



## *Review of some European projects that focus on inland navigation and (highly) autonomous sailing – Identification of missing research gaps*

*Within the framework of the Interreg NSR project AVATAR work package 6*

AVATAR is a project co-funded by the  
Interreg North Sea Region programme 2014-2020



## Colophon

- “Review of some European projects that focus on inland navigation and (highly) autonomous sailing – Identification of missing research gaps” within the framework of the Interreg NSR project AVATAR work package 6.
- Interreg VB: AVATAR
- This document is published within [the AVATAR project](#), an INTERREG project of the North Sea Region programme 2014-2020 as one of the reports for WP6.
- It is allowed to distribute this publication.
- The publication may be cited as: Kia, G. and T. Pauwels (2023): Development of an open source vessel – Guidelines how to set up a conceptual approach of an open source fleet, publication in the framework of AVATAR, a project co-funded by the INTERREG North Sea Region programme 2014-2020 (ERDF).
- Source of the photo(s) on the cover: POM Oost-Vlaanderen

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### Document version:

Version	Date
V1.0	30.06.2023

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### Project partners AVATAR:



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# 1. Introduction

The massive under-exploitation of inland waterways (IWW) in the North Sea Region (NSR), especially in and around urban environments, provides opportunities for technological innovations. The AVATAR project aims to deploy (highly) zero-emission automated vessels that can do regular trips between the urban consolidation centers outside of a city and inner city hubs.

The AVATAR project aims to tackle challenges of city freight distribution by developing, testing and assessing adequate technologies and business models for urban (highly) autonomous zero-emission Inland waterway transport (IWT) solutions. Through this, the project unlocks the economic potential of urban vessels and corresponding waterways, increases available solutions for full-cycle automation and sets up a sustainable supply chain model for urban goods distribution and waste return.

In chapter 2 an overview is given of some European research projects on (highly) autonomous sailing leading to some lessons learned for the AVATAR project. In chapter 3, research gaps in six key areas are listed.



## 2. Research and development projects at SEAFAR

Seafar is a use case leader in many different European Research and Development projects. In each project, there is a specific innovation conducted by Seafar to improve safety, grow the company's technology, and enhance a semi-autonomous sailing of a vessel. Some of these projects are funded by the EU Horizon program and some are government funded projects. To discuss the innovations in the projects, let's first have a look to the elements in a remote operation scenario since the innovation can be applied to each part of the remote operation to improve the whole system.

There are different parts involved for a successful sailing of a semi-autonomous vessel. The first one is the vessel which is sailing by the command of remote captains, the second one is the communication to transmit and receive the data to/from the remote control center, and the third one which is the remote control center. A number of elements are involved in a remote operation scenario. The most important ones are explained as follows.

- 1) The vessel and the required hardware on it, which is sailing on a specific trajectory and receiving commands from remote captain is one important part. The control system onboard is designed by Seafar hardware engineer and the integration of the software and hardware are done by the R&D and software team.
- 2) Communication is done by 3G/4G (or 5G based on signal coverage) links. The data which are collected by the sensors onboard the vessel, should be provided to the remote control center. In this way, the remote captain can have the similar situational awareness as the captain onboard while he has access to the data from cameras/radars/ other sensors visualized on the monitors.
- 3) In the remote control center at Seafar, the captain is remotely navigating the vessel through the specific trajectory. In addition to the sensors information, he also utilize the artificial intelligence-enabled tools.
- 4) The remote captain makes the decision based on the data and tools provided to him. He sends his decision as a command to the vessel. There are also traffic controllers available at the remote control center who controls several vessels at the same time.
- 5) Finally, the decision that the captain/traffic controller makes will be sent to the vessel. The command will be sent over 3G/4G/5G signals. The network configuration will be done prior to the demonstration by the network engineer.

In each navigation scenario, position information plays an important role. The accuracy of position has a high impact in some critical scenarios. One of the projects at Seafar is **Novimove** (<https://novimove.eu/>). This project aims to centralize the logistics system by

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improving container load factors and by reducing waiting times in seaports, by improved river voyage planning and execution, and by facilitating smooth passages through bridges and locks. Seafar contributes in accurate vessel positioning by collecting data for sensor fusion. Different sensors are installed for the specific trajectory and the big barge to be utilized for the project demonstration. The collected data is provided to partners such as Imec and University of Antwerp for algorithm development. The developed solution will be then tested by project partners and illustrated in the final event.

