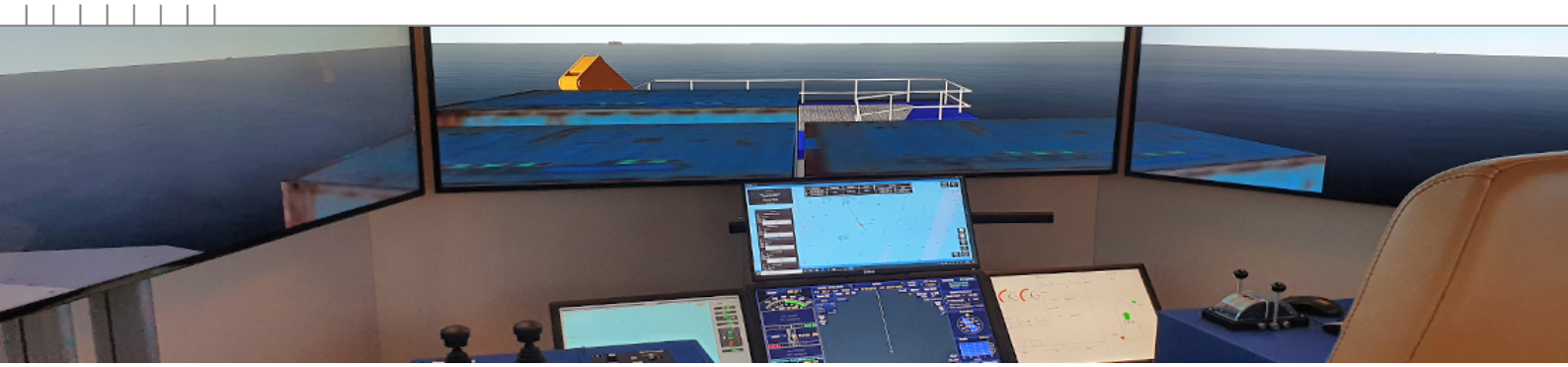


Collision Avoidance Testbed

Joint Industry Project

Worldwide a substantial effort is spent on the development of collision avoidance systems for use in the maritime sector. What is currently lacking is a structured, well-defined and broadly accepted methodology to test and validate the performance of these systems. It is MARIN's objective, as an independent organisation, to jointly develop this standard, to further extend it and support it in the future.

Stakeholders

- Governmental authorities
- Classification societies
- Port Authorities
- Pilots
- Collision Avoidance system product developers & suppliers
- Integrated Bridge system product developers & suppliers

Related MARIN experience

- MARIN has extensive experience in developing maritime simulation systems. These systems are internally used for engineering studies, model testing in the MARIN facilities and in operator training on MARIN's full mission bridge simulator.
- Analysis, advice and assessment of safety of marine traffic, maritime operations and port layouts.
- Evaluation of navigational performance of human operators both on bridge simulators and at sea.

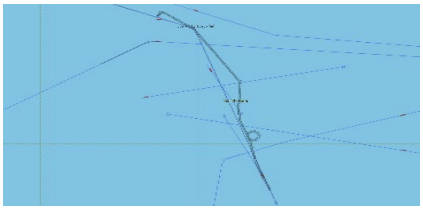
Background

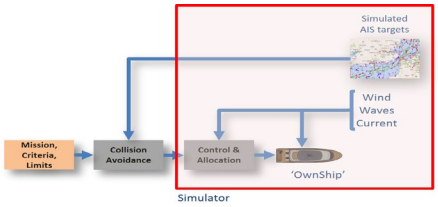
An important requirement for autonomous ships will be the ability to safely interact with other shipping. For this they need to be equipped with sensors and algorithms to detect and evaluate traffic situations and to make correct and safe decisions in accordance with the governing rules.
Eventually these systems have to proof themselves at sea in all kind of situations. However, tests at sea are costly to organise, repeatability is not guaranteed and environmental conditions cannot be controlled. Fast-time simulation based tests, on the other hand, do not suffer from these drawbacks. Repeatability can be guaranteed, environmental conditions can be accurately controlled and with a proper setup (and sufficient computer hardware) a significant number of scenario's can be evaluated in a relatively short time. This makes simulated tests not only effective but thorough as well. An important requirement is that the simulation models for the maritime environment, the ship(s) and its equipment represent the reality sufficiently accurate and that the evaluation system is effective in determining the safety level of the interaction with other ships.

