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From Ship to Shore – Studies Into Potential Practical Consequences of Autonomous Shipping on VTS Operation and Training

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ABSTRACT: Vessel Traffic Services (VTS) are to improve the safety and efficiency of vessel traffic and to protect the marine environment by interacting with the ship's traffic in monitored coastal areas. Today, VTS operators are maritime professionals with nautical education from a university or technical college and practical experience on board. This experience and nautical background is a key element of the work as a VTS operator. It is to support understanding the daily work. The current situation in the maritime domain is undergoing substantial changes, such as introducing new technologies, implementing the e-Navigation concept based on sustainable digitalization and ambitions to realize unmanned and autonomous shipping. This paper will present preliminary results of a pilot study conducted in VTS Centres along the coast of North and Baltic Sea and discuss selected options and opportunities for education and training of future VTS operators, which might not have the advantage of practical sea experience anymore.

1 INTRODUCTION

1.1 *Background*

It is estimated that maritime trade represents an 80% of total world merchandise trade (UNCTAD, 2020) while (Georg, 2014) mentions, that even 90% of all the goods are being transported by shipping at least once. Obviously, shipping is going to continue to play a key role for our global economy. However, the maritime industry finds itself, like many other industries, in a state of digital transformation. A part of this transformation is the prospect of more automation and even the autonomous operation of ships. The provision and integration of digital elements on board ships will allow for machines to interact and to act more and more independently (Johns, 2018).

The increasing level of automation and expected autonomy on board ships has also a significant influence on shore-based components of the Maritime Traffic System (MTS) (Baldauf et. al, 2018). Vessel Traffic Services are functioning as a control and monitoring system within the MTS (Relling, Praetorius, & Hareide, 2019). The VTS Centres actively inform, support and regulate the traffic to enable smooth and safe traffic flow on the maritime shipping routes. VTS Centres are actively in contact with the ships by VHF. VTS stations receive position, course, speed and many other information through AIS and radar data via chains of radar stations along the coast and river fairways. The VTS stations are regularly broadcasting information services, containing weather data, tidal changes or particular information about traffic characteristics as well as changes to be expected. On the other hand, VTSs are also alerting and instructing individual ships or informing them at an early stage to avert danger, see i.a. (Relling, Praetorius, & Hareide, 2019). The traditional structure of services provided by VTS is sketched in the figure below.

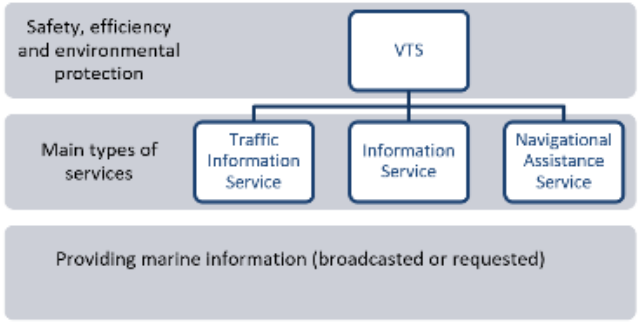

Figure 1. Original structure of VTS services, own illustration, adapted from IALA VTS Manual (2021)

1.2 *Revision of the IMO VTS Guidelines*

Over a period of almost three decades, VTS were established and organized according to IMO-Resolution A.857(20), firstly introduced in 1997. The main aim was defined as to contribute to safety, increase efficiency and also protect the marine environment by implementing VTSs where deemed necessary. This original resolution also contained a clear distinction between Coastal, Harbor and Port VTS stations and the services were divided into the three main types of services: INS (Information), TOS (Traffic Organization) and NAS (Navigational Assistance).

Nevertheless, after more than 25 years of worldwide experience in operating VTS and with the introduction of new technologies and further developments in the maritime industry a substantial revision of the guidelines was realized. Different stakeholders related to VTS operations joined their efforts to update the resolution and affected the legal framework, the definition and provision of services and the training and qualification standards (Juncadella & Martinez de Oses, 2020).

