Vessel Traffic Services (VTS) to ensure safety of maritime transportation: studies of potentials in Sunda Strait

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Abstract. Vessel Traffic Services (VTS) are well established all over the globe. They become increasingly important in contributing to safety, the efficiency of maritime traffic and the protection of the marine environment. The Sunda Strait with a high traffic density in its coastal waters, serving national and international shipping, including crossing passage of the national heaviest ferry traffic, is one of the major safety concerns in Indonesia. Moreover, four accidents of ships’ collision, grounding, and fire on board have been recorded in the area from 2011-2019 as officially reported by the national safety committee (KNKT). At the same time, VTS provides valuable services to mariners. The implementation of operational standards that comply with international rules and regulations, such as IMO Resolution A.857(20), and IALA Guideline 1111, should be further developed to benefit from the broader set of VTS function. A basic marine engineering study has been done to investigate the roles of Merak VTS implemented at Sunda Strait. Spotlight empirical studies were used to collect primary qualitative data and analysis of secondary data concerning the aspects of human element, the technical and administrative work. The study revealed that the Merak VTS contributes to traffic safety and in combination with the new routeing and the mandatory ship reporting systems. Optimized procedures, advanced equipment, and well-trained VTS staff have the potentials to further improve and optimize the operation of Merak VTS.

1. Introduction

Shipping has always been the foundation of the global economy and international trade. It carries nearly ninety percent of goods into our regions [1] and provides livelihoods for various businesses in almost all countries worldwide [2]. Nevertheless, there are factors driving uncertainty regarding the possible safety and security incident.

Early VTSs were basically intended to minimize traffic delays and increase the efficiency of traffic flow in general. Later on, attention was given to the number of shipping accidents and VTS was also
used as a way to reduce the accident numbers. The concern that a disaster might happen in port approaches and port areas furtherly expanded the use of radar surveillance and the management of vessel traffic [3].

As maritime safety and security have been the primary concerns of the International Maritime Organization (IMO), increasing look for policy and protection for the trade is necessary. Ship routing systems such as Traffic Separation Schemes (TSS), Areas To Be Avoided, precautionary areas [4] and VTS [5] are being introduced to address those concerns. As one component of the maritime transportation system in port approaches, VTS was introduced to support smooth traffic flow [6].

VTS is an essential shore-based system to ensure safety and efficiency of vessel traffic in national waters and to protect the marine environment of a coastal state by monitoring vessel traffic and sending out information, warning, and advice or even instruction in case a developing risk or an existing danger has been recognized by an operator in a VTS centre. Nowadays, Fleet Operation Centres (FOC) operated by shipping companies to monitor their own ship fleet is another shore-based system affecting vessel traffic. However, so far, there has been no guidance or procedure to handle any potential relations between VTS and a FOC yet [7].

IMO recognizes the ultimate value of VTS in the management of potentially high-risk geographic areas and protection of the environment. The basics of VTS standards, rules and regulations are provided by the International Convention for the Safety of Life at Sea (SOLAS 1974), Chapter V: “Safety of Navigation”. It provides the framework of when to implement a VTS and offers regulations as practical guidance for ships owners, crews and others. The use of VTS can only be mandatory in territorial waters and shall follow guidelines adopted by IMO in Resolution A.857(20). According to this resolution, VTS should be able to interact with the traffic and respond to traffic situations developing in the VTS area. For these purposes, three types of services are identified, which are Information Service (INS), Navigational Assistance Service (NAS) and Traffic Organization Service (TOS), which have specific functional characteristics. Furthermore, the resolution describes guidelines and criteria for VTS, as well as for qualifications and training of VTS operators. However, this resolution is under revision by IMO due to the rapid change of organization, operation, and technology in the maritime domain [8].

Any recognized VTS is providing marine information, by broadcasting or as requested, and by using VHF as the primary communication means or any available means within the mobile maritime service of its VTS [3].

The present developments, among others, are characterized by the increase of digitalization. The e-Navigation concept introduced by IMO aims at more comprehensive and reliable support of the human operators on board and ashore. Implementation of e-Navigation would bring great contribution in creating favorable sea traffic management in the maritime field [9]. Furthermore, combining the digitalization and automation supports the introduction of autonomous navigation and even unmanned ships.

According to the Indonesian Directorate General of Sea Transportation (DGST) report released in 2018, significant traffic density that serves national and international shipping with crossing passage of the heaviest ferry traffic in Indonesia is the concern in the Sunda Strait area. There have been collaborative actions between Indonesia and IMO to ensure the safety of navigation and to reduce the number of ship collisions by adopting the TSS and mandatory Ship Reporting System (SRS) [10]. On the other hand, the ecological, social, economic, cultural, scientific, and educational value, as well as international shipping traffic, are on the ascendancy in the Baltic Sea area. According to the Baltic Marine Environment Protection Commission guide published in 2016, there have also been collaborative actions by coastal countries of the Baltic Sea to ensure the safety in the Baltic, e.g., in regards to winter navigation and to protect the marine environment by adopting TSS, deep-water routes, mandatory SRS, and particularly sensitive sea area [11].

The research presented in this paper takes into account state of the art basically by referring to two previous studies, firstly, Praetorius: “Vessel Traffic Service (VTS): a maritime information service or traffic control system?” [6] and secondly Kuma: “Vessel traffic service as a maritime security tool:
vessel traffic management information systems (VTMIS) in Ghana” [12]. The first study mainly addresses the everyday performance of the VTS system, especially how to increase and identify its service modeling. Meanwhile, the second study mainly discussed the contribution and capabilities of VTS, the shortfalls of its use and ways to overcome. The difference related to the research focusing on Sunda Strait aside the location, is that the previous studies did not analyze primarily based on the rules and recommendations. Therefore, this study is more focusing on the implementation of rules in the operational procedures, functions, and technical equipment.

Sunda Strait where, among others, is characterized as a congested crossing lane. The hydrography chart of the Sunda Strait showing Merak and Bakauheni could be seen in Figure 1, which then has become the monitoring area of Merak VTS in Indonesia [13, 14]. Three accidents have been recorded in the area with some fatal accidents of ships’ collision and grounding from a total of 101 accidents in Indonesia between 2007-2018 [15]. In comparison with Sunda Strait in the same period, the Baltic Sea had six accidents from the total 105 accidents in Germany caused by ship’s collision, grounding, fire on board, and foundering [16]. As depicted in seen in Figure 2, Warnemünde VTS is covering vessel traffic in southern Baltic Sea area with its related ports [17].

