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ORIGINAL ARTICLE

Non-technical communication factors at the Vessel Traffic Services

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Abstract
This study done at the Vessel Traffic Services (VTS) explored how the VTS operators (VTSOs) communicated with ships and other actors in the maritime sociotechnical system and how decisions were made with regard to assisting traffic in maintaining safe passage in port areas, where most vessel movements are seen and accidents occur. The fieldwork was done during four independent visits to a VTS centre under the Swedish Maritime Authority, with a total sample of six VTSOs and one VTS instructor. The qualitative data were sorted and coded using a grounded theory approach. The data pointed at non-technical information processing and communication factors that play a role in decision-making and ultimately in safety. During protocol operations at the VTS, these factors influenced how VTSOs judged the skills of the vessels' bridge teams, and how they approached them. This is a time where much effort is being put into upgrading technological systems, and these will have the power to change the ways in which the maritime network obtains and processes information, as well as how they can communicate with each other. The further development of technological systems, work protocols and training programmes can benefit from taking the soft aspects of communication and the needs of the operators and their tasks into account for the enhancement of safety.

Keywords Safety · Control · Information processing · Decision-making · Trust

1 Introduction

Shipping is a self-organizing network where each ship is its own principal decision-maker and responsible for maintaining own safe operations (de Vries 2017). Whereas in general terms the domain is a loosely coupled (Orton and Weick 1990) sociotechnical system with distributed control (Hollnagel et al. 2006; Praetorius 2014), safe navigation and manoeuvring of large vessels within Vessel Traffic Service (VTS) areas are activities that require coordination between the navigators onboard the ship and the shore-based VTS centres (de Vries 2015; Praetorius 2014). Decision-making is based on communication between ship and shore operators and on local information integration for preparation and prediction (de Vries 2015, 2017).

The VTS is an internationally defined shore-based organization by the International Maritime Organization (IMO 2017) and the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA 2016), physically distributed through different VTS-jurisdiction areas around the globe and locally instigated by a Competent Authority (IALA 2016). VTS-jurisdiction areas are, according to the IMO's A.578 resolution (IMO 2017), those confined channels with high-traffic density in the proximity of ports, where most vessel movements and accidents occur (Brödje 2012). Ships entering a VTS area must report to the respective VTS, and although the ship captain is still responsible for the vessel's own operations, the VTS will have a range of responsibilities and influence over the traffic within its geographical area. This range of responsibilities can vary from simple Information Service (INS) to Traffic Organization Service (TOS), to Navigational Advice and Assistance Service (NAS), decided at a national level (IALA 2009, 2016).

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INS is the most basic service provision worldwide (IALA 2016). INS refers to the provision of vital and opportune data through the very high frequency (VHF) radio for vessels in the VTS area to make safe navigational decisions and for situations where vessels will meet. These relevant data for navigation range from traffic in the vicinity, meteorological information and temporary events in the fairways, as examples. TOS is intended to help coordinate traffic regarding speed limits and authorizing berthings. NAS has an active support role in ship bridge navigational decision-making by providing advice, positions of other traffic, a vessel's course and speed or warnings to a vessel (IALA 2016).

This paper is a result of fieldwork at a VTS centre with INS delivery. The intent of the fieldwork was to explore the operations of the VTS with regard to how the VTS operators (VTSOs) communicated with ships and other shore operators, and how decisions were made to assist the traffic in maintaining safe passage in port areas. During this process, non-technical communication factors that influence the VTSOs' judgements, expectations and assistance to ships, and reflect challenges in the role of the VTS, were identified. This paper describes these aspects complementing previous research (Bruno and Lützhöft 2010; Brödje et al. 2010, 2013; de Vries 2015; Praetorius and Hollnagel 2014; Praetorius et al. 2012, 2015) in the deeper understanding of everyday VTS operations through naturalistic field observations, specifically with regard to the non-technical factors which lack documentation in the literature. This knowledge is important because it reflects the ways in which the VTSOs adapt to the challenge of limited information sources for situational awareness and trust building (Brödje et al. 2010; de Vries 2017), communications and predictions at a distance, and lack of role directives (Brödje et al. 2013), as well as how this impacts their judgements and assistance to ships. This can have a bearing on new developments of technological systems (de Vries 2017), work protocols, regulations and training programmes.

