

WILL THE FUTURE OF SHIPPING BE BASED ASHORE?



Michael Baldauf, Momoko Kitada, Raza A. Mehdi, Maher A. S. Al-Quhali, Jia C. Chong,
World Maritime University, Sweden

Since the International Maritime Organization's introduction of the concept of e-Navigation in 2006, development and integration of new and sophisticated information and communication technologies are gaining ground. Information and data exchange between two or more ships as well as between ships and all kinds of shore-based maritime organizations and service providers has grown into a new dimension. This is resulting in safer and more efficient ship operations and traffic flows along many coastal regions.

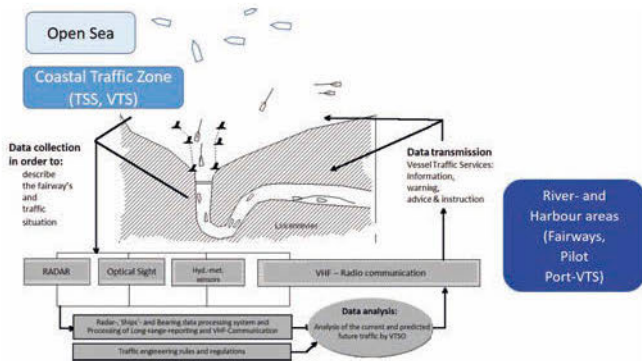
It seems a question of time as to when autonomous ships with minimum crew will become a reality. Perhaps even no crew at all. The present situation in international shipping is characterized by rapid fundamental changes affecting the basic concepts of operating ships and even changing traditional paradigms of

controlling ships. As a consequence, even the rather conservative maritime domain might see the future of shipping and ship operations move ashore.

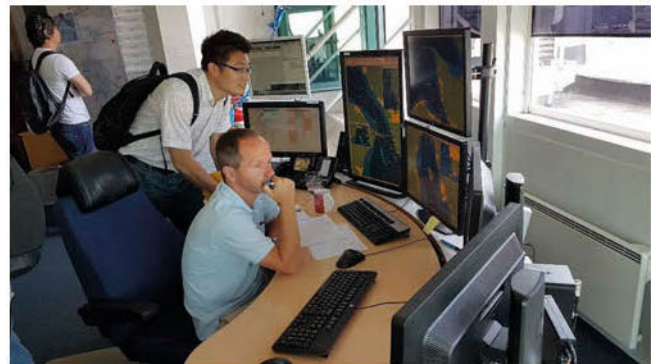
Shipping companies are establishing shore-based fleet operations centres to monitor the movement and progress of individual ships in their fleet on a worldwide scale. Coastal states have established and improved their surveillance capabilities in order to ensure safe and efficient traffic flow in their territorial waters and are exploring opportunities to enhance overall maritime traffic organization and control. Ports want to be called at by unmanned ships and are preparing their infrastructure to handle the monitoring of traffic flows consisting of conventional and sophisticated remote controlled and unmanned vessels. However, all will still need operators ashore.

SHIPS, VTS AND FOC

Autonomous and unmanned vessels are rather rapidly emerging phenomena in the maritime sector. These vessels are expected to bring about significant improvements in the domain of safety. They are friendlier to the environment and contribute to a better financial performance for shipping companies. However, stakeholders are also acutely aware of the potentially negative impacts that may arise if the industry transitions towards the above mentioned types of vessels in an ill-prepared manner. In order to understand these impacts, it is necessary to examine maritime operations as a complex socio-technical system. The safety and efficacy of maritime operations thus depend on the performance of the various sub-systems and processes, both on-board seagoing vessels and ashore. Typically, the sub-systems of a transportation system can be categorized as follows:



Monitoring and traffic and providing services to ensure safe and efficient traffic flow and protection of the marine environment – a functional sketch of VTS



A typical work around of a VTS operators work station comprising numerous displays to collect all kind of traffic, environmental and administrative data

1. Transport means (e.g., vessels of various types, sizes)
2. Workers and drivers (e.g., ship crew including captain, officers, engineers, etc.)
3. Transport paths (e.g., open sea, coastal waters, routing measures like recommended routes or traffic separation schemes (TSS) etc.)
4. Traffic management (e.g., ship reporting systems, vessel traffic service (VTS) systems, etc.). It is important to highlight at this point that the advent of autonomous and unmanned vessels has also added a new type of traffic management sub-system: shore-based monitoring and control.
5. Organization and administrative components (e.g., International bodies such as the International Maritime Organization (IMO), International Hydrographic Organization (IHO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), as well as national authorities and administrations that provide, implement and enforce standards, rules and regulations to ensure safe and efficient vessel traffic in clean oceans)

Traditionally, and until today, all rules and regulations in the maritime domain are made for globally trading merchant ships that have to be manned accordingly. Additionally, especially in areas with high traffic density, ships are monitored and their crews are supported by shore-based surveillance and control centres providing the services of a vessel traffic system (VTS).

