Standardisation of Buoy Arrangements in the Korean Navigational Fairway

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INDEX

Contents

1. Overview

Blue-Highway in the Navigational Fairways

Standardisation of Buoy Arrangements ♪

Confirmation of the Visible Range for Buoy Perception ♪

Scientific Aspects
Survey, Sea trials and Simulations

2. Visible Range for Buoy Perception

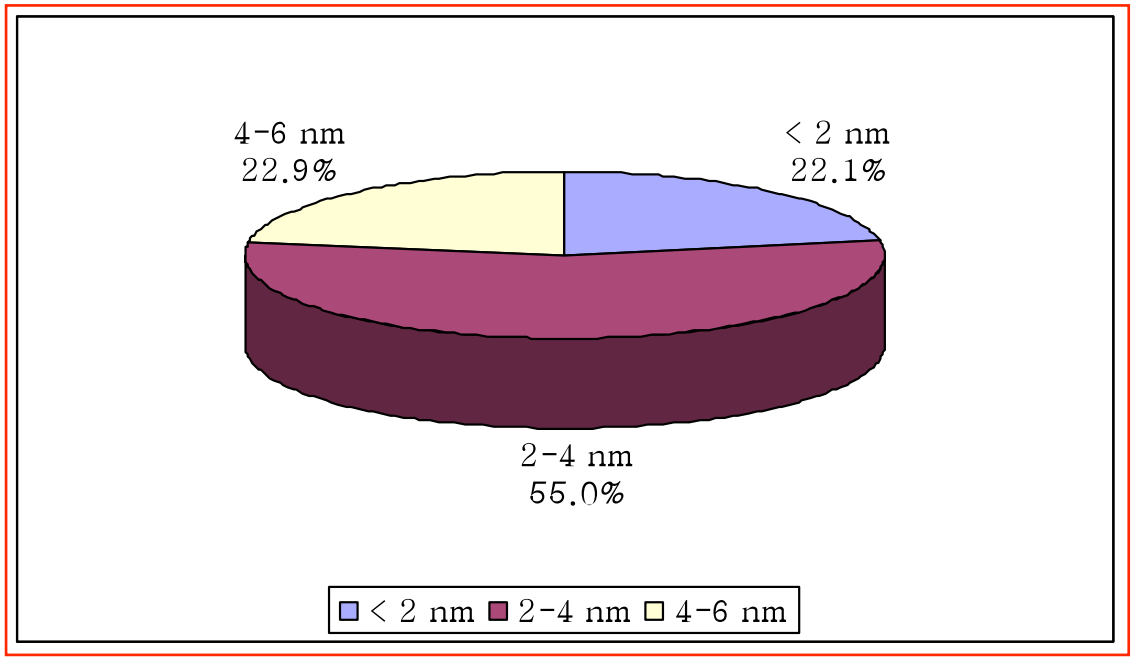
How far from can the mariners recognize a buoy?

- **User Questionnaires**
- **Sea Trials for Visual Perception of Buoy**
- **Simulations for Visual Perception of Buoy**
- **Visible Range for Buoy Perception**