2 Theoretical background

Communication establishes a relationship between two or more parties in the exchange of information and feedback (Flin et al. 2008; Miller 2012). This generates knowledge, helps predict behaviour patterns, and is essential to maintaining good teamwork, safety and efficiency. Communication is comprised of four components (Flin et al. 2008): *what* (the content to be communicated); *how* (the means and shapes through which the content is communicated); *why* (the reason for communicating); and *who* (those with whom the content is being communicated).

As in Crew Resource Management (CRM) training, the VTSOs are trained in keeping a closed-loop feedback communication model (Brödje et al. 2013) and using the Standard Marine Communication Phrases (SMCP) defined by the IMO (2001) (a code followed by all maritime professionals, containing a set of communication standards). Closed-loop communications require that the sender and the receiver of the communication content work together to accomplish a mutual understanding and that confirmation and potential correction of content are facilitated (Flin et al. 2008) to increase accuracy and reliability of information and thus predictability of behaviour.

The general systems theory of Cybernetics, which from the Greek means "steersman" or "rudder" (Miller 2012; Skyttner 2005; Woods and Hollnagel 2006), refers to a closed-loop feedback model in terms of maintaining control of a dynamic and complex system being steered, controlled and regulated (Woods and Hollnagel 2006) towards the achievement of system goals (Miller 2012), allowing the system's behaviour and response to be better predicted (Skyttner 2005). The same is true in control theory, where continuous feedback loops of information are necessary to maintain control and for a system to remain within its safety boundaries (Dekker and Pruchnicki 2014). Regulating the system depends thus on communication (Johansson and Persson 2009; Skyttner 2005), information processing, planning/adaptation and decision and is measured through the extent to which the system is achieving its intended goal (*effectiveness*), with a minimal use of resources (*efficiency*), and contributing to the goals of the higher-level system in which it is contained (*efficacy*) (Skyttner 2005).

Communication, information integration (de Vries 2015) and trust (Bruno and Lützhöft 2010; Brödje 2012) have been described as key factors in navigational assistance for maintaining safe and efficient operations at sea. Particularly, spoken communications through VHF radio or cell phone help to reduce uncertainty (Johansson and Persson 2009), gain insight into the skill of the navigator and build trust (Bruno and Lützhöft 2010; de Vries 2015), as well as help the VTSO get a perception of the standpoint of the crew (Bruno and Lützhöft 2010) and build a mental model of the local traffic (Brödje 2012). However, a previous study by Brödje et al. (2013) concluded that regardless of the fact that the VTSOs had full situational awareness of a given critical instance in the channels, they sometimes chose to refrain from informing bridge officers or pilots of safety aspects when in situations not subjected to a protocol. The authors suggested that this problem was linked to insufficient directives to delimit and guide the responsibilities of the VTS, and to the VTSOs' anticipations that the bridge officers and the pilots would react negatively towards them.

Previous research has pointed at the ambiguity of the INS, TOS and NAS services provided by different VTS centres (Nuutinen 2005, 2006; Praetorius and Lützhöft 2012). The issue of homogenizing the delivery of VTS across the globe has been under debate in IALA (2013), which should help foreign vessels better understand what to expect from and report to VTSOs, as well as build trust in them (Nuutinen 2005; Praetorius and Lützhöft 2012).

As trust between the actors in the maritime context is built around how roles are being performed and not around personalities or personal relationships (Bruno and Lützhöft 2010), the ambivalence of the VTS role and/or the notion that the VTS stands at a lower hierarchical level than the mariners (Brödje et al. 2013) immediately represents a communicational barrier, notwithstanding the fact that the actors are not co-located. It helps the mariners to build trust in the VTSOs if they can sense that the VTSOs have an understanding of their standpoint and have their best interests at heart (Bruno and Lützhöft 2010). For the VTSOs, however, their trust and reliance on the mariners that they have a good idea of what is happening in the fairways based on the way they manoeuvre the vessel and/or communicate over the VHF radio often keeps the VTSOs from communicating certain information to the mariners that they expect the mariners already know (Brödje et al. 2013). The VTSOs try to avoid providing what they fear is redundant information to the mariners and seeming arrogant (Brödje et al. 2013). In this sense, although trust helps promote effective communication and safety performance, it can also have the opposite effect (Cox et al. 2006; Sætren and Laumann 2015; Schöbel 2009).

3 Methods

This study utilized a qualitative research approach to data collection and analysis (Creswell 2014; Czarniawska 2014; Patton 2002), which is appropriate to capture non-technical factors in communication at the VTS. Inductive reasoning was used to argue for general principles based on empirical evidence.