The need for an update and revision of the definition of services provided by the VTS was also pointed out by the German Federal Bureau of Maritime Casualty Investigation in the report 408/17 which dealt with the grounding of the bulk carrier "MV Glory Amsterdam" 1,6 nautical miles off the German coast within a nature protected area (BSU, 2019). The vessel was located at the deep-water anchorage area in the German Bight. Due to severe weather conditions the vessel started dragging the anchor and moving to a southerly direction. All attempts to secure the vessel and prevent the grounding failed.

The investigations identified several factors that might have influenced the outcome. Among others the report mentions that the services provided by the VTS and the Central Command for Maritime Emergencies (CCME) were not sufficiently clear distinguished.

Similar facts were discussed by experts from different maritime organizations, such as the Nautical Institute, the International Federation of Shipmasters' Associations (IFSMA) or the International Maritime Pilots Association (IMPA) at IALA-seminars and workshops preparing the revision of IMO's VTS-Guidelines. Among others, 54 participants were asked if they are satisfied with the removal of the types of services and 96 % agreed with the removal and intention of revision (Southall, 2019). The major concern of the participants agreeing with the revision was that these services are not being declared or delivered globally in a consistent manner. This causes confusion among the stakeholders, particularly masters and officers navigating the ship through a VTS area, resulting in misunderstandings, which may create ineffective traffic management. (Southall, 2019).

That was one of the reasons, why the new VTS guideline (IMO, 2022) is no longer distinguishing between types of services. The purpose of VTS is now laid down as "to contribute to the safety of life at sea, improve the safety and efficiency of navigation and support the protection of the environment within a VTS area by mitigating the development of unsafe situations". This shall be realized through

- the provision of "timely and relevant information …",
- "… monitoring and managing ship traffic …" and
- the response "… to developing unsafe situations …"

The guidelines further clarify that for these purposes VTS operators may "provide information or issue advice, warnings and instructions, as deemed necessary". The decision about the exact measure fits best in a certain situation remains with the operator's judgement. Usually, operators are trained to use the measures dependent on the risk level of a certain situation and the level of urgency as it is visualized in figure 2.

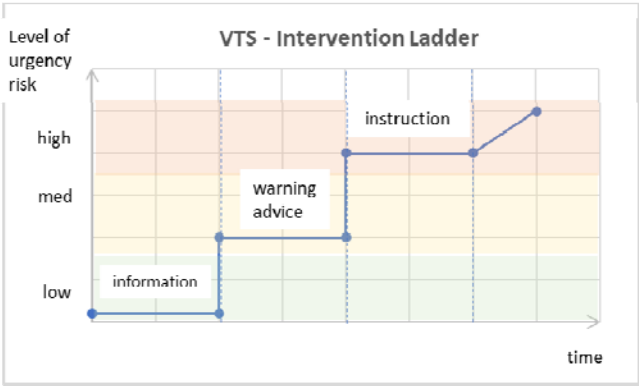

Figure 2. Model for measures of VTS interventions to respond to unsafe navigational situations

Firstly, in an early stage of development of an unsafe situation and independent of what type of service is provided, "information" shall be applied. "Warning/Advice" shall be used if in a developing situation concrete risk exists and only in rare case of an escalated risk of a collision or grounding etc. operators shall send out "Instruction". Different from the old guidelines, the new one provides samples about what VTS may inform, warn, advise, or even instruct. It includes, i.e. position, identity, intentions etc. of ships or information about route deviations, guidance to an anchor position but also meteorological conditions or support for emergency services.

In this way, all references to the former type of services are obsolete. Moreover, the revised guidelines contain a paragraph that VTS may provide

services even beyond territorial sea. It is also important to note, that the new resolution calls for consideration of future technical and other developments accordingly. Finally, yet importantly, qualification and training of personnel has been updated as well.

1.3 *Challenges from Digitization and Automation*

The revisions of the VTS guidelines addresses very well the ongoing digital transformation and technological development in communications, which have major impacts on operation of VTS and the training and recruiting of VTS personnel.

