RAMS
Reliability, Availability,
Maintainability, and Safety

Thesis Title

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PROJECT

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Preface

Some preface.

Trondheim, 2012-12-16

(Your signature)

Ola Nordmann

Acknowledgment

I would like to thank the following persons for their great help…

O.N.

(Your initials)

Summary and Conclusions

...

Contents

Chapter 1

Introduction

Introduction to the problem, some background about the Survey Explorer project..

1.1 Background

Where do we stand? What has been done before?

Problem Formulation

Literature Survey

What Remains to be Done?

...

1.2 Objectives

The main objectives of this project are

1. Investigate existing solutions for HIL testing of autonomous boat
2. Describe implementation of sensors and data processing on Odin and/or Jolner for situational awareness above the surface.

3. Discuss complexity and solutions related to simulation of raw sensor data from Radar, Lidar and camera versus simulation of pre-processed data.
4. Specify interface between simulator and autonomous navigation system.
5. Specify system for logging and visualization of simulation in real-time and for post simulation analysis.
6. Necessary protyping in C++ and MATLAB to verify assumptions.
7. Investigate which other agents (ships, small boats etc.) that can be interesting to implement as a part of the simulation environment.
8. Discuss methods for using the model as a part of an automized test environment related to ROS, MROS, scripting, repetition and regression testing.

1.3 Limitations

1.4 Approach

1.5 Structure of the Report

The rest of the report is organized as follows. Chapter 2 gives an introduction to ...

Chapter 2

Existing Solutions

This chapter goes through some of the existing tools used for HIL simulations of marine systems. The key properties of each tool are listed, and an evaluation is made about the possibilities of using the tools in the implementation of our own simulation environment.

2.1 CyberSea Simulator

The CyberSea Simulator developed by Marine Cybernetics is an advanced simulator for HIL testing of Dynamic Positioning (DP) systems. It is *probably* super expensive (how can i investigate this?) and mainly focused on motion dynamics of big vessels at low speed (less than 3kts).

Key properties of the CyberSea Simulator [1]:

- Capabilities for real-time presentation of results.
- Emphasis on vessel dynamics and accurate simulation of vessel motion during DP.
- Advanced simulation of wave, wind and current loads in six degrees of freedom.
- Several options for practical interfaces between simulator and computer control system, both analog and digital using for example NMEA protocol or normal network protocol.
- Generation of realistic signals from all the common sensors and position reference systems such as *"Gyro-compasses, VRUs, wind sensors, thruster feedback [...], power feedback*

[1] Johansen et al. (2005)

from thrusters, switchboard and generator sets"[2] used in modern DP technology. The signals can also be contaminated with noise levels typical for the sensors in use.

- Advanced generation of GNSS signals with possibility of simulating a broad specter of common failure modes.

The CyberSea Simulator, although powerful and highly customizable, is probably too expensive to use as a part of our simulation environment. It is also not certain to which extent the simulator can simulate other active agents such as ship traffic for testing of collision avoidance.

2.2 Marine Systems Simulator (MSS)

The Marine Systems Simulator (MSS) is a free toolbox for MATLAB/Simulink developed by Thor I. Fossen and Tristan Perez at the Norwegian University of Science and Technology (NTNU). It is a merge of 3 previously existing toolboxes: Marine GNC Toolbox, Marine Cybernetics Simulator (MCSim) and DCMV. The toolbox contains possibilities for modeling of the dynamics of ships, underwater vehicles and floating structures under different wave, wind and current conditions.

Key properties of MSS [3]:

- Good modularity in Simulink.
- Emphasis on vehicle dynamics and thereby well suited for developing good motion control of such vehicles.
- Can be set up to do HIL simulations.
- Possibility of 3D animation using Marine Visualization Toolbox.

The Marine Systems Simulator is free and well suited for simulation of marine vehicle dynamics. It is likely that this toolbox can be used as a part of our simulation environment to simulate Odins motions and possibly for 3D animations of such dynamics.

[2] Johansen et al. (2005)
[3] Perez et al. (2006)

2.3 MCSim (Marine Cybernetics)

Now part of MSS, not really useful to research this?

2.4 Gazebo (ROS)

Looks interesting. Even has done some research on this...

Chapter 3

Implementation and Simulation of Sensors

3.1 Sensors Implemented on Odin

A brief description of the sensors on Odin used for situational awareness above the surface. How is the data processed?

3.1.1 Radar

...

3.1.2 Lidar

...

3.2 Generating Virtual Sensor Data

How to generate realistic sensor data during simulation. Discuss complexity and benefits regarding generating raw data versus preprocessed information.

3.2.1 Generating Data from Virtual Environment

Using maps of sea and coast line, information of other simulated agents and 3D models of installations in sea (for example harbors) to decide what the sensors "see".

3.2.2 Raw vs Preprocessed Sensor Data

Complexity and benefits regarding generating raw data versus preprocessed information.

Chapter 4

Simulator - HIL interface

4.1 Physical Interface

4.2 Software Interface

4.2.1 Necessary Exchange of Information

4.2.2 Message Protocol

Chapter 5

Logging and Visualization of Simulation

5.1 Logging

5.2 Visualization

5.3 C++ example?

Chapter 6

Use of Model in Autonomous Testing Environment (ROS)

Chapter 7

Other Agents and their Behavior as Part of Simulated Environment

7.1 Possible Agents

7.1.1 Ships

7.1.2 Small Boats

7.2 Pros and Cons of Agents Behavior

7.2.1 Reactivity?

7.2.2 Predictability

7.2.3 Possibility of Repeating Scenario

Chapter 8

Summary and Recommendations for Further Work

8.1 Summary and Conclusions

8.2 Discussion

8.3 Recommendations for Further Work

Appendix A

Acronyms

FTA Fault tree analysis

MTTF Mean time to failure

RAMS Reliability, availability, maintainability, and safety

Appendix B

Additional Information

This is an example of an Appendix. You can write an Appendix in the same way as a chapter, with sections, subsections, and so on.

B.1 Introduction

B.1.1 More Details

Bibliography

Johansen, T. A., Fossen, T. I., and Vik, B. (2005). Hardware-in-the-loop testing of dp systems. Technical report, Marine Cybernetics, Norwegian University of Science and Technology, Trondheim, Norway.

Perez, T., Smogeli, Ø., Fossen, T., and Sørensen, A. (2006). An overview of the marine systems simulator (mss): A simulink toolbox for marine control systems. Technical report, Norwegian University of Science and Technology (NTNU).