Objectives

Within this project we would like to jointly develop:

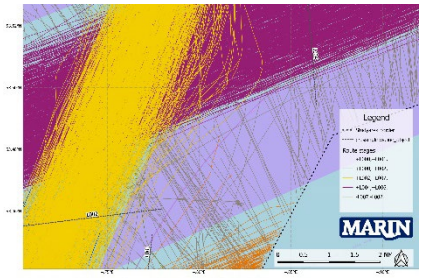
- a testbed to evaluate collision avoidance systems;
- criteria for safe and COLREGs compliant behaviour;
- a methodology to create a set of representative and distinctive scenarios.

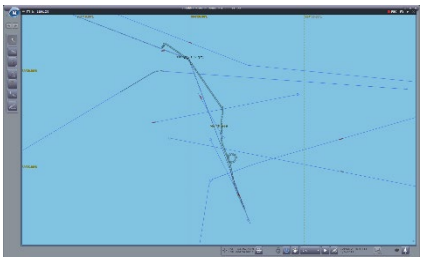




Deliverables

- A uniform approach for testing collision avoidance systems based on the safety of ship encounters and COLREG compliancy. The C/A assessment can also be used on board or for the evaluation of trainees on a bridge-simulator.
- A method for generating relevant test scenarios and realistic target behaviour.
- A set of industry accepted criteria for COLREG compliance and safe behaviour for use in the testbed, based on AIS studies and expert sessions.
- The availability of a test environment for autonomous systems.





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Approach

- In this Joint Industry Project a testbed will be build, based on the MARIN X-simulation environment. The testbed will consist of several modules:
  - The **simulator environment**, which provides a realistic nautical environment together with ships and their relevant equipment;
  - A **scenario generator** in which realistic, but also extreme conditions are included to create distinctive tests. A scenario describes amongst others the weather, current, waves and shipping activity (number of ships and behaviour of ships);
  - An **assessment module**, that quantifies the performance of a C/A system based on the results of a set of scenarios using a defined set of criteria. The program will include a study to define the evaluation criteria and the influence of sensor performance on the C/A performance.
- The C/A system to be evaluated will be included as Hardware/Software in the Loop, and interfaced with the simulated own ship using standard protocols. This will allow the C/A system to steer the vessel in the simulator environment. Using the software in fast-time mode or on a cluster will allow for the evaluation of many scenarios in a limited time period. The ability to speed up the process will be crucial for scenario sensitivity analyses requiring a large number of scenarios to be evaluated. It will require a different, yet to be defined, setup of the C/A system to be tested.
- An important delivery of the JIP is the creation of a representative set of maritime traffic scenarios. The scenarios will include situations that allow for an evaluation of all Collision Regulations (COLREGs) under various metocean conditions and in various areas with different vessel density. A methodology will be defined to vary the scenario parameters in an intelligent way for the purpose of a sensitivity and robustness test.
- The JIP will study how the influence of sensor performance and sensor fusion algorithms can be taken into account. The aim is to include these effects on the C/A system in a numerical way.
- AIS data will be used to determine realistic traffic situations. For the target vessels a parameterized captains' decision mimic will be developed to create realistic interactions between simulated targets. These target vessels behave in accordance with the COLREGs, but in some cases may also deviate to test the systems robustness.

  The AIS data will also be used to determine the benchmark for safe and COLREG compliant behaviour in a specific area. Together with simulator sessions in which scenarios are studied by experts we will establish the criteria and their safe limit values for use in the testbed.
- A dedicated Collision Avoidance Assessment Module will evaluate the performance of the own ship. Each ship encounter will be assessed on safety and compliancy with the COLREGs. Using a set of algorithms, the applicable rulesets and appropriate actions are determined for each ship encounter. Each encounter is evaluated against the criteria found in this project using a system of rewards and penalties. At the end of the simulations the system reports the overall score for safety and COLREGs compliance, the score is given per rule set, scenario, weather condition and complexity ranking, to determine weaknesses and strengths of the C/A system.