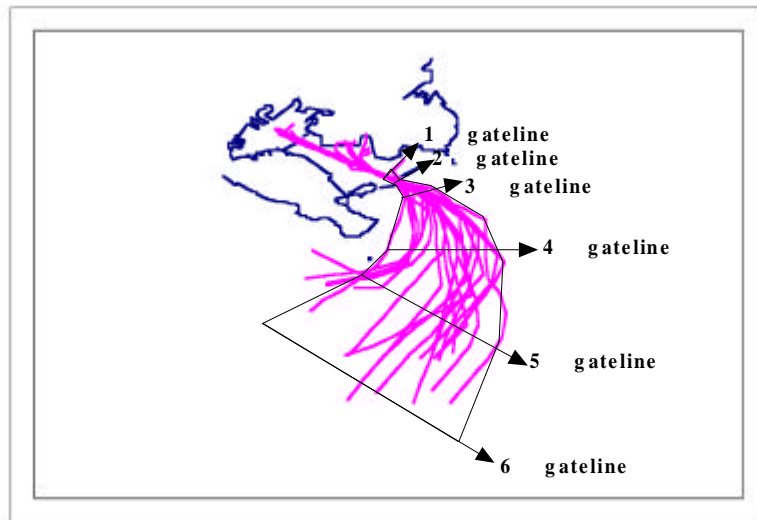
3

gate line

< 4.2 > 3

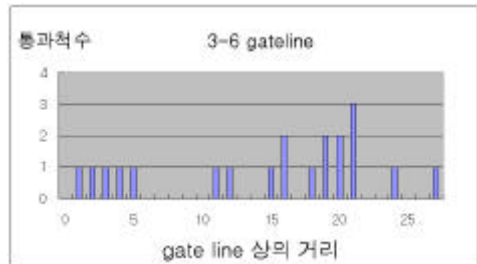
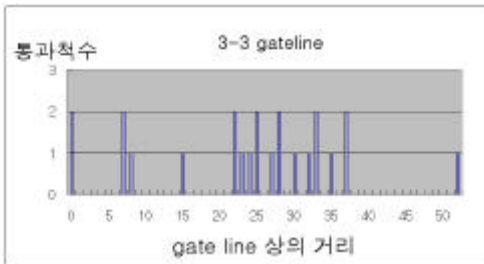
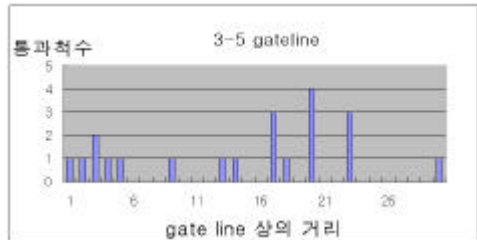
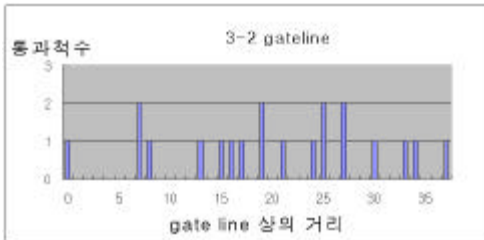
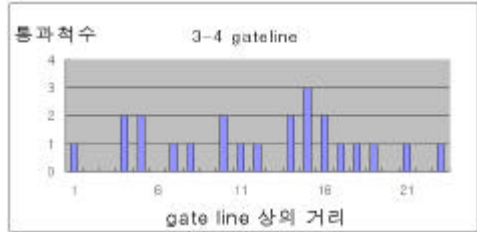
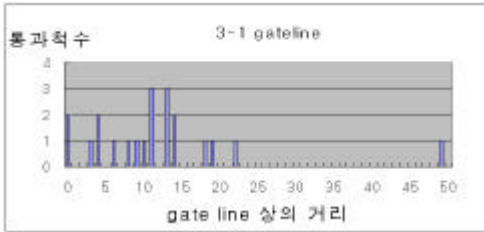
gate