VTS's are well known and recognized in this respect. Defined by IMO and described as "shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of

traffic within a port or waterway," VTS may include an information service, navigational assistance service, and traffic organization service. The division and definition of these services, however, is under consideration for revision.

From an engineering point of view, a VTS can be simplistically considered as a system that collects environmental and traffic data in order to create a traffic image that is continuously analysed by the operators who assess if there are any developing or already existing risks that require interaction with the traffic. If a VTS operator becomes aware of a vessel that is, e.g., not complying with the rules, violating regulations, or in case s/he detects a situation with a risk of grounding or collision then the VTS can intervene by sending out information, warning/advice or instructions to all or specific vessels using VHF voice communication.

Aside from the monitoring of vessel traffic in sea areas within national jurisdiction through a VTS operated by or under the direction of public authorities, there is an increasing number of company-based fleet operation centres (FOCs). They are not regulated by IMO or any other organization. They function as an additional safety barrier within a shipping company's safety regime. FOCs monitor the safe and efficient progress of company-owned ships and, just as VTSs, operate 24 hours a day, 7 days a week. The operators in FOCs used to be active navigating officers and captains that may have worked on board the vessels they are remotely monitoring.

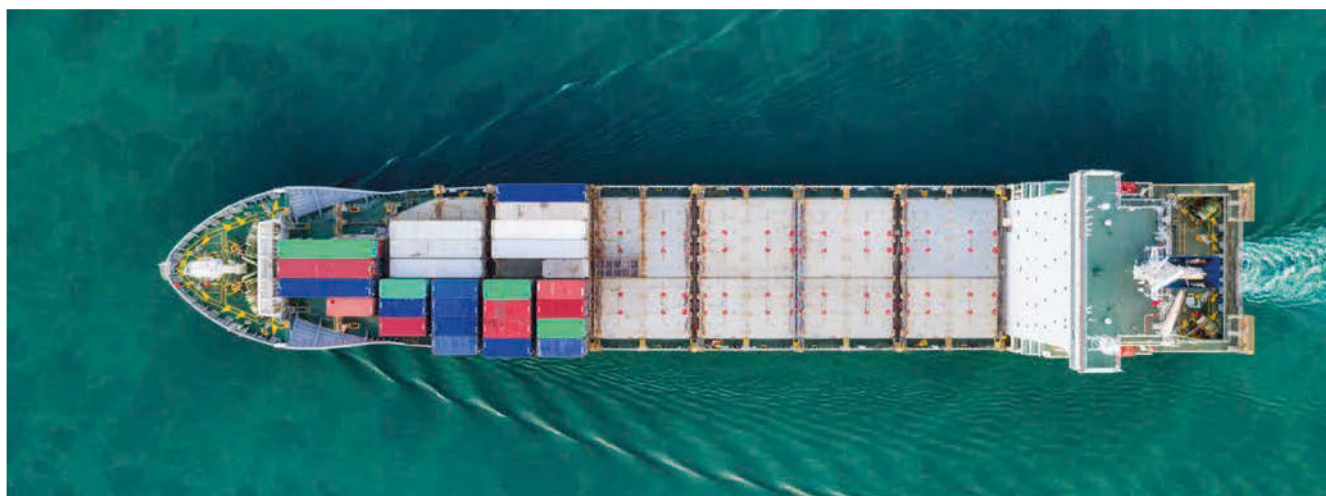
The data available in an FOC is much more detailed and much more comprehensive than in a VTS, as they are focussing on the entire operations on-board, including especially navigation and engine operation. FOC operators have almost real-time information of the navigation process including information

and data from ship's position sensors, gyro, speed, and sounder, but also displays of Radar-ARPA and ECDIS covering the complete set of ship operation processes. The technical infrastructure of an FOC may comprise of the same decision support systems installed on-board. Finally, FOCs have the opportunity to directly contact the OOW or captain in order to request or provide additional information.

However, VTS's and FOC's differ in terms of geographic reach and monitoring area. VTS's monitor and provide services over a defined body of water, while FOC's monitor ships as they sail on any of the world's seas. Of course there are substantial differences in the underlying legal frameworks and liabilities.

So far, the relation between the navigators on board and the operators ashore (whether in an FOC or a VTS) is characterized by the status quo that the shore operator provides additional information in order to support the decision making processes of the bridge team on-board. So far, however, there is no guidance about any potential relations between VTSs and FOCs. In the light of the development and introduction of MASS, FOCs are seen as potential prototypes of shore control centres that may at once even have the ability to remote control an unmanned ship.

