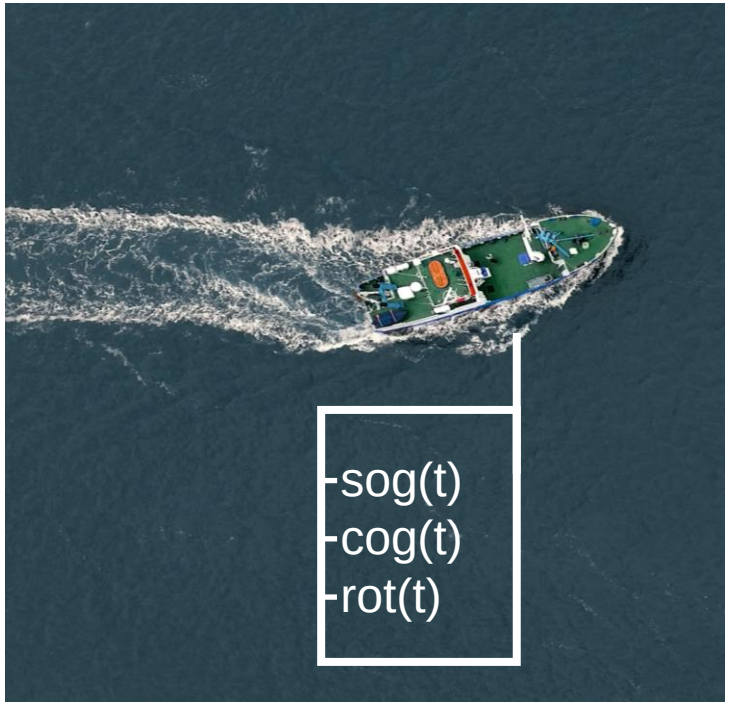
A TEST ENVIRONMENT FOR SIMULATION-BASED TESTING OF MASS-FUNCTIONS IN TRAFFIC SEPARATION SCHEMES

HYDRO2025

Nina Wetzig, Anna Austel, Daniel Paland, Bernd Westphal

Safety and Rule Compliance of MASS

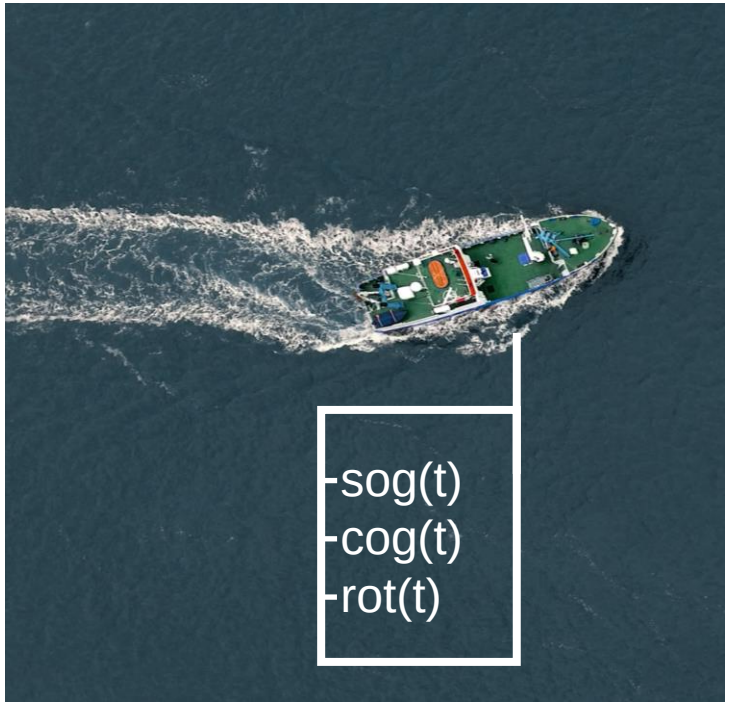


sog = speed over ground, cog = course over ground, rot = rate of turn

- MASS needs to behave in such a way that their drive is safe.
  - i.e. follow the rules and avoid collisions
- Safety/compliance with rules must be verified.

