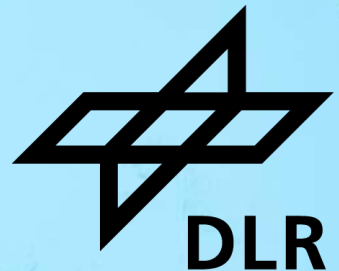


A WHAT-IF SIMULATION TO SUPPORT VESSEL TRAFFIC SERVICES IN THEIR DECISION MAKING PROCESS

Steffen Kleinert (DLR) - AISS 2026



Overview



- 1) State of Vessel Traffic Services
- 2) Problem
- 3) Related Work
- 4) Concept
- 5) Example
- 6) Implementation
- 7) Proof of Concept
- 8) Conclusion and Future Work

State of Vessel Traffic Services

- Vessel Traffic Services (VTS) got established to improve safety and efficiency of navigation [1]
- AIS receivers, land based radars, ...
- situational picture on a digital map
- VTS-Operator observes and informs
- Xiao et al. “Next-generation vessel traffic service systems – from passive to proactive” [2]



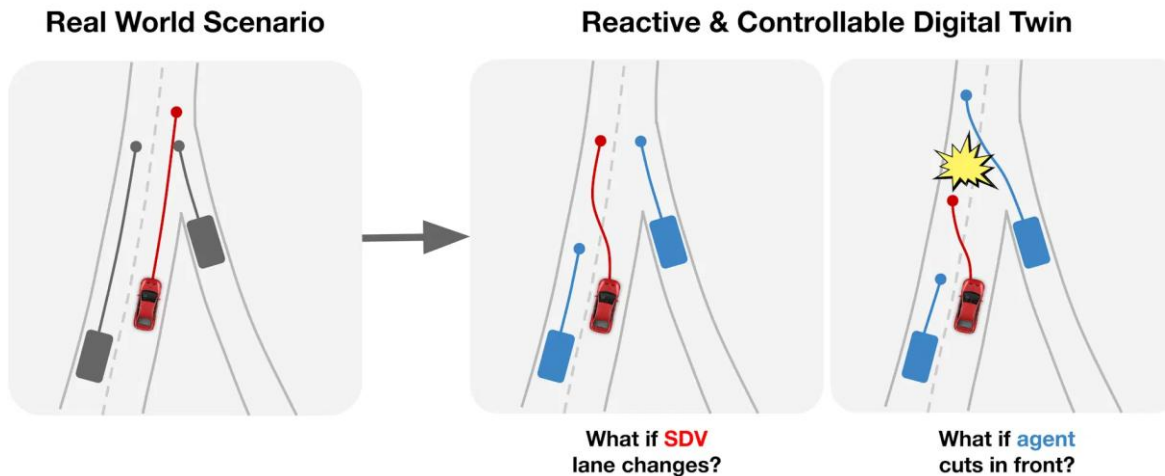
Problem

- plan ahead, instructing traffic participants
- what are the consequences?
- blindly trust AI / Decision Support Systems (DSS)?
- **at hand:** situational picture, communication
- **needed:** future situational picture of outcomes

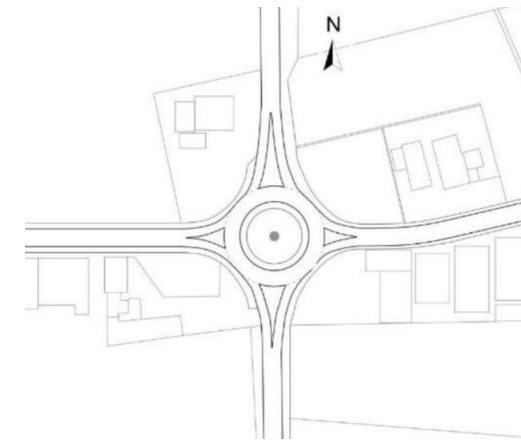


Related Work: What-If Simulations

- What-If Analysis is an established term across domains
- in the automotive domain, approaches of What-If Simulations can be found



