

Sustainable urban freight transport with autonomous zero-emission vessels

– Project AVATAR

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Texas Smart City Events, University Texas Austin

Oct. 29, 2021

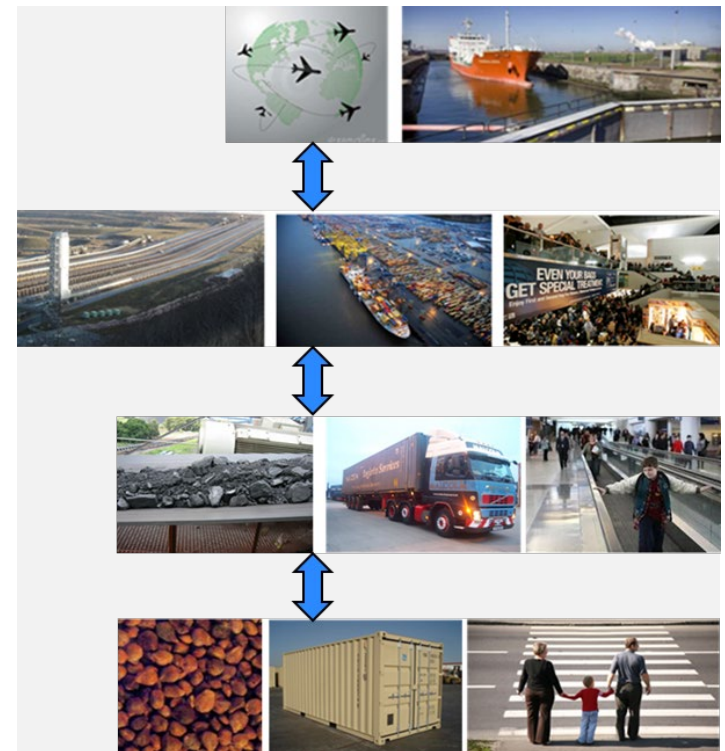
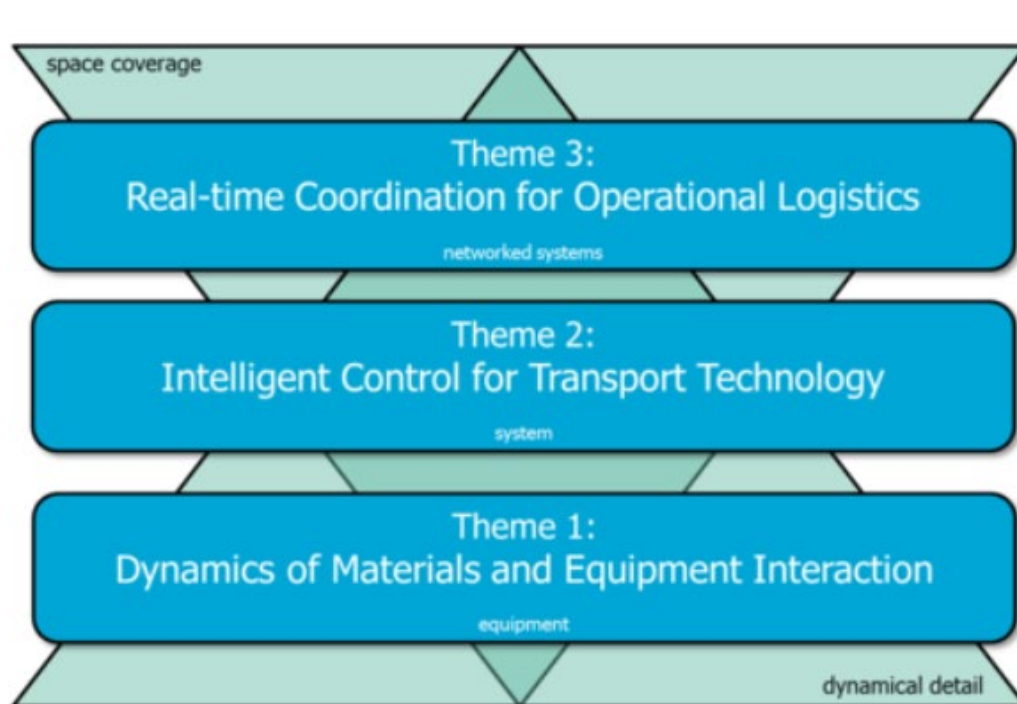
Interreg
North Sea Region
AVATAR
European Regional Development Fund