line



< 4.1 > 3

gateline



< 4.2 > 3

gate line

,

. 3

6 gate line

. 3

gate line

,

가 가

,

3-1

3-2 gate line

4

10

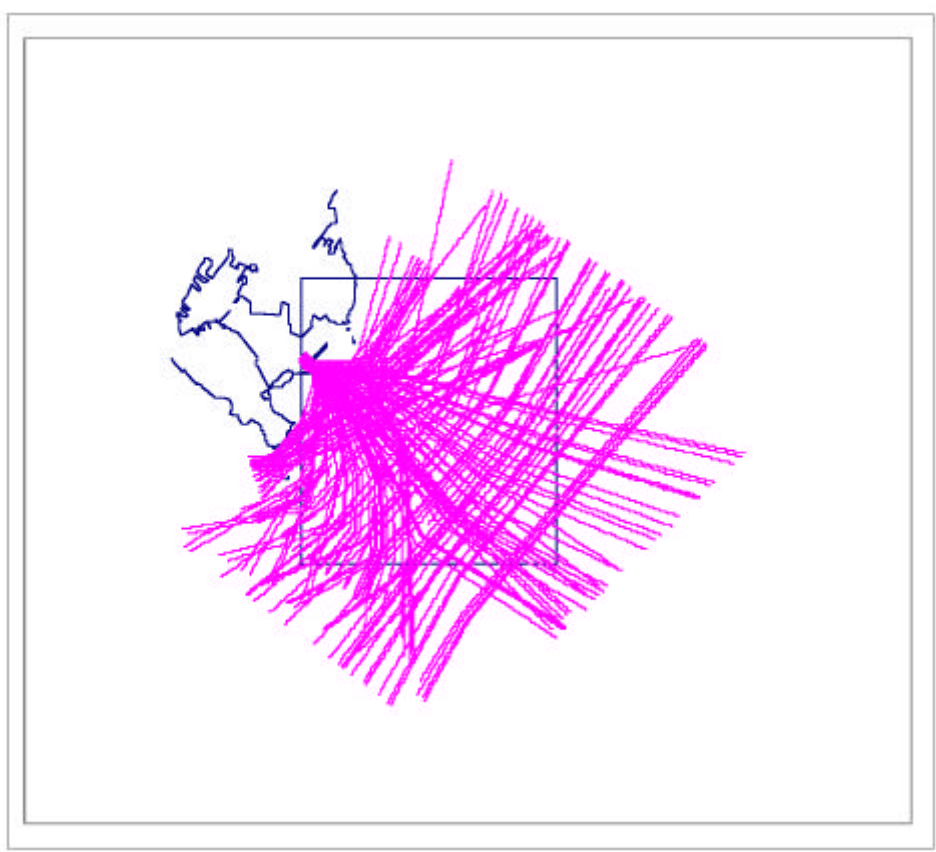
가

L

4.3.1

< 4.3 >

, 가
가 4
가



< 4.3 >

4.3.2

7
 < 4.2 > 159 ,
 . < 4.1 > 가 30%
 . ,
 , 1 가 가 .
 , 1 가
 , 1 1 5 가 가
 가 가
 30% 가 가
 ,
 가 가 .

< 4.4 > (7)

	1	2	3	4	5	6	7	8	9	10	11	12	
	7	7	21	14	4.66	16.33	2.33	14	9.33	14	0.7	9.33	119.68
	12	10	29	19	3	16	3	23	12	20	0	12	159

100ton , 500ton , 3,000ton , 20,000ton ,

20,000ton

< 4.3 >

< 4.5 >

	1	2	3	4	5	6	7	8	9	10	11	12		%
100ton			5	7	3	7		1		2		9	34	21.38
500ton	2		3	6		6		1	3	5		3	29	18.23
3,000ton	6	5	4	5		3	1	16	1	7			48	30.18
20,000ton	4	1	12	1			2	4	7	5			36	22.64
20,000ton		4	5					1	1	1			12	7.54
	12	10	29	19	3	16	3	23	12	20	0	12	159	99.97