New Concept of **"Background Factor"** *proposed*

User Questionnaires

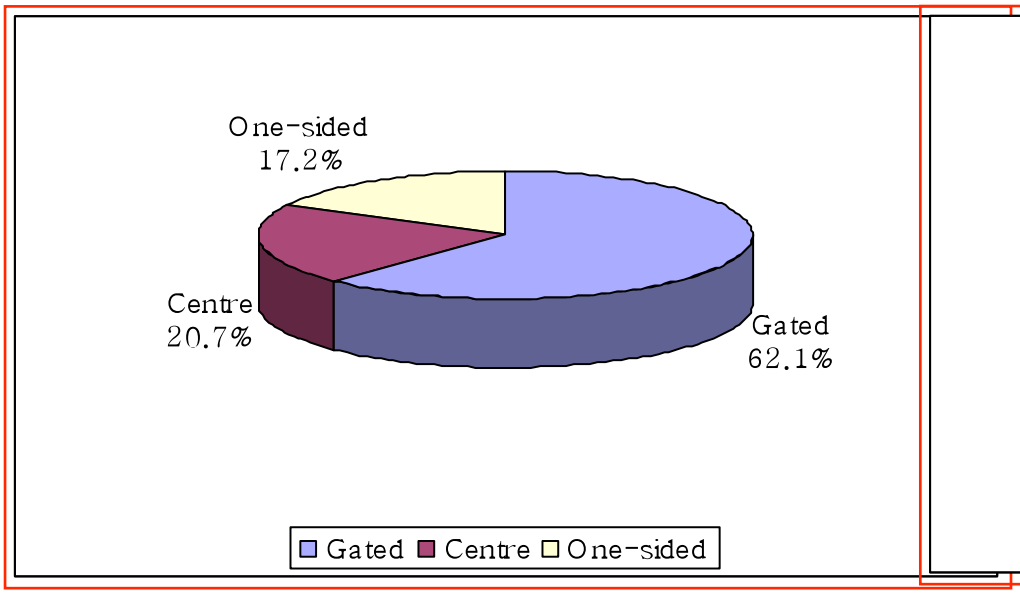
- Period of Survey : September – November 2007
- Subjects : In/Out Fairways of 15 South Korean Trade Ports
- Effectively completed Questionnaires : 131 out of 356



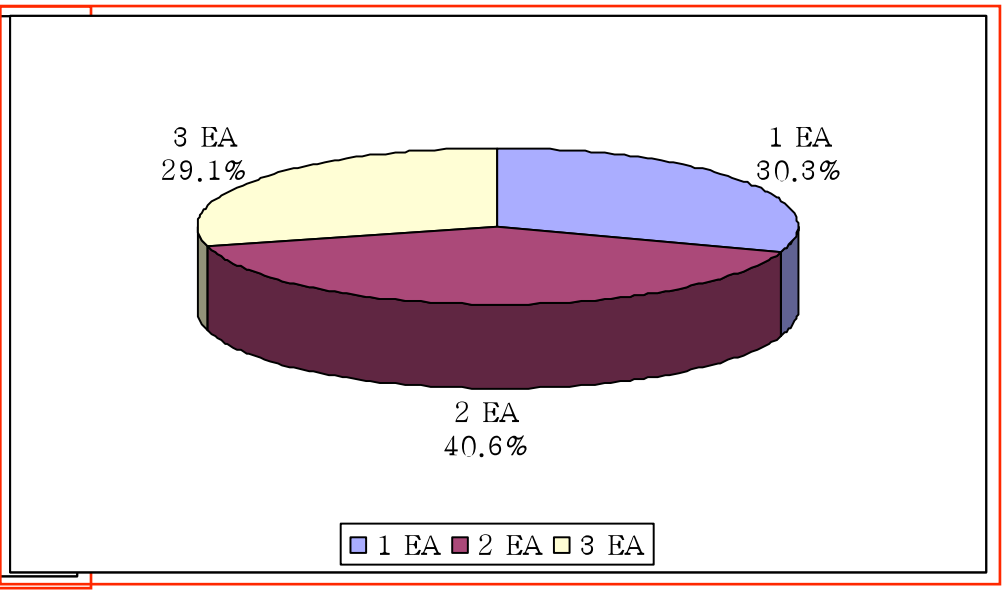
- Corrected or Uncorrected Vision of Ship Officer
- Daytime
- Bright Weather

Visual Perceptive Range

User Questionnaires



Preferred Arrangements of Buoys



Preferred Numbers of Buoys

Preferred Interval between Buoys : 1.09 nm (2,018.7 m)

Sea Trials for Visual Perception of Buoy

Background Factor :

The ratio of the standard visible range and the actual visible range

Equals to 1, when;

- ***fine weather conditions are prevalent***
- ***the height of the observer's eyes equals 15m***
- ***the background for observations is sea***
- ***red floating aids are used***
- ***brightness contrast between the background (sea) and buoy (red): 0.81***
- ***visibility factor: 0.74***
- ***dynamic eye sight: 0.95***

Visible Perception Range

$$l_{d,B} = E_D \times V \times C \times B \times \sqrt{\frac{A}{\tan^2 \theta} - h^2}$$

