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Identification of errors committed by Vessel Traffic Service operators

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Abstract

This paper examines the factors affecting the performance of VTS operators. A general review of the human factor as a determinant of navigational safety is presented. The elementary nature of the system and its structure are defined, and the ability of a VTS operator to perform planned tasks within a specified timeframe and in a specific manner is analyzed. A reliability assessment scheme is proposed, which is based on the interpretation of factors affecting the VTS operator's efficiency. The effective performance of VTS operators, along with the specific nature of the maritime environment and reliability of the vessel traffic management support, are key determinants in the process of ensuring the reliability and security of the entire system.

Introduction

Although many studies and literature reviews are available in the literature on the subject, there is no comprehensive analysis of the effectiveness of VTS (Vessel Traffic Service) systems. An assessment of the effectiveness of a VTS system plays a major role in ensuring efficient management of vessel traffic. Such an assessment requires a comprehensive analysis of the human factor (Uzarski & Abramowicz-Gerigk, 2014). Effectiveness is a key element integrating vessel traffic management at the operational and strategic levels. The lack of consolidated VTS system components may compromise the decision-making process and, thus, affect a VTS operator's performance.

Improving a VTS operator's performance requires a review of the entire system's operational efficiency. Since a system's security relies largely on relations between the human operator and their work environment (man-machine relation), its effectiveness must be analyzed in two aspects: effectiveness of the VTS operator and effectiveness of the system as a whole (including its internal processes). In order to determine the effectiveness of coherent goals in these two aspects, the authors of this paper have estimated the impact of negative factors.

A system consisting of a human and a technical object is dynamic in nature: it changes over time and affects its operating environment. Through interactions with other systems operating in the same environment, it can modify a predetermined action plan.

VTS operators play important roles in regulating maritime traffic systems. The correct operation of the entire system requires expert knowledge about how and when to react. The IALA V-103 recommendations require personnel to be adequately qualified and trained to perform their duties as VTS operators in accordance with IMO guidelines. The quality of the VTS system operation depends on the efficiency and effectiveness of all system components. In order to ensure the effective operation of the system, appropriate working conditions must be provided to allow the operator to fulfill their obligations and detect incidents. The VTS operator is responsible for the continuous and simultaneous observation of several screens while sitting in the same position; therefore, the workplace should be designed to enable appropriate monitoring of the VTS area. Assessment of human performance is based on the analysis of human behavior and a human's influence on certain environmental conditions (normal and emergency conditions). The HRA (Human Reliability Analysis) method is used to assess the human impact on an environment in terms of system performance. The method is based on analyzing the influence of human activity on a system. Mistakes made by an operator, even those that seem insignificant at first glance, can affect the efficiency and/or security of the system. Increasing the intensity of vessel traffic should not adversely affect the navigational safety and reliability of the VTS system. A ship's crew is responsible for its safe navigation (van Westrenen & Praetorius, 2014), while the VTS is supposed to help seafarers use waterways safely and efficiently (IALA, 2016).

VTS systems are complex social engineering systems, and people are important regulators that maintain the stability of the system (Rellinga et al., 2019). Hollnagel and Woods (Hollnagel & Woods, 2005) argued that human performance is limited by the conditions under which it occurs. In order to organize and analyze collected data, the most commonly used method for assessing human performance, i.e. cognitive task analysis (CTA), aims at understanding activities that require significant cognitive activities from the user. These include decision-making, problem-solving, memory, attention, and judgment. CTA is used to understand the tasks and outcomes that people are trying to achieve. This method examines how people think, what they know, what they are trying to understand, and how information is organized and structured (Crandall, Klein & Hoffman, 2006).

May and Barnard (May & Barnard, 2004) define cognitive task analysis (CTA) "as techniques for modeling the mental activity of a task operator". Crandall, Klein, and Hoffman (Crandall, Klein & Hoffman, 2006) argued that using more than one method or tool in a CTA provided a greater effect and clearer result. For this reason, this study uses applied cognitive task analysis (ACTA) and the critical decision method (CDM). ACTA is typically used to analyze cognitive needs as part of a task, while CDM focuses on non-routine incidents (Stanton et al., 2013).

This study was conducted on a group of ten operators to understand how VTS operators respond to various factors in everyday activities and unusual events. The research undertaken in the article was also aimed at developing a model of human behavior in the field of VTS reliability and safety assessment. The main goal was to assess the reliability of a VTS operator. In order to perform a comprehensive analysis, it was necessary to use many complementary measurement methods. In order to fully analyze the risks related to the work of VTS operators in this study, it was decided that a group of operators would perform exercises of various difficulty levels on a simulator. These methods allow us to identify factors that influence operator performance. The research made it possible to assess the sources of threats resulting from human activity as a part of the VTS system and to analyze human errors in the field of system reliability and safety.

The structure of work performed by a VTS operator

In the management of vessel traffic, VTS operators use the support of navigation systems. Land-based VTS operators coordinate the interchange of complex data in easily-understood formats.

A VTS system is a service center designed to ensure safe and effective navigation. The system's infrastructure relies on delivering authorized data, ship-to-shore and shore-to-ship, which enables the system to operate securely and reliably.