Transport Engineering and Logistics

Delft University of Technology

- Faculty Mechanical, Maritime and Materials Engineering (3mE)
 - Department Maritime and Transport Technology
 - Section Transport Engineering and Logistics



AVATAR Project

AVATAR:

Autonomous **V**essels, cost-effective tr**A**nshipment**T**, w**A**ste Return

Goals:

- Sustainable urban freight transport with autonomous zero-emission vessels >>> modal shift from road to water
- Last mile innovation through urban/inland waterway transport solutions

Motivation

- Many European cities have large & branched waterway networks that was built for and originally used for cargo transport
- Navigation and use of city waterways generally not economically viable for freight distribution
→ underutilized
- Road congestion, increasing competition for urban space and need for sustainability in urban commercial transport
- AVATAR project aims to tackle those challenges by developing, testing and assessing adequate technologies and business models for urban autonomous zero-emission inland waterway freight transport



General Info

- Co-financed by the European Union from the Interreg North Sea Region (European Regional Development Fund)
- EU innovation project on urban, autonomous & zero emission water-bound cargo transport solutions for last mile distribution
- Focuses
 - Develop prototypes of automated to autonomous ship units
 - Develop remote monitoring and control concepts
 - Develop use cases and business cases in an urban context
 - Analyze the political and legal framework for the deployment of autonomous ship units in the participating regions (Ghent, Leuven, Delft and Hamburg)
 - Perform pilot tests in the regions

Project Partners

- Delft University of Technology, the Netherlands
- Provincial Development Agency (POM) East-Flanders, Belgium
- University of Leuven (KUL), Belgium
- University of Oldenburg, Germany
- Expertise center for construction materials in logistics, Belgium
- E. Van Wingen NV, Belgium
- Logistics Initiative Hamburg, Germany
- SEAFAR NV, Belgium
- SSPA Sweden AB, Sweden
- Urban Waterway Logistics, Belgium

Supportive partners:

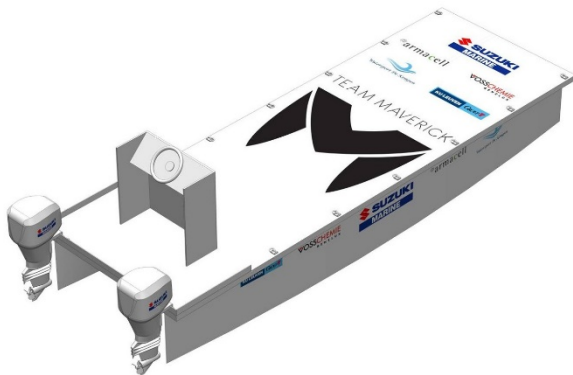
Free and Hanseatic City of Hamburg
Ministry of Economics and Innovation
Digital Hub Logistics Hamburg
Metropoolregio Rotterdam The Hague
Maritime Cluster of Northern Germany

ERTICO - ITS Europe
The Vlaamse Waterweg NV
DEMCON Unmanned Systems
Koedood Marine Group
Innovation Quarter

Autonomous Vessels

– pilot scale

- In a first step, AVATAR is currently converting an existing 1 ton vessel (MAVERICK) and expanding the automation level (0→2/3) of this vessel in Leuven Belgium.
- The MAVERICK catamaran from KUL is currently being equipped with perception sensors (LiDAR, stereo cameras, GNSS, IMU), fully electric drive system, onboard computer and control system.



Autonomous Vessels – full scale

- In a second step, a newly built vessel with a capacity of 20 tons is being developed
- Currently, the aluminum hull is being built in a Dutch shipyard, the fully electric drive system will be integrated in Ghent Belgium
- Technologies and learnings from SEAFAR NV and the Maverick will be scaled up and subsequently implemented onto the new vessel