The general aim of the fieldwork was to learn about the VTS everyday operations (information exchange and communications) in a complex and dynamic work environment (Stanton et al. 2013), monitoring and assisting traffic in maintaining safe and efficient passage in port areas. The fieldwork consisted of four independent visits to a VTS centre (who provided INS) administered by the Swedish Maritime Authority (SMA). The first visit began with a briefing given by a VTS instructor on the general purposes of the VTS and of the specific INS service offered. Here, a description was given on how VTSOs are trained to communicate with vessels in everyday circumstances as well as in more dangerous situations, such as near-collision or near-grounding. This session was followed by four separate instances of naturalistic direct observations (Patton 2002; Stanton et al. 2013) of VTS normal operations and communications (no accidents were observed during fieldwork). During the observations, the VTSOs were asked pre-prepared open-ended questions as well as opportunistic clarification questions about the vessels' movements observed on the electronic charts, information being received or VHF radio communications taking place, among other aspects of their work.

Each visit had the duration of 3 to 5 h, beginning at different hours of the morning to try to capture different traffic patterns, change of shifts and the hand-over procedure between VTSOs. Each visit would observe the work of two VTSOs, making up a sample of six VTSOs. The VTSOs followed their regular schedule, and our observations took place out of convenience and availability of the centre, arbitrarily resulting in two of the VTSOs being observed twice on different days. All of the respondents had studied nautical sciences and/or had significant onboard experience before becoming VTSOs.

In accordance with an informed consent form signed by each respondent, the sessions were audio-recorded and annotated. Codes began being devised during fieldwork as patterns were identified, and this spawned initial questions and theories which helped determine the aspects to follow up next (*theoretical sampling*) (Corbin and Strauss 2008; Czarniawska 2014; Orr 1990). The audio recordings were later transcribed verbatim, and the transcriptions were highlighted where relevant according to the codes, and *memos* were written (Corbin and Strauss 2008). The process of coding and of understanding relationships (*axial coding*) was iterative and incremental, based on the grounded theory approach (Corbin and Strauss 2008). This analysis resulted in five groupings of data that describe the symmetries found in the work of the operators, presented in Sect. 4, representing non-technical communication factors interpreted to influence decision-making and the safety of operations in the system: role ambiguity; judgement, trust and overreliance; language proficiency, acquaintances and frequency of visits; norms, patterns and expectations; closed-loop versus open-loop communications. From these findings, further literature was studied to help understand and support the observed phenomena. Similar analyses have been frequently used in the context of complex sociotechnical systems studies (e.g., Sætren and Laumann 2015), including in the context of navigational assistance (e.g., Brödje et al. 2013; de Vries 2017).

The field studies with naturalistic observations and open-ended questions were useful tools to investigate everyday operations and communication patterns at the VTS centre under study. Although a sample of six VTSOs and one VTS instructor may be small, the sample was representative of this particular centre (six out of seven VTSOs that work at this centre) and the number of visits resulted in data saturation. As this centre is situated in one of the most traffic-intense areas in Sweden and provides the most common service globally, INS, the general conclusions taken here that resulted from empirical evidence are considered indicative of the mechanisms of other VTS centres with an INS role.

Qualitative research is not intended to culminate into statistical or numerical data, as much as grounded theory coding is not meant to be rigid and can be done at different levels of analysis. This suits the purpose of gaining an understanding—and creating/providing a description—of phenomena with a particular nature that cannot be directly quantified (Corbin and Strauss 2008; Langford and McDonagh 2003). The knowledge created is an outcome of the researcher's interpretation of the observed phenomena, and thus results may vary depending on the researcher, but the careful inspection and search of symmetries in the data ensure ecological validity and the rigour of the findings (Corbin and Strauss 2008; Orr 1990). The methods used in this study are replicable.

4 Results

An individual VTS workstation is mainly characterized by the VHF radio communications and the computer monitors with the electronic chart with integrated radar and Automatic Identification System (AIS) information through which the VTSO monitors the traffic situation in their respective VTS geographical area, along with the use of other information systems or services (e.g., email, pilot schedule, weather forecast) (see Fig. 1).