As mentioned in the necessary elements of a successful remote operation scenario, connectivity plays an important role. Considering the recent improvement in 5G technology, Seafar is considering 5G projects for improving the semi-autonomous vessel navigation. 5G-Blueprint (<https://www.5gblueprint.eu/>) is one of the 5G projects at Seafar. The overall objective of this project is to design and validate a technical architecture, business and governance model for uninterrupted cross-border teleoperated transport based on 5G connectivity. Seafar is the automated vessel use case leader in this project, studying on the challenges in cross border scenarios. Seafar also works on another 5G project called Vital 5G (<https://www.vital5g.eu/>). The strategic objective of VITAL-5G is to create an open, virtualized and flexible experimentation facility comprised of an intelligent virtual platform, three distributed European 5G-testbeds and associated vertical infrastructure, to enable the testing and validation of Transport & Logistics (T&L) Network Applications in real-life conditions, utilizing 5G connectivity. Seafar has developed a network application in this project to assist the captain onboard for a safe sailing. The dashboard is integrated with other solutions developed by Imec and Digitrans.

Situational awareness of a remote captain is highly important in an automated barge scenario. In Pioneers project (<https://pioneers-ports.eu/>), Seafar is developing computer vision algorithms to do the object detection. When the remote captain utilize the AI-enabled tool, (s)he can see the objects near the vessel that he is sailing and in this way, he will make more accurate and faster decisions. This will improve the safety and avoid collisions. The overall goal of the PIONEERS project is to rethink all aspects of port operations ranging from terminal operations, safety, mobility, connectivity, fuels to models for cooperation and production, storage and use of energy. The PIONEERS consortium produced 19 demonstrators in the field of clean energy production and supply, sustainable port design, modal shift and flows optimization, and digital transformation..

ReNEW project (<https://renew-waterways.eu/>) is another project which considers small urban barges. This project considers a rescue scenario where the simulation of floods and other disasters are taken into account. The ReNEW project is a collaborative endeavor involving experts from 11 European Union countries, aiming to facilitate the transition of Inland Waterway Transport (IWT) into an environmentally sustainable and resilient sector. By leveraging past achievements and collaborations, ReNEW will create a comprehensive decision-support framework for IWT infrastructure, enhance resilience through innovative



solutions like autonomy and green energy, establish data-sharing platforms and a digital twin, and demonstrate these ideas in Living Labs. The project also emphasizes broad dissemination and impact maximization through outreach and scaling efforts. Seafar activities in ReNEW is within the Living Lab of Ghent. It includes remote operation of a crane which is applicable to the yard considered for the specific living lab. Furthermore, there is close collaboration with Imec to develop the digital twin required for the rescue team.

An overview of other European projects on autonomous sailing is available here:

=> <https://www.inlandwaterwaytransport.eu/inland-navigation-week-2023/autonomous-sailing-and-resilience/>

=> <https://www.inlandnavigation.eu/connected-automated-shipping/>

=> <https://link.springer.com/article/10.1007/s13437-023-00316-3>

=> <https://automation.ccr-zkr.org/1000-en.html>

### *Lessons learned for AVATAR*

The most important lessons learned for AVATAR include methodologies to tackle live demonstration challenges considering the availability of the barge and the resources for docking, the communication with the remote operation center and establishing a suitable way to show the system to the attendees. Another lesson is planning the architecture of the system together with the partners who are contributing to system implementation. A brainstorming session can assure all the partners that they receive the data and device that they require on time.

There is a lot of room of innovative activities for the future of AVATAR vessel in the field of autonomous shipping. Autonomous mooring is one of the possibilities. Furthermore, the communications between the vessel and remote operation center can be implemented with 5G for higher bandwidth and lower latency. Another innovative aspect can be the utilization of GNSS RTK solutions or sensor fusion methodologies for accurate vessel positioning.



### 3. Research gaps in autonomous sailing

AVATAR project partners Rudy Negenborn (TUD) and Peter Slaets (KUL) contributed to an article in Nature about research gaps in autonomous sailing.

Research gaps in six key areas are described:

- (i) understanding the challenges at different levels of autonomy;
- (ii) defining the role of humans;
- (iii) assuring safety and security;
- (iv) rethinking ports;
- (v) embedding autonomy in legal and regulatory frameworks;
- (vi) setting out the case for autonomous ships.

The full article is available [here](#).

See also the AVATAR [LinkedIn](#) message.

### 4. Reference

Negenborn, R. R., Goerlandt, F., Johansen, T. A., Slaets, P., Valdez Banda, O. A., Vanellander, T. and N. P. Ventikos (2023), Autonomous ships are on the horizon: here's what we need to know, Nature (02/2023), <https://www.nature.com/articles/d41586-023-00557-5>



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