Autonomous Vessels – model scale

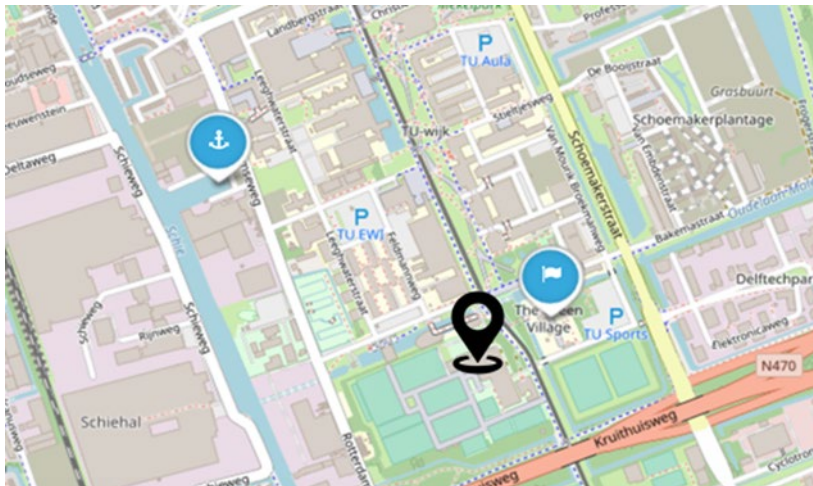
- In parallel, as a third pillar, research on vessel-to-vessel communication & multiple vessel coordination is being carried out with small-scale research vessels developed and equipped at the TU Delft ResearchLab for Autonomous Shipping (RAS).
- University of Oldenburg is researching and developing remote control systems (control center, vessel-to-shore communication & communication layer) for the project



- Research, development and realization
- Testing and experiments in unknown and unpredictable environment

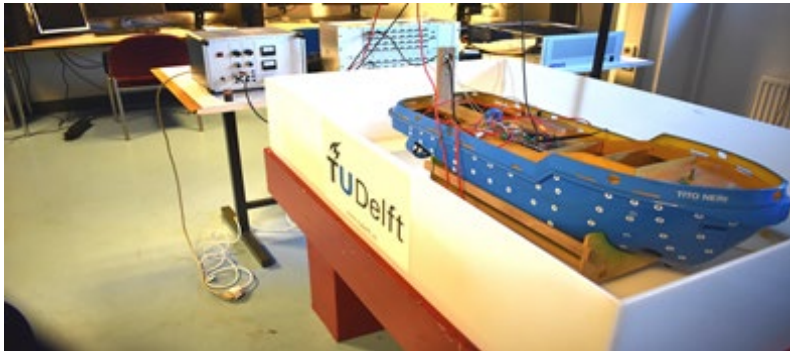


RESEARCHLAB
AUTONOMOUS SHIPPING

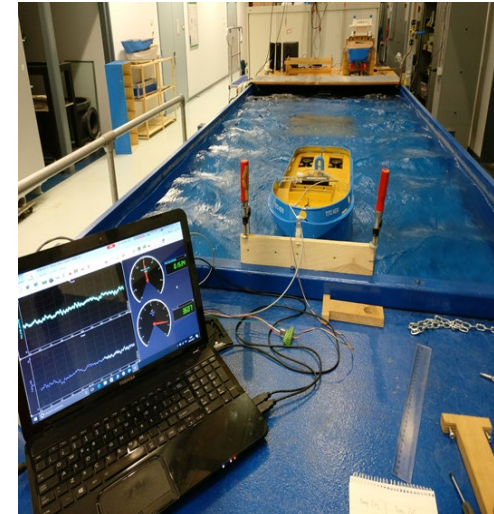


Experimental facilities

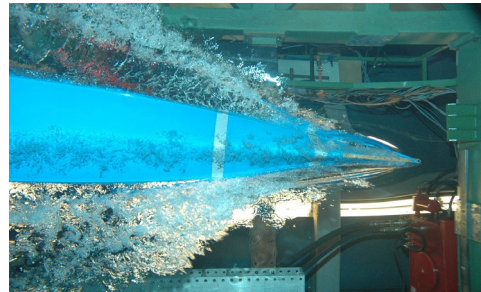
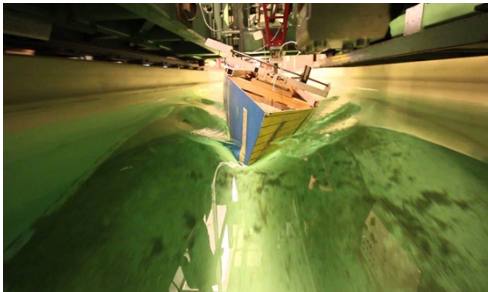
Autonomous shipping laboratory