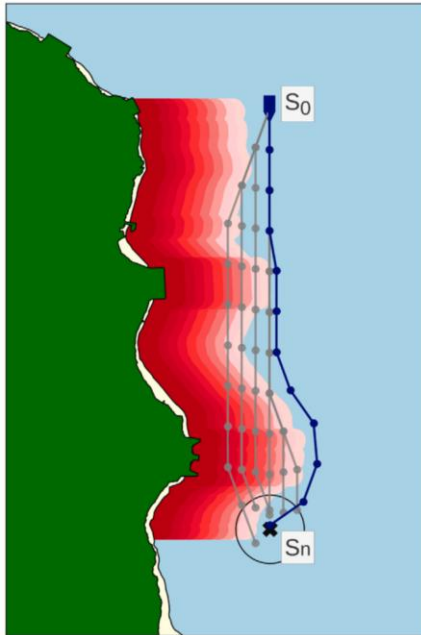
Suo et al. "MixSim: A Hierarchical Framework for Mixed Reality Traffic Simulation" [3]



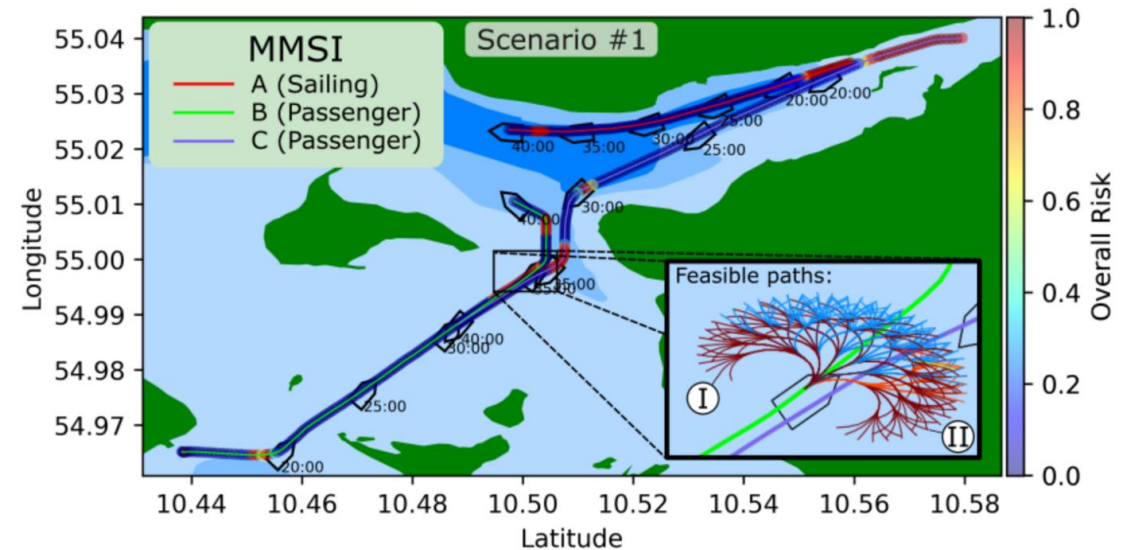
Tumminello et al. "Simulation-Based Analysis of "What-If" Scenarios with Connected and Automated Vehicles Navigating Roundabouts" [4]

Related Work: Maritime Simulations

- existing path planning simulations are essentially spanning “What-If” decision trees



