

Model-Driven Scenario-Based Assurance for the COLREGS Compliance of ASVs

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Motivation

Autonomous surface vehicles (ASVs) must safely navigate open-sea traffic while complying with the International Regulations for Preventing Collisions at Sea (COLREGS). However, COLREGS rely on human judgment and contain ambiguities, making systematic compliance assurance challenging. Existing simulation-based testing can evaluate ASV behavior in realistic scenarios, but provides limited guarantees that assurance suites are relevant, complete, and diverse, and does not address generation and execution at scale.

Objectives

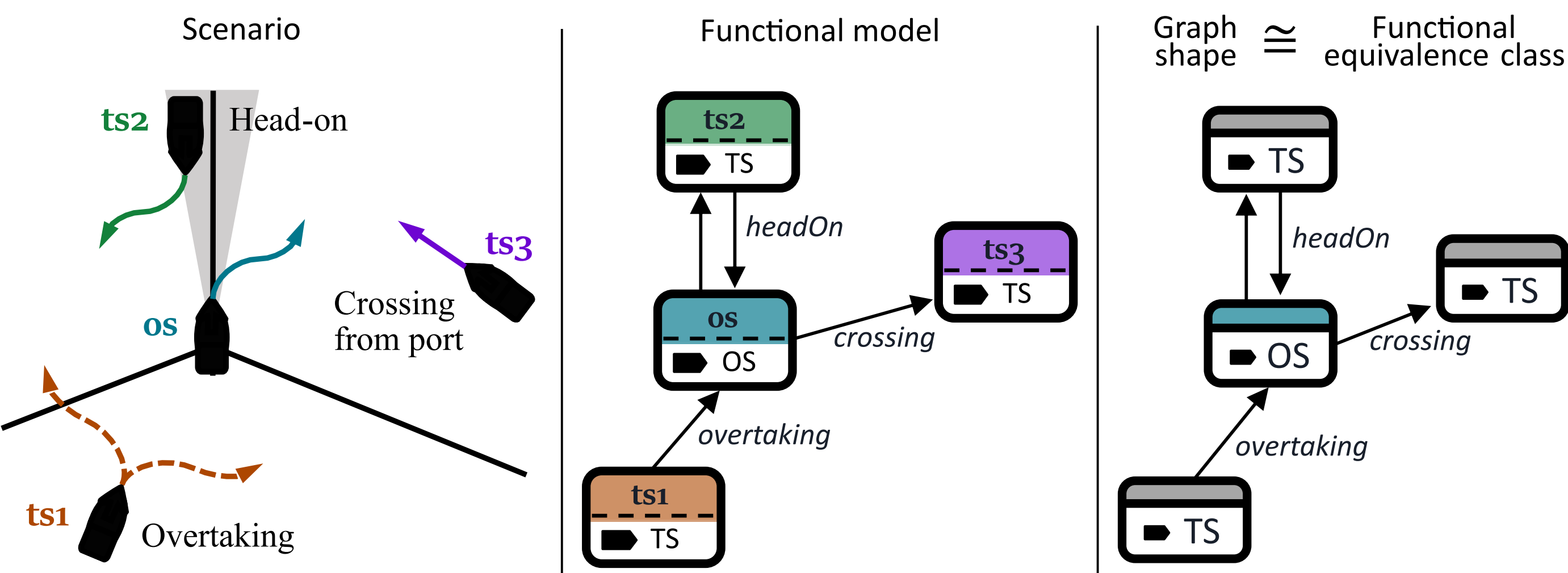
COLREGS-driven scenario modeling
A modeling method using **qualitative abstractions** for representing maritime encounters (vessels, obstacles, environmental conditions, geometric relations, and COLREGS situations)^[1].

Automated assurance-suite generation
Model-driven technique^[2] to generate **relevant, functionally complete, diverse, and robust** multi-vessel assurance suites while detecting geometrically infeasible scenarios early.