Even though, i.e., general Ship Reporting still remains a manual process and requires a great deal of attention from the shipmaster or officer on board and VTS operators as well. Inter alia, there are multiple forms to deliver to numerous different institutions. These forms are varying and are a confusing mix of procedures, standards and technologies (Tijan, Agatic, Jovic, & Aksentijevic, 2019). The IMO e-Navigation initiative addresses these issues. E-Navigation is defined as "the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment" (IMO, 2014). The Strategy Implementation Plan (SIP) provides a list of tasks required to undertake five prioritized e-navigation solutions. Those solutions describe means for standardized and automated reporting and improved communication of the VTS service portfolio (Hauge, 2020).

Solutions for automatic reporting system are, for instance, the Maritime Single Window (MSW), which enables all stakeholder involved to use a single-entry point and provides other station with the information by automatic data exchange (Tijan, Agatic, Jovic, & Aksentijevic, 2019). Another method was tested in EMSA's pilot project "Facilitation of ship to shore reporting". By means of re-use of data and the "reporting once" principle, the burden of communication and collection of relevant data for both, the ship master and the VTS operator was reduced, and harmonization of the reporting system on a European level (EMSA, 2022) was demonstrated. Next steps will show how a VHF Data Exchange System and harmonized European reporting systems impact the MTS.

Further popular approaches to implement new technology into VTS operation and the exchange process of data from ship to shore are automatic speech recognition (see i.e. Tagaki et al 2016). Miscommunication in the maritime domain has been identified as a major contributory factor to ship-ping accidents and therefore the IMO has made substantial efforts to reduce ambiguous language patterns by first developing the Standard Marine Navigational Vocabulary and later on the Standard Marine Communication Phrases (SMCP) (John, Brooks, & Schriever, 2019) with special units dealing with ship/shore communication.

Automatic speech recognition is developed specifically for maritime communication by being extensively trained with real and simulated VTS and bridge team communication and with the IMO SMCP (John, Brooks, & Schriever, 2019). It provides another channel to exchange information and might reduce distraction by other means (John, Brooks, & Schriever, 2019).

Communication is essential for VTS operation and the rapid developments to introduce maritime autonomous ship (MASS) requiring concepts and preparation for the operational integration of this new type of ships into the existing structures.

Even though these new technologies are on the horizon and implemented ashore and on board, they represent major challenges for maritime education and training facilities as well.

This paper will focus on the maritime education and training standards for VTS personnel by presenting preliminary results of a study conducted in selected VTS Centres along the coast of North and Baltic Sea.

2 TRAINING AND QUALIFICATION STANDARDS AND TODAY'S PRACTICE

Until today, according to international guidelines and specific national requirements, operators working in a VTS are trained maritime professionals and experienced captains or navigating officers. To get a position in a VTS Centre applicants need to have the at least minimum STCW qualification for watchkeeping officers. Most of the operators have over one year of experience as watchkeeping officers and/or captains. With this prerequisite, VTS applicants are trained according to the VTS model course V-103 by the International Association of Marine Aids to Navigation & Lighthouse Authorities (IALA) (IALA, 2016). Besides theoretical training providing the basics of international and national legal frameworks, rules and regulations, operators are also trained in practical operation in simulator courses, get a theoretical knowledge of the national maritime industry and law, and are later trained on the job.

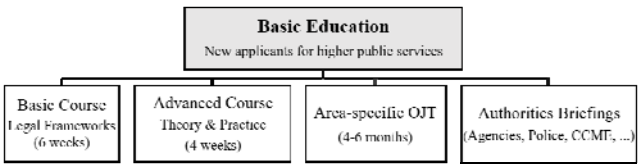

Figure 3. Basic structure of VTS training and education elements applied to beginners / new VTS staff

Figure 3 provides a visualization of the basic structure as exemplarily applied for training of VTS operators in Germany. For purposes of a more detailed assessment of the present situation along the coasts of North and Baltic Sea, an empirical spotlight study applying questionnaires and semi-structured interviews was conducted. The pilot study was developed after conducting field studies within selected VTS Centres. In a first step two groups of

operators were involved. 22 operators from three different nations participated and shared their views.

Future steps will be expert interviews and specifically designed simulator trials.

Preliminary results show that 11 participants have a university degree with a diploma in maritime or nautical studies, 9 participants hold a degree from a technical college. Whereas 18 of them have a nautical license according to STCW standards, either coastal voyages or international voyages unlimited. 3 of the participants hold a license according to the STCW-F standards or national nautical license, that was made before 1998. Over 70% of the participants have seafaring experience between 1-5 years as a nautical watchkeeping officer. The average experience as a captain or chief officer is 5-10 years.