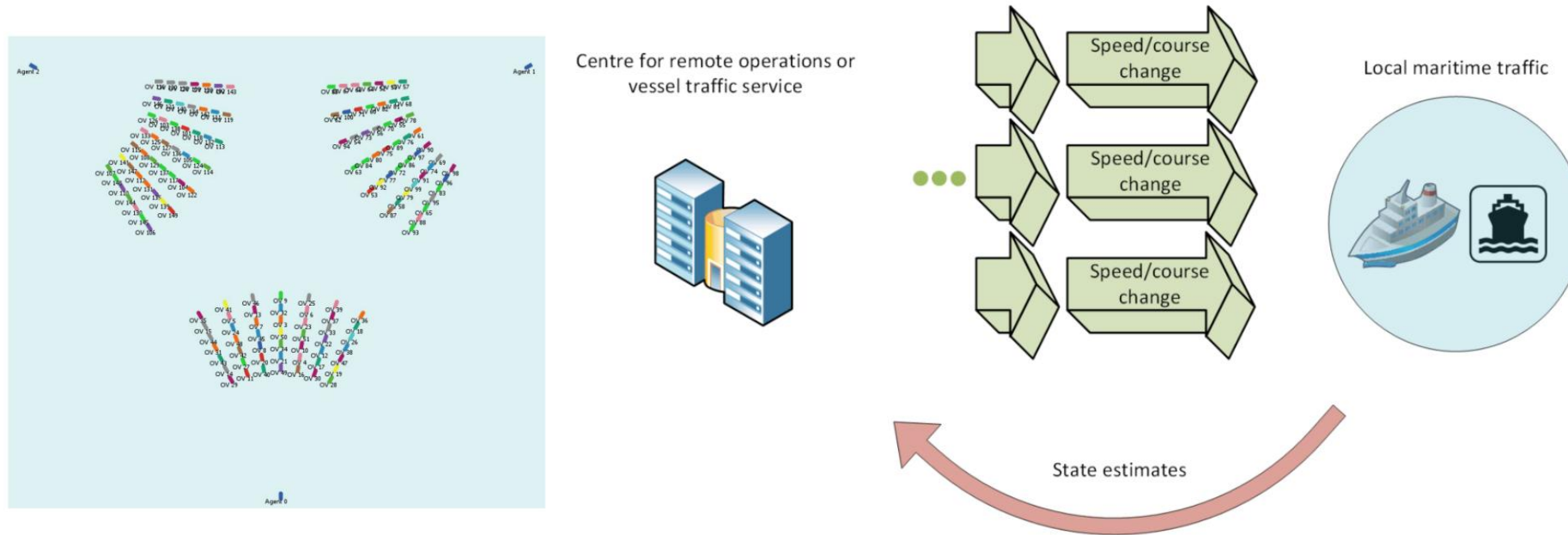
Maidana et al. “Risk-based path planning for preventing collisions and groundings of autonomous surface ships” [5]



Prabowo et al. “Codification of Good Seamanship in Complex and Congested Waterways” [6]

Related Work: Maritime Simulations

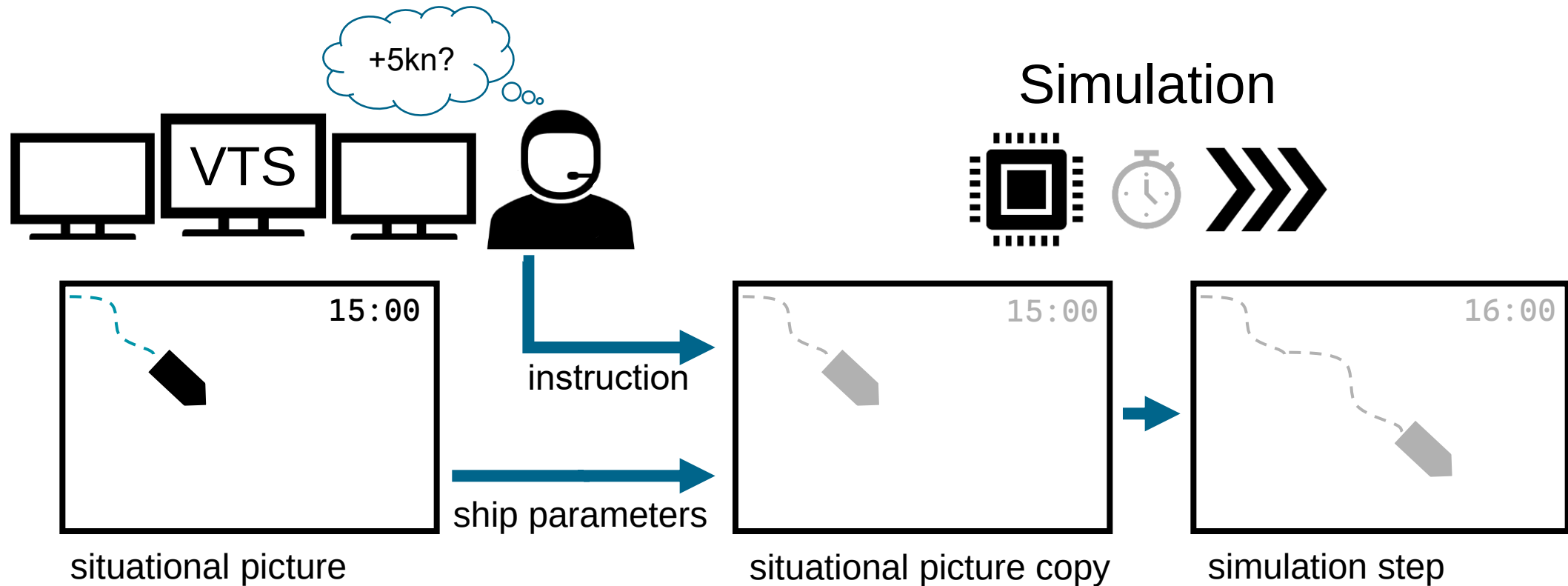
- a more similar use-case of aiding VTS in traffic optimization