The VTSOs described their centre as an aid to the navigators in achieving safety, efficiency and environmental protection, and making arrival more convenient for the vessels, by providing them with the necessary information at the right time so that they can adjust their Estimated Time of Arrival (ETA) when/as needed, as the VTSOs have local experience and knowledge of the local traffic ("We are here to give the best updated information (…) to prevent accidents"). Safety—just like environmental protection—was generally described as the avoidance of accidents or taking the right measures to "minimize impact" in case of an incident or accident, but in practical terms the concept of safety seemed to be more individual and subjective, based on operator knowledge and experience ("What is safe or not safe is a lot up to the person sitting here and what kind of knowledge you bring in. If you have been a captain for 20 years, you make one judgement. If you've been for 2 years or not at all, then you make a different judgement") (see also Praetorius and Lützhöft 2012). As to what helps achieve safety, this resulted in a multifaceted discourse: safety depends on normal and recognizable communication and navigational patterns accounting for parameters such as weather conditions, bathymetric data and vessel characteristics. The VTSOs' responsibility was described as providing good information and confirming that the vessels understood said information and what was happening in their vicinity ("When it comes to the information we give out, it could be that it's consistent, that it follows the same pattern so it's recognizable; that we don't talk too much—just give the essential information"). Part of this task was about monitoring traffic and making sure vessels kept following a "normal pattern".

From the standpoint of providing remote assistance, VTS operations depend on the information received via sensors on computer systems, and on VHF radio voice communications. The latter include protocol reporting communications and influence essential judgements and safety decisions. The results of the fieldwork list the non-technical factors

Fig. 1 Individual work station at the VTS centre

(described in the following subheadings) that impact judgement and decision-making.

4.1 Role ambiguity

The VTS centre under study has an INS role intended to monitor local traffic and operations, and inform passing vessels. Despite this, it was observed that the VTS performed activities overarching all three services (see Sect. 1 for a definition of these services).

The VTS can ask questions to clarify the vessels' intentions, give a warning (e.g., "Warning: You are heading for shallow waters"), or even provide advice from a general perspective, but usually once vessels have reached an agreement as to how they will meet, the VTS is not to intervene. Moreover, the VTSOs can only assist traffic up to a certain point and will not interfere when accidents are just about to take place, as there is a point where VTS interference is thought to actually do more harm than good ("It's about two minutes until they will have their closest point of approach. Now, I would say it is too late for us in the VTS, because you always come through the limit where you do more harm than you will do good"; "If they are going to come a little bit close, then I know what their intentions are, so I am not that worried. But it is very difficult to say as well, because you can have a manoeuvre problem very soon").

The VTS instructor preferred that advice was given with caution, not to risk the VTS being misinterpreted by vessels as having given an order to the captain and then potentially becoming implicated in case of an incident or accident. Thus, VTSOs preferred to ask clarification questions making sure that the vessel had understood the traffic situation ("Advice should be used only when nothing can go wrong"). However, the VTSOs sometimes expressed a need to communicate beyond their role as an information service (e.g., "You cannot leave the fairway in that direction. You have to pass two more green lighthouses before you go to starboard"—VHF radio communication). In this case, the VTSO said that perhaps the ship could have gone clear through the channel it was heading to with the particular draught it had, but that it was still "not the procedure" (see Sect. 4.2.2). This example was one of managing traffic rather than informing it, but in some circumstances the VTSOs find it difficult to avoid changing their approach and giving instructions to manage the traffic situation: "If you tell them that for some reason 'you cannot arrive at the pilot station earlier than 11.00' and you can see that they will be there at 10.30 and you call them (…) still they don't do anything until you basically say… You have to tell them to stop!". The VTS instructor suggested that having a level of VTS service at their centre able to instruct ships would potentially increase safety but decrease efficiency as a result (possibly interfering with the bridge team's decisions) and put more responsibility and blame on the VTSOs if an incident or accident were to occur.

Besides ways of communicating with vessels, another example of control by the VTS was their role of authorizing ships to leave berth or hold current position. It was also the VTS who decided and coordinated the ships' anchorage points or pilot boarding points. The VTS would also advise ships to take a tug boat, and if these ships chose not to do so, the VTS would report it to the SMA and the coast guard. This advice provided by the VTS, then, served as an instruction.

Speed limits or channel deviations were also advised by the VTS when temporary events were taking place in the fairways (e.g., diving operations or port construction activities). The VTS would also serve as the intermediary for coordinating certain operations, as the example of vessels reporting a navigational buoy that was out of order. The vessels would not directly call the Maritime Safety Information (MSI); instead they would contact the VTS so that the VTS could take charge of informing the necessary authorities. The same applied to when a vessel wanted to order linesmen: it would be the VTS who contacted them for the vessel before approaching berth.

