Navigational Alarms and Warnings to Support VTS Operation

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Abstract

In this paper, the authors discuss the current development of IMO and IALA regulatory framework and future technological developments to look at the present state of VTS operation. Taking into account the importance of situational awareness and any dangerous situations that could potentially be overseen, collision avoidance warnings to support the operation onboard and ashore are highlighted. Research is ongoing by participating observations, online surveys and interviews of VTS operators around the world. The selected results emphasized that although technology is rapidly developing, heading to digitalization and autonomous operation, the basis of alarms and warnings functions are still the same. In the future different mixed traffic situations, reliable technology and adaptive training would be very much suggested to achieve the harmonization of VTS operation by competent VTS operators.

Keywords: Vessel Traffic Services, IALA, Alarms and Warnings, Harmonization of Maritime Safety, Competent VTS Operators

1 Introduction

Vessel Traffic Services (VTS) has been originally developed from radar and voice radio assistance [1], [2] that over the years turned into multi-sensor shore-based surveillance, integrated marine radar chains integrated with AIS and ECDIS systems, along the coastal waters and ports worldwide to have a real-time information exchange. Regulated by the International Maritime Organization (IMO), VTS plays an essential role in ensuring and increasing the safety and efficiency of maritime traffic flow and protection of the marine environment by its capability to interact and respond to the traffic developing in the monitored area. The services are to pro-actively respond to developing risks. Besides IMO, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) provides fundamental guidelines on the implementation and operation of VTS in a harmonized

manner to effectively achieve its purpose to ensure the safe and efficient traffic flow of vessels from and to ports and to protect the marine environment. This is basically done through provision of information, warning, advice and instructions to support mariners' decision making onboard and consequently avoid accidents.
In maritime traffic, *collision*, *contact* and *grounding/stranding* have represented 44% of all casualty events within the period of 2014-2019 [3]. VTS operators are using a wide spectrum of technologies in order to enhance and improve assessment of developing risks, detect violations of predefined limits and provide decision support for vessels to take appropriate actions [4]. However, although sophisticated technology is available to combine shore-based and onboard data collection from the traffic and environment, the number of accidents is still high and, as seen from the grounding of "Ever Given", has far reaching consequences.
The continuous development of digitalization and automation has improved watch alarms and warnings that may help to ensure sufficient situational awareness of VTS operators when monitoring, commanding and controlling ships sailing in their VTS areas. Therefore, the installation of alarms and warnings are vital to strengthen the safety barrier and help the process of decision-making by navigators onboard and operators ashore.

2 Present State of VTS Operation: A State of Change

2.1 Legal frameworks

VTS is regulated by IMO, according to the International Convention for the Safety of Life at Sea (SOLAS) in Chapter V Regulation 12 about *Vessel Traffic* Service and guided by IALA. It takes into account the coastal states' national regulatory frameworks. The legal basics for VTS are laid down in IMO Resolution A.857(20) as *Guidelines for Vessel Traffic Service*. As it has been 24 years since the presently valid resolution was adopted in 1997, a revision of this guideline is becoming essential to adapt to various developments in the maritime domain and will come to final adoption in December 2021 [5], [6].
The new draft of the IMO resolution gives more concise guidance for VTS to provide services proportional to the volume of traffic and the degree of complexity within a VTS area [7], [8]. According to the current development in maritime transportation, IMO and IALA found that three different labellings of VTS services (Information Service (INS), Navigational Assistance Service (NAS) and Traffic Organization Service (TOS)) are not necessary any longer. They also deleted the distinction between a Port/Harbor VTS and Coastal VTS from the resolution. This would ease the scope of each Government to adapt its regulatory framework according to the needs. In preventing any confusion to ship-masters sailing around the world, the

establishment of VTS is no longer just an option and more parties are recommended to take part.

