MSc Thesis

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

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TU Delft

DAMEN

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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

Contents

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

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 is 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°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°/20°zig-zag test should not exceed 25°.

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 Input

There is a lot of literature written on the manoeuvrability of vessels. The used parameters have a big influence on the quality of the prediction. Therefore different methods are discussed, using different input parameters. Mostly based on the information which can be acquired from own vessels and others in the area. Detailed analysis use often Computational Fluid Dynamics (CFD) or equilibrium of forces. Using a digital version of the hull. However these are expensive calculation. Thereby do these theoretical calculation not add value to determine what a ship really does in practice. For this most classification societies prescribe a set of tests at the sea-trial. For example turning circles, Z-manoeuvrer, spiral manoeuvrer, pull-out manoeuvrer, williamson turn, stopping and backwards. These different test show the limits on which a ship can sail.

3.2.1 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.

Shiptypes

Nomoto, more detailed is Norrbin equation

3.2.2 Prediction with limited data

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

3.3 Limits

What are maximum values for manoeuvring capability. Based on trial run are values found for Nomoto (other theories?)

3.4 Desired capability

What are normal movements for a ship of a specific size

3.5 Expected route

Ship will most likely keep sailing straight and on same speed

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

8 Information at the bridge

8.1 Instruments

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