Figure 4. Analysis results of training periods in different VTS stations

Furthermore, participants were asked what, according to their opinion, is important for the successful training of a VTS operator. Answers included knowledge of the monitored area, technical training in VTS simulators and experience as a nautical officer or more extensive on-the-job training in the VTS Centre. When asked what was missing during their training, 55% (n=22) stated that standardized and structured training would be helpful.

According to national rules, operators usually repeat the simulator and theoretical courses every two years to refresh the knowledge and learn about new terminology or technology used in maritime surveillance as well as conducting specific simulation exercises with incident and accident scenarios.

According to the expert opinions, the most important scope of training is the familiarity with the area to be monitored, and the specific knowledge of terminology used in that monitoring area. One participant mentioned, that "it is taking months to learn the 'Weser-language'" It is to be noted, that the participant's answer is referring to a special term and terminology used when monitoring his area. The original term he used was "Weser-Sprech". - The interview with the participant was conducted in German and translated into English by the authors.

As an overall outcome of the interview, it is suggested, that according to the participants' opinion the training for becoming a VTS operator is still very traditional and not yet sufficiently enough focusing on new technologies.

On the other hand, in another section of the questionnaire the operators were asked about their views and opinions in regards to the relevance and importance of sea-going experience as OOW, Chief officer/captain as a prerequisite to fulfil the tasks of a VTS operator. The next figure summarizes the views of the experts grouped by their nations.

Quite obviously, the great majority of the participants in this pilot study still see practical experience on board ships as a "very" or "quite important" skill to understand the work in the VTS. In their responses about the reasons, why practical experience is or is not important the participants added comments like "It allows me to relate to the seafarers' problems/conditions", "better knowledge/ understanding for the ships monitored" or "I get a good idea about CPA, what CPA is acceptable, … you get to know cultural aspects onboard". Another aspect that was mentioned in the responses was, knowledge about the behaviour of ships: "You have so much understanding of navigation and manoeuvring if you have sea time!" From this first spotlight study, it seems, that operators feel more confident when providing information and what exact information to navigators onboard. There seems to be a tendency that shore-based operators see themselves as colleague using situational awareness and to generate assistance that is supportive in a concrete situation.

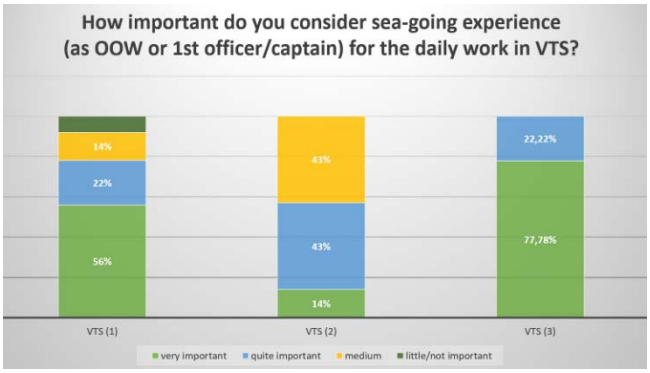

Figure 5. Expert opinion in regards to elevance of practical sea experience in scope of VTS operation

However, the revised IALA model courses C0103-x for VTS operator training to which IMO guidelines explicitly refer are very flexible in respect to sea-time experience. On the one hand, IALA issued guideline for recognition of prior learning. This guideline provides a framework about how to assess "prior learning" which authorities can adapt and apply to their specific needs. The model courses do not provide detailed syllabuses but a framework for the development of training modules. Module 4, named "Nautical Knowledge", i.e. might be adapted to the needs if seafaring experience is assessed as not sufficient and the applicant might compensate through enhanced and extended module content respectively. The recommended duration in hours ranges from 23-44 hours lectures/presentations and 16-31 hours exercises/simulations. This gives room to design various versions of the module addressing the specific needs of the students identified during the assessment of prior learning.