Flume tank



Towing tank



The Green Village



Tito Neri

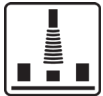
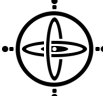
Tug boat 1:30 scale model


16 Kg


1,45 m


Mono Hull

Sensors:

 Accelerometer  Encoder  Distance  (D)GPS  Gyro



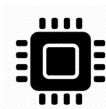
Application:

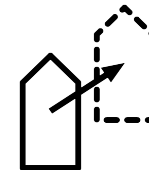
Communication:


WiFi


Radio

CPU Hardware:

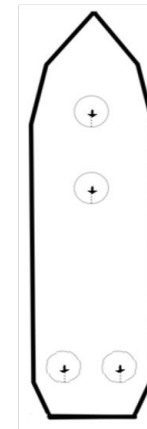
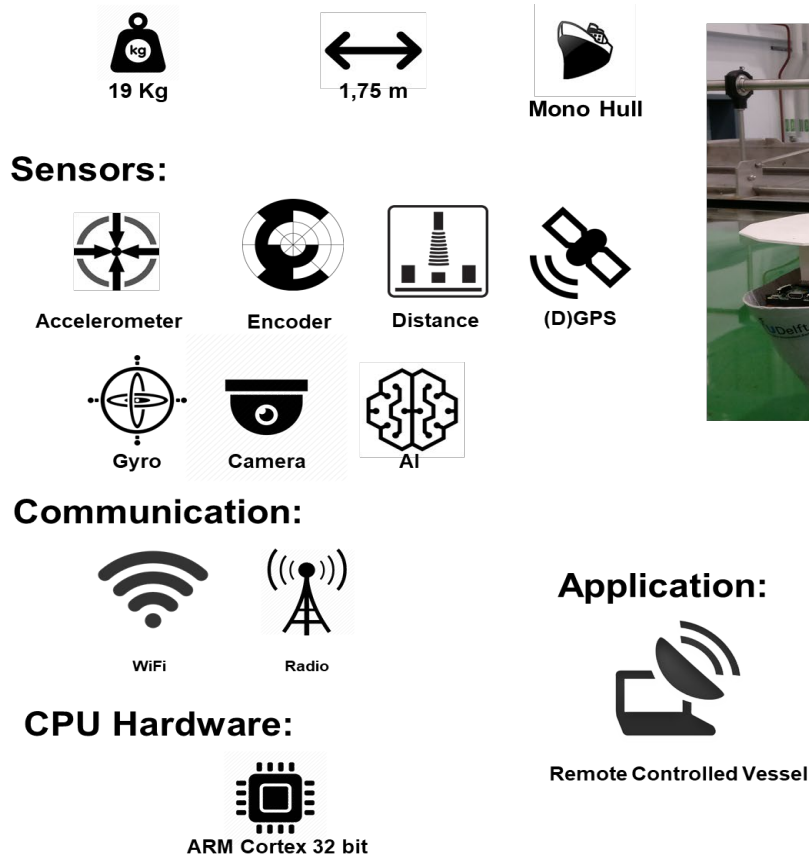