COLREG rule 10:
(b) A vessel using a traffic separation scheme shall:
(i) proceed in the appropriate traffic lane in the general direction of traffic flow for that lane;

Safety and Rule Compliance of MASS

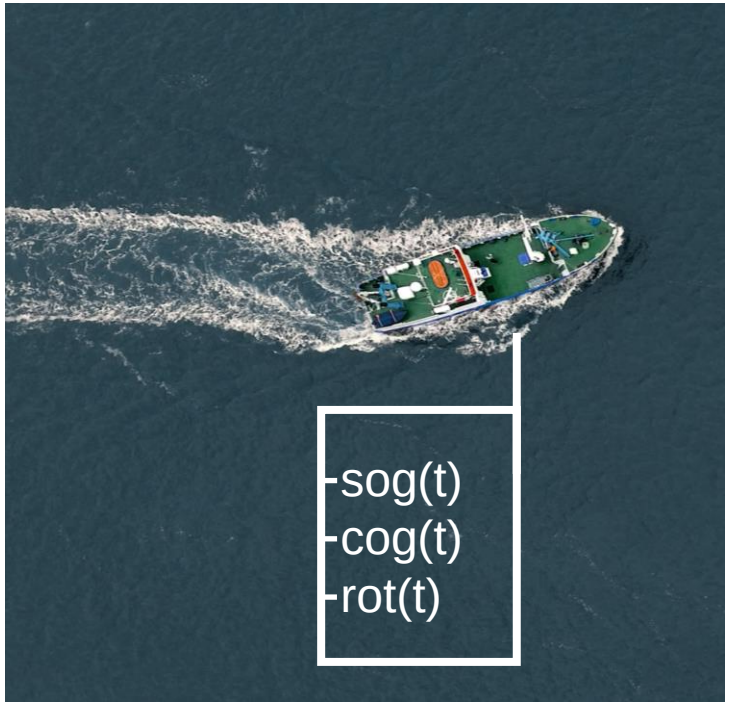


sog = speed over ground, cog = course over ground, rot = rate of turn

- MASS needs to behave in such a way that their drive is safe.
  - i.e. follow the rules and avoid collisions
- Safety/compliance with rules must be verified.

COLREG rule 10:
(b) A vessel using a traffic separation scheme shall:
(i) proceed in the appropriate traffic lane in the general direction of traffic flow for that lane;

Safety and Rule Compliance of MASS



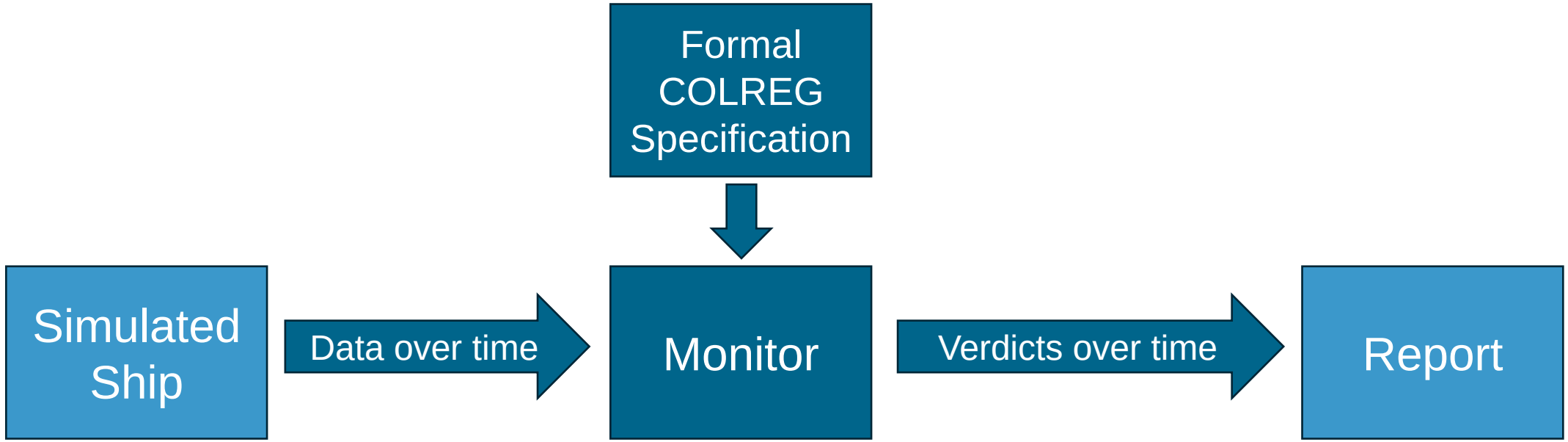
sog = speed over ground, cog = course over ground,
rot = rate of turn

Problem statements

- For the automated evaluation of a MASS drive we need a formal specification of what is correct behaviour.
- And we also need monitoring software to compare the observable data of the drive with the specification.