The purpose of a VTS remains, it should be able to mitigate developing unsafe situations. Firstly, through the provision of information on factors that may influence the ship's movement and assist onboard decision making (former INS). Furthermore, nowadays VTS shall additionally provide the reporting formalities and ISPS code details, support and cooperate with allied services. Secondly, through the monitoring and management of ship traffic (former TOS). Regarding this, VTS has empowerment for the compliance of vessels and enforcement of the existing regulatory framework. Thirdly, through responding to developing unsafe situations (former NAS). Difficult navigation circumstances are now including some more elements, such as a ship unsure of its route or position, a ship deviating its route, a ship needing guidance for anchoring or a ship is at risk of grounding or collision.

2.2 VTS personnel

VTS personnel has to be competent and only considered competent when appropriately trained and qualified for their duties. In this case, IMO recommends VTS personnel training to the IALA model courses. The model courses are only effective if it is applied based on the prior qualification held by the personnel and based on approval from the Government, which is responsible to the training applicable in their country. Meanwhile Competent authority provides regulation, approves training and certification, the VTS provider operates VTS and ensures the appropriate training and qualification of its VTS personnel are being met. Periodic assessment should be carried out through monitoring and observation of VTS personnel performance to maintain their competencies.

In a critical situation, VTS operators immediately have to take proper measures ensuring smooth communication and interactions between navigational officers and VTS. Shifting the vessel participation from voluntary to mandatory allows for reducing inattention errors by the mariners involved and acting more proactively in traffic management. Taking into account the wide range of tasks and situations in VTS monitored areas, this requires also effective support of VTS operators' situational awareness including alarms and warnings at the VTS operators' workstations.

2.3 Technological developments

The fundamental development is currently characterized by IMO's e-Navigation initiative and the rapidly increasing digitalization and automation in the maritime domain. This development is addressed in [9] highlighting the advances in data sharing and the potential of Sea Traffic Management (STM). It is expected that STM connects and updates marine stakeholders in real-time with efficient information exchange concerning, e.g., effective arrival times, route optimization, port call synchronization and more efficient risk management. The integration of electronic data interfaces and the development of remotely and autonomously operating vessels are where the VTS interface gets going. Several studies and projections of the future maritime transportation system (i.a. [9]–[12]), assume new scenarios of mixed traffic and technical solutions regarding decision support for the VTS operators with even more sophisticated alarm and warning functions as of today. Consequently, situational awareness of VTS operators remains a key element of safe and efficient vessel traffic in coastal waters and therefore needs to be studied and to be adapted to changing legal, technical and organizational circumstances.

2.4 Onboard and shore-based Collision Avoidance

Collision avoidance is a permanent task of the officer of the watch onboard and of most of the operators in VTS centers.

The presence and response of alerts onboard vessels, in particular to the collision avoidance alarms of Radar/ARPA devices, were found to be unsatisfying [13]. One of the reasons is that the thresholds for triggering a collision warning have to be configured manually from which operators onboard and in a VTS tend to switch them off instead of continuously adjusting them based on the changing traffic circumstances. In contrast, collision alerts in air traffic have clearly defined minimal time and space standards for separating aircraft, in which the pilot cannot switch the alert off nor change the alarm thresholds.

There are numerous studies discussing collision risk assessment and proper alarming. Studies into adapting solutions from air traffic to the maritime domain [13]–[16] are ongoing with promising results. Fast-time simulation techniques for calculating rudder response times, maneuvering parameters for the actual ship status (in ballast/full laden) and environmental conditions (e.g. wind and current) are being applied, suggesting dynamic adaptation of the fixed thresholds to the prevailing circumstances of a given situation. It was demonstrated that the number of collision alerts in a shore station could be reduced by 40 per cent with the variable thresholds compared to the conventional fixed limits [14], [17], [18]. However, collision warnings are only one alarming function out of many others implemented in the workstation of VTS operators.