ARM Cortex 32 bit



Autonomous Dynamic Positioning

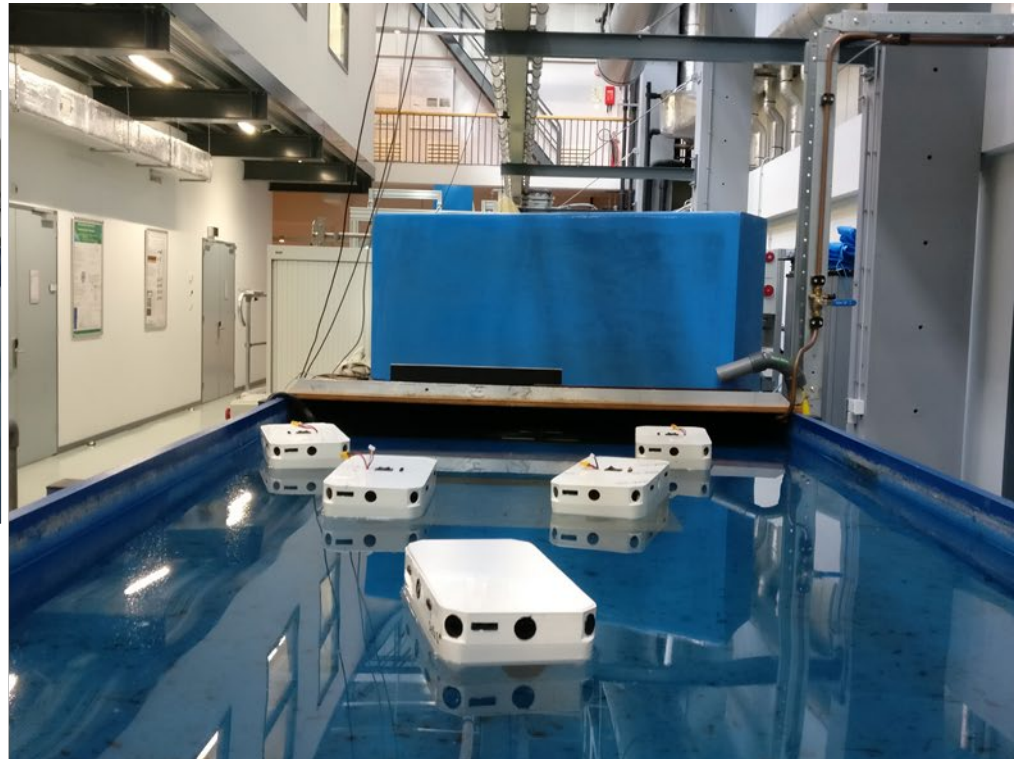
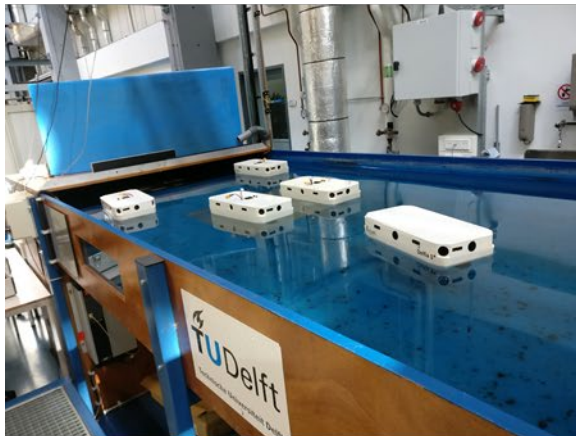
Grey Seabax