For this study, the VTS system will be presented in the form of two components: one representing a human-operator and one representing the work environment. We understand that a work environment is a tool necessary for the proper functioning of the system – the entire system of devices. The main observation tool is the radar, from which images are automatically applied to the electronic map. On the electronic map, data from the automatic identification system (AIS) transmission can be displayed, and data can also be entered manually.

VTS is also equipped with a system of TV cameras that allow for visual observations, and they are very useful in places such as locks and port areas. Communication between the VTS station and ships is accomplished using VHF radiotelephony where each VTS station uses its own channel to communicate with ships. VTS provides weather information and warnings via indirect-wave radiotelephony and Navtex. In the recommendations of the IALA V128 (IALA Recommendation V-128 Operational and Technical Performance Requirements for VTS Equipment), the basic operational requirements of the VTS system are discussed, which relate to:

- VTS – Radar System,
- Automatic Identification System (AIS),
- Communication,
- Closed-circuit TV (CCTV) cameras,
- Hydro-meteorological devices,
- VTS Databases – Data System.

For this study, the VTS operator was defined as a person working at vessel traffic control – a unit that regulates vessel traffic in the area of VTS responsibility. The operator's tasks include supervising vessel traffic in the VTS area (12/24 hours shift system), running a nautical and hydrological-meteorological information service for the areas covered by the monitoring system, collecting and storing information in the system, and maintaining a database of monitored vessels. Their duties include running a sea assistance service for ships in the area of VTS responsibility, as well as cooperation with others, such as port authority traffic services or SAR. All of these tasks are achieved by providing three kinds of services: information on the movement of maritime units, organizational traffic, and navigational aids – assistants (IALA, 2008).

When a vessel is approaching the VTS area, the officer of the watch (OOW) reports to the VTS on the VHF (e.g., reports the planned route while the ship sails within the VTS area). Information is then exchanged (ship and cargo details, current position). The VTSO on watch responds by repeating the information provided by the vessel's OOW, based on which the OOW can either confirm or correct it. This process is called a closed-loop, and it is used to ensure that both parties correctly understand a given situation. VTSO provides OOW with up-to-date information on the VTS area, including the intensity of vessel traffic, possible disruptions to a ship's deviation from the planned course (e.g., possible interactions with another vessel), ongoing works in the water area, etc. (Śniegocki, 2002). The information may concern the current hydrographic or meteorological situation in relation to factors such as currents, tides, and fog.

Recently, there has been a growing interest in the analysis of of human reliability in technical facilities and systems technical systems in which a human being supervises the course industrial process (Kosmowski, 2008).

Between two elements – the VTS operator and the work environment – certain processes occur constantly due to their interactions (Figure 1).

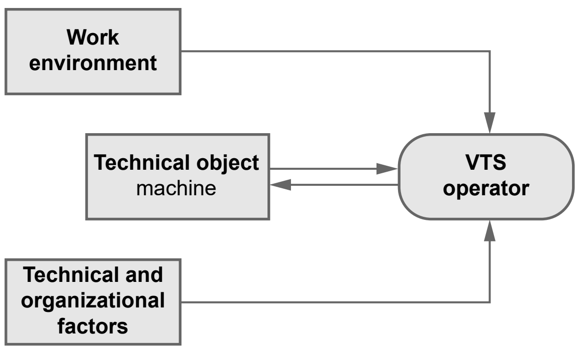

Figure 1. Model of the human–technical system (based on (Sienkiewicz, 1983))

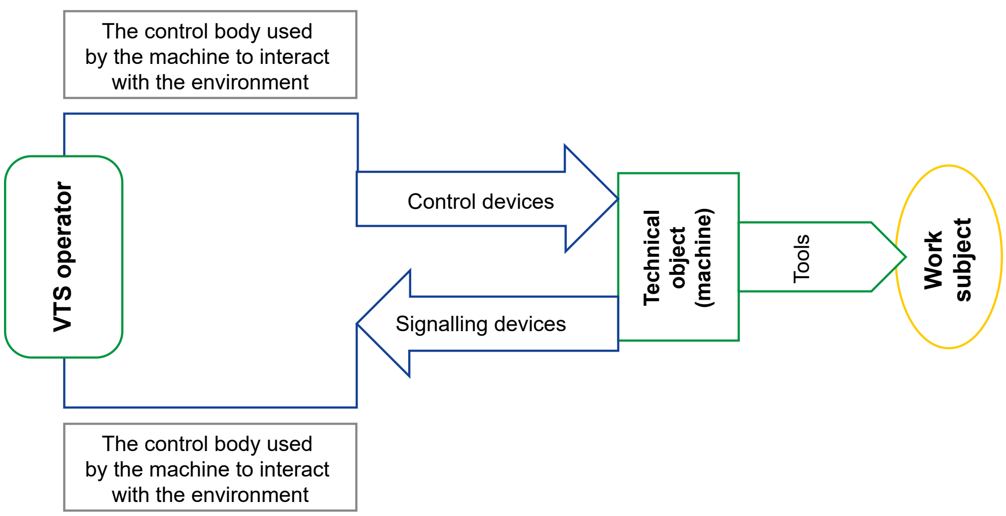

Figure 2. Diagram of interactions between the VTS operator and the technical facility (based on (Sienkiewicz, 1983))

Both of these elements work under specific conditions of the external environment, which affects each of these elements. These system elements also impact the environment; therefore, a more accurate concept is the human-device-environment system shown in Figure 2.