$l_{d,B}$: Visible Perception Range (on sea surface)♪
Ed : Dynamic Eye Sight♪
V: Factor of Visibility♪
C: Brightness Contrast♪
B: Background Factor♪
A: Cross sectional Area of Floating Aid♪
θ : Angle of Elevation (Sea surface to observer's eye)♪

Sea Trials for Visual Perception of Buoy

Results in Port of Ulsan

Port of Ulsan	LL-26(M)-Red	Theoretic visual range	Reflected upon Height of Eye	Reflected upon Visibility (×0.74)	Reflected upon Brightness Contrast (×0.81)	Reflected upon Dynamic Sight (×0.95)	Measured (m)	Background Factor
	H 15m	3867.46	3867.43	2861.90	2318.14	**2202.23**	**2222**	**1.0090**
	H 3m	3867.46	3867.43	2861.90	2318.14	2202.23	1296	0.5885
						Average	1,759	

Results in Port of Busan

Port of Busan	h 4m	Theoretic visual range	Reflected upon Height of Eye	Reflected upon Visibility (×0.74)	Reflected upon Brightness Contrast	Reflected upon Dynamic Sight (×0.95)	Measured (m)	Background Factor
	LL-26(M)-Red	3867.46	3867.46	2861.92	(×0.81) 2318.14	**2202.23**	**1766.67**	**0.8022**
	LL-26(M)-Green	3867.46	3867.46	2861.92	(×0.65) 1860.25	**1767.24**	**1933.33**	**1.0940**
						Average	1,850	

Simulations for Visual Perception of Buoy

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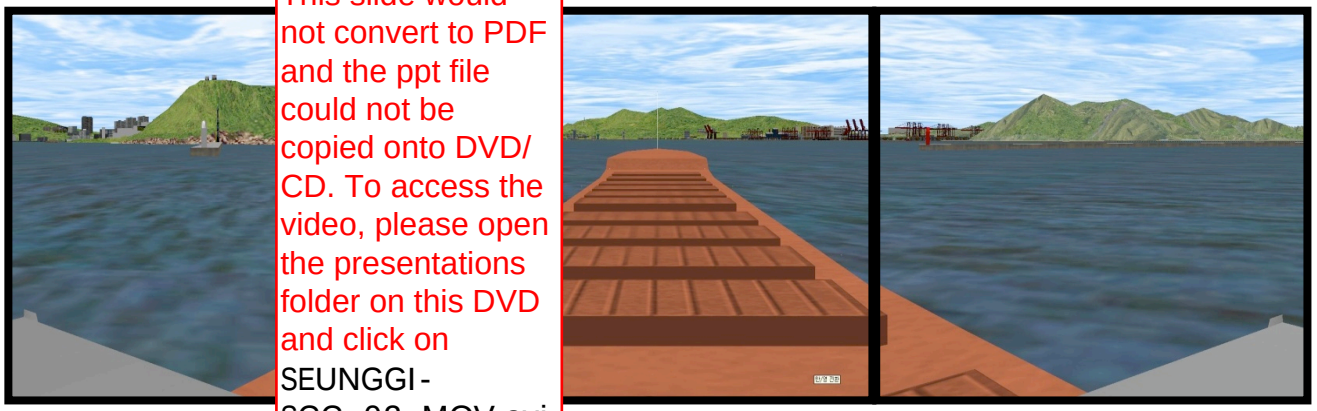
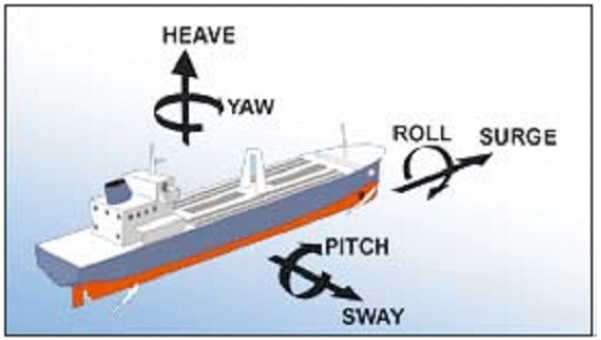
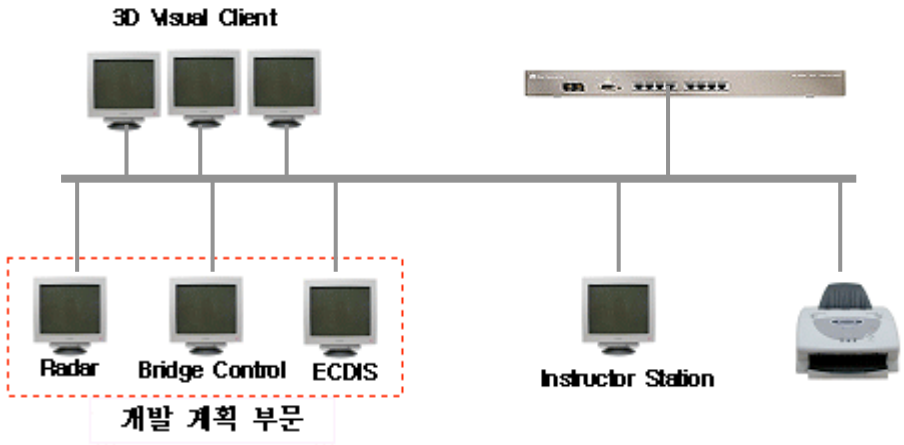