3 Empirical Studies into VTS Alarms and Warnings

A spotlight study is ongoing to investigate the use of alarms and warnings in VTS. The empirical studies are carried out by participating observations, online surveys and guided interviews with VTS operators. The survey is aiming to understand how the alarms and warnings support operators and benefit VTS operations. In these selected preliminary results, we have gathered worldwide responses, regarding the implementation, usefulness and limitation of alarms and warnings, for providing services in each VTS center. The study collected 43 valid data out of 47 total responses in 20 countries in Europe, Asia, Africa and South America. Respondents were VTS operators having nautical backgrounds or expertise in port and technical operations.

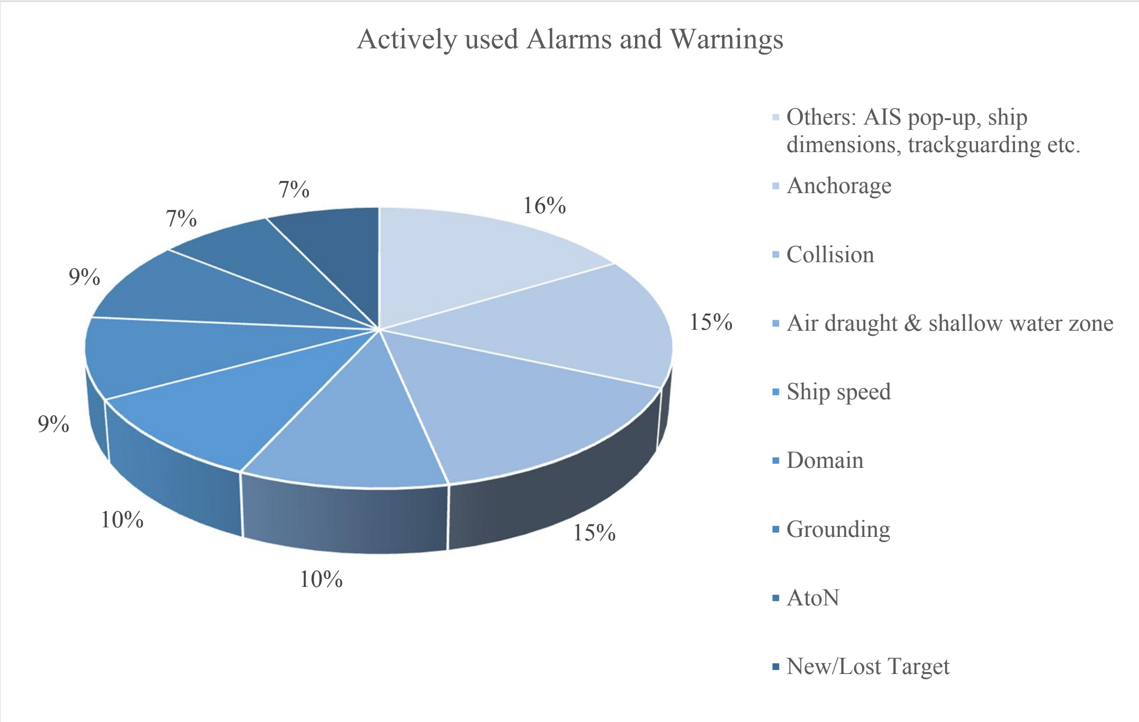

Figure 2. Actively Used Alarms and Warnings, responses to the question "Which alarms/warnings do you actively use?"

The alarm and warning functions act as decision support tools for VTS to respond and indicate potentially unsafe traffic situations. Overall, there is a wide range and number of alarms and warnings. Looking at an exemplary selected "Operator Manual" of a VTS monitoring workstation, there are 56 operational warnings mentioned, while, from the survey we gathered there were even 95 different warnings presented in participants' VTS.

Operators being confident and satisfied with their alarms and warnings always switched on and actively used it, as shown in Figure 2, mainly mentioning its high importance for collision and grounding predictions. The alarm for ship length and breadth helps VTS monitor the passage during wind restrictions, the high-speed alarm helps VTS due to the ferry swell in port and air draught alarm triggered due to the airport safety limit. Alarms and warnings would be beneficial as well for a vessel not under command or diverging from the Traffic Separation Scheme.