4.4

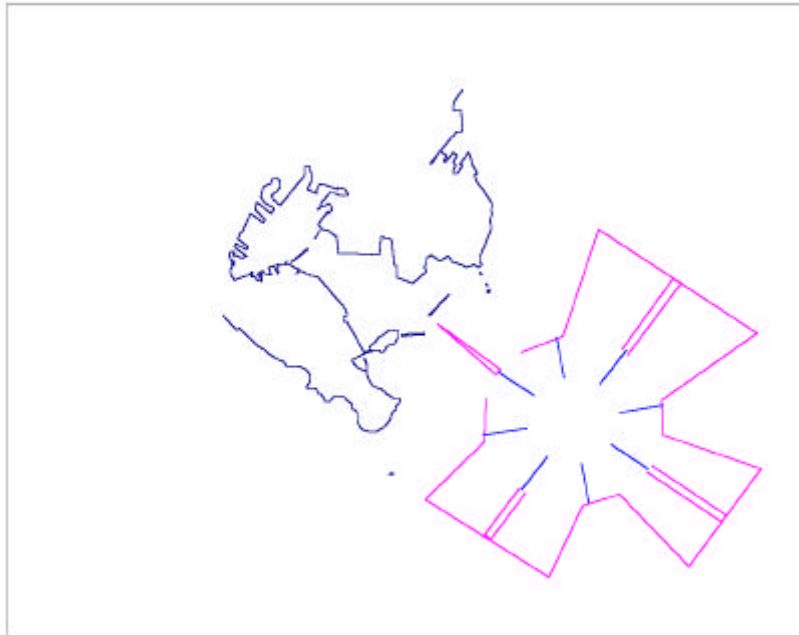
가 가 , 가

. 1998

roundabout

() .¹²⁾ ,

. < 4.4 >



< 4.4 >

4.4.1

500ton

,

500ton

500ton

9, 10

2

500ton

, 500ton

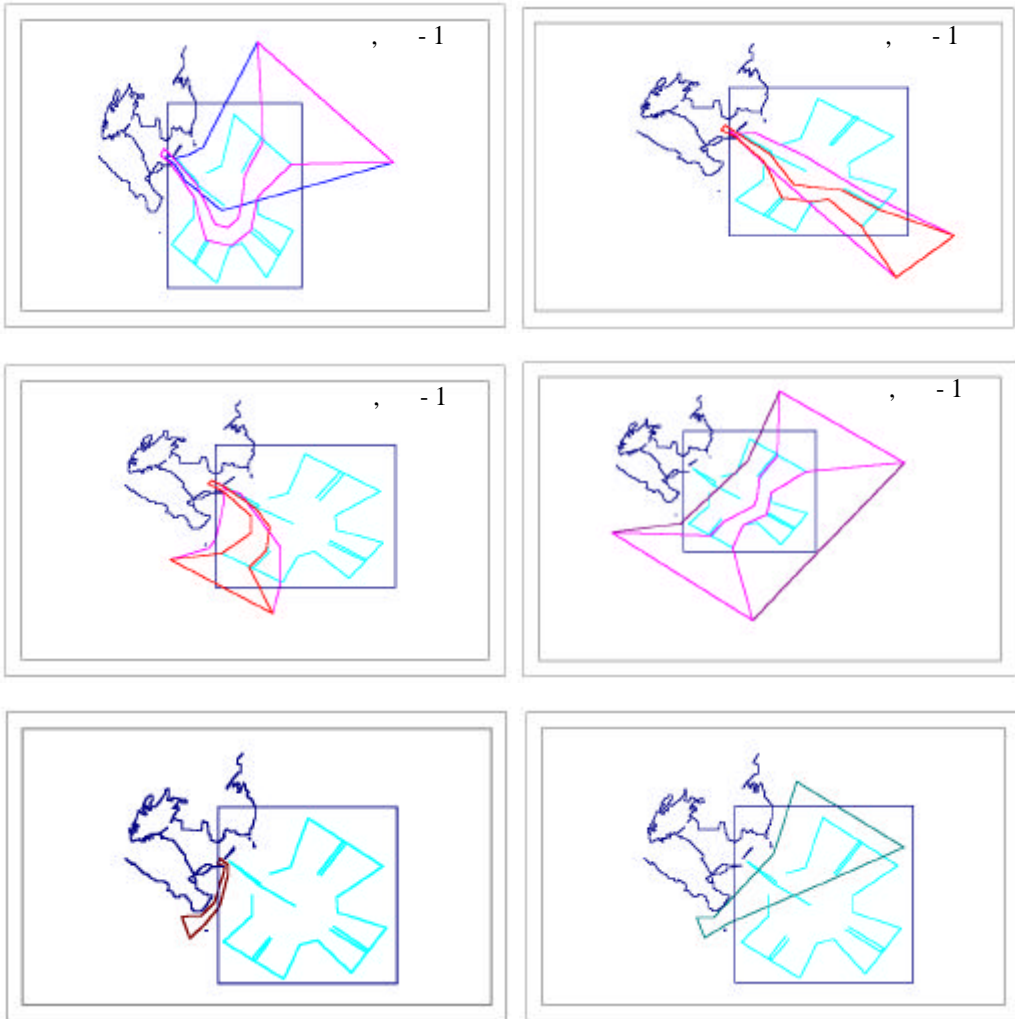
1, 2, 3, 4

7, 8,

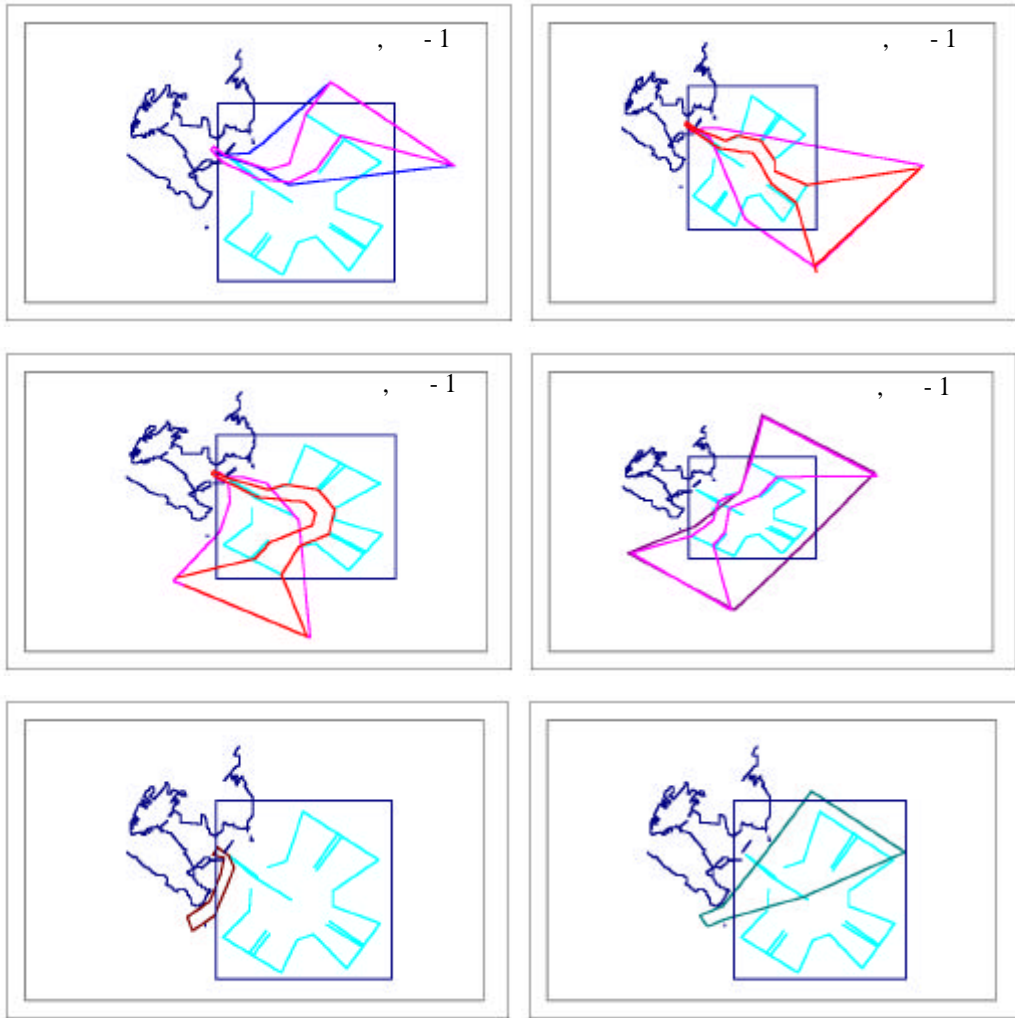
, 5, 6

11, 12

4.5 > < 4.6 >



< 4.5 >