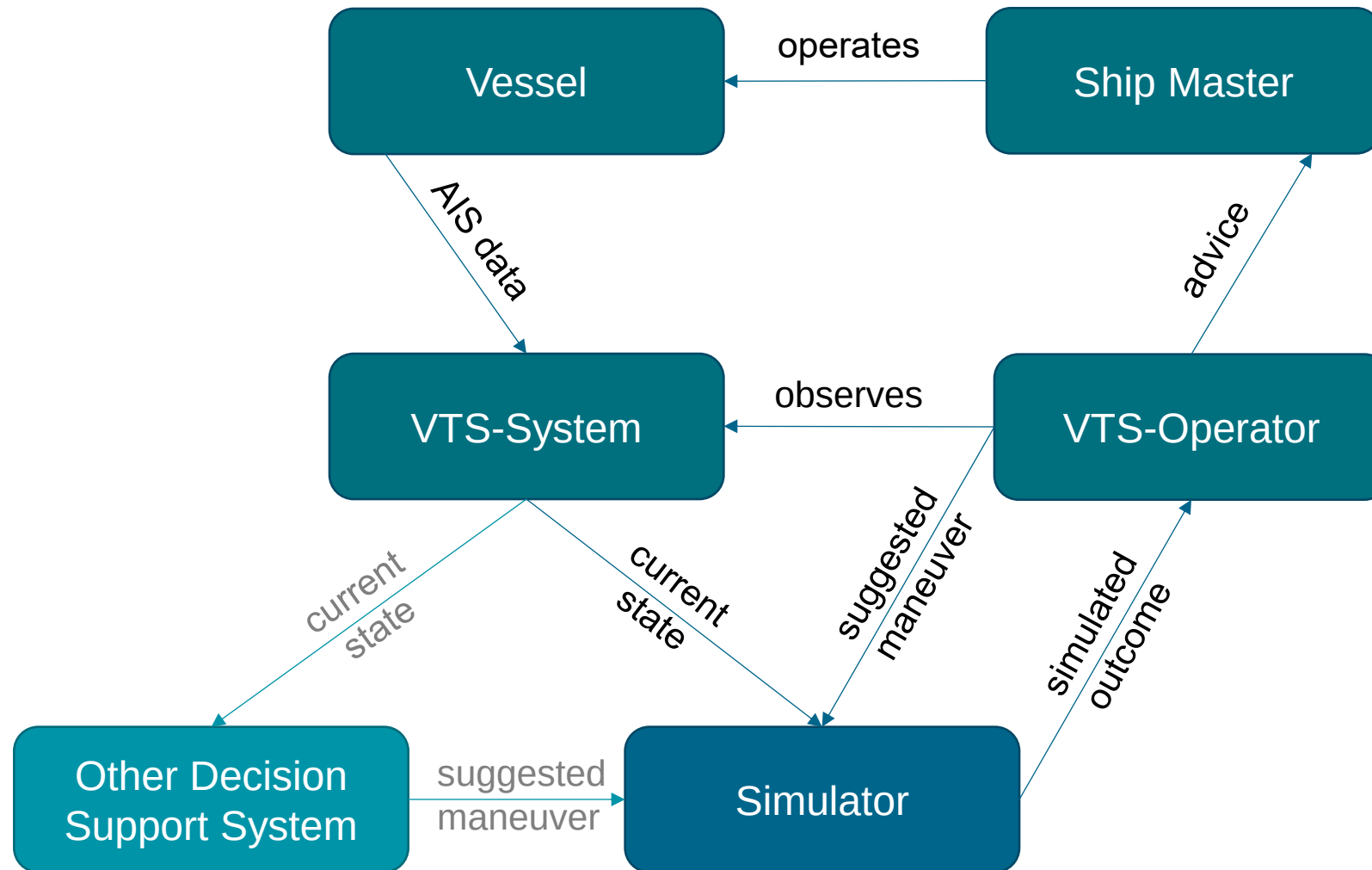
Grgičević et al. "Centralized Decision Support in Maritime Vessel Traffic Services: A Polymatrix Game Solution" [7]