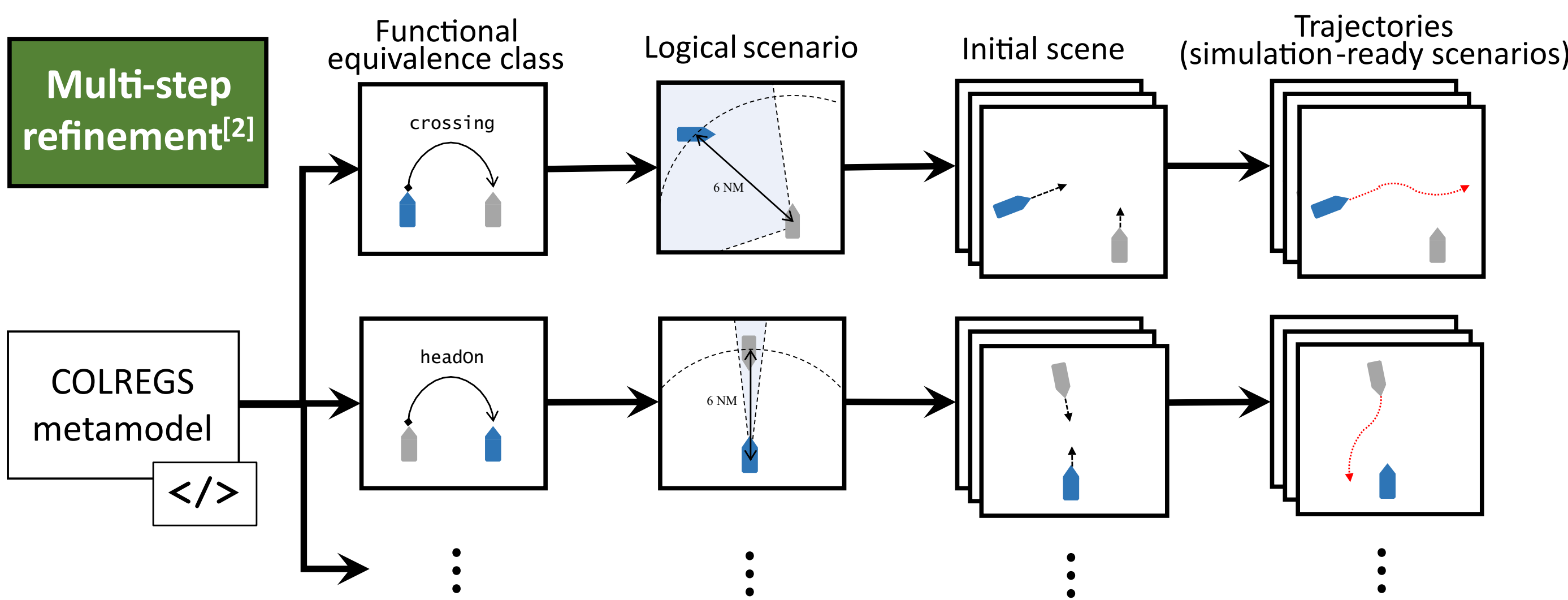
Scalable simulation-based assurance
A workflow for transforming scenarios into simulation runs and **executing large assurance suites efficiently in realistic maritime simulators**, including hybrid real/simulated setups^[3].

Runtime monitoring
A COLREGS monitor and oracle that **identifies, classifies, and explains** safety and COLREGS violations^[3].

COLREGS-driven scenario modeling



Automated assurance-suite generation



Scalable simulation-based assurance and runtime monitoring

Trajectories (simulation-ready scenarios) → **Test execution (simulation)**

COLREGS monitor and oracle → **COLREGS Violation Report** / **CERTIFICATE Assurance evidence**

External control
The manual or autonomous control that represents the ASV is connected through a MAVLink interface or the WARA PS MQTT protocol.

End-to-end assurance

SceneGEMS
Scenario Generation and Execution Framework for the Safety Assurance of Maritime Autonomous Surface Vehicles

A framework for end-to-end assurance of ASVs, integrating systematic assurance scenario generation, simulation execution, and continuous monitoring of COLREGS compliance to produce assurance evidence.

References

- [1] Assessing Scene Generation Techniques for Testing COLREGS-Compliance of Autonomous Surface Vehicles
D. Frey, U. Kargén, D. Varró. ISSTA, PACMSE, 2025, Trondheim, Norway
- [2] Automated Generation of Functionally Complete Assurance Suites for COLREGS-Compliance of Autonomous Surface Vehicles
D. Frey, U. Kargén, D. Varró. MODELS, 2026, Malaga, Spain
- [3] SceneGEMS: Scenario Generation and Execution Framework for the Safety Assurance of Maritime Autonomous Surface Vehicles
D. Frey, U. Kargén, D. Varró. MODELS, 2026, Malaga, Spain