< 4.6 >

< 4.5 > < 4.6 >

12

,

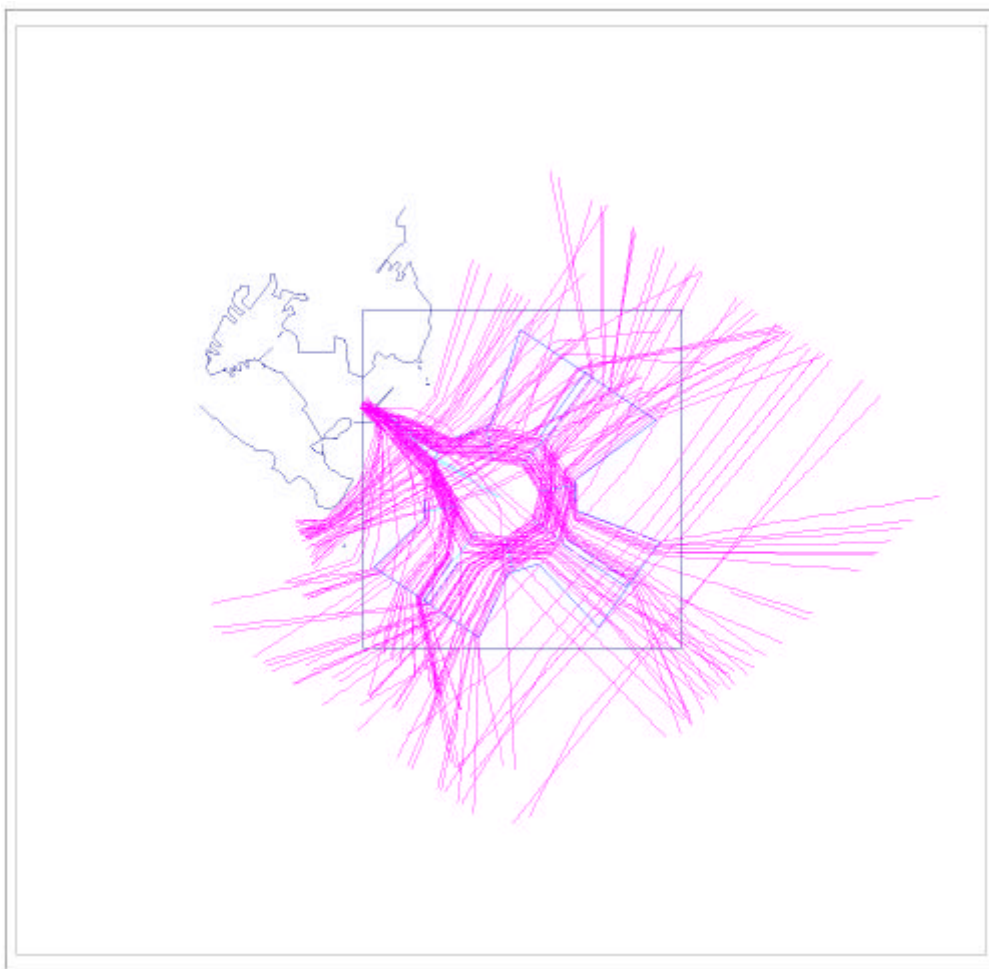
,

20

4.4.2

> 20

< 4.7



< 4.7 >

4.4.3

500ton, data 500ton
 500ton, 1, 2,
 3, 4, 5 7, 8, 9, 10, 11 data 500ton
 , 1- 1,
 2- 1, 3- 1, 4- 1 7- 1, 8- 1, 9- 1 10- 1 500ton
 . < 4.4 > < 4.5 >
 . < 4.4 >
 가 25% .
 .
 1
 5 가 . < 4.5 >
 .
 .

