Sharing intentions via trackpilots used in inland shipping can make inland navigation more efficient and safe.

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Introduction

Proactive sharing your navigational intentions with the surrounding vessels is currently very rare in sea and inland shipping. Of course, using VHF to communicate the intentions is common practice, but this communication likely takes place after assessing that routes of individual ships will interfere or when coordination is desired.[1]

The skipper or captain estimates whether route interference could take place. Knowing his intentions and situational awareness, the captain makes assumptions on the behavior of the other ships, using information on:

- The sailed route so far and the current course and speed that it sails right now;
- Traffic rules and the normal behavior of ships in the specific area;
- If available: the destination of the other ship.

However, assumptions do not always hold; there is always a chance that the other ship acts contrary to the expectations. Often an incident arises from misconceptions of the captains on the sailing behavior of other ships involved.

This makes the question relevant if making navigational intentions available uncalled can contribute to the safety and efficiency of traffic on sea and inland waters.

Digitally sharing intentions has the potential to increase the safety of shipping and a higher efficiency of vessel traffic management. Moreover, it can be a perfect tool to let ships with different levels of automation sail safely and efficiently in the same environment during the transformation to more automated shipping, a first step leading to coordinated sailing vessels in the future. In the prospect of a collaborative and interconnected maritime ecosystem, ships not only share data with other fairway users but can coordinate with traffic and authorities ahead of time, preventing conflicting sailing paths. It further allows to optimize traffic flows, realize just-in-time arrivals and also therefore increase fuel efficiency.

Studies carried out on sharing intentions at sea

Considerable research on this subject has been carried out already, inventoried in a literature study by MARIN[2]. The research has been carried out in European research projects[3] and focuses on coastal and high seas areas. The main concepts involves sharing route intentions via AIS and ECDIS; automatically route sharing; route suggestions from the VTS via AIS and strategic route planning within VTS. The intended routes of ships were presented on an ECDIS display.

[1] In inland shipping a blue sign is used to signal that a ship wants to sail portside-portside using the characteristics of the river. This is a rare example of active communication.
[2] Digitaal intenties delen, literature study, MARIN commissioned by Rijkswaterstaat, report number: 33282.600, June 2021
[3] The relevant studied were: EFFICIENSEA (2009 – 2012), MONALISA 1 (2010 – 2013), ACCSEAS (2012 – 2015), MONALISA 2 (2013 – 2015), EFFICIENSEA2 (2015 – 2018), STM Validation (2015 – 2019), STM Balt Safe (2019 – 2021).

Commonly, vessels shared eight route waypoints ahead of their own ship, that were inserted manually by a short sea captain. This made detection of and warning for the closest point of approach possible and more reliable.

The studies – which included several simulations - indicated that the concept of intent sharing is promising. It provides support in avoiding close quarter situations and the disclosed information to the captains was proven to be more useful in open seas than in approaches. Sailing with shared intentions showed a tendency to improve navigational safety in traffic situations when used as a tool for the longer range – strategic planning. Surprisingly, no significant reduction in VFH communication was observed.

Apart from the positive outcome, there were also concerns described in literature:

- A risk to deviate from the intended and broadcasted route was noticed.
- In very tight and time constrained collision situations none of the ships will have time to enter new waypoints (intentions) into the ECDIS.
- The tool cannot be used as a collision avoidance tool in close quarters situations.
- There were Human Machine Interface (HMI) design issues, further research into HMI is required.

An important limitation in the method used in these projects was that the captain had to provide the intended route by manually entering waypoints. This is a time-consuming procedure, prone to human error and less suited for more complex maneuvers.

Increasing use of trackpilots

In recent years, the use of a trackpilot[4], a system that can sail an inland ship on a pre-defined track automatically has really taken off in Western Europe. It provides a means to implement digitally sharing intentions. A trackpilot does not only know where it wants the ship to be in the next future, but the system will also do its utmost best to keep this 'promise' by maneuvering the vessel back to the sailing track if the loses course. This makes the trackpilot an ideal instrument to provide the sailing intentions.

It has been estimated that at the end of 2022 about 600 inland ships in Western Europe have been equipped with a track pilot, making it 6% of all vessels used in a professional way[5]. This is not only relevant for the functions it does have nowadays, but the trackpilot is an ideal basis for additional functionality, like route conflict warnings and collision warnings.

In the present time, there are three main suppliers of trackpilots in Western-Europe we are aware of[6]:

1. Argonics of Germany
2. Shipping Technology from the Netherlands
3. Tresco of Belgium

[4] A trackpilot has two distinctive functions:

1. It provides a sailing track given the location of the ship and the destination set by the crew. This sailing line is automatically generated on the bases of past tracks of ships (partly) sailing the same track earlier. The calculation of the track can be more or less advanced, sometimes taking expected keel clearance and other ship and environment issues into account.
2. Once activated, the trackpilot controls the rudder to keep the track as best as possible. Nowadays the power throttle is not used, but it is foreseen that new extensions will cover this as well in the near future.