Based on the study, VTS operators mostly monitored specific areas with ship routeing measures and they found the existing alarms and warnings in their VTS center had given them the benefit to be aware of dangerous encounter situations. Especially in high traffic density, these functions were very helpful as many operators had overseen more than three potential developing risks to the navigation safety in their VTS area at a time. These are the responses from participants to the question ”Have you ever experienced that collision alarm/warning has made you aware of a dangerous encounter situation that you maybe have overseen and how often?”. However, VTS operators expressed they had too many alarms which sometimes generated incorrectly or alert all the time causing distraction and confusion, especially in a narrow VTS area. Operators later would switch them off or mute the sounds for every ship that is not of concern, while the warning sensors are still working in the background. In other cases, VTS personnel considered that vessels are already relatively safe with the presence of a pilot onboard and for near the port area.

The configuration of the traffic monitoring functions in each VTS had mostly been preloaded automatically by the manufacturer and each different function correspondingly had a different effect on user performance. Since there is no one-fit model for all VTS with different areas, both open water and enclosed river, the experience of VTS operators is the superior choice to have a good interpretation of situations displayed on the electronic charts. Unfortunately, operators who had not been provided with such functions were having difficulties assessing and responding to the traffic and should rely on their visuals.

Almost all VTS centers are equipped with alarms and warnings functions, with either set alarms or individually configured alarms. Regarding the collision warnings, VTS has fixed alarm thresholds (17 responses) and sets the thresholds individually (24 responses). These configurations could be seen in Figure 3 and Figure 4. For the integrated configuration, VTS personnel has to first estimate the situation and choose suitable alarms. This includes the ship type, ship dimensions, ship speed, sea area and traffic situation, environment conditions and unknown objects in the waterways a vessel navigates in. The previous study proved that a 10 min vector for monitoring collision risk based on potential danger, such as ship dimension and dangerous goods onboard, was commonly used [4], [13]. VTS operators expressed that having 0.3 nm and 6 min for their CPA/TCPA limits would be great for their operation.

Different countries applied different functions to their VTS personnel competencies. One-fourth of operators observed had participated in refresher training during the last year, yet another one-fourth of operators had never participated in any kind of training. In general terms, authorities seem to provide training for compensating deficiencies in the initial entry qualification of their VTS operators. Those without training are considered to have a good grasp of tackling the traffic situation as they had been for quite a long time (5 to 27 years) working onboard vessels.