Safety and Rule Compliance of MASS

We propose a Test Environment for automatic evaluation of simulated drives in regard to mTSC-Specifications of COLREG rules at runtime.

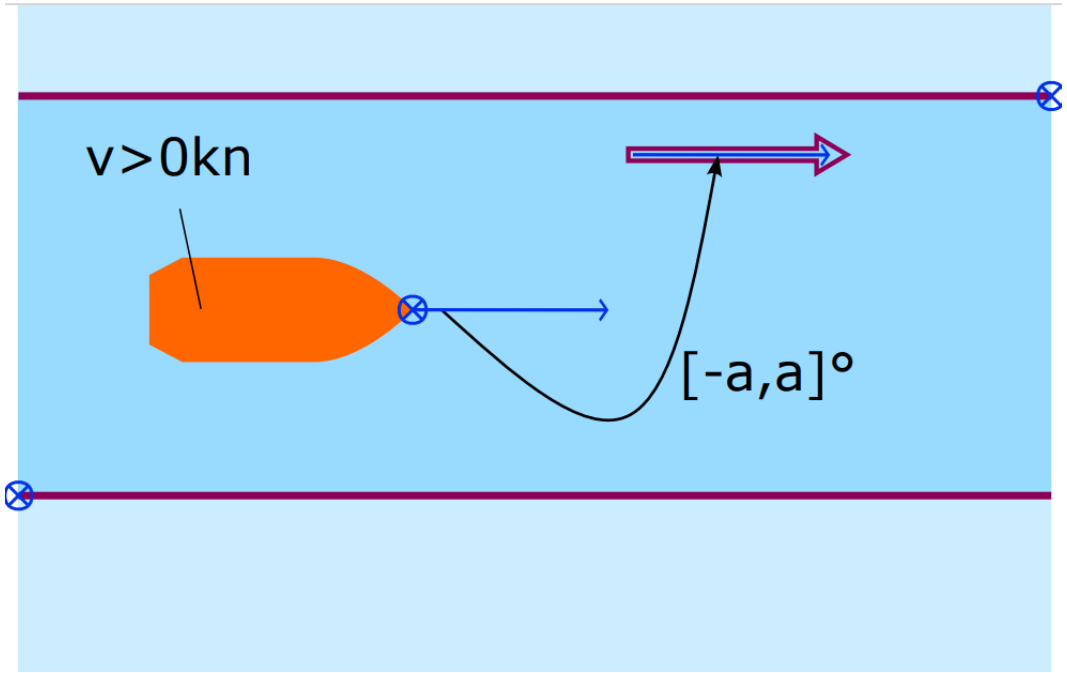


Specification of Rule Compliance

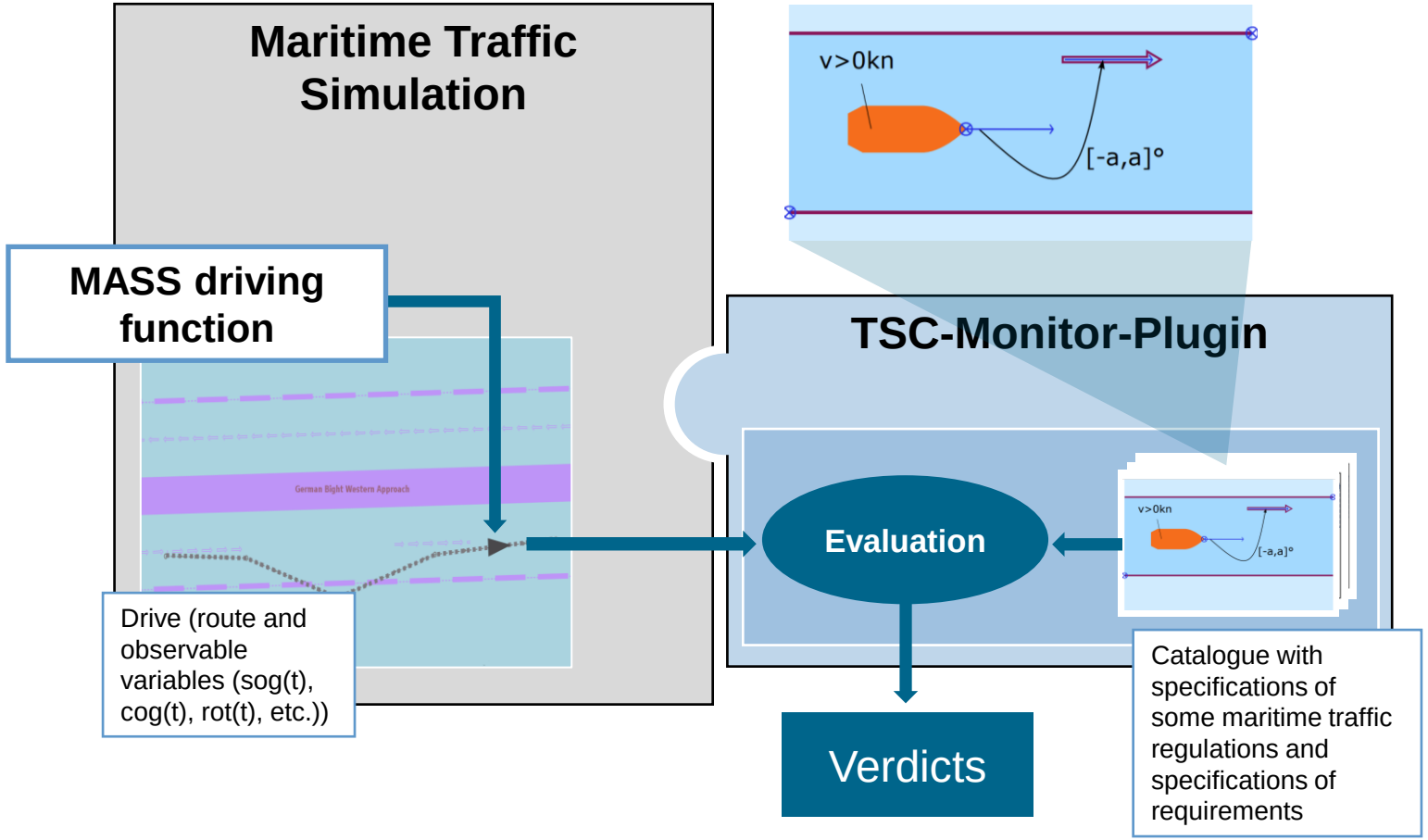
COLREG rule 10:

(b) A vessel using a traffic separation scheme shall:

(i) proceed in the appropriate traffic lane in the general direction of traffic flow for that lane;