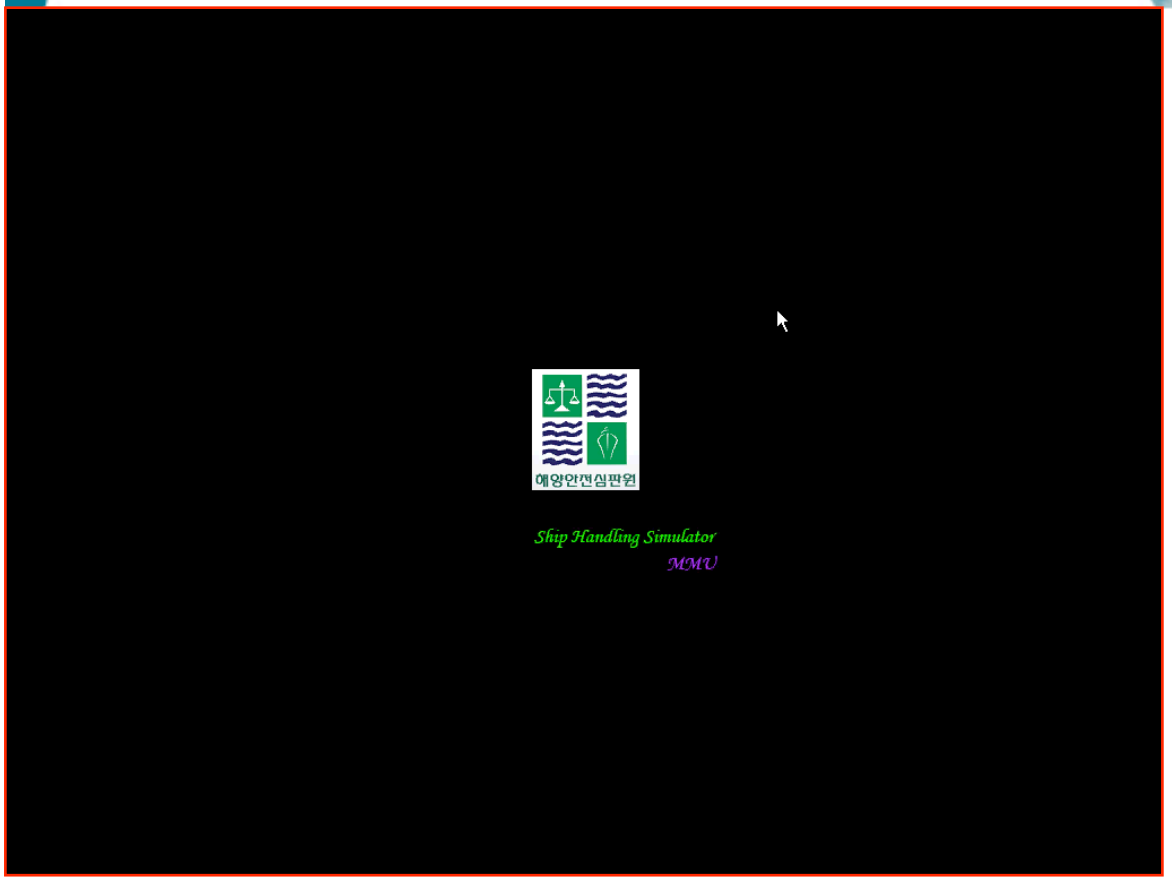




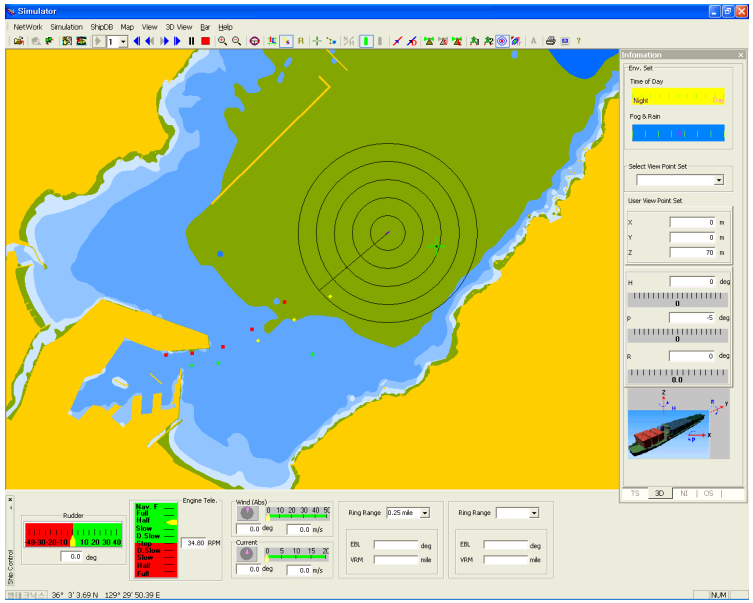
Ship Handling Simulator

- Conning Console
- Visual Monitor with 3 Channels
- Mathematical Models
- Printer
- Electronic Navigation Chart (ENC) converter

Simulations for Visual Perception of Buoy



- Observing point: 1.2m
  from the monitor
- Model ship
  . LOA: 122m
  . Width: 19m
  . Depth: 15m
  . DWT: 7,000tons



Simulations for Visual Perception of Buoy

Results of Visual Perception (experienced)

	Green (m)	Red (m)
Group E1	1,225	1,881
Group E2	1,336	2,085
Group E3	1,683	2,650
Mean	1,424	2,206
	1,815	

Results of Visual Perception (non-experienced)

	Green (m)	Red (m)
Group N1	683	922
Group N2	1,076	1,430
Mean	880	1,176
	1,028	

User Questionnaires : 2,021 m

Sea Trials : 2,222 m (RED, h : 15m)

Simulations : 2,206 m (RED, Experienced)

Theoretic Range : 2,202m (Dynamic)

Optimum Perception Range for Buoy

Optimum Perception Range based on the "Background Factor"