4.2 Judgement, trust and overreliance

A part of the VTSOs' work is the prediction of possible traffic scenarios and outcomes based on the information at hand. However, the VTSOs expressed the challenge of ship and shore operators having different perceptions of reality and perceived that it should be easier for the captain or pilot onboard the ship to predict certain movements and events in the fairway than for the VTSO: "The pilot onboard, he can see ahead. You cannot see ahead here [at the VTS]". For this reason, the VTSOs must rely on the pilots and bridge officers to follow the rules: "Hopefully they're following the rules. Then we don't have to do nothing".

When monitoring a 'vessel's behaviour' and/or communicating with its bridge officer, the VTSO produced a judgement of their competence/skill to communicate effectively and/or navigate the vessel safely. Different factors influenced this judgement, which in turn determined how much trust/reliance the VTSO could put on them or how much additional attention they would require to ensure that no incidents or accidents would occur. Stakeholders were trusted depending on the way they communicated over the VHF radio and how they gave an impression of being skilled mariners or not. The experience and local knowledge of the pilots and captains who passed through the area frequently were almost taken for granted, even though VTSOs admitted that this might be a risk on its own: "It depends on what you rely on, but they could, of course, sometimes make mistakes as well".

4.2.1 Language proficiency, acquaintances and frequency of visits

Factors like the captain's nationality and how prone he/she was to being proficient in the English language, to how well a VTSO knew the captain or pilot he/she was talking to, were aspects that influenced the VTSOs' reliance on the vessel. One example was of a Dutch vessel that skipped some of the necessary information when reporting inbound to the VTS, such as intended route and destination, but the VTSO maintained trust in the vessel's bridge team based on perceived language proficiency: "(…) you know, he's Dutch, he knows English (…)". Difficulties communicating in the official language, English, by the bridge officer on duty usually alerted the VTSOs to keep a closer look at that vessel. That is, perceived language difficulties decreased the VTSOs' trust in the vessel, since the VTSOs did not feel secure that the communication between them had been clearly understood by the bridge officer or that he/she would proceed with what was agreed upon: "You know you have to try to use other different words or possibly try to use the same phrases all the time if they don't understand you (…). You keep it simple (…). Of course you make a judgment".

For foreign ships, a respondent reported to replace Swedish geographical names with numbers or use a landmark reference point that was more recognizable to communicate locations to ships. Cultural differences also had an impact on judgement: "I'm not saying that there are certain nationalities that are better or worse, but it's the way they think".

In circumstances where the VTSO and the bridge officer or the pilot onboard were well acquainted, the VTSO could get a quicker sense of trust in that they had the navigational expertise necessary and the situation under control. For instance, when asked if the VTSO was satisfied with a particular vessel's behaviour, the VTSO responded: "Not really, because I think it's easy for him to slip up to the other side. But I know these captains; they are very familiar with the area without pilots". Also, a ship's high frequency of visits to the same VTS area was usually indicative of having more local knowledge, to the extent that some had a pilot exemption licence. The more frequent those visits were, the more the VTSOs relied on those ships to follow normal patterns of behaviour and communication in the area: "You cannot stop observing them, because anything can happen. But, of course, I think every human being makes a judgement based on someone appearing a lot of times than a single vessel coming once a year". The ships that passed through the area more sporadically and that asked the VTS questions that the VTS did not expect to be asked, such as where the reporting point was located or what to report, made the VTSOs more apprehensive about that ship's future behaviour.

4.2.2 Norms, patterns and expectations

The VTSOs monitored their area on the basis of traffic patterns, of normal behaviour both in terms of navigation and communication (e.g., making "turns in a planned way"; "Normally the vessel turn starts here on the way"; "Normally they go here"). Vessels deviating from what was considered "normal" usually caught the attention of the VTSOs as potential "troublemakers". What was considered "normal" was not just based on formal regulation but also on informal norm such as the experience of the VTSO and the expectation of how vessels should act in certain situations in the area.

Another informal norm was the recognized and accepted preferences of certain captains, pilots and/or shipping companies that were regularly navigating through the area, even when these preferences and behaviours differed from the rest of the traffic (e.g., pilots on a particular cruise line always took a shortcut, described by a VTSO as "(…) a little bit tight. They could use the fairway better, they really could. But that's really common"; "I know they [pilots] always go there [over the marked shallow areas] (…) But if it had been another type of vessel, I would have reacted". So, consistent behaviours deviating from the norm sometimes became the new norm for that particular captain or pilot, thus becoming accepted and even expected by the VTSOs. It was also reported that different vessel types and sizes have different communication patterns more specific to their own procedures and experiences, causing a communication gap between them.