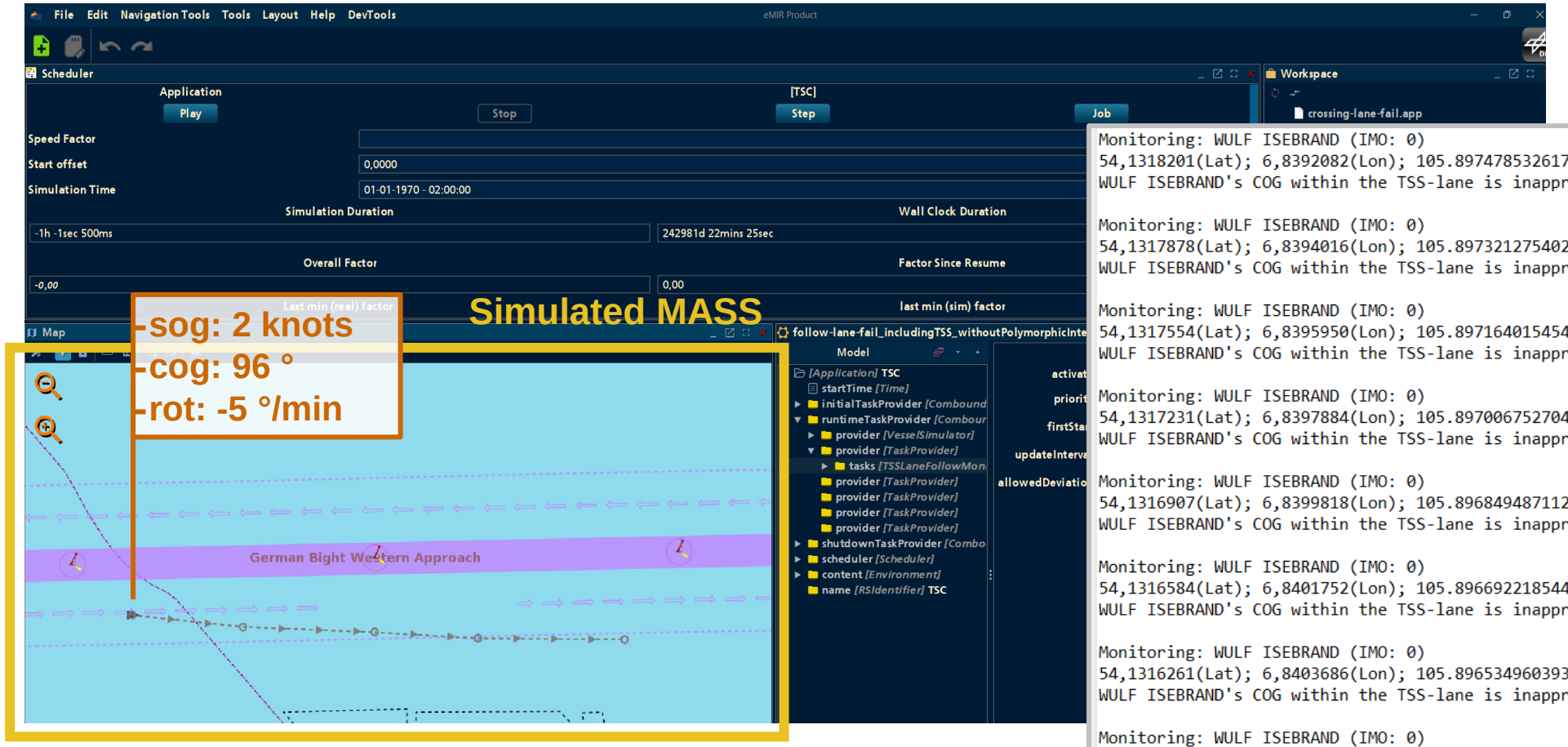


Test Environment for Simulation-based Monitoring



- We now have a mTSC-based Test Environment for automating the monitoring process.