Concept

- VTS-Operator as the responsible human-in-the-loop
- visualized micro-simulation of individual vessels



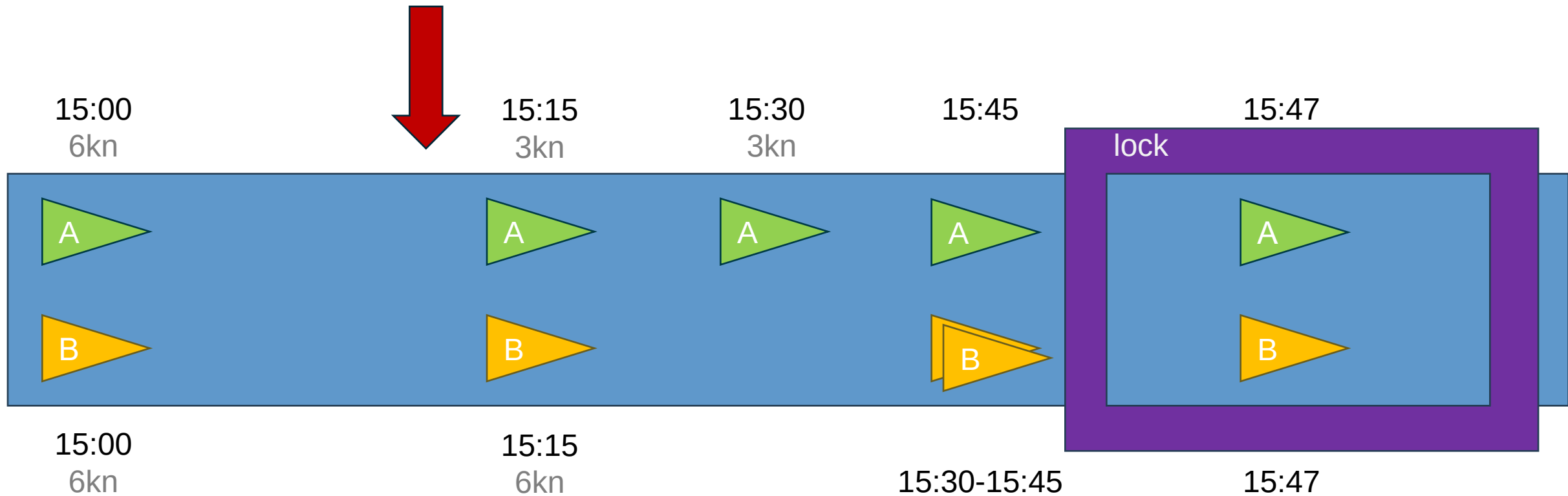
Concept