4.3 Closed-loop versus open-loop communications

Communication ship–ship within a VTS area consists of communicating intentions, negotiating, compromising, and reaching an agreement of when and how they will meet in the fairway and affect each other's navigation plans. The VTS overhears this back-and-forth communication over the VHF radio, which in some respect verifies if the traffic situation is under control. This communication of intentions (which should be a closed-loop communication) usually gave the VTSO enough reassurance that the ships would keep their safe distances ("It's good that they communicate to get the confirmation"; "That's important, to have a closed loop"; "It's not so much about the distance, at least not in the fairways (…). I am more relying on that they have actually communicated, so that I can know what they are doing"; "That's good. Now they have talked to each other and the situation is clear"). The VTS has the role of intervening when closed-loop communication does not take place or is disjointed in time, in order to clarify what has been shared and agreed upon. However, this was more easily done when the

VTS was already involved in that communication and even then it was not always deemed necessary or appropriate.

As per the closed-loop communication model, when there is VHF radio communication between the VTS and a vessel, the VTSO should repeat the information provided until the bridge officer of that vessel repeats what he/she just heard followed by an "understood", "well-received" or "copy that". However, sometimes the ships simply responded "understood", "well-received" or "copy that" without repeating what they heard. This is, thus, not a guarantee that the information was indeed understood as the VTSO intended it to be. The VTSOs could sometimes hear the same situation happen over the VHF radio between two ships, and they did not commonly intervene straight away. They would give the ships time to act on what they had agreed upon, as this is part of the VTS' protocol.

The VTSOs often continued to rely on the bridge officers despite their open-loop communications ship-shore or ship–ship, even though it was understood that this could potentially result in misunderstandings. They chose the trade-off of an ambivalent communication to some extent (knowing that in most cases the ships indeed understand the information properly and have the right behaviour afterwards) over creating a hostile environment over the VHF radio by questioning the bridge officers or correcting how they communicated.

Along with the closed-loop communication, IMO's SMCPs (IMO 2001) are to be transmitted in English so that anyone implicated in a certain traffic situation listening in on the VHF radio can equally understand what other parties involved are communicating despite everyone's nationalities and origins (see also Praetorius and Lützhöft 2012). It was observed, though, that some of the communication happened in Swedish, mainly that between fishing boats, pilots and VTSOs, as fisherman were reported to seldom master the English language, and pilots and VTSOs sometimes wanted to be able to communicate without having an impact on everyone else listening in.

5 Discussion

Safety, efficiency and environmental protection were the main high-level concerns in maritime operations. In the VTS, safety was described as being dependent on (a) the communication of updated local information to the vessels (also found in Brödje et al. 2010; de Vries 2017), ensuring that this information is well understood to provide the overview of the local traffic; and (b) the monitoring of traffic to make sure it follows the "normal patterns" (also found in Brödje et al. 2010), accounting for all parameters that can affect safety.

Being ashore and having limited information sources to build situational awareness and trust (Brödje et al. 2010; de Vries 2017), and to anticipate vessel movements (Praetorius et al. 2012), the VTSOs' work depends on the screen-based visualization of traffic and also greatly on VHF radio voice communications with ships and between ships (Brödje et al. 2010; de Vries 2017). VHF radio communications are useful to capture the intentions of the vessels and provide verbal assistance (Brödje et al. 2010; Praetorius et al. 2012; van Westrenen and Praetorius 2012). However, it was found that there are communication limitations linked to (a) the ambiguity of the VTS role; (b) the judgements and expectations of traffic and communication behaviours that VTSOs can make from ashore; and subsequently (c) the trust versus overreliance that the VTSOs build on the mariners. These limitations ultimately have an impact on how the VTSOs approach the vessels' bridge teams and provide them with assistance (see Fig. 2).

As depicted in Fig. 2, in protocol operations, inbound vessels report predefined information when entering the VTS area and the VTS confirms and relays through VHF radio relevant local traffic and weather information as deemed appropriate. Monitoring the vessel movements on the screens will then provide sensor information on whether a vessel is following the route that was communicated, the regulations and recommendations for the area. But as shown in this study, and adding to the results of Brödje et al. (2013), non-technical communication factors and limitations exist beyond the protocol, regulations and technical solutions and have an influence on VTS decision-making and assisting ships.