< 4.6 > (7)

	1	1-1	2	2-1	3	3-1	4	4-1	5	6	7	7-1	8	8-1	9	9-1	10	10-1	11	12	
	651	07	616	084	177	455	756	784	336	1631	21	07	1162	231	812	119	966	434	07	91	12138
	11	.	9	4	26	7	5	8	4	15	3	.	18	2	13	2	15	4	.	11	157

< 4.5 > (%)

		1	1 ₁	2	2 ₁	3	3 ₁	4	4 ₁	5	6	7	7 ₁	8	8 ₁	9	9 ₁	10	10 ₁	11	12		%
100 ton		0	0	0	5000	0	4001	0	5900	2500	5900	0	0	0	2500	0	0	0	11.11	0	7700	346.12	1731
		0	0	0	2500	0	2857	0	5000	000	6667	0	0	0	5000	0	0	0	0	0	81.82	302.05	1780
500 ton		0	100	0	5000	0	5999	0	4100	7500	4100	0	100	0	7500	0	100	0	88.89	100	2300	793.89	3969
		0		0	7500	0	7143	0	5000	1000	3333	0	0	0	5000	0	100	0	100	0	18.18	597.94	3520
3000 ton		69.23	0	64.29	0	27.77	0	6800	0	0	0	77.78	0	6000	0	4000	0	5500	0	0	0	522.05	26.10
		63.64	0	66.67	0	26.92	0	8000	0	0	0	0	77.78	0	46.15	0	66.67	0	0	0	0	427.82	25.20
20000 ton		30.77	0	7.14	0	41.26	0	3200	0	0	0	22.22	0	2500	0	4000	0	4000	0	0	0	238.39	11.92
		36.36	0		0	5000	0	2000	0	0	0	66.67	0	16.67	0	53.85	0	2000	0	0	0	263.54	15.50
20000 ton		0	0	28.57		30.95	0	0	0	0	0		0	15.00	0	2000	0	5.00	0	0	0	99.52	4.98
		0	0	33.33		23.08	0	0	0	0	0	33.33	0	5.56	0	0	0	13.33	0	0	0	108.63	6.39

4.5

가

가

가' 5

가

가 가 . 가
 가 ,
 .
 가 2.3
 (ESA) .

4.5.1 가

가 .
 . 가 ,
 ESA ,
 ESA
 .

1) ESA
 , 가 250m .
 . 가 ESA
 ,

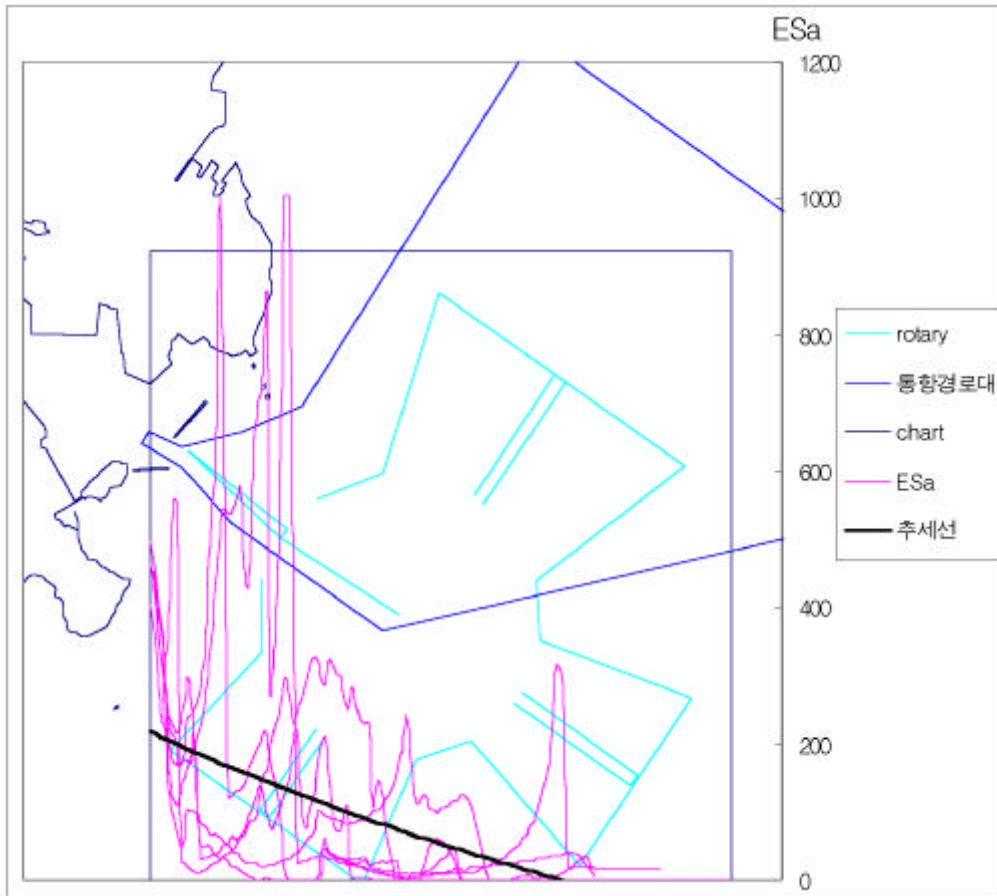
ESA 가 ESA .
 가 ESA 가 .
 < 4.8 > 가 .