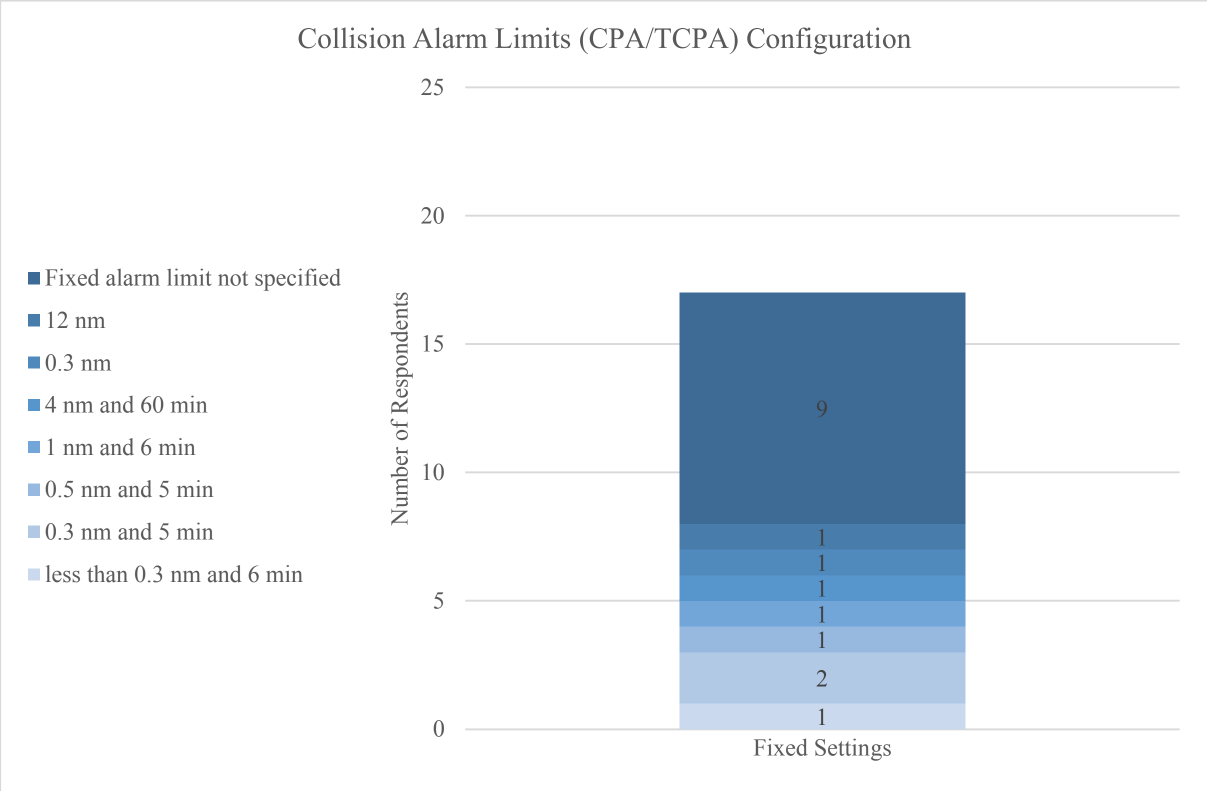

Figure 3. Configuration of Fixed CPA/TCPA Limits, responses to the question "If there are fixed settings, what are the alarm limits in your area?"