Example: Vessel approaching a lock

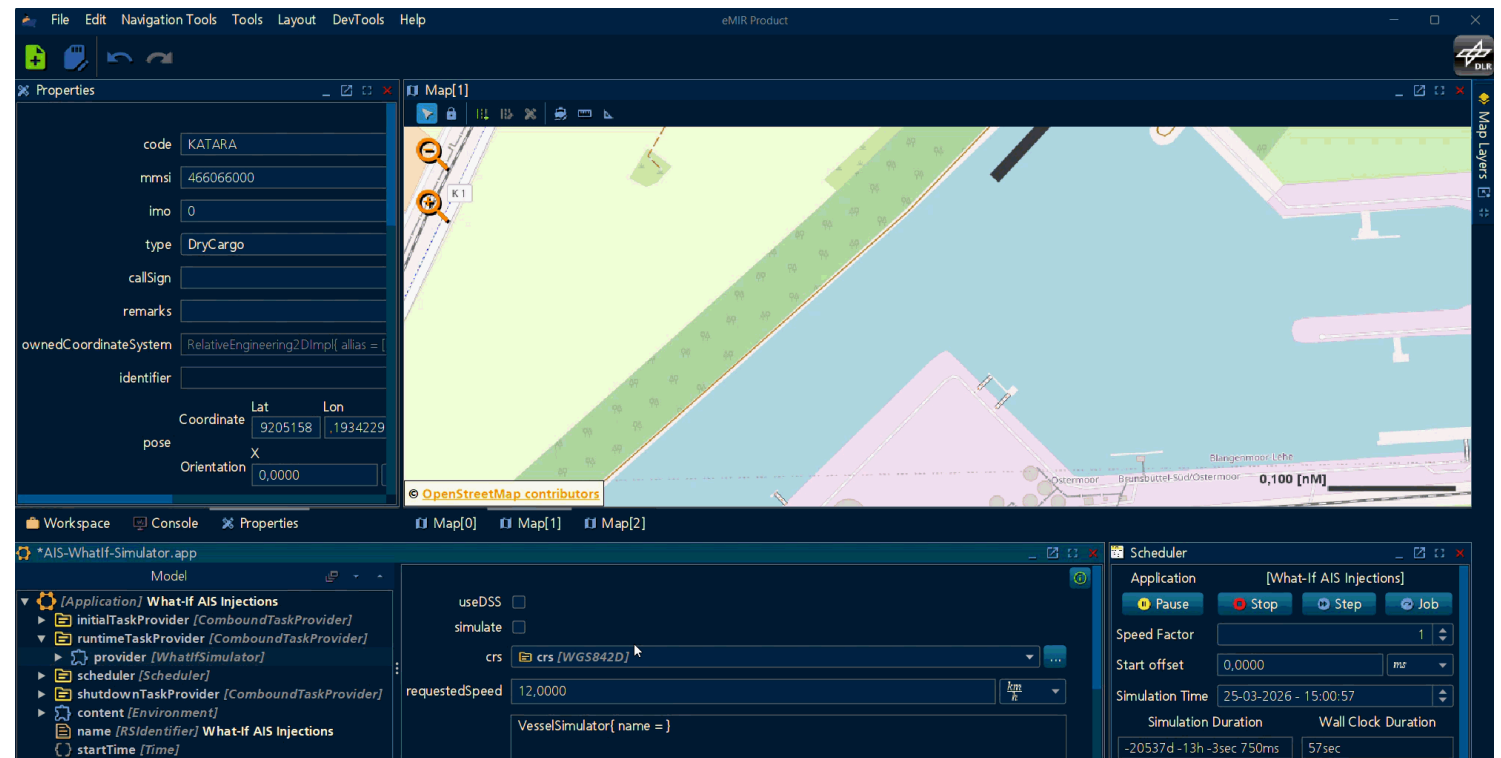
VTS instruction:

“reduce speed from 6 to 3 knots, to arrive at the lock just-in-time at time stamp 15:45”