In this regard IMO's e-Navigation initiative needs to be mentioned and highlighted as well. IMO together with IALA make an effort to introduce state-of-the-art technologies to improve and harmonize the collection, processing, and presentation of data and information to support human operators on-board and ashore to ensure the safety of navigation from berth-to-berth. Even though e-Navigation clearly addresses the human operators, the captain, the OOW, and the whole bridge team as well as the VTS supervisor and his watch standing



operators in shore-based centres, e-Navigation is obviously supporting even more enhanced services. Together with the increasing level of digitalization and automation it is supporting the introduction of autonomous navigation and even unmanned ships. Making them a reality will fundamentally change the existing transportation system.

PRESENT SITUATION

IMO's MSC99 working group on MASS has defined four levels of operation:

1. Ship with automated processes and decision support
2. Remotely controlled ship with seafarers on board
3. Remotely controlled ship without seafarers on board and
4. Fully autonomous ship

IMO intends to provide guidelines for MASS trials by the end of 2018 and MASS specific regulations by 2025. It is expected that regulations take into account all aspects of operation and training and education issues might be addressed as well, but it is not yet on the agenda. Experiences and related studies are obviously lacking.

Present concepts proposing and researching the introduction and operation of unmanned ships usually contain a kind of shore-based control centre that monitors the status of such ships and the navigational and technical processes. In the MUNIN project, such a centre was named the ship control centre (SCC) and provided for direct remote control options whenever necessary.

However, the introduction of such transportation systems has not only various technical-technological, but also administrative-organizational and human factor related challenges. The technical-technological aspects are widely covered in numerous research and technical development projects. However, the consideration of operational aspects, such

as the interaction with other conventional ships and moreover with a VTS, have so far not been considered in great length and is comparably rare as a subject of ongoing study and research. In contrast, operational and human factor related aspects appear prominently in the research agenda.

THE FUTURE

In order to gain experience in researching how unmanned ships can be integrated into the existing traffic flow of conventional ships along coastal areas and fairways to ports, a pilot simulation trial was designed using a constructed scenario with typical traffic load under usual normal environmental conditions. One aim of the trials was to provide a different set of equipment for monitoring and remotely controlling the unmanned ship integrated in the overall scenario and to test different compositions of the control teams in respect to the operators' seafaring background. One of the groups comprised individuals with experience from having served as navigating officer while the other group was composed of individuals who did not have any seagoing or navigation experience. Participants came from Asia, Europe, North- and South America and have background of the main languages.

The basic initial event of the designed scenario was a breakdown of the autonomous mode on board the unmanned ship and the need to take over command by remotely controlling the ship from the remote shore centre.

The traffic scenario for the simulator study was created using historic AIS/radar data from a real VTS centre, and consisted of a spotlight of more than 15 targets. The simulated area was created on a real sea area and environmental parameters were set to good visibility in daylight, moderate wind (<2 BFT), calm sea-state (2), and no current. The MASS implemented was an

average 4,000 TEU Panamax container ship (length 218 m; breadth 32 m) with standard engine, single screw propeller and bow thrusters.

VTS coverage was added to the simulation by live VHF communications with standard messages, prepared with the scenario script, throughout the duration of the simulation exercises and included regular standard weather and traffic reports. The participants acting as the operators in the shore control centre could listen to the reports but were unable to communicate with the VTS station as well as with targets. The messages were spoken by participants who are either active VTS operators or are familiar with VTS operation and communication procedures and Standard Marine communication phrases.

CONCLUSION

In regard to the question headlining this article it seems that the future of steering a ship very probable will be based ashore. A very important question in this regard is the job profile and are the skills and knowledge of operators working in those shore-based centres. This is the focus of considerations and thoughts derived from the experiments. Some samples are given below.

Overall as an interim finding from observations during the simulation trials, it can be stated that – with only one exemption – all teams were able to remotely steer the ship safely through the traffic area in this sample scenario. Groups with navigational background took action in a rather strategic and more pro-active manner, also tending to use VHF in order to coordinate manoeuvres with other ships. Experienced navigators seem to take into account manoeuvring characteristics more sensibly and also observe the response to a manoeuvre more carefully. This seems to present us with a strong argument that training and

experience among others specifically in ship-handling is a significant issue for future remote operators.

Participants with seafaring background expressed that the manoeuvring behaviour as well as the engine characteristics (minimum, maximum and critical revolution ranges) need to be integrated in future training programs if remote operators will become a reality. Manoeuvring characteristics and engine behaviour are seen as essential background followed by the legal implications in the area of operation.

Non-seafarers on the other hand expressed the need for better support of remote steering. Features shall be provided that visualizes, at a minimum, e.g. estimates of the effects of rudder and engine commands (decision support systems for manoeuvring have been subject to previous lectures).

From the recorded feedback of the participants it seems to be that there is a preference to make use of the full range of the bridge navigational equipment. Participants with a seafaring background expressed that they prefer cross-check of displays using view out of the window. This refers obviously to the tradition of good seamanship and will require appropriate integration in training and education schemes for future shore-based operators with capability to directly control a ship remotely.