L_{op} : Optimum Perception Range

$l_{d,B}$: Theoretical Perception Range (in standard condition) 2202.23m

Background Factor : 0.9818

$$L_{op} = \frac{\sum_{1}^{131} L_i}{131} = 2020.86$$

$$L_{op} = 0.918 \times l_{d,B}$$

Standard Interval between Buoys

I : Standard Interval between Buoys

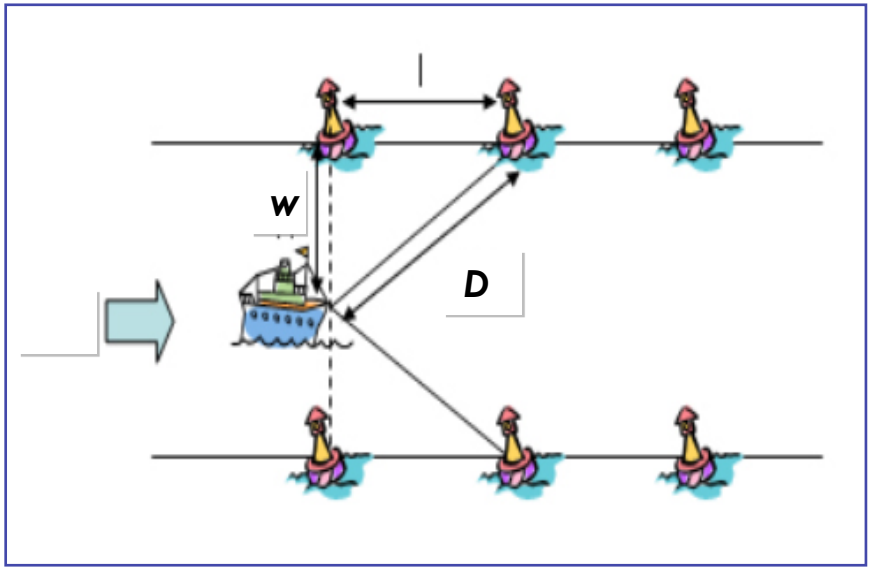
D : Optimum Perception Range (2,021 m)

w : ½*Width of Fairway (in case of 1,000m)

$$I = \sqrt{D^2 - w^2} = D\left(1 - \left(\frac{w}{D}\right)^2\right)^{\frac{1}{2}}$$

$$= D\left(1 - \frac{1}{2}\left(\frac{w}{D}\right)^2 + \cdots\right) \cong D - \frac{w^2}{2D}$$