The human-machine/technical object system is characterized by the following features (Sienkiewicz, 1983):

- it can take purposeful actions;
- it can cooperate with other systems;
- it consists of other systems;
- it prevents interference;
- it creates conditions for itself and other systems to take action;
- it undergoes development and can change and improve itself.

For this study, an elementary human-machine system consists of a human and a predefined number of specific types of technical measures taken by the human to perform certain tasks at a certain time and in a certain manner. The system is elementary (one of its structural features), which means that, if deprived of any one of its components, it would be incapable of performing tasks as planned (Sienkiewicz, 1983).

Reliability of a VTS operator

As a human being, a VTS operator is prone to committing errors, as making mistakes is inherent to human nature. Thus, the "**human factor**" plays a vital part in ensuring the safety of maritime navigation. It comprises eight key areas:

- Interpreting situations (different people tend to interpret a given situation differently):

  The uncertainty, ambiguity, and complexity of an event affect the proper understanding of the situation. Excess information received by a VTS operator at a given moment is also of great importance. A person unknowingly makes an initial interpretation of the situation by taking into account their own past experience and substantive knowledge. The experience of similar situations includes dangerous situations, incidents, or serious accidents in the past. Based on this, the operator makes a preliminary interpretation at a given moment, which allows them to make a decision more quickly.
- Risk-taking:

  In human consciousness, risk decreases with increasing control of a situation. The perception by the VTS operator of the risk of an accident on board a sea-going vessel is twice as high as in the opinion of the crew. The risk assessment is primarily influenced by excessive self-confidence, lack of experience, ignorance, or the accompanying stress and fatigue at work.
- Decision-making:

  An important element that influences the human factor is the decision-making process. Decision-making is a compromise between the information available at a given moment and the time to act. Experience has a great influence on decision-making because an experienced operator in a similar situation intuitively makes a quicker decision. The reduction of time increases the productivity of work, which gives an operator more time to act, i.e. complete a task. Unfortunately, a "quick decision" sometimes affects the reliability of a task.
- Committing errors:

  Not every threat leads to an error, and not every error leads to an undesirable condition – it depends on the type of error and many accompanying factors. Errors are the decisions and actions that lead to a dangerous situation or accident. A mistake can also be defined as situations in which no appropriate decisions and actions were taken to prevent their occurrence. A person who has extensive experience and knowledge will perceive dangerous conditions differently than a less-experienced person.
- Getting tired/stressed:

  Psychophysical conditions are one of the most important human factors. Fatigue and stress affect factors such as workload, sleep quality, job satisfaction, environment, work atmosphere, and above all, optimal workplace ergonomics. In an operator's job, each day is different, e.g., the number of controlled vessels. Every day, the VTS operator learns to react to new situations. The ship traffic controller works in a 12/24 hour shift mode, which also has a significant impact on their fatigue.
- Communicating:

  Proper communication between a traffic controller and ship is influenced by the correct interpretation of a situation, as well as the practical use of the equipment and the correct use of available information. The number of controlled vessels is also of great importance for the continuous flow of information.

All the constituents of human nature mentioned above affect the reliability of any system that operates in collaboration with a human being. This study focuses on decision-making because decisions made by VTS operators are crucial for the security and reliability of VTS systems (Kum et al., 2007).

For this study, **decision-making** shall be defined as the process to decide on taking the right action. Its objective is to evaluate the prevailing situation and choose the most favorable option (Klincewicz, 2016). Any situation in which a VTS operator, looking for the best solution among many available options, is required to make a choice, is inextricably linked with the decision-making process.

However, what happens when a human being – the VTS operator – falls into a routine and starts to make decisions automatically? Relying on experience, he/she chooses solutions that worked in the past and did not cause unwanted consequences, while at the same time being convinced of compliance with applicable regulations and correctness of their actions. This study, conducted on the Navi-Harbour 5000 simulator from Transas, has helped identify the reasons for errors made by VTS operators.

Vessel traffic management relies largely on the reliability of traffic control systems. The ever-growing density of traffic in VTS areas has necessitated the implementation of new technologies to ensure safe navigation.

Many companies (such as Kongsberg Gruppen, Transas (part of Wärtsilä), Rolta India, L3 Technologies, Saab, Kelvin Hughes, Indra, Atlas Elektronik, Vissim AS, and TERMA A/S) have developed state-of-the-art technologies to support secure and efficient vessel traffic management. They offer a variety of vessel traffic control solutions for a fully-functional VTS system.

Konsgsberg Gruppen (based in Norway), one of the leaders on the market, operates in Europe, North, and Latin America, as well as Africa. The vessel traffic management system Indra from Konsgsberg Gruppen is deployed, among others, on Poland's coastal waters and in Southampton (UK).

MaritimeControl^{TM}, another popular system released by Saab, offers proven solutions for vessel traffic management in VTS areas. Saab is an active member of the International Association of Lighthouse Authorities (IALA). Saab systems are used by vessel traffic services in Rotterdam, Hong Kong, and Ningbo.

Vessel traffic management systems from Transas, enjoying a great reputation all over the world, are used, inter alia, in Morocco and Mombasa. They have an open configuration, which means they can be easily extended with add-on applications.