- In our paper we demonstrate the functionality of this Test Environment with drives of vessels in interaction with TSS.

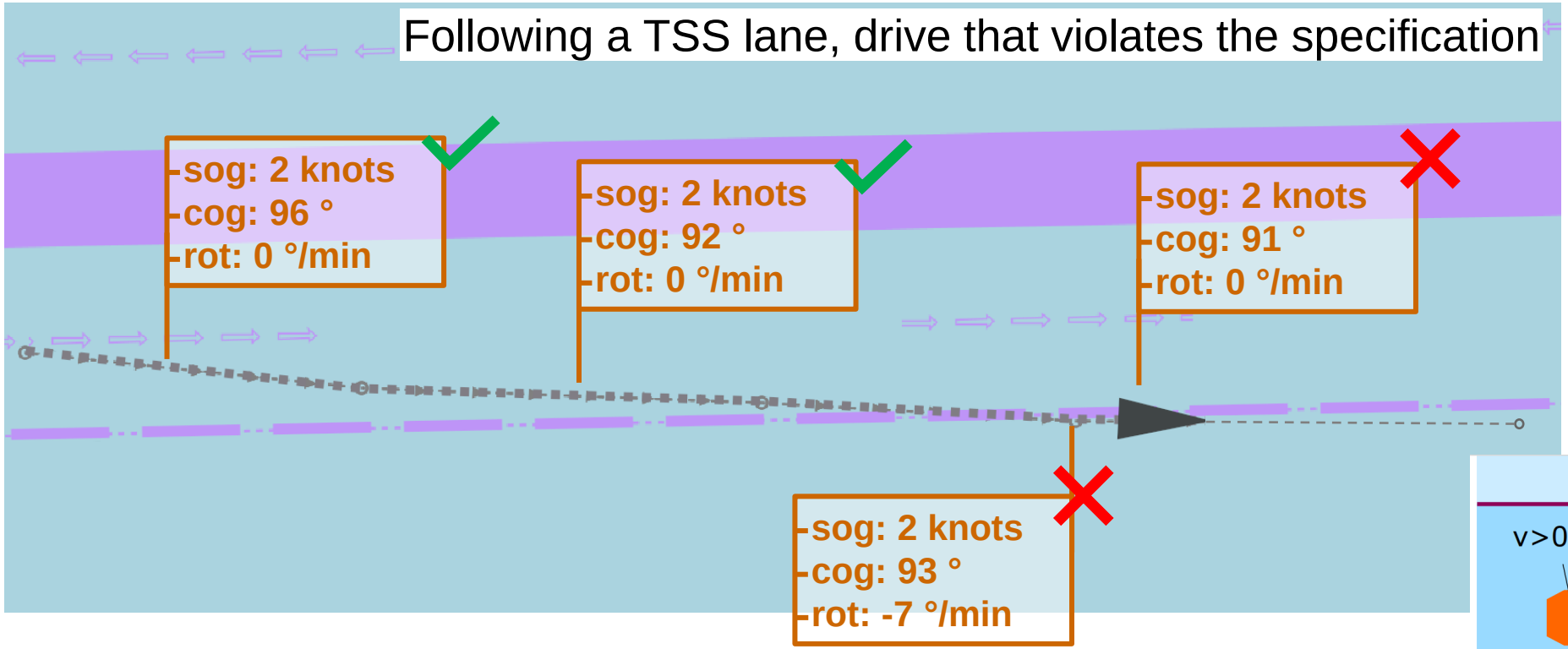
Test Environment for Simulation-based Monitoring