2) ESA
 ESA 가 ,
 , 가가 가 . <

4.9 > 1 가
 . , ESA 가 1000 가
 ESA 가 , 가
 Simulation ,



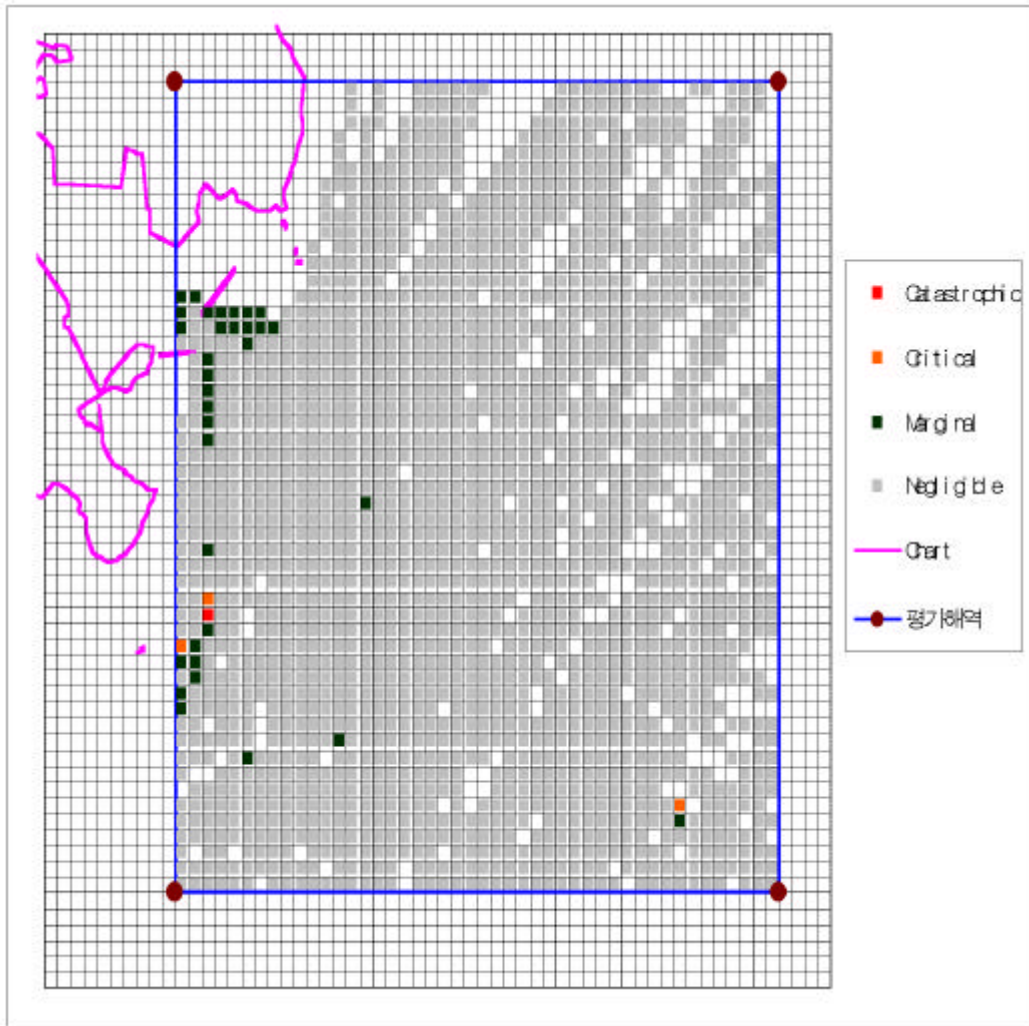
< 4.8 > 가