Scope of the study

Navi-Harbour 5000 VTS simulator from Transas

This study aimed to identify errors committed by VTS operators and was conducted on the Navi-Harbour 5000 simulator from Transas. Fully compliant with the requirements defined in the IMO Guidelines for VTS (Resolution A.857(20)), the simulator offers a fully-functional VTS system equipped with such features as:

- receiving information about navigational situations,
- delivering data on tracked objects (in tabular and graphical formats),
- monitoring and planning vessel traffic in an area,
- generating alarms according to user-predefined criteria,
- storing digital data and vessel traffic images for further review and analysis (especially useful in the event of a system failure or a breach of applicable legal regulations by vessels in the VTS area) (NH UserManual, 2012).

All the simulator workstations have the same functionality and are operated in the same manner. The image of the VTS area is fully integrated with an electronic chart. By selecting a section of the chart, the traffic image can be focused on a specific area and the chart scaled appropriately. A wide selection of tools available in the main menu supports the easy operation of the system. The home window includes the following items:

- an electronic chart,
- the menu,
- information in a tabular format.

The main menu of the program contains a full list of functions that enable the user to fully control the system and properly perform the tasks of the VTS operator. It includes many additional functions that allow the operator's working environment to be adjusted to suit their needs (Figure 3).

The toolbar consists of buttons for quickly displaying information related to commands or selecting a specific tool. It is designed in a very practical and understandable way. A particular tool/function is launched after selecting the button assigned to it, which is on the main toolbar (this is an option for the most frequently-used tools). Of course, it is possible to start a specific function from the main menu or by using the function keys.

The use of the Navi-HarborTransas 5000 simulator permits the design of an exercise on studied areas with various conditions, e.g., changing traffic

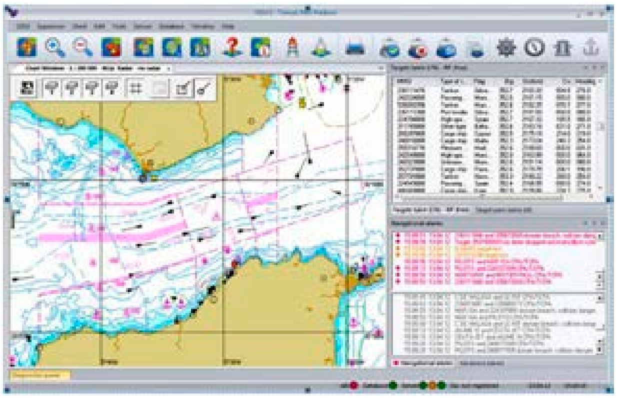

Figure 3. Home window of Navi-Harbour 5000 VTS simulator from Transas

volumes, emergencies, etc. It includes many additional functions that allow an operator to adapt the working environment to a given test scenario.

This research aimed to identify the sources of threats resulting from human activity as part of the VTS system and the analysis of human errors in the field of system reliability and safety. The concept of operator reliability is introduced as a tool to describe and evaluate the work of VTS operators (Kotkowska, Gucma & Marcjan, 2016). A scoring system for the performance of tasks by a VTS operator was introduced, which was based on the specific features of their work, such as the accuracy and processing of information obtained through the system. The research scheme has been divided into stages that are presented in Figure 4.

VTS operators – study participants

The study was conducted on a sample of ten specialized persons, including VTS operators. Each participant performed the same tasks with varying degrees of difficulty. The participants were divided into groups. Ten participants with different experiences and qualifications were used to diversify the obtained results. These people are very familiar with the area where the study was conducted and have been trained in the use of the Transas system. Currently, in the area that is the subject of research (the area of responsibility of VTS Szczecin and VTS Świnoujście), there are a total of 24 VTS operators (with similar qualifications as the operators who participated in the study) active in the profession. Ten participants thus constitutes almost half of the total population that meet similar requirements. A representative sample (ten operators), which, apart from the size, is very similar in terms of the distribution of certain features to the real population.

Simulation venue

During the simulation, the VTS operator and simulation coordinator were seated in separate rooms. All simulator workstations have the same functionality and are operated in the same manner. The image of the VTS area is fully integrated with an electronic chart.

One of the advanced functions of Navi-Harbour is the 3D VTS, which offers a three-dimensional image of traffic in the VTS area. This enhanced tool, which relies on VTMS data, enables viewing traffic from several perspectives.

The VTS system operated by the study participants offered the following functions, which included:
- Radar, AIS, CCTV, RDF, and Meteo-Hydro sensors;