First, vessel reporting and communication protocols happen within an environment of VTS role ambiguity (see Sect. 4.1) in the sense that there are contradictions in the way the INS role is performed in practice. There were occasions where the VTSOs felt they needed to be more intervening with vessels than usual to avoid compromising safety or breaching the "normal patterns" for the area. At the same time, there were occasions where even a breach would not prompt the VTSOs to intervene, and this sharpened intervention boundaries and intrinsic hierarchies of the INS role. Moreover, it was perceived by the VTSOs that foreign vessels felt uncertain with the different roles of different VTS centres. This calls into question the services provided by VTS centres and their directives on the assistance of traffic (also see Brödje et al. 2013).

Second, the VTSOs will make judgements of the skills of the vessels' bridge teams based on: whether the vessels' navigational behaviour is following normal patterns for the area, for the traffic circumstance, vessel characteristics (see Sect. 4.2.2) and frequency passing through the area (see Sect. 4.2.1); not only what is being communicated from the vessel (or among vessels) but also on how

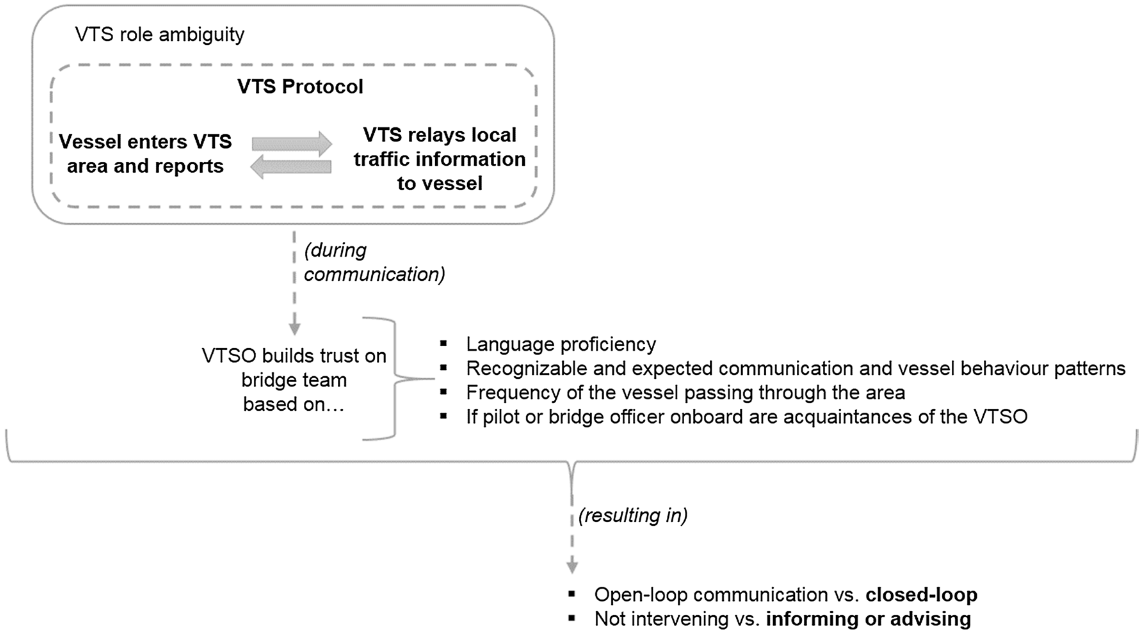

Fig. 2 Non-technical factors in information processing and their impact on trust and decision-making in everyday operations (no accidents were observed during fieldwork)

(Brödje et al. 2010) and when it is being communicated; and language proficiency (see Sect. 4.2.1). What was considered "normal patterns" of navigational behaviour was not defined equally for all ships or circumstances. This was based on the VTSOs' experience of ship types and of the local waters, but also on the knowledge and expectations of the navigational preferences of specific captains who navigated through the area more frequently. Although the VTSOs were aware that, for example, being acquainted with the mariner on the bridge or the vessel's frequency of visits did not guarantee a trouble-free passage, or that the bridge officers' English language proficiency did not directly imply being skilled or not (Brödje et al. 2010), this had a clear and almost inevitable impact on the VTSOs' level of confidence in the bridge officers (also see Praetorius and Hollnagel 2014).

Based on these aspects, the VTSO will build an awareness of the situation onboard and either trust the vessel's bridge team or choose to keep a closer look-out on them. The VTSO may then intervene to provide additional navigational information to try to improve the situational awareness of the bridge team (see Sect. 4.2). In situations of trust, the VTSO will sometimes leave communication loops open or refrain from interfering, even in dubious situations, not to overstep or seem prepotent (see Sect. 4.3) (also see Brödje et al. 2013), which once more highlights the issue of ambiguity with the VTS' role. While trust contributes to safety of navigation (Bruno and Lützhöft 2010; Brödje 2012), the factors that determine this trust are not free of uncertainty.