[5] This estimate is made by the writers based on the amounts sold given by the three suppliers of trackpilots.

[6] There are more versions, but these are largely based on one of these three. For example: Alphatron sells its AlphaRiverTrackPilot. The interface has been customized, but the heart of the system is derived from Argonics and equal to Argonics trackpilot.

Simulation study at MARIN

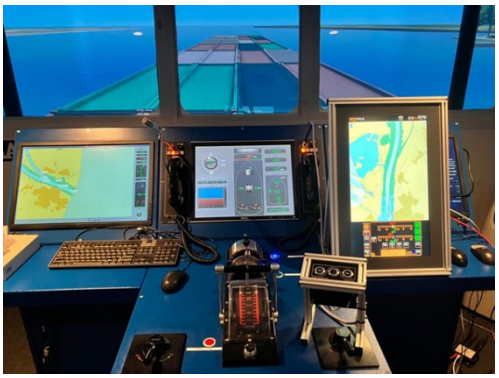

Figure 1: One of the bridge simulators used in the project. The interface of the trackpilot of Argonics is right on the picture.

Based on the experiences and recommendations in studies on short sea shipping as mentioned above, Rijkswaterstaat decided to ask MARIN to carry out a simulator experiment. The central question, can efficiency and safety benefit from intention sharing in inland shipping, was broken up to three questions:

1. How does Intention sharing influence resolving traffic situations, such as crossing and passing?
2. How does Intention sharing influence communication, situational awareness and decision-making?
3. Are there operational boundaries, such as time and distance between vessels, traffic density or traffic complexity, to utilize any found advantages of IS?

Trackpilots provide the technology to send out and receive waypoints – the intended route – and have not been used before in studies about Intention sharing. The three suppliers of trackpilots were consulted to participate in a simulator study at MARIN to research the potential benefits of Intention sharing on inland waters. All suppliers were enthusiastic and a simulation study was set up with trackpilot systems installed on MARIN simulators.

Preparation of the trackpilots for the simulation

The trackpilot manufacturers had to adapt their product to be able to participate.

Figure 2: Bridge simulator at MARIN. The trackpilot of Shipping Technology as well as an alternative visualization are on the left.

First, they had to be able to address future positions of the vessel with a time mark related to these positions, indicating where the vessel will be in time. This data was communicated in a specially and rather quickly designed format making use of a wired data network, to perform the experiment.

Secondly, the trackpilot interfaces had to be adapted to show the intention data of the ships in the environment. All three suppliers used their own design resulting in different ways presenting the information on an Electronic Navigational Chart (ENC). Since Shipping Technology normally has a very limited display and makes use of an already installed ECDIS to show additional information, they made an alternative display system. Also Argonics used a special version of an ECDIS.

The experiment was carefully prepared. Before the experiment, a proof of concept took place to demonstrate the proper communication between the systems. It gave the suppliers the time to do some last changes in the functionality as well.

Simulating with inland skippers at MARIN

The experiment took place on September 12 and 13 in 2022. Two groups of three skippers each participated in the experiment, using 8 scenario's in two conditions: with and without sharing the intentions. By observing the sailing behavior of the skippers, asking them questions and letting them fill in a questionnaire, as well as using an eye-tracking system, the information was gathered.

The skippers used a 3D world view, radar, an inland ECDIS system and the interface of the trackpilot to collect their information. The rudder, thruster, VHF-like intercom and buttons to change from trackpilot to manual control and back were there to be used by the skipper to steer their virtual ship. All three virtual ships were in the same environment, sometimes with additional ships as well. The skippers were asked to sail with the trackpilot and retain their speed, as long as the situation allowed to their own judgement.