$$\approx 1.1(nm)$$

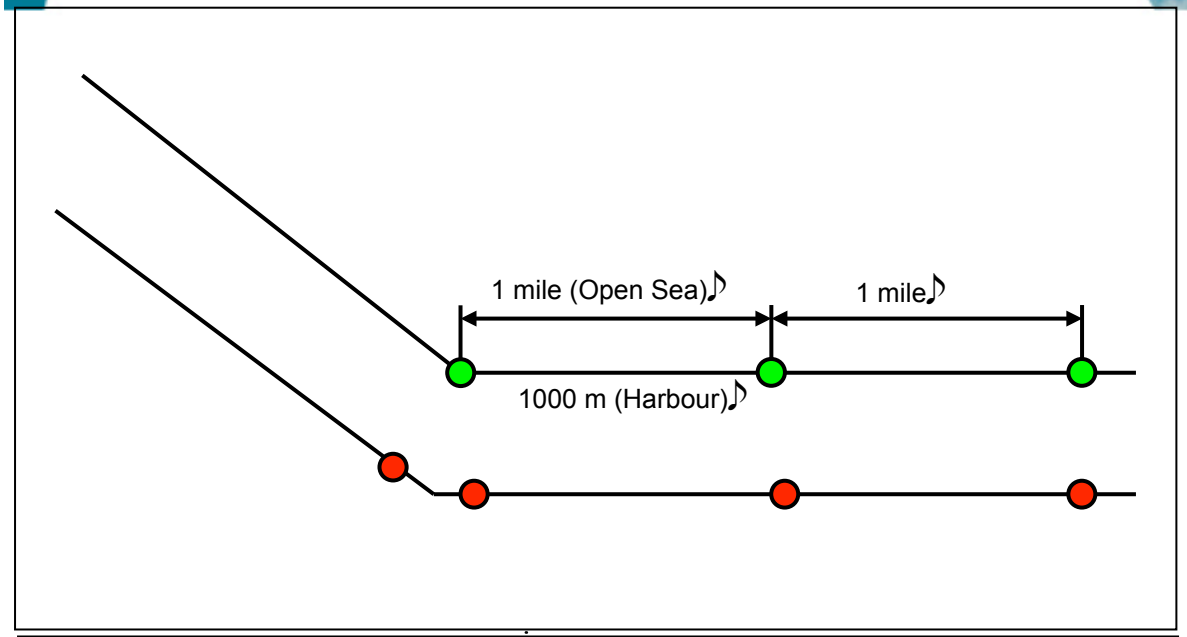


3. Standardisation of Buoy Arrangements

General Proposals

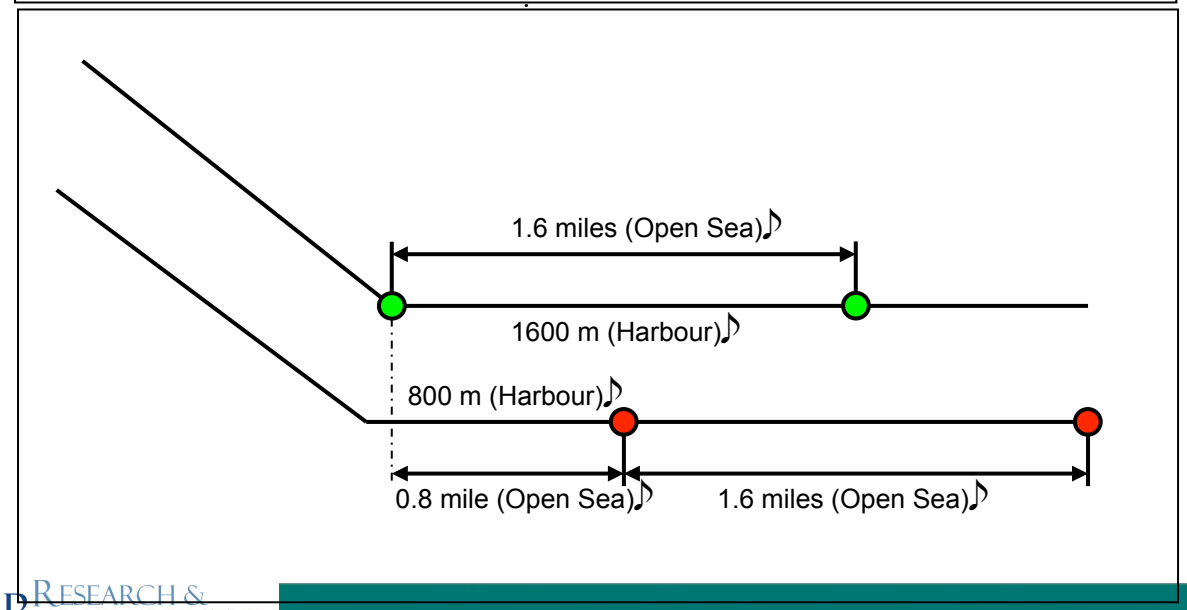
- Gated Arrangements of paired buoys should be utilised
- Buoys should be consecutively arranged to be perceived