It surely will be interesting to study how more enhanced equipment such as, e.g., virtual reality based decision support system, may or may not have an impact on the safe operation of remotely controlled unmanned ships. From these first very basic experiments it can be stated that more detailed investigations and analysis of the impact of a seafaring background for shore-based operators shall be performed in order to provide a more profound database when developing standards and training programs.

As an overall outcome in respect to the draft and development of job profiles it seems that shore-based operators need to have a profile with enhanced skills and knowledge of VTS operators. Consequently, the IALA model courses for VTS operators seems to be the starting point for the development of training programs for shore based remote control operators. Further operational aspects of the integration of MASS into conventional traffic have been identified. However, this requires more detailed research and in-depth studies that shall follow from the pilot studies presented in this paper.

LITERATURE AND REFERENCES

- [1] IMO, 2008, MSC 85/26/Add.1, Annex 20. Strategy for The Development and Implementation of e-Navigation. Maritime Safety Committee, International Maritime Organization, London, 2008.
- [2] M. Baldauf, K. Benedict, C.M. Krüger "Potentials of e-Navigation – Enhanced Support for Collision Avoidance" The International Journal on Marine Navigation and Safety of Sea Transportation (TransNav), vol. 8, no. 4, pp. 613–617, 2014.
- [3] Noma, Tomotsugu, "Existing conventions and unmanned ships- need for changes?" (2016). World Maritime University Dissertations. 527
- [4] IMO (2018). Regulatory scoping exercise for the use of maritime autonomous surface ships (MASS). MSC 99/5/12, 27 March 2018.
- [5] M Baldauf, R Mehdi, M Kitada, D Dalaklis, " Shore Control Centers for Marine Autonomous Systems: Exploring Equipment Options", Paper presented at MATS - Marine Autonomy & Technology Showcase, Southampton, 2017
- [6] Burmester HC, Bruhn WC, Rodseth ØJ, Porathe T (2014). Can unmanned ships improve maritime safety? In proceedings of TRA, Paris/France, 14.-16. April 2014.
- [7] Porathe T, Prison J, Man Y (2014). Situation awareness in remote control centres for unmanned ships. In Proceedings of Human Factors in Ship Design & Operation, 26-27. February 2014, London, UK.
- [8] Chong JC (2018). Impact of Maritime Autonomous Surface Ships (MASS) on VTS Operations. World Maritime University Dissertations, Malmö.
- [9] Quinisio, BS (2018) Development of a strategy for management of autonomous ships by coastal states. World Maritime University Dissertations, Malmö.

ABOUT THE AUTHORS

Michael BALDAUF (PhD in Transportation Safety – Wuppertal University (Germany)). After almost a decade at World Maritime University (WMU) where he was Associate Professor and Head of Maritime Simulation, he recently became head of VTS-Simulation department at Hochschule Wismar's Maritime Simulation Centre and is lecturing and researching in VTS related subjects.

Momoko KITADA, PhD (Social Sciences – Cardiff University) is a former seafarer and joined WMU in 2011. She serves as Associate Professor in Maritime Education and Training (MET). Her edited books include 'Maritime Women: Global Leadership' (2015) and 'Trends and Challenges in Maritime Energy Management' (2018) by Springer but also cover maritime digitalization and human element issues.

Raza Ali MEHDI graduated as a PhD in Maritime Affairs from WMU in September 2018. He has background from mechanical engineering with a wealth of experience in risk, safety and reliability engineering topics. His latest research was focused on safe and reliable of vessel operations in the vicinity of offshore wind farms.

Maher A. AL-QUHALI has maritime background as Navy and Coastguard Officer but also as a VTS-Operator. He studied Naval and Maritime Science at University of Pisa and recently graduated as Master of Science on Marine Spatial Planning

from Universities of Seville, Azores and Venice. Presently, he is involved in research projects at WMU.

Jia Chyuan CHONG has a mariner's background and holds a COC – Master Mariner Class 1 and served on container vessels in worldwide services. After his seafaring career he joined Maritime and Port Authority Singapore and works in the VTS department. He recently graduated as Master of Science in Maritime Affairs from World Maritime University.

ABOUT THE ORGANIZATION

Hochschule Wismar is a University of Applied Sciences for Technology, Business and Design in Wismar, Germany. The Department of Maritime Studies and its unique Maritime Simulation Centre is located in Rostock-Warnemuende. It is also the home of the Institute for Innovative Ship Simulation and Maritime Systems which is well known for research in international projects.

The World Maritime University in Malmoe, Sweden, is a postgraduate maritime university founded by the IMO. The aim of the WMU is to further enhance the objectives and goals of the IMO and its member states around the world through education, research, and capacity building.

ENQUIRIES

Web: <https://www.wmu.se>