1:30 scale model Seabax one - Offshore Ship



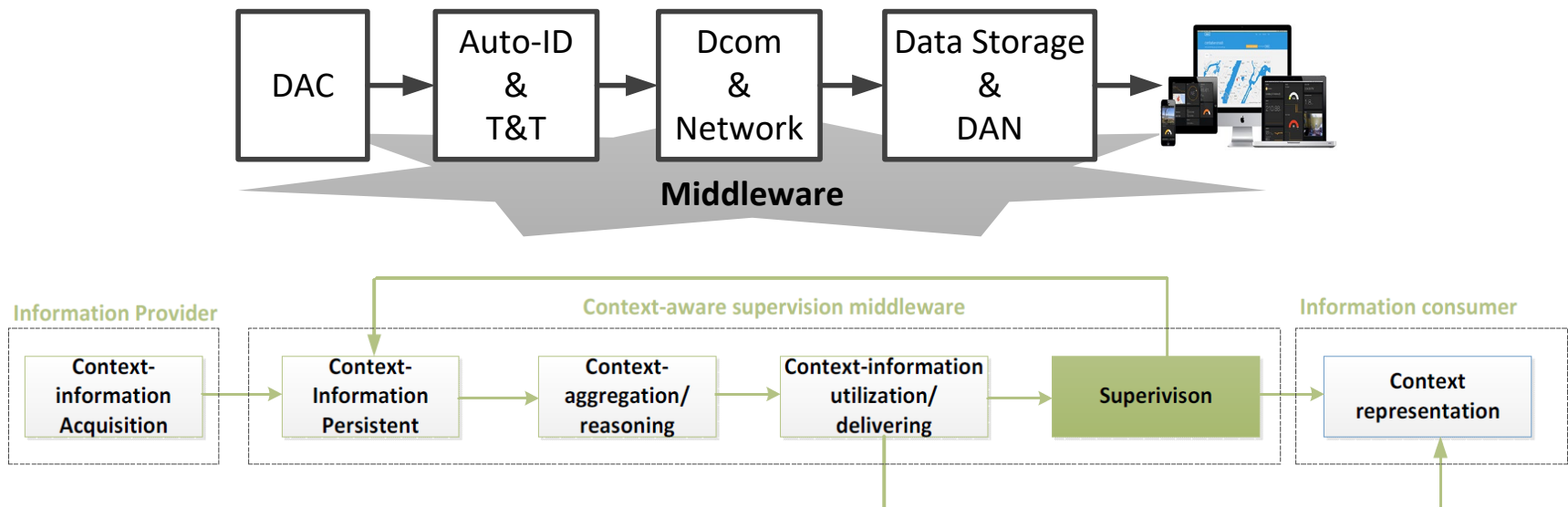
Delfia 1*

Towards multi-agent distributed control



Research

- Control for individual and multiple ships
- Adaptive control, coordination & monitoring of multiple ships
- Real-time optimization of transport and logistics
- Human-machine intelligence interaction and middleware of control system
- Experimental validation using high-fidelity simulations with real-life data and small-scale vessels (fleet of ~20 vessels)

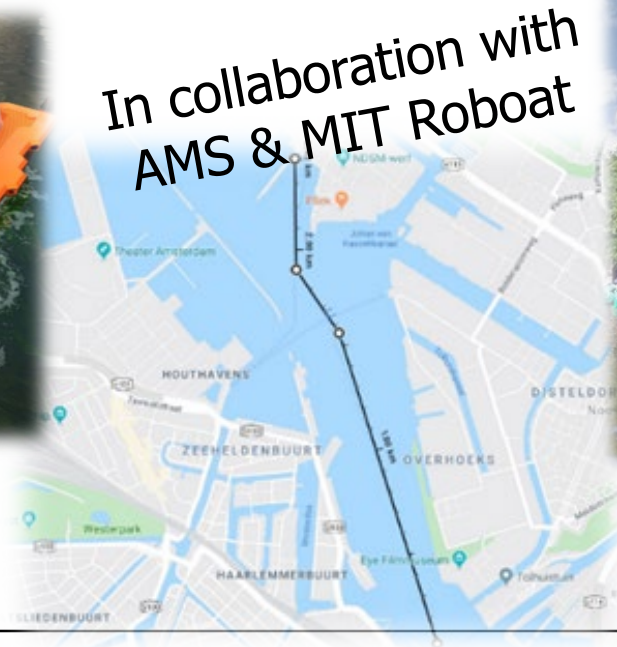


Control for individual ships

- Adaptive model predictive manoeuvring control
- Predictive thrust allocation to minimize energy use and improve manoeuvrability