- Be arranged to make equidistant and symmetrical characteristic
- Lighted Beacon can be used in order to mark dangers, change of course
- Be numbered sequentially (Numbering, Flash rhythm)

Standardisation of Buoy Arrangements



Gated Buoy Arrangement

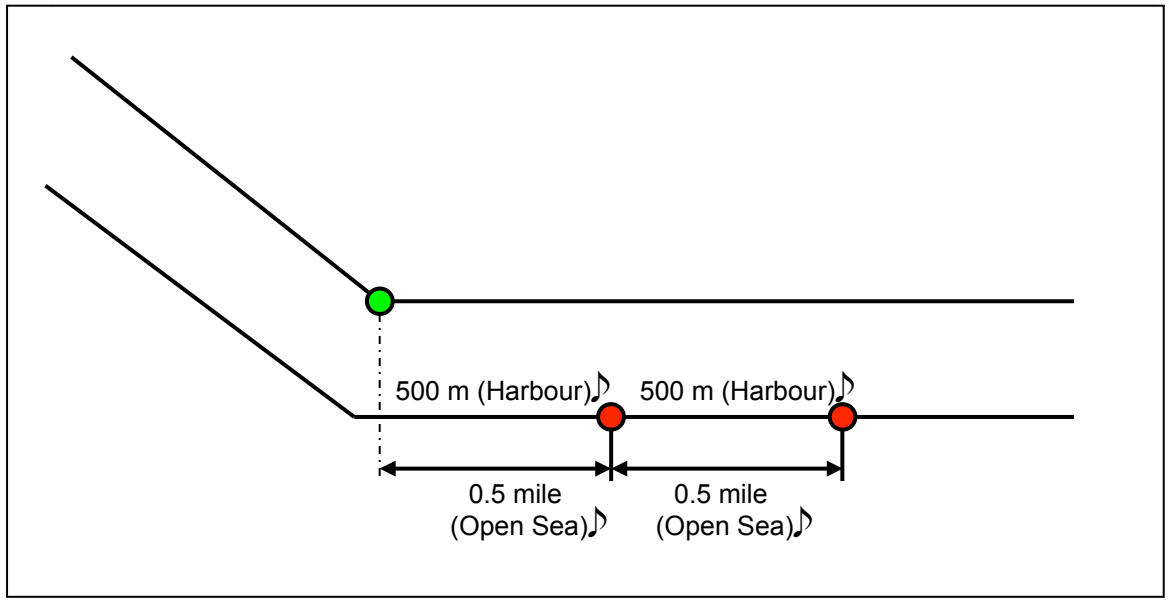
- 1 nm (in Open Sea)
- 1,000 m (in Harbour)