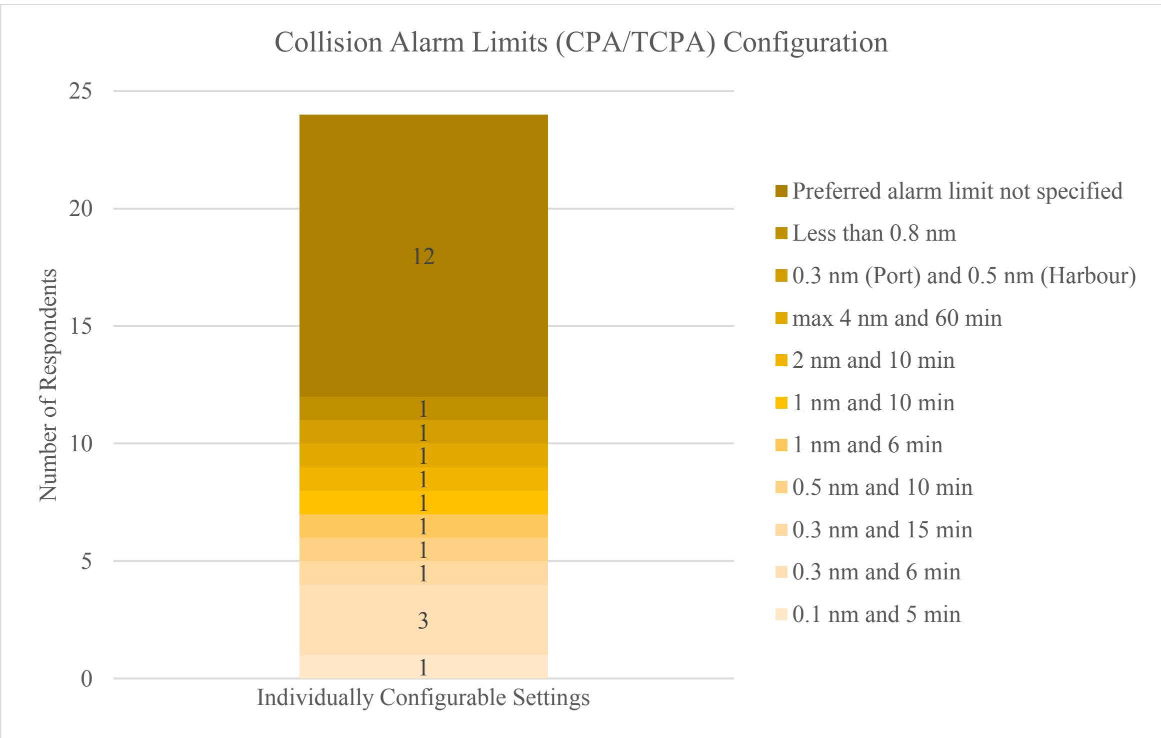

Figure 4. Configuration of Individual CPA/TCPA Limits, responses to the question "If

individually configurable, what are your preferred settings for the CPA- and for the TCPA limit for collision avoidance when you are monitoring your area?"

For this, the revised IMO resolution for final adoption at Assembly 32 urges appropriate training for VTS personnel to be considered competent [6]. This consists of generic training, On-the-Job Training (OJT) and refresher/revalidation training which shall be an output-driven measure and subsequently issue appropriate certifications for them. As such, IALA VTS Committee has recently accredited organizations in 24 countries to deliver effective training and at the moment is updating their training model courses and its modernization [19].

4 Summary and Conclusions

Maritime industry and specifically the shipping domain is undergoing substantial changes in terms of revision of existing regulatory frameworks and organizational structures, but moreover, in regard to technological developments with increasing digitalization and automation [20]–[23] and new demands in relation to training and education [24]. Shipping of the future will be characterized by vessel traffic consisting of a mixture of conventional ships and automated carriers navigating remotely controlled or autonomously and unmanned. VTS will have to ensure the safe and efficient traffic flow of such mixed traffic. Situational awareness to detect and react to situations requiring intervention by VTS remains essential for meeting the objectives. In this paper, the authors presented preliminary results of ongoing empirical studies into shore-based alarm and warning functions implemented in the workstations of VTS operators. The outcome of participating observation, online survey and interviews shows that operators are aware of the manyfold options. However, there is overall a huge number of warnings of which only a limited number is used and known and participants expressed that some of the functions are not really satisfying.

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References

[1] C. T. Hughes, “When is a VTS not a VTS? Part 1,” *J. Navig.*, vol. 62, no. 3, pp. 439–442, 2009.

[2] C. T. Hughes, “When is a VTS not a VTS? Part 2,” *J. Navig.*, vol. 62, no. 3, pp. 439–442, 2009.

[3] European Maritime Safety Agency, “Annual Overview of Marine Casualties and Incidents 2020,” 2020.

[4] M. Baldauf and E. Wiersma, “Risk Recognition and Collision Avoidance by VTS Operators,” *IFAC Proc. Vol.*, vol. 31, no. 26, pp. 239–244, Sep. 1998.

[5] IMO, “Resolution A.857(20), Guidelines for Vessel Traffic Services,” *Assembly 20th session, Agenda item 9*, no. 1. International Maritime Organization, London, pp. 1–22, 1997.

[6] T. Southall, “Revision of IMO Resolution A.857 (20) Guidelines for Vessel Traffic Services,” Saint-Germain-en-Laye, 2019.

[7] G. Praetorius, E. Hollnagel, and J. Dahlman, “Modelling Vessel Traffic Service to understand resilience in everyday operations,” *Reliab. Eng. Syst. Saf.*, vol. 141, pp. 10–21, 2015.

[8] F. van Westrenen and M. Baldauf, “Improving conflicts detection in maritime traffic: Case studies on the effect of traffic complexity on ship collisions,” *Proc. Inst. Mech. Eng. Part M J. Eng. Marit. Environ.*, vol. 234, no. 1, pp. 209–222, 2020.