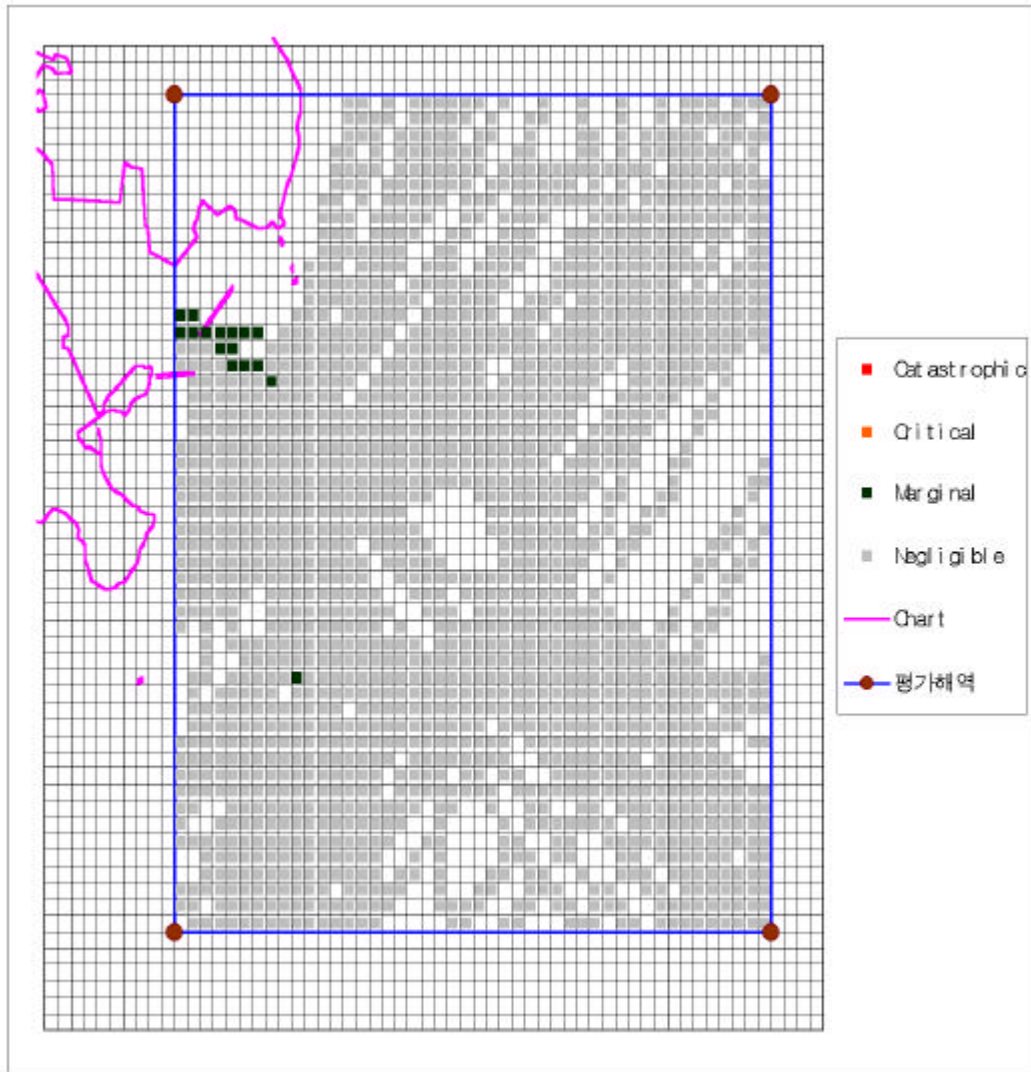
< 4.9 > ESA 가 (1)

4.5.2 가

< 4.10 > < 4.11 >
 가 , 가 250m
 ESA .

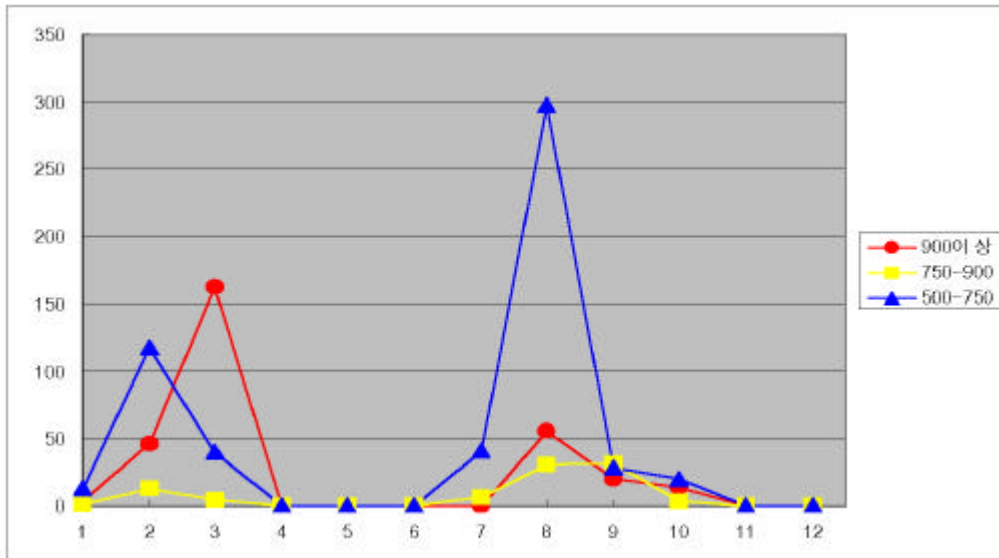


< 4.10 > 가 ESA ()

