



# MSc Thesis

Improve safety at sea by increasing  
the situational awareness of the crew

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 **TU Delft**

**DAMEN**

WINCH AREA



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MSc Thesis

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# Notes

# Preface

# Abstract

# Glossary

## Abbreviations

**AIS** Automatic Identification System

**AMS** Alarm Management System

**CAM-HMI** Central Alert Management Human Machine Interface for presentaiton and handling of alerts

**CFD** Computational Fluid Dynamics

**DOF** Degrees of freedom

**DP** Dynamic Positioning

**ECDIS** Electronic Chart Display Information System

**ENC** Electronic Navigational Chart

**IEC** International Electrotechnical Commission

**IHO** International Hydrographic Organization

**IMO** International Maritime Organization

**MARPOL** International Convention for the Prevention of Pollution from Ships

**SOLAS** International Convention for the Safety of Life at Sea

**STCW** International Convention on Standards of Training, Certification and Watch-keeping for Seafarers

**TEU** Twenty foot Equivalent Unit

**UID** User Input Device

**VHF** Very High Frequency radio

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# **1 | Introduction**

## **1.1 Research background**

## **1.2 Problem statement**

## **1.3 Research questions**

## **1.4 Scope**

including boundaries

## **1.5 Thesis structure**

## **2 | Current knowledge**

### **2.1 Accidents**

### **2.2 Current projects**

#### **2.2.1 Shipping industry**

#### **2.2.2 Bridge**

### **2.3 Shipping crew**

**Part I**

**Maritime Technology**

# Introduction

Question: What certainty on the location and route of another vessel is needed, to avoid collision, panic and need for communication?

Hypothesis:

## 3 | Manoeuvring capability

Ship manoeuvring is the ability to keep course, change course, keep track and change speed. Minimal requirements are given by International Maritime Organization (IMO) standard. However, shipowners may introduce additional requirements. Ship manoeuvrability is described by the following characteristics:

- Initial turning ability (start turning)
- Sustained turning ability (keep turning)
- Yaw checking ability (stop turning motion)
- Stopping ability (in rather short distance and time)
- Yaw stability (ability to move straight ahead)

During sea-trials these capabilities can be determined. However this project will aim at predicting manoeuvrability while using limited input. Thereby is there a difference between the maximum limits and what a ship is likely to do. This will eventually lead to the possible movements of the vessel.

### 3.1 IMO standard

The manoeuvrability of a ship is considered satisfactory if the following criteria are complied:

1. *Turning ability.* The advance should not exceed 4.5 ship lengths (L) and the tactical diameter should not exceed 5 ship lengths in the turning circle manoeuvre.
2. *Initial turning ability.* With the application of 10° rudder angle to port or starboard, the ship should not have traveled more than 2.5 ship lengths by the time the heading has changed by 10° from the original heading.
3. *Yaw-checking and course-keeping abilities.*

(a) The value of the first overshoot angle in the 10°/10° zig-zag test should not exceed:

- i. 10° if  $L/V$  is less than 10 seconds
- ii. 20° if  $L/V$  is 30 seconds or more
- iii.  $(5 + 1/2(L/V))$  degrees if  $L/V$  is between 10 and 30 seconds

where L and V are expressed in m and m/s, respectively.

(b) The value of the second overshoot angle in the 10°/10° zig-zag test should not exceed:

- i. 25° if  $L/V$  is less than 10 seconds

- ii.  $40^\circ$  if  $L/V$  is 30 seconds or more
- iii.  $(117.5 + 0.75(L/V))$  degrees if  $L/V$  is between 10 and 30 seconds
- (c) The value of the first overshoot angle in the  $20^\circ/20^\circ$  zig-zag test should not exceed  $25^\circ$ .
- 4. *Stopping ability*. The track reach in the full astern stopping test should not exceed 15 ship lengths. However, this value may be modified by the Administration where ships of large displacement make this criterion impracticable, but should in no case exceed 20 ship lengths.

## 3.2 Limits

These standards give guidance during seatrials, but won't help much. What are maximum values for manoeuvring capability. Based on trial run are values found for Nomoto (other theories?)

Wat is constant? Versnelling/vertraging of de afgeleide daarvan

Clarke, D., Gedling, P. and Hine, G. (1983). The application of manoeuvring criteria in hull design using linear theory. *The Naval Architect*, pp. 45–68

## 3.3 Desired capability

What are normal movements for a ship of a specific size

## 3.4 Expected route

Ship will most likely keep sailing straight and on same speed

## 3.5 Input

Nomoto, more detailed is Norrbins equation

### 3.5.1 Detailed capability

Key equipment for the manoeuvrability are rudders, fixed fins, jet thrusters, propellers, ducts and waterjets. However it is not practical to determine this for every ship which is nearby. Therefore a more statistical approach is taken using comparable ships.



### **3.5.2 Prediction with limited data**

Own vessel input comes from sea-trial, other vessels based on received information via AIS. DWT, L, B, speed, etc.