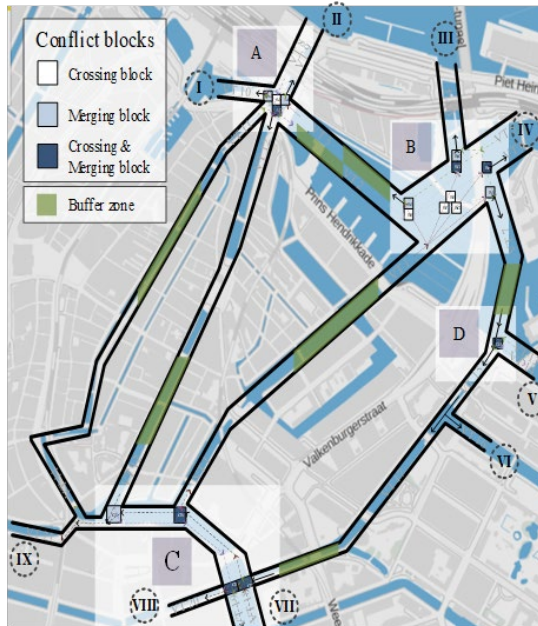


In collaboration with
AMS & MIT Roboat



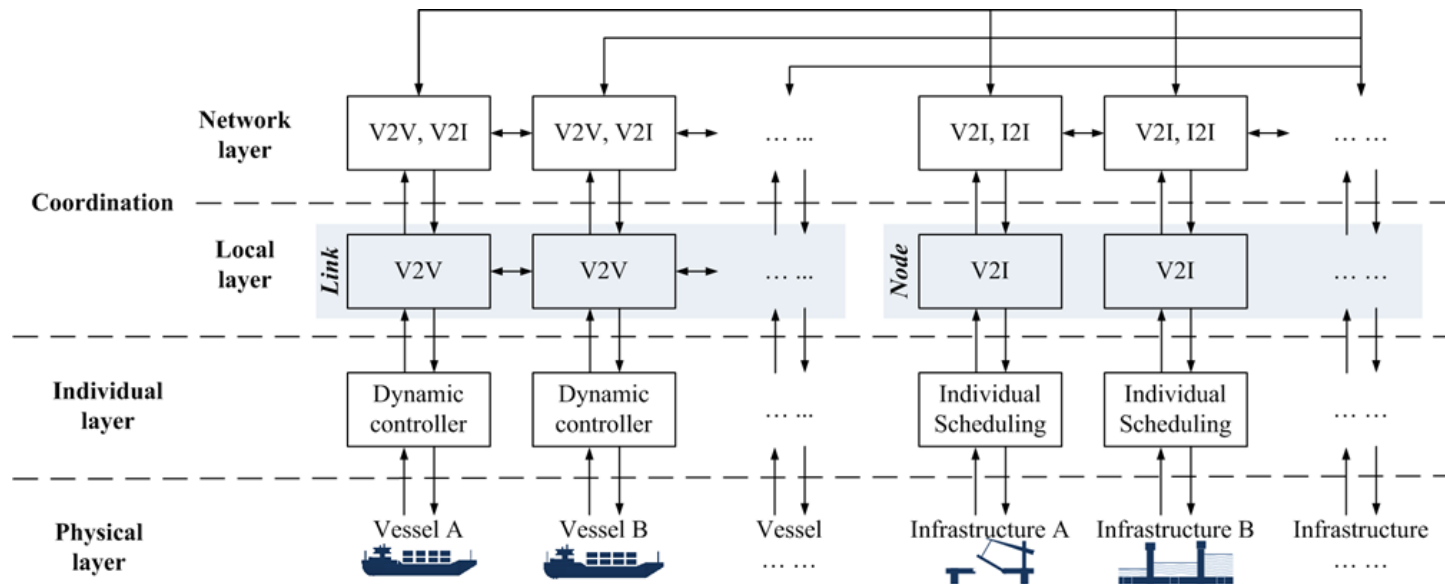
Control for multiple ships

- Cooperative control for city waterway transport
- Vessel-to-Vessel and Vessel-to-Infrastructure Cooperation
- Sailing in formation for fuel efficiency

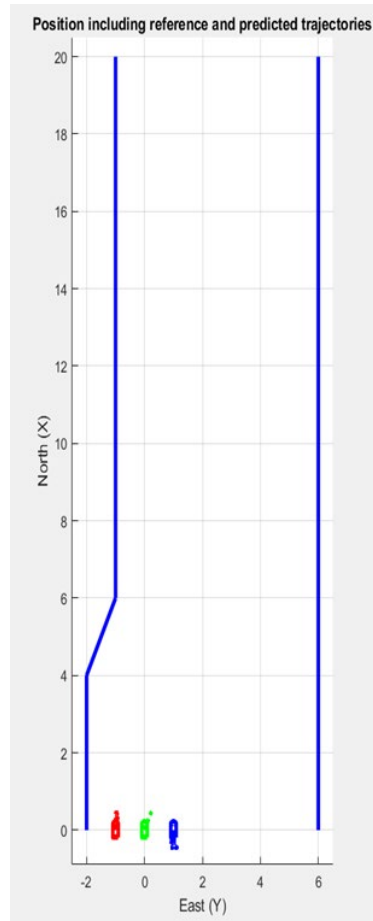


Control for multiple ships

- Hierarchical architecture of cooperation in waterway networks
- Ship2ship & ship2infra



Experiments and Validation



Methods for integration in environments with both autonomous and human controlled vessels; compliance with 'rules of the waterway'--- when necessary

Distributed control – Platooning



Decentralized Control – using AI



Sailing in Formation



Questions ?

Thank you very much!

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Project AVATAR:

<https://northsearegion.eu/avatar/>

<https://www.linkedin.com/company/avatar-interreg-north-sea-region>