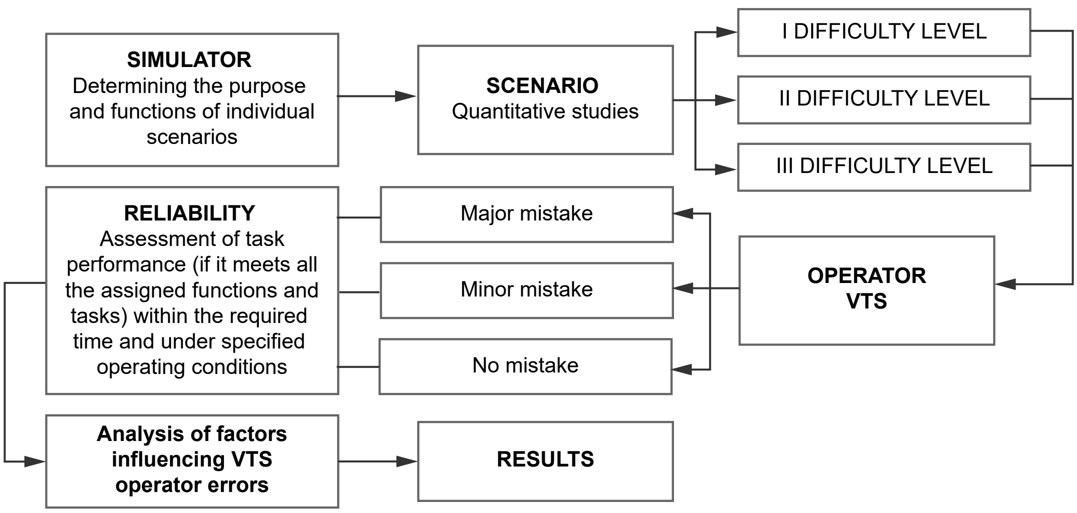

Figure 4. The research scheme

- manual and/or automatic adding and deleting of objects;
- manual and/or automatic identification of objects;
- video radar image;
- AIS data display;
- transmission and reception of AIS text telegrams;
- object echo simulation (creation, modification, and tracking);
- management of recommended routes;
- forecasting objects' maneuvers;
- managing alarms, including navigational alarms;
- recording and replaying;
- highly-functional charts, including the ability to edit and support the S-57 format.

The study participants were trained in the operation of all tools available at their workstations in order to familiarize them with the functionalities of the simulator.

The simulation schedule

The entire duration of the simulation was split into 6-hour watches. Each type of simulation was performed during a single watch. The scenario with the lowest degree of difficulty was scheduled for three watches; i.e., 18 hours. The scenarios with medium and high degrees of difficulty were scheduled for 12 hours each; i.e., the operator performed each scenario over two watches. In total, each VTS operator spent 42 hours participating in the study; i.e., stood seven watches.

Simulation scenarios

All simulation scenarios were developed in consultation with and on the basis of surveys conducted among current or former VTS employees.

Scenarios with a low degree of difficulty included situations that commonly occur during the watch of a VTS operator (Figure 5). They were applied in thirty simulations.

In each simulation, there was a moderate number of vessels within the VTS area. The maximum number of vessels underway (entering/leaving the Port of Szczecin/Świnoujście) was five, and the number of vessels anchored or moored ranged from ten to twenty. None of the vessels were hampered or carried dangerous goods.

The operator was supposed to have become familiar with the situation in the VTS area and, having identified the entering vessels, organize the traffic based on the applicable port regulations, including the positions in which the vessels were permitted to pass each other.

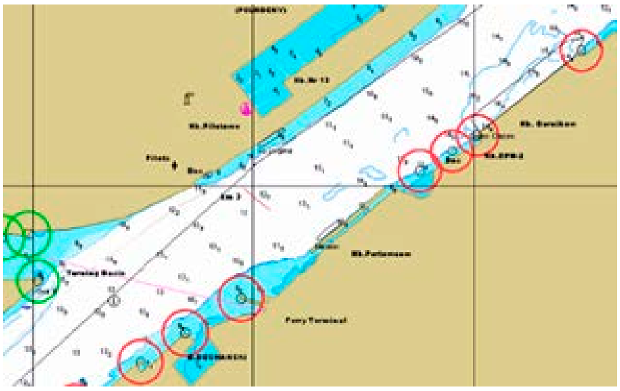

Figure 5. Example simulation with a low degree of difficulty

The VTS operator was also required to provide information to vessels entering the VTS area or getting underway and provide navigational assistance on-demand.

Conclusion scenarios with a medium degree of difficulty

Scenarios with a medium degree of difficulty included situations that frequently occur during the watch of a VTS operator, with a special focus on ships carrying dangerous cargo (Figure 6). The twenty simulations performed were varied but had some common characteristics. The traffic density was higher than normal. The number of vessels underway (entering/leaving the Port of Szczecin/Świnoujście) was more than six, and the number of vessels anchored or moored was more than twenty. The simulations included hampered vessels and/or vessels carrying dangerous cargo.

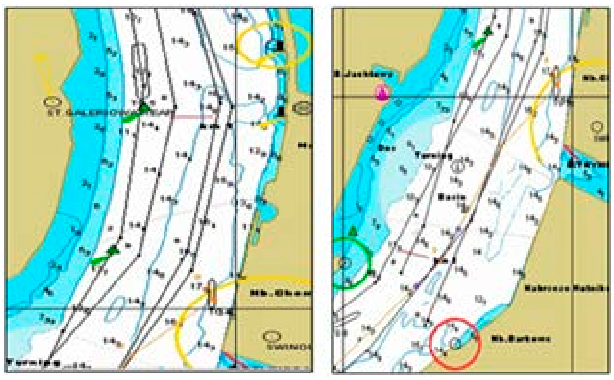

Figure 6. Example simulation with a medium degree of difficulty

Scenarios with a high degree of difficulty

Scenarios with a high degree of difficulty included situations that do not commonly occur during a VTS operator's watch (Figure 7). Each of the twenty simulations was different and required a different solution. Some of them presented an additional difficulty caused by the high traffic density. At least two vessels in the VTS area carried dangerous goods. Moreover, some ships were hampered vessels or push tows. Some simulations involved emergencies and accidents (e.g., collision, grounding, or fire onboard). They were designed to induce the launch of appropriate emergency procedures (e.g., grounding). Additionally, certain restrictions to navigation were introduced; e.g., on the Świnoujście–Szczecin fairway (on the section from II BT to IV BT), navigation of vessels with a draft of more than 8.5 m was restricted to one-way traffic, and vessels were expected to keep to the middle part of the fairway.

