AUTONOMOUS SHIPS

NAUTICAL TRAFFIC IN PORTS

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With ongoing trade globalization, waterborne cargo transportation has notably grown in recent years. Due to the growth in ship sizes, with lower manoeuvrability, and higher flows, the safety in these confined areas needs to be guaranteed. Nautical traffic operations in ports are now impacted by more data availability and the disruption of automation processes, and port stakeholders need to adapt to these changes.

ACTUAL AND FUTURE NAUTICAL TRAFFIC

The implementation of automatic identification systems (AIS) in vessels was a turning point in the evolution of nautical traffic in information acquisition. Nowadays, nautical traffic in ports is mainly organized by VTS operators from port authorities, where the AIS information of each ship is known by the other ships. Previously, VTS operators were in charge of guiding incoming and outgoing ships sailing into ports, such operations are performed in a manual way based on operator knowledge. The drawbacks in such expert knowledge-based operation are the possible human errors or the non-optimal on the spot decisions.

A lot of new data and tools, such as the recently launched Port Call Optimization platform (PRONTO) by the Port of Rotterdam, allow seafarers and harbour coordination centres to better schedule ship arrivals and improve the operational efficiency of the whole port. However, most of these operations are still experience based, while there is much more information available to avoid or resolve future nautical conflicting situations. Simulation models are already applied by captains and pilots to simulate manoeuvring in some ports. They can choose specific environmental conditions and ship characteristics to assess their entrance in the port and foresee difficult manoeuvring along the port infrastructure. These tools are not used yet to forecast future encounters with other ships or to predict their individual manoeuvring, so they cannot anticipate possible complex encounters. However, they could be developed further to be applied for this purposes.

The trend for the future seems to be automated intermodal transport, where not only the warehouses are automated but also rail, road and nautical traffic too. With the introduction of autonomous ships in ports, there will be great challenges with both manned and autonomous ships, – ranging from the management of port traffic through to safety and legal issues. Therefore, the departments of Transport & Planning and Hydraulic Engineering (Section Ports & Waterways) at Delft University of Technology (TU Delft) are developing a new nautical traffic model and are proposing methodologies to evaluate the traffic efficiency of ports (risk and capacity). This generic nautical traffic model is expected to simulate real ship behaviour as closely as possible. Thanks to a detailed AIS data analysis, the ship sailing behaviour pattern in a port area and its relation to external factors can be determined. AIS data from real ports can be used for its calibration and validation. A tool like this would allow the prediction of a future situation given a certain port layout and environmental conditions.

There are two areas of great interest for port authorities and port stakeholders: the capacity and safety of the port. Terminal capacity has been extensively studied before and there are many risk assessments

focused on historical accidents. However, the estimation of future capacity for different nautical traffic situations and a dynamic risk indicator would be extremely useful. The model under development will include a systematic methodology based on simulation results to evaluate nautical risks and port capacity. The integration of decision-making methods in such a detailed model can be used as a dynamic assessment tool for changes in traffic rules, future fleet compositions, or new port designs. This can help the port authorities to improve their future port planning or manage traffic in different ways, with the eventual purpose of increasing port capacity while keeping risks below the desired threshold.

AUTONOMOUS SHIPS

When autonomous ships become a reality, our present model of vessel traffic management will completely change. New legal regulations and traffic management strategies will be a necessity. Planning for this has already begun. Some companies, such as Rolls Royce, are sourcing knowledge and support from other companies and universities. Another collaborative research initiative is the MUNIN project which aims to develop and verify the concept of autonomous ships to overcome the current challenges in increasing transport volume and a possible shortage of seafarers.

As defined by Lloyd's Register, there are generally six levels of autonomy resulting in different phases of autonomous ship development. The current manned ship is has the lowest autonomy. For the ships with the first two levels of autonomy, all actions are still taken by a human operator but there is decision support from shore. In the third and fourth levels of autonomy, humans are present on-board, but only in supervisory roles. For the highest two levels of autonomy, ships are fully autonomous with decisions made and performed without human intervention.

All the stakeholders (VTS operators, pilots, terminal operators, port planners) need to adapt to the communication and operation of autonomous ships during the transition period. Only then can the goal of making navigation safer, cheaper and more efficient be achieved.

THE TRANSITION PERIOD

Ports with only autonomous ships and intelligent terminals are expected to be smart with a high level of safety and capacity. Considering the life cycle of existing ships and the time for autonomous ship building, the transition period with both manned and autonomous ships will be long. Thus, the challenges with regard to the coexistence of both types of ships needs to be assessed in advance with the use of advanced simulation tools to evaluate a variety of situations.

During the transition period, ports will be challenged to adapt to this situation. First of all, the communication between manned ships and autonomous ships needs to be changed. The communication between two manned ships is usually through instant VHF calls during encounters for a safe passage. The cooperation between autonomous ships during encounters is based on the shared information of path planning for both ships. When one ship is manned while the other is autonomous, the communication could be unbalanced before a global protocol is issued, which would lead to a wrong decision-making process.

Secondly, the coordination role of VTS centre needs to be adapted due to the change in communication. The report of ship arrival and departure can be automatically performed by autonomous ships. But in emergent situations with different types of ships, the VTS operator needs to coordinate with the remote operator which takes decisions based on information sensors.

In cases of technical failures on board, there is hardly a remedy to solve the problem, which may lead to serious consequences. Thus, it can be expected that the ships at autonomy levels three and four will be important during the transition period. Most of the time, ships will manoeuver autonomously. But in unexpected situations, the human operator on-board can take over responsibility in communication and making decisions. When the autonomy levels five and six are achieved, it can be expected that the goal of fully autonomous navigation is close.

CONCLUSION

Most research on autonomous ships focuses on the situation with only ships operating at the highest levels of autonomy, while there is seldom research investigating the impact of autonomous ships on port traffic during the transition period, with both manned and autonomous ships.

Unlike the assumption of fully autonomous ships for the whole port, the authors and the research team started their approach of the problem from the current real-life situation. Based on the simulation model for the manned nautical traffic in ports, where the traffic situation in different scenarios can be presented. This way, thanks to simulation-based evaluation methods, port authorities could forecast the traffic through the port, assess the possible risks and the capacity expected, and adapt the traffic management rules and strategies for future mixed traffic.

The upcoming challenges during the transition period will make the forecast of uncertain situations more important where ships have different levels of automation. It is expected that a simulation modelling approach should be applicable when dealing with situations. Hence, the development of further research in advanced simulation models, such as the one being developed in TU Delft, will help to maintain an efficient ship traffic model and better prepare stakeholders for autonomous ships. Based on a prediction overview of port operations, port stakeholders can be prepared for the uncertainty after the introduction of autonomous ships, and have the necessary tools to support the changes from human-based operations to complementary supervision.

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ABOUT THE AUTHOR

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ABOUT THE ORGANIZATION

Delft University of Technology is international and multi-disciplinary organisation that promotes research, innovation and education in many technical fields. The Transport & Planning department englobes all transportation related projects, such as road traffic and safety, public transport, active modes (bicycles and pedestrians) and freight and logistics. The Ports & Waterways section, within the Hydraulic Engineering department focuses on the fields of port and waterways design, shipping, nautical matters, safety and capacity. Their project is partly funded by NWO (Netherlands Organisation for Scientific Research) and supported by the Port of Rotterdam Authority and SmartPort Rotterdam.

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