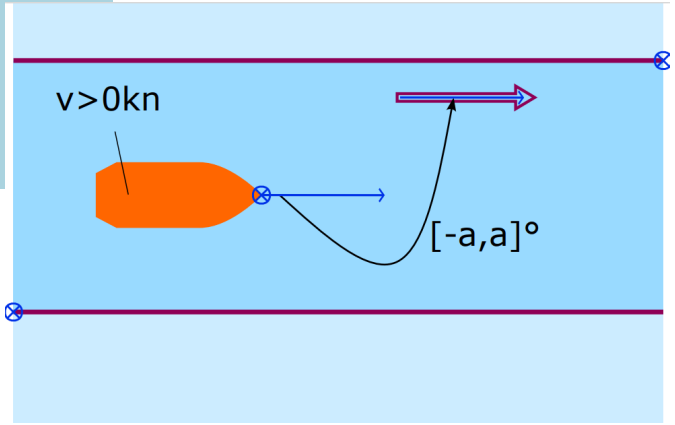


Report

```
Monitoring: WULF ISEBRAND (IMO: 0)
54,1318201(Lat); 6,8392082(Lon); 105.89747853261741°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1317878(Lat); 6,8394016(Lon); 105.89732127540208°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1317554(Lat); 6,8395950(Lon); 105.89716401545462°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1317231(Lat); 6,8397884(Lon); 105.89700675270447°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1316907(Lat); 6,8399818(Lon); 105.89684948711248°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1316584(Lat); 6,8401752(Lon); 105.89669221854403°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1316261(Lat); 6,8403686(Lon); 105.89653496039323°(COG)
WULF ISEBRAND's COG within the TSS-lane is inappropriate

Monitoring: WULF ISEBRAND (IMO: 0)
54,1315937(Lat); 6,8405620(Lon); 105.89637769370215°(COG)
WULF ISEBRAND is not on a TSS-lane

Monitoring: WULF ISEBRAND (IMO: 0)
54,1315614(Lat); 6,8407553(Lon); 105.89622041784598°(COG)
WULF ISEBRAND is not on a TSS-lane
```

Interpreting the Monitoring Report





- We specified three COLREG rules regarding TSS interactions and evaluated drives for each:
  - Entering a TSS from the side
  - Crossing a TSS
  - Following a TSS lane

Conclusion and Future Work

- We have a test environment to monitor and evaluate the behaviour of simulated MASS relative to mTSC-Specifications of COLREG rules.

- Further steps to improve the test environment include:
  - Formalizing further regulations (e.g. covering more COLREG rules)
  - Improving the user-interface for displaying the verdict and reporting relevant data
  - Further automating the activation of the monitoring

THANK YOU FOR YOUR ATTENTION!

Imprint

Topic:	**A Test Environment for Simulation-based Testing of MASS-functions in Traffic Separation Schemes**
Date:	2025-10-28
Author:	Nina Wetzig
Institute:	Institute of Systems Engineering for Future Mobility
Image sources:	All images “DLR (CC BY-NC-ND 3.0)” unless otherwise stated