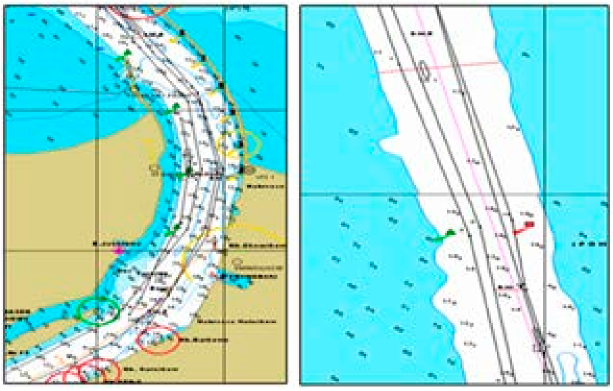

Figure 7. Example simulation with a high degree of difficulty

Results of the study

The example measurement table below shows the results of the simulations carried out in the study (Table 1). Fields marked with "X" indicate an error committed by the VTS operator. Empty fields indicate simulations carried out without errors or oversights. Remarks noted by the study coordinator during the performance of tasks by the VTS operators are marked with "R".

Figure 8 below shows the number of errors committed by the VTS operators in a simulated scenario with a low degree of difficulty.

Analysis of the results led to the conclusion that the VTS operators with the most work experience committed the most errors of all the study participants. The most common error was the **automatic granting of clearance** for entry. Some mistakes were also made when estimating the time when vessels passed each other.

Figure 9 shows the number of oversights committed during simulations. Oversights are irregularities

Table 1. Example measurement table

Simulation with a low degree of difficulty	VTS operator									
	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5	Operator 6	Operator 7	Operator 8	Operator 9	Operator 10
Simulation 1	R									
Simulation 2										R
Simulation 3								R	R	
Simulation 4		R					R			R
Simulation 5	R			X					X	
Simulation 6	X						R			X
Simulation 7		R	R		R				R	
Simulation 8				R						R
Simulation 9					X			R	X	
Simulation 10			X		R					
Simulation 11		R		R			R	R		
Simulation 12										
Simulation 13									R	
Simulation 14	X	X					R	X		
Simulation 15					R					
Simulation 16						X			R	
Simulation 17										
Simulation 18	R	R		R			R			X
Simulation 19					R	R				
Simulation 20		R		R			R	X		R
Simulation 21					R					
Simulation 22	R			X	X			R		R
Simulation 23							R		X	
Simulation 24				X	R	R		R		R
Simulation 25	R		R				X			
Simulation 26								R		R
Simulation 27					R	R	R	X	R	
Simulation 28		R				R				X
Simulation 29	R		R					X		R
Simulation 30		R				R	X		R	R

X – an error by the VTS operator,
R – an oversight by the VTS operator

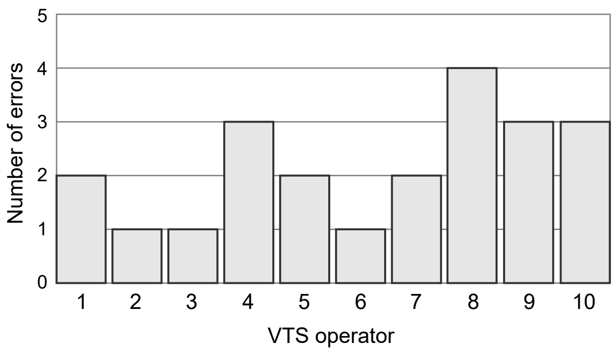

Figure 8. Scenario with a low degree of difficulty

that can cause danger to navigation, such as poor ship-VTS operator radio communications, misinterpretation of documents or other correspondence from other collaborating units, etc.

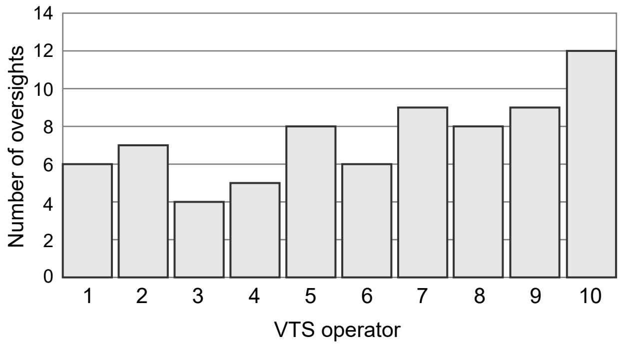

Figure 9. Scenario with a low degree of difficulty

Figure 10 presents a summary of the results obtained by each of the VTS operators in simulations with a low degree of difficulty.