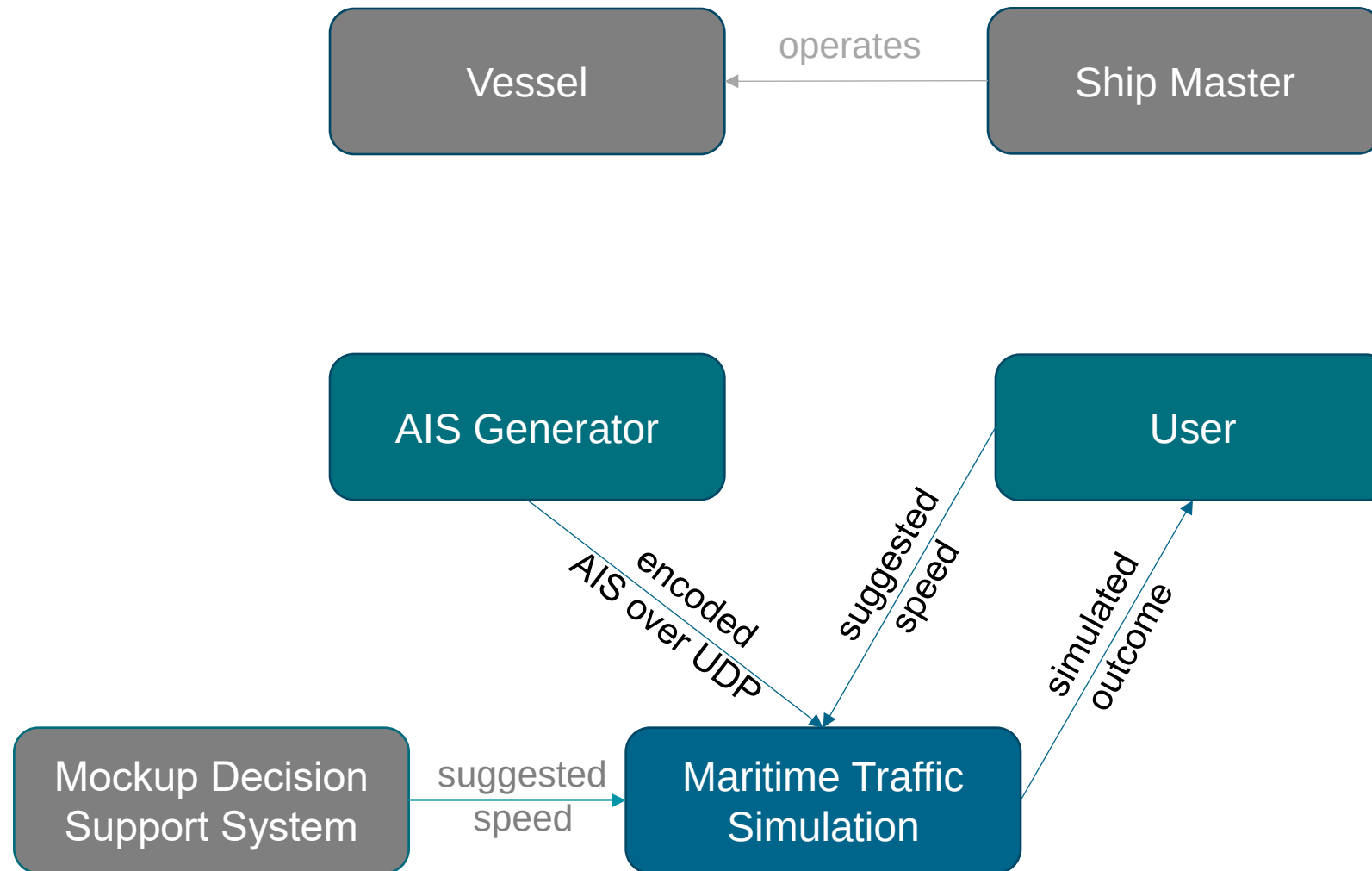
Implementation

- Maritime Traffic Simulation (MTS)
- generated AIS stream
- inject AIS encoded messages into vessel simulations (Coordinates, SOG, COG, MMSI, name and vessel dimensions)
- check-box → injected situational picture becomes a full-fetched simulation
- modification and speed-up