Even though, when asked about alternative ways to substitute practical experience, 80% (n=22) of the

participating operators suggested professional simulator training and job experience, maybe, can be an alternate option. However, the challenge in regards to the module design, will be to identify and to define criteria for the missing experience, a future operator is expected to have. Ship-handling, certainly can be very well trained in a simulator environment, and would match with the comment about "understanding the manoeuvring" mentioned above. On the other hand, probably, it would not really meet the "cultural aspects" also responded to the questionnaire.

However, in the light of the decreasing number of applicants for VTS operator positions in some coastal nations, there is not only a need to further develop career paths, there is a rising need and urgency to adapt and further develop training and qualification schemes as well.

3 REVIEWING NEW WAYS OF TRAINING – THINKING OUT OF THE BOX

3.1 *Background and IALA-Requirements*

Training is one of the key elements to learn a new job. Even though the applicants for a job in VTS have (mostly) a degree in nautical studies and experience on board sea-going ships, they still need to adapt to the new work environment. A common issue among the case studies about VTS and other maritime surveillance training standards was the topic "operator skills"; namely, what skills would be required, how they would be obtained, and how they would be retained (Veitch, Hynnekleiv, & Lützhöft, 2020).

Considering autonomous or unmanned shipping for most of the Shore Control Centre (SCC) operators, it was suggested that they hold the necessary nautical licenses and diplomas since they are considered experienced navigators or seafarers. However, some suggested that given the new working environment, a unique set of skills must be defined (Relling, Praetorius, & Hareide, 2019).

The revised IALA model course C0103-1 for VTS operators has been developed to provide guidance on training and skills sets for authorities, which implemented VTS Centres. The IALA classifies 5 levels of skills, whereas the first level is guided response and the fifth level modification or creation of actions based on knowledge and experience. A summary of skills and level of competence is presented in the table below.

Table 1. Short summary of VTS operator skills and subject of area adapted from IALA model course C0103-1 (December 2022)

Skill Element/ Subject area	Level of competence
Communication, coordination and interaction	3-4
Legal framework	1-3
Provision of VTS	2-3
Traffic management	4
Nautical knowledge	1-3
Equipment and technical support tools	2-4
Human factors	2
Safety management	4
Emergency handling	2-4

3.2 *E-Learning*

The COVID-19 pandemic challenged all education and training institution, schools and universities on a worldwide scale. Students could not enter classrooms at universities or teaching facilities, and everything had to be switched from classroom teaching to online teaching via video platforms and sharing platforms. Most of the teaching institutions adapted quite fast to the new situation and made teaching and learning available online.

This experience is valuable and has potential for future training as well. A few online platforms provide nautical students already with the possibilities to study the SMCP.

This platform is accessible by trainees in the VTS Centre (without practical experience) as well to get familiar with the phrases used on a daily basis.

3.3 *VTS-Simulator Training using Virtual Reality*

Another important tool to acquire necessary skills as a VTS operator is simulator training. For now, in Germany, VTS simulator training is part of the basic training and then repeated yearly. For trainees, who do not have the necessary practical experience on board ships, bridge team simulator courses can be included and the VTS simulator training can be extended.

Other very recent options for developing training for VTS operators, relates to Virtual Reality (VR) technologies.

Figure 6. Snapshot of training on board an ice breaker using VR technology (photo: author)

Figure 7. Sample of training equipment needed, taken from https://www.morildinteraktiv.no/icenav (accessed 13.03.2021)

Presently a popular option, VR has potential to provide the trainee with the "ship sense" and "feeling

of the ship" while manoeuvring. This technology is already in use by training institutions today to train ice navigation, for instance.

We can use this VR and 3D technology for ECDIS training and for daily VTS operation. The Electronic Navigational Charts (ENC) are two-dimensional charts. It is a generalization and abstraction of the actual world. New technology can give the operator the possibility to look from a different perspective and avoid misinterpretation of the situation.

Thinking one step further and imagining an autonomous ship navigating within the VTS area, the VR technology can be used to get a view from the ship's perspective.