Staggered Buoy Arrangement

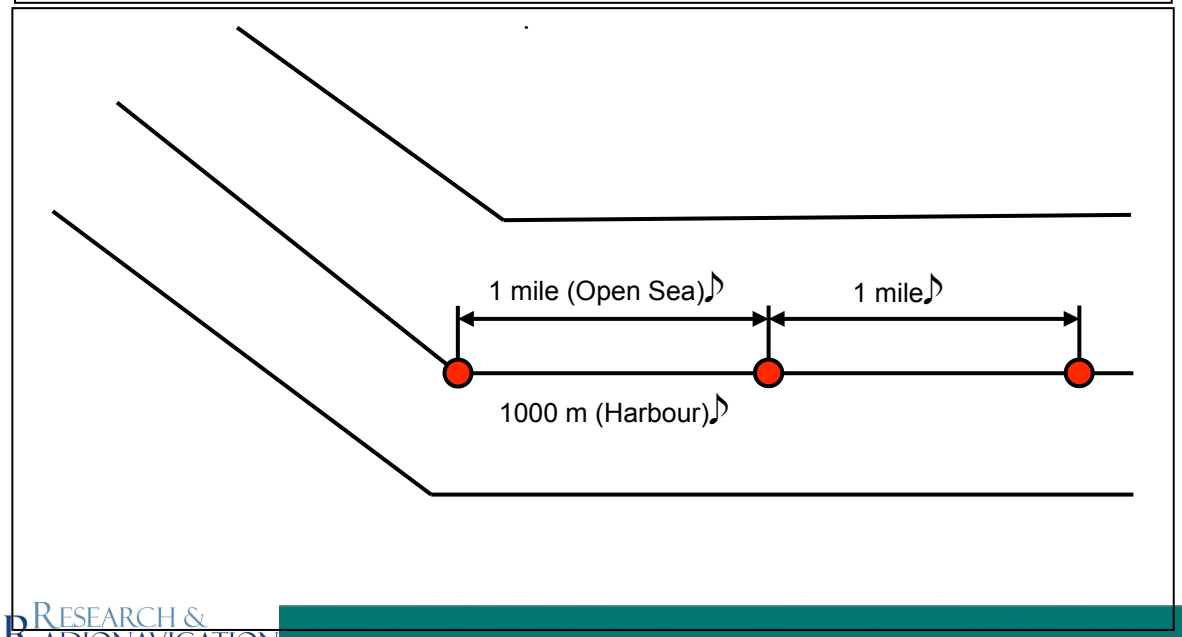
- 0.8 nm (in Open Sea)
- 800 m (in Harbour)

Standardisation of Buoy Arrangements



One Sided Arrangement

- 0.5 nm (in Open Sea)
- 500 m (in Harbour)



Single Centred Arrangement

- 1 nm (in Open Sea)
- 1,000 m (in Harbour)

4. Conclusions

Standardisation for Buoy Arrangements *In South Korean Navigational Fairways*

- To determine the optimum standard arrangements for buoys, various attempts for the visible range of buoy perception had been done
- After classifying the navigational fairways, a standard arrangement of buoys in the fairways was proposed
- Provides a substantial understanding of buoy perception and arrangements (reliable, efficient and cost effective buoyage service)
- Further work regarding the “Background Factor” needed (sea trials, simulations etc)

Thank you for your kind attention!