## 4 | **Filter situation**

Input from static objects shown on the map

### **4.1 Traffic separation schemes**

input from local authorities

### **4.2 Navigational aids**

map/radar/etc.

### **4.3 Accepted probabilities**

Which probabilities can be ignored to speed-up calculation

### **4.4 Other filters**

Significant wave height/ weather/ windspeed

## **5 | Safe motion parameters**

### **5.1 Regulations**

Existing COLREGs, local regulations,

### **5.2 Well-clear**

can also be rephrased to acceptable distance, safe behavior, etc. Depends on captain, company, etc. Also based on assumptions of Marin or other literature.

### **5.3 Visualization**

Research of szlapczynski Describe the desired input and output

## **6 | Probability index**

### **6.1 Input**

What is needed from safe motion parameters and manoeuvring capability

### **6.2 Map for other vessels**

### **6.3 Predicted capability envelope**

## 7 | Visualization

### 7.1 Determine closes point of approach

Method to define if something is a hazard. Incorporate well-clear from previous chapter.

### 7.2 Hazards

Pin-point hazards, to show why a route is most likely.

### 7.3 Routeplanner

What is most likely the route. Based on high probability, combined with low probability other vessels.

# **Part II**

## **Computer Science**

# Introduction

Question: Which communication and parameters are necessary to enable the crew to make the right decisions, during critical situations entering a port?

Hypothesis:



## 8 | Information at the bridge

The bridge of a vessel can be separated into four elements. The human operator, procedures, technical system and the human-machine interface. This chapter will focus on the technical system and human-machine interface. Thereby a separation will be made between the instruments available, the information which can be deduced from this and how this can be used.

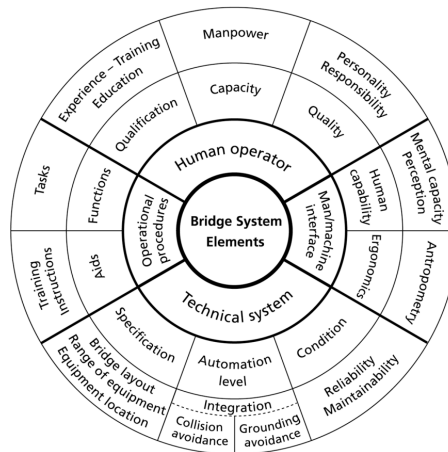


Figure 8.1: Bridge system elements

The ship's navigation bridge shall enable the officer in charge of the navigational watch to perform navigational duties unassisted at all times during normal operating conditions. He shall be able to maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make full appraisal of the situation and the risk of collision, grounding and other hazards to navigation.

### 8.1 Instruments

At least the following instruments and equipment shall be installed [DNV GL(2011)]:

- |                                          |                                              |
|------------------------------------------|----------------------------------------------|
| • Navigation radar with radar            | System (ECDIS)                               |
| • Propulsion control                     | • Steering mode selector switch              |
| • Manual steering device                 | • VHF unit                                   |
| • Heading control                        | • Whistle and manoeuvring light push buttons |
| • Other related User Input Device (UID)s | • Internal communication equipment           |
| • Electronic Chart Display Information   | • Central alert management system            |

- General alarm control
- Window wiper and wash controls
- Control of dimmers for indicators and displays
- Propulsion
- Emergency stop machinery
- Gyrocompass selector switch
- Steering gear pumps

What do regulations say about systems which should be on board

## 8.2 Parameters

Which information really comes from instruments at the bridge

## 8.3 Usage

Which parameters are relevant for the crew

## **9 | Communication**

### **9.1 Systems for communication**

Which systems or instruments are available, for which communication.

### **9.2 Protocols**

What do protocols prescribe and what are thoughts behind this. Based on regulations and education.

#### **9.2.1 Regulation**

What is stated in regulations.

#### **9.2.2 Education**

What is thought on schools.

### **9.3 In practice**

How does communication take place in practice? Find out by discussing with seafarers.

# 10 | Mental model

## 10.1 Situational awareness

What is situational awareness and how is it achieved.

## 10.2 Shared between ships

Based on the communication, what is known on all ships. Difference between ships (flagstate, origin of crew, etc.)

## 10.3 Master and crew

Considerations of the crew at own vessel

### 10.3.1 Thought process

What steps does the crew take in their head

### 10.3.2 Desired input

What do they need to take good decisions

### 10.3.3 Information overload

What if you give them too much

# 11 | Possible decisions

## 11.1 Considerations

How to presents list of possible decisions

## 11.2 Test with seafarers

Test to validate if addition help

### 11.2.1 Set-up

### 11.2.2 Results

# **Part III**

## **Wrap-up**

## 12 | Results

Describe results when both researches are combined. Do they support each other.



## **13 | Conclusion**

**13.1 Answers to research questions**

**13.2 Recommendations for future research**

# Bibliography

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