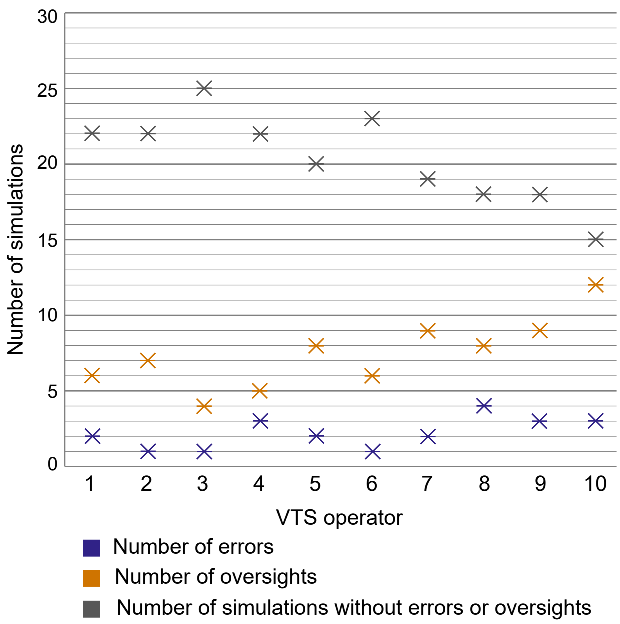

Figure 10. Scenario with a low degree of difficulty

Figures 11–13 present a summary of the results obtained by each of the VTS operators in simulations with a medium degree of difficulty.

Figures 14–16 present a summary of the results obtained by each of the VTS operators in simulations with a high degree of difficulty.

To summarize all the simulations carried out on Navi-Harbour 5000 from Transas, five types of errors committed by the VTS operators can be distinguished.