3.4 *Cloud-based training*

Simulation training is a state-of-the-art method for basic and refresher training of VTS operators. Training providers integrate different kind of simulators for different training purposes from simple desktop-computer simulator stations up to full-mission VTS simulators, which may provide full-scale equipment of workstations as originally installed in the work environment of a real VTS station. Full mission simulators facilitate options to replicate the complete workaround of a shift for one or several linked VTS areas. High sophisticated VTS simulators may even pro-vide connection with part- or full-mission ship hand-ling simulators, i.e. to increase the level of reality when training of complex scenarios like VTS monitoring of vessel with pilot on board.

A still recent option for training of VTS operators is web-based simulation. Trainees join a network-session from several places and may handle simulated traffic in one generic VTS area. Desktop computer with standard equipment provide generic VTS workstations but can be linked to full mission VTS simulators as well. Communication between trainees and instructors is realized using additionally equipment.

First courses using this new technology were delivered with promising results (AMCS, 2021). Considering the rapid technological developments, one may expect a further development of the technology and its extensive use for VTS operator training.

3.5 *Integration of remote-controlled ships – simulating the future*

Besides the new and enhanced technical facilities of VTS simulation aforementioned, simulation allows for the implementation of hypothetical scenarios VTS operators potentially being faced with.

From the responses of the questionnaires it is seen, that operators want to be confronted not only with escalating risky and emergency scenarios, as often derived from real collision or grounding situations. Operators also want to experience new and even unexpected situations in training sessions. However, integrating sophisticated future scenarios, i.e. into a training session of i.e. a refresher course may also cause conflicts with meeting requirements of a training course and therefore requires careful and comprehensive preparation.

During regular training course a first pilot simulation study involving remote controlled ships in a typical traffic scenario of a VTS area familiar to the trainees has been conducted. For this specific purpose communication with the operator in the remote control centre (RCC) of the MASS target has been integrated in the scenario.

During briefing and debriefing sessions, the experienced VTS operators were asked to reflect the handling of the unmanned vessel especially. In this discussion the operators expressed that the handling was managed according to the existing rules and regulations and that there is no big difference compared to handling a manned vessel. An overall tendency was: as long as there is stable connection and fluent communication with the remote-control operator they feel confident with their tasks. A major issue, however, was that the VTS operators expressed their urgent request that a remote controller shall have appropriate qualification and experience in navigating a ship. This, according to their opinion, may form a first good basis for navigating through the VTS area.

Even though, just preliminary results of the experimental trial, it shows again, that seafaring experience seems to be a main focus to whether a person in command of a vessel is seen suitably qualified and competent. Of course, further systematic trials are required to proof and further elaborate the statements gained so far.

4 SUMMARY AND CONCLUSIONS

After 25 years of worldwide practice of vessel traffic services a revision of IMO's VTS guidelines has been carried out. The revisions consider the experiences gained during the past period of successful world-wide operation of VTSs. On the one-hand the revisions overcome some inconsistencies and clarify interpretations of the old guidelines. On the other hand, the revisions address current technological developments and future changes and their potentials for instance to provide services even beyond territorial seas. VTS operator education and training need to take into account the revisions and ongoing changes accordingly. An empirical spotlight study into potential consequences of the changing situation has been carried out with specific focus on seafaring experiences as prerequisite for VTS operator training and potential changes in training content. According to the first preliminary results, there seems to be a tendency supporting that seafaring experience is the most valuable source for successfully performing the tasks of a VTS operator. However, compensation of lacking active seafaring time by dedicated courses in ship-handling simulation was seen as a potential option by the participants.

Using new technology and the results of the empirical studies directing to next steps, that will include expert interviews and specific simulator trials addressing future traffic scenarios, also integrating new technology. Developing ideas into strategies to

apply training modules meeting the new standards as well as possibilities for integrating the new technologies into today's training and operation is the aimed outcome.

VTS operation and training today is still very traditional and based on practical experience. As the study had shown, most of the participants still see their time at sea as the major skill to work in a VTS. However, the new IALA model courses open the door also for non-seafarers to a highly interesting and attractive job. With the ongoing research on autonomous shipping, VTS training standards not only in Germany might have a new perspective for reviewing and new technologies need to be implemented.

Research is still ongoing and future scenarios will be developed and tested carefully, considering the operation training of other VTS personnel within the European Union.

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