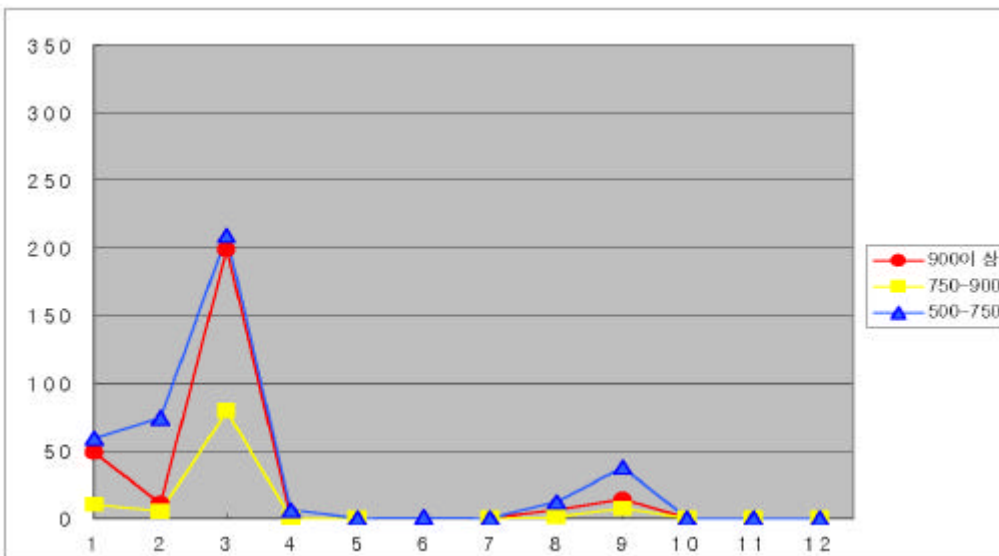


< 4.11 > 가 ESA ()

가 , 1 7
 , 3 9
 ESA
 ESA 가 500 , ESA 가
 가 , 가 ESA
 가 500 750 Marginal 22 , 750 900 Critical
 3 , 900 Catastrophic 1 .
 , 가 ESA 172,194 .
 가 ESA 가 500 750
 Marginal 16 , ESA .
 가 ESA 130,990 .
 ESA 가 15 . , 15
 가
 30 ESA 가 120 .
 15 가 가
 , . 가
 가 가 . < 4.12 > , < 4.13 > 15
 ESA 가 가 , < 4.6 >
 ESA 가 .
 20 , < 4.12 >
 < 4.13 > , < 4.6 > 12



< 4.12 > ESA 가 ()



< 4.13 > ESA 가 ()

< 4.8 > ESA 가 (%)

ESA		1	2	3	4	5	6	7	8	9	10	11	12	
		900	0.37	3.89	6.82	0.00	0.00	0.00	0.00	2.62	1.98	0.83	0.00	0.00	2.25
750-900	0.12	1.10	0.17	0.00	0.00	0.00	2.29	1.41	3.07	0.18	0.00	0.00	0.66	
500-750	1.62	9.89	1.68	0.00	0.00	0.00	15.65	13.96	2.77	1.19	0.00	0.00	4.17	
	2.12	14.88	8.67	0.00	0.00	0.00	17.94	17.99	7.82	2.19	0.00	0.00	7.09	
900	4.12	0.62	7.03	0.00	0.00	0.00	0.00	0.29	0.89	0.00	0.00	0.00	1.85	
750-900	0.84	0.28	2.82	0.00	0.00	0.00	0.00	0.05	0.44	0.00	0.00	0.00	0.68	
500-750	4.97	4.18	7.38	0.53	0.00	0.08	0.00	0.58	2.41	0.00	0.00	0.00	2.65	
	9.93	5.08	17.23	0.53	0.00	0.08	0.00	0.91	3.74	0.00	0.00	0.00	5.19	

, 2, 3 8, 9 가
 , 가 가 ,
 . , 1 3
 가 가
 . 1 3
 , 3
 , 1
 가 가
 .
 ,
 가 가 가
 .

5

5.1

가
가
OD 12
가
12
500ton
500ton
가
500ton
가

12

20

가

ESA 가

가 ,

가

. 가

가

ESA

15

ESA 가

가

2

3

8

9

,

가

가

가

가

가

가

ESA

가

1

9

가

가

가

5.2

가

가

가

Simulation

12knots

, data

가

가

가가

1. , “ ”, , 1998
2. , “ ”, , 1998
3. 藤井、巻島、原、“海上交通工学”、海文堂、1981
4. 井上欣三、“海上交通量の観測日数と精度”、日本航海學會 論文集 50號、1973
5. 井上欣三、“直線航路における航跡分布モデル 航路分離に関する一考察” 日本航海學會論文集 58號、1977
6. 原潔、“輻輳海域における避航操船基準の有效性”、日本航海學會論文集 85號、1991
7. 今津、小山、“避航開始時期の決定について”、日本航海學會論文集 70號、1984
8. 長澤、原、井上、小瀬、“避航操船環境困難度一”、日本航海學會論文集 88號、1993
9. 長澤明、“交通環境評價の具體化”、日本航海學會誌 120號、1994
10. 長澤明、“避航を考慮した海上交通シミュレーション”、日本航海學會學會誌 80號、1984
11. 井上欣三、原潔、金子光浩、増田憲司 “操船者の危険感に基づく操船環境の評價 - 平價指標として環境ストレス値の定義”、日本航海學論文集 95號、1996
12. 井上欣三、久保野雅敬、宮坂眞人、原大地、“危険の切迫に對して操船者が感じる危険感の定量化モデル”、日本航海學會論文集 98號、1998
13. 朴 榮 守、井上欣三、“海上交通管理に関する基礎的研究 一 1”、日本航海學會論文集 103號、2000