The overreliance on the vessels and shortening the VHF radio communications down to open loops of information, the incoherence of VTS service levels, the specificities of different VTS locations, and the uncertainty in the expectations of the mariners can compromise safety as a goal. However, being a loosely coupled system, the looseness of the safety boundaries of navigation may go unnoticed for some time (Dekker and Pruchnicki 2014). Still, the limitations identified must be assessed and control loops maintained, for the maritime system to accomplish their goal(s) at their full potential, without failure (Dekker and Pruchnicki 2014).

Maintaining closed loops in communication is all the more important when there is lack of information technology integration and the information being exchanged among ship and shore operators is conflictive. Recent studies have found that parameters such as the draught of a vessel can be communicated to the VTS from different sources or stakeholders in the system (e.g., port agent, port controller, bridge officers), and by multiple means (e.g., AIS transponder, VHF radio, email, web forms or telephone). This information is not always updated and may even be conflictive, causing the VTSO to have to/prefer to check it directly with the ship captain via VHF radio to decrease the uncertainty of the sources and of the information received (Costa et al. 2018; de Vries 2017).

It is an idea to consider for the maintenance of safety that the role and training of VTS be internationally harmonized to guide the work of VTSOs (Nuutinen 2005; Praetorius and Hollnagel 2014; Praetorius and Lützhöft 2012; Praetorius et al. 2012), and within it highlight the aspects and effects of trust on the safety performance of the system (Bruno and Lützhöft 2010; Brödje et al. 2013; Cox et al. 2006; Sætren and Laumann 2015; Schöbel 2009). VTS homogenization may, however, face the challenge of disparate resources available between centres to achieve the specific goals of the VTS area: different work shifts, local traffic density and information, how the VTS works together with other local services such as the ports and pilots. Thus, how different centres adapt to their special circumstances must be weighed in (Nuutinen 2005; van Westrenen and Praetorius 2012).

This is a time where numerous technological developments are being made towards the digitalized dissemination of information such as the maritime example of e-navigation by the IMO (2014). Information technology developments may transform the structures of the maritime stakeholder network and affect the need for and the ways in which maritime actors communicate with each other if more decision-making power is shifted to technology (Costa et al. 2018). The softer aspects of communication may be taken into account in information technology development so as to accommodate the needs of the shore operators and their tasks, or even potentially alleviate current communication limitations and maximize the capacity of the VTS to assist vessels with maintaining safety. The disregard for such softer aspects in technological development, on the other hand, may instead exacerbate existing communication barriers or create new ones.

6 Conclusions

The purpose of the fieldwork was to explore the operations of the VTS with regard to how the VTSOs communicated with ships and other shore operators, and how decisions were made to assist the traffic in maintaining safe passage in port areas. The data suggested non-technical aspects of information processing and communication that influence the VTSOs' judgements, expectations and decision-making in the assistance to ships and reflect challenges in the role of the VTS. This paper complements previous research (Bruno and Lützhöft 2010; Brödje et al. 2010, 2013; de Vries 2015; Praetorius and Hollnagel 2014, 2015, Praetorius et al. 2012) in the deeper understanding of everyday VTS operations through naturalistic field observations, specifically with regard to the non-technical factors which lack documentation in the literature. Future research is planned to capture technical and non-technical communication aspects from the perspective of the mariners.

This research reflects the ways in which the VTSOs adapt to the challenges of limited information sources for situational awareness and trust building (Brödje et al. 2010; de Vries 2017), communications and predictions at a distance, and lack of role directives (Brödje et al. 2013), as well as how this impacts their judgements and assistance to ships. Specifically, this may contribute to authorities such as IALA in their considerations towards the homogenization of the delivery of VTS around the globe, with regard to the extent of intervention by the VTS, their flexibility and adaptability to local circumstances, and to trust building between VTS and bridge teams.

This qualitative research also contributes to practical knowledge to manufacturers, policy makers, educators and trainers on considering the whole spectrum of communication—not only technology-related but also the softer aspects—as an important part of the design of ongoing and future e-navigation support systems (Bruno and Lützhöft 2010; Praetorius and Lützhöft 2012), policy developments, VTS education and training programmes for the augmentation of safe and efficient passage in dense and confined waterways. Such changes will affect the ways in which maritime actors work (de Vries 2017), how they obtain and process information, as well as how they communicate. The factors identified here represent an opportunity for future shore-based assistance organizations, regulations, training programmes and technical solutions to further support operator needs.

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