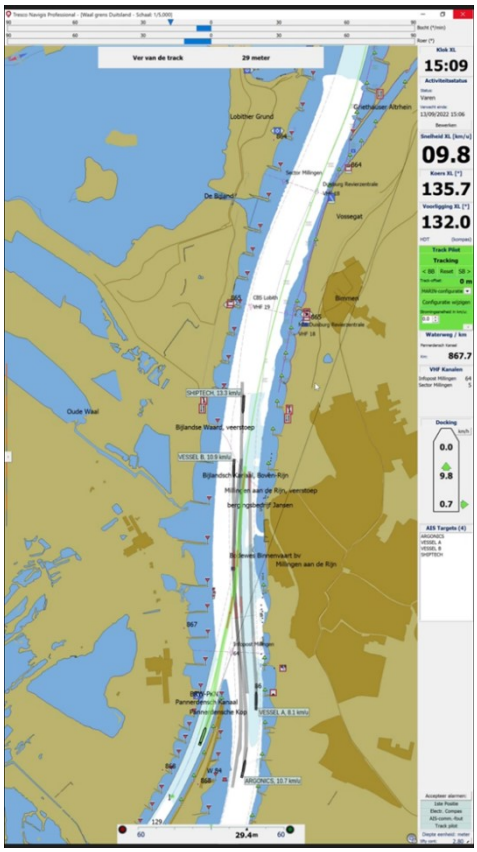

Figure 3: Intentions shown on an Inland ECDIS system of TRESCO Engineering.

Skippers opinion

The skippers judged the simulation scenario's to be realistic. The information on intentions was judged to be very useful, varying 4 to 7 on a scale of 7. They believed navigational safety will benefit from Intention sharing (5.7 out of 7, again depending on the scenario).

The skippers also gave information on how the system could be improved; the recommendations were merely related to interface-design. Very much liked was the function that visualized the future traffic situation in a short animation, part of the Argonics interface.

Simulation study conclusions

MARIN observed that the skippers needed help with the systems in the beginning, but quickly learned to use it in their benefit resulting in more anticipating sailing behavior and less VHF communication.

MARIN[7] concluded that Intention sharing could improve safety and efficiency on inland waters, by supporting situational awareness. Intent sharing can be viewed as a new set of eyes, which is most useful in low visibility conditions.

However, there are risks as well. Due to the task transfer of sailing from skipper to a (track control) system, there is a risk of lowered situational awareness and out-of-the-loop problems, overreliance on the system, and risk-compensation behavior because skippers are aware that their intended route can be seen by the surrounding traffic.

[7] Digital Intention sharing, Simulation study on the benefits of intention sharing, MARIN commissioned by Rijkswaterstaat, report number 33281-1-MO-rev.2, December 2022, https://open.rws.nl/overige-publicaties/2022/digital-intention-sharing-simulation/

Two types of recommendations were made:

1. There are also risks using the trackpilot when no intentions are shared. It is advised to mitigate these risks by improved design and clear operational procedures on how to use the trackpilot. These risks can be identified and assessed when building a safety-case. Drawing guidelines for human-machine control and the interface can help the suppliers of trackpilots making their systems (and the use of it) more safe.
2. When implementing Intention sharing, defining an operational concept and a proper user-interface can help trackpilot suppliers to implement the concept as safe as possible and to reap the full potential of trackpilots. This should be part of the implementation plan.

Further steps

Figure 4: Photo made during the conference on November 16th 2022 in Rotterdam.

At an event on November 16th 2022, organized to present the conclusions of the simulator study, the three suppliers of trackpilots announced that they were considering the introduction of Intention sharing in their products. Following a call to other potential parties that could favor from the development of this functionality, new participants other parties stepped forward. One of them is the Port of Rotterdam, looking at possibilities to resolve the work pressure in Vessel Traffic Services. When a ship enters the VTS area it must announce itself and clarify its intentions, which may be covered with the functionality as well.

To reap the full potential of the concept, interoperability is needed. A user of Intention sharing functionality must see the intentions of vessels equipped with systems of a different supplier as well and must be able to rely on the functionality. In addition, for market reasons, new suppliers of systems that disseminate and/or use intention information must be able to join as well.

One of the technical questions to be resolved is the communication channel to be used for exchanging intentions. VDES would be the best solution, however the implementation path for VDES will give extra hurdles. AIS and client-server-techniques can be used alternatively, but also have limitations. A hybrid solution may partly overcome these shortcoming.

Further work on how to safely implement Intention sharing and reap the potential of using trackpilots is expected to start in spring 2023. We are reaching out to additional partners who share the potential of Intention sharing and would like to use it.

Overall conclusions

- Sharing intentions in inland shipping could improve safety and efficiency on inland waters, by supporting situational awareness.
- The increased use of trackpilots in Inland shipping makes Intention sharing possible.
- There are risks to be mitigated. Some of these risks derive from the use of a trackpilot, even when no intentions are shared. It is advised to mitigate these risks by improved design and clear operational procedures on how to use the trackpilot.
- When implementing Intention sharing, defining an operational concept and a proper user-interface can help trackpilot suppliers to implement the concept as safe as possible and to reap the full potential of trackpilots. This should be part of the implementation plan.
- Other stakeholders do see the relevance as well and have the aim to join the implementation.
- In 2023, MARIN and Rijkswaterstaat will continue to work on both the safety of the use of trackpilots as well as the implementation of Intention sharing in inland shipping.