[9] G. Hanchrow, “Vessel traffic services: Innovation, adaptation, and continued relevance,” in *Advances in Marine Navigation and Safety of Sea Transportation - 13th International Conference on Marine Navigation and Safety of Sea Transportation, TransNav 2019*, 2019, pp. 73–78.

[10] T. Relling, “A systems perspective on maritime autonomy: The Vessel Traffic Service’s contribution to safe coexistence between autonomous and conventional vessels,” Norwegian University of Science and Technology, Aalesund, 2020.

[11] M. Baldauf, S. Fischer, M. Kitada, R. Mehdi, M. A. Al-Quhali, and M. Fiorini, “Merging Conventionally Navigating Ships and MASS - Merging VTS, FOC and SCC?,” *TransNav, Int. J. Mar. Navig. Saf. Sea Transp.*, vol. 13, no. 3, pp. 495–501, 2019.

[12] M. Kitada *et al.*, “Command of Vessels in the Era of Digitalization,” in *Advances in Intelligent Systems and Computing*, vol. 783, Cham: Springer, 2019, pp. 339–350.

[13] R. Mehdi, M. Gluch, S. Fischer, and M. Baldauf, “A perfect warning to avoid

collisions at sea?," *Zesz. Nauk. Akad. Morskiej w Szczecinie*, no. January 2018, pp. 53–64, 2017.

[14] M. Baldauf, K. Benedict, S. Fischer, F. Motz, and J. U. Schröder-Hinrichs, "Collision avoidance systems in air and maritime traffic," *Proc. Inst. Mech. Eng. Part O J. Risk Reliab.*, vol. 225, no. 3, pp. 333–343, Sep. 2011.

[15] R. Szlapczynski, "A unified measure of collision risk derived from the concept of a ship domain," *J. Navig.*, vol. 59, no. 3, pp. 477–490, Dec. 2006.

[16] M. Gil, J. Montewka, P. Krata, T. Hinz, and S. Hirdaris, "Determination of the dynamic critical maneuvering area in an encounter between two vessels: Operation with negligible environmental disruption," *Ocean Eng.*, vol. 213, p. 107709, Oct. 2020.

[17] H. Hilgert and M. Baldauf, "A common risk model for the assessment of encounter situations on board ships," *Dtsch. Hydrogr. Zeitschrift*, vol. 49, no. 4, pp. 531–542, 1997.

[18] M. Baldauf, K. Benedict, J.-U. Schröder-Hinrichs, and F. O. Motz, "Quantification of maritime operational risks to enhance onboard alert management of ship-borne integrated navigation systems," in *Reliability, Risk and Safety - Back to the Future (ESREL 2010)*, 2010, pp. 2047–2055.

[19] IALA, "IALA Accredited Training Organisations Delivering ALA R0103 (V-103) VTS Model Courses." International Association of Marine Aids to Navigation and Lighthouse Authorities, France, p. 16, 2020.

[20] K. Aylward, A. Johannesson, R. Weber, S. N. MacKinnon, and M. Lundh, "An evaluation of low-level automation navigation functions upon vessel traffic services work practices," *WMU J. Marit. Aff.*, pp. 1–23, Jun. 2020.

[21] F. X. Martínez de Osés and À. Uyà Juncadella, "Global maritime surveillance and oceanic vessel traffic services: towards the e-navigation," *WMU J. Marit. Aff.*, vol. 20, no. 1, pp. 3–16, Mar. 2021.

[22] A. Weintrit, "Relationships between e-Navigation, e-Maritime, e-Shipping and ITS," in *Communications in Computer and Information Science*, 2016, vol. 640, pp. 487–498.

[23] M. Gil, "A concept of critical safety area applicable for an obstacle-avoidance process for manned and autonomous ships," *Reliab. Eng. Syst. Saf.*, vol. 214, p. 107806, 2021.

[24] T. J. Janßen, M. Baldauf, G. Müller-Plath, and M. Kitada, "The Future of Shipping: A Shore-Based Experience?," in *The 1st International Conference on Maritime Education and Development*, Cham: Springer International Publishing, 2021, pp. 51–61.