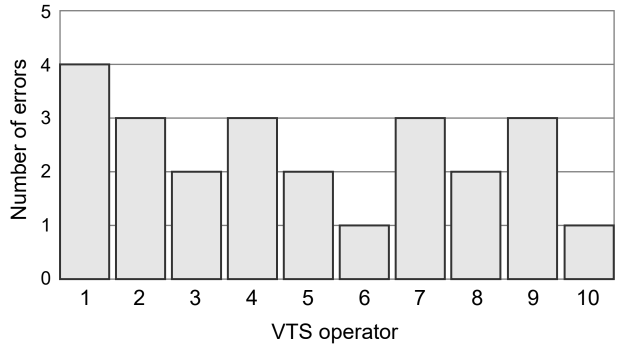

Figure 11. Scenario with a medium degree of difficulty

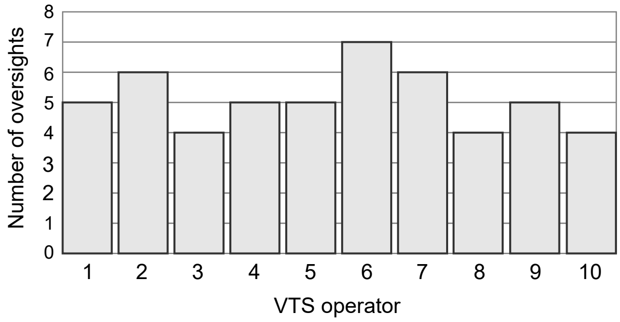

Figure 12. Scenario with a medium degree of difficulty

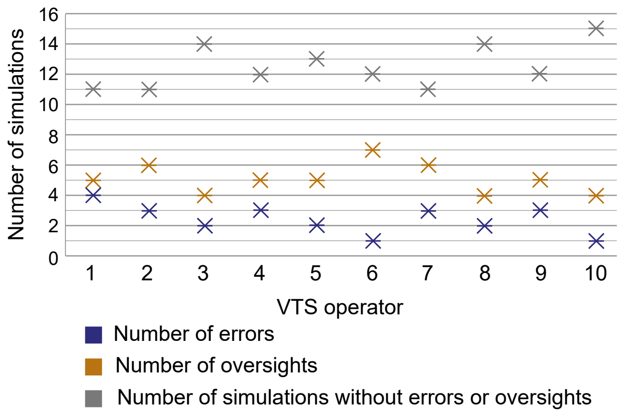

Figure 13. Scenario with a medium degree of difficulty

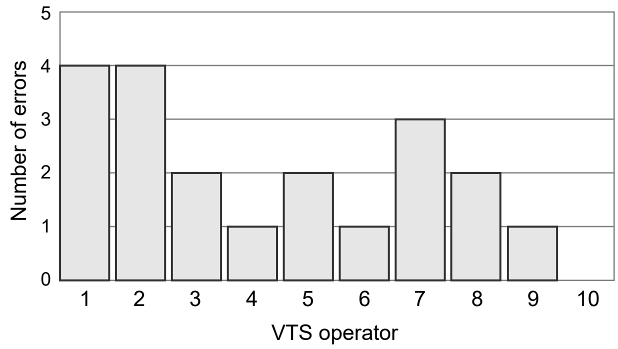

Figure 14. Scenario with a high degree of difficulty

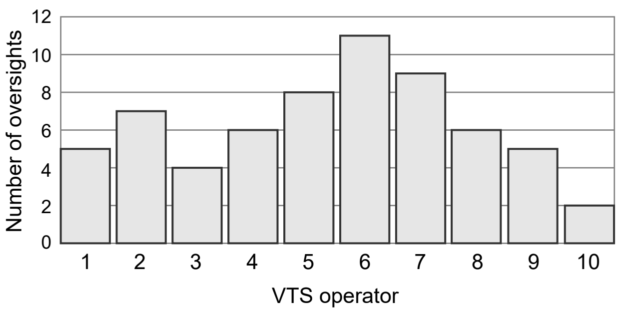

Figure 15. Scenario with a high degree of difficulty

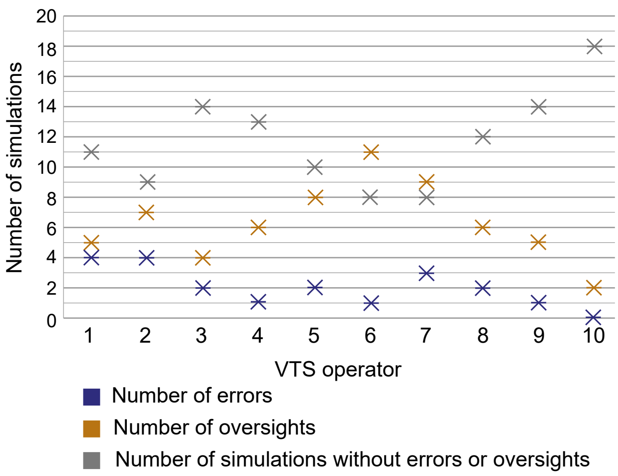

Figure 16. Scenario with a high degree of difficulty

One of them involved the VTS operators "acting on autopilot" when granting clearance for entry in which vessels entering the port on repeated occasions were not verified for any special conditions, etc. For example, a vessel reported with a request for permission to pass from Szczecin to Stepnica. Having obtained standard information on the number of passengers, the number of crewmembers, the person having the conn, etc., the VTS operator granted permission. However, just as the vessel was about to enter the Port of Stepnica, it turned out that the skipper did not hold a license to enter that port. As a result, the vessel was turned back.

Another common mistake was a failure to verify whether there was a berth available for the entering vessel.

The duty service is required to verify whether the vessel requesting permission to enter has all the necessary documents, whether there is berth clearance for it, as well as sufficiently deep water.

For example, a vessel was granted permission to enter by the duty service (during the simulation, the function was performed by the coordinator) provided that there was a berth clear to it. However, the VTS operator let the vessel enter, even though the berth was still not clear (another vessel moored at that berth was not ready to get underway due to precipitation and the nature of its cargo).

Other errors committed by the operators included a failure to monitor the under-keel clearance or miscalculations.

For example, all draft calculations were made for a water level of 512 cm for the Port of Szczecin and 507 cm for Police. When the water level in the harbor decreases, the VTS operator is required to continuously monitor the drafts of ingoing and outgoing vessels, as well as changes in the water level. Many participants in the study committed the same error – having received information "entry at the water level of 487", they let vessels enter even though the actual water level was lower.

Poor organization of traffic, resulting in vessels passing each other in places where passing was prohibited, was another error identified during the simulation. According to the Port Regulations, some vessels can move only in one direction, depending on their cargo or ship parameters. Some VTS operators miscalculated the standard duration of a passage or failed to consider a vessels' parameters, such as its length, breadth, and draft, resulting in vessels passing each other in positions where passing was prohibited.

Misinterpretation of official letters issued by the Port Authority was another common mistake committed by the VTS operators. In special circumstances, acting in accordance with the Port Regulations, the Port Authority may impose certain restrictions on ingoing or outgoing vessels, which do not normally result from the applicable vessel traffic regulations. Some scenarios involved such restrictions. For example, a tug towing a pontoon was granted permission to enter provided specific conditions were met (including, among other things, only at daytime and only if the wind force did not exceed 5 Beaufourt scale). One of the VTS operators applied the conditions to the entry of the tug only, which was only 30 m long.

Conclusions

The scenarios carried out on the VTS simulator have provided insight into the most common mistakes committed by VTS operators, namely:

- VTS operators grant standard permission for entry without taking into consideration the prevailing circumstances.
- They fail to verify whether an entering vessel has a clear berth to proceed to and let it enter, even though entry is prohibited until the berth is clear.

- They tend to miscalculate, for instance, drafts of vessels, or fail to verify parameters that affect the safety of navigation.
- They plan traffic improperly.
- They tend to misinterpret documents and other official letters issued by units cooperating with the VTS.

All of the mistakes listed above were committed due to misinterpretation of the prevailing situation. The duties of a VTS operator were performed automatically. When a person repeats the same daily task in a standard manner, sooner or later they fall into a routine. This is especially evident in the group of VTS operators with more 20 years of work experience who, acting “on autopilot”, committed more mistakes than others. A conclusion can be drawn that when organizing traffic, the VTS operator tends to make mistakes when relying on a routine. It should be noted here that the VTS operators with longer work experience tended to use the tools offered by the system – for example, to precisely calculate the time for two vessels to pass each other – less frequently than others. Their overconfidence often led to dangerous situations. Additionally, they would ignore warnings displayed on the screen (e.g., system or navigational alarms).

Fewer mistakes were made during simulations with a high degree of difficulty, as the operators took more time to handle the challenges. Before the final decision was made, they made sure that any danger to navigation was avoided.

To sum up, mistakes are caused by several factors resulting from taking the wrong actions. This paper looked at factors related to human nature, including a lack of experience or qualifications, poor communication, fatigue, and routine.

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