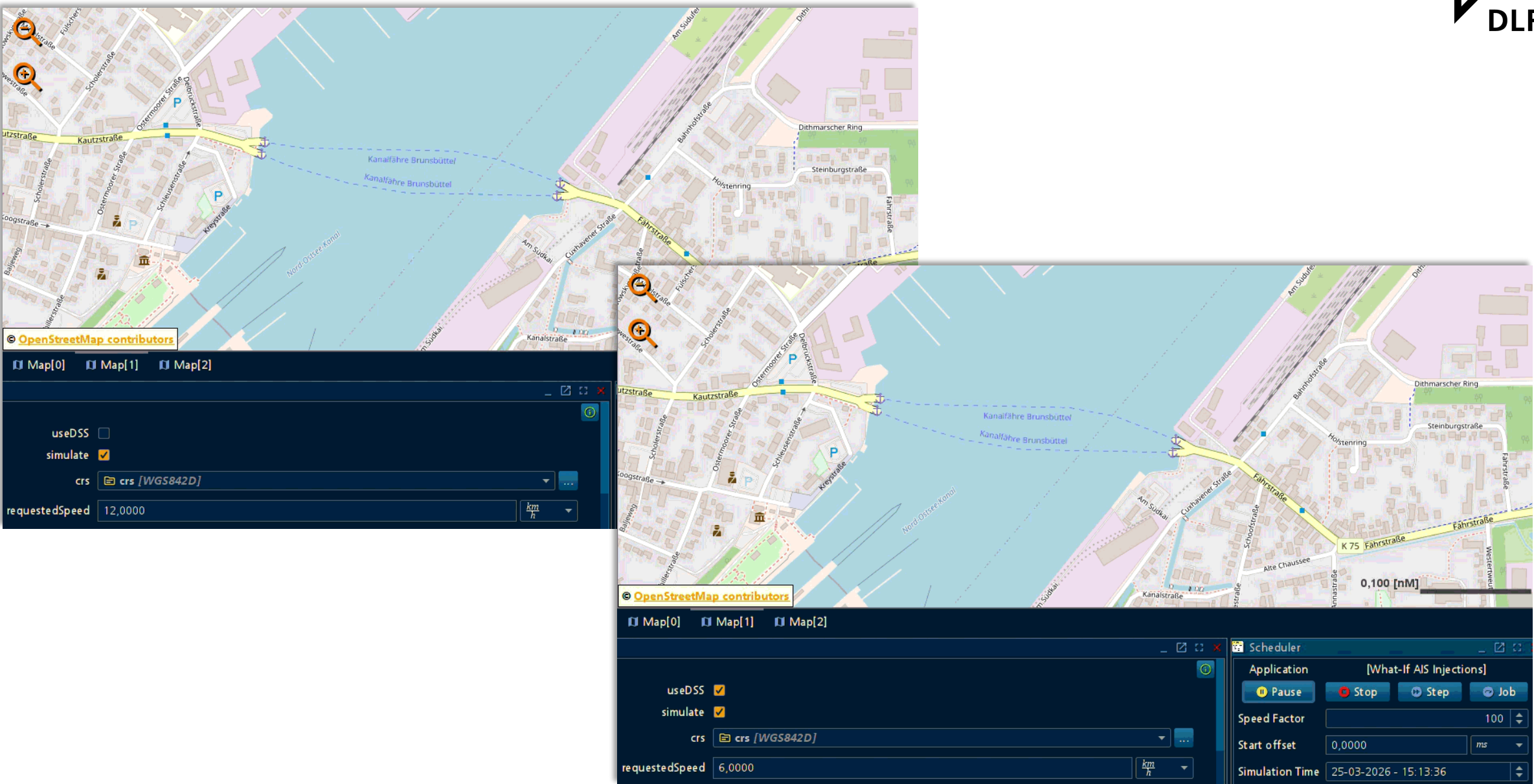


Maritime Traffic Simulation [8],[9]

Implementation



Proof of Concept



Conclusion

- Keep the human-in-the-loop in mind
- What-If simulation as a mediator to make outcomes visually graspable
- build trust in instructions to be given
- possibility of vessel interactions
- combination with existing DSS



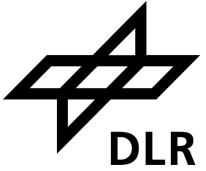
Photo by Ibrahim Boran on Unsplash

Future Work

- Go beyond pure AIS injections
→ robust replicas of the underlying vessel states (accurate coordinates, fitting dynamic models, ...)
- Intelligent vessel agents
→ better represent possible vessel interactions (human reasoning, social interaction, ...)



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- [2] Z. Xiao, X. Fu, L. Zhao, L. Zhang, T. K. Teo, N. Li, W. Zhang, and Z. Qin,
["Next-generation vessel traffic services systems—from "passive" to "proactive""](#)
- [3] S. Suo, K. Wong, J. Xu, J. Tu, A. Cui, S. Casas, and R. Urtasun,
["Mixsim: A hierarchical framework for mixed reality traffic simulation"](#)
- [4] M. L. Tumminello, E. Macioszek, A. Gran`a, and T. Giuffr`e,
["Simulation-based analysis of "what-if" scenarios with connected and automated vehicles navigating roundabouts"](#)
- [5] R. G. Maidana, S. D. Kristensen, I. B. Utne, and A. J. Sørensen,
["Risk-based path planning for preventing collisions and groundings of maritime autonomous surface ships"](#)
- [6] Y. A. Prabowo, P. N. Hansen, D. Papageorgiou, and R. Galeazzi,
["Codification of good seamanship in complex and congested waterways"](#)
- [7] L. Grgi`cevi`c, E. M. Coates, T. I. Fossen, R. T. Bye, and O. L. Osen,
["Centralised decision support in maritime vessel traffic services: A polymatrix game solution"](#)
- [8] A. Hahn and T. Noack,
["eMaritime integrated reference platform"](#)
<https://www.dlr.de/en/se/research-transfer/research-infrastructure/emir>
- [9] EPD open source release
<https://github.com/DLR-SE/epd>

Topic: **A What-If Simulation to support Vessel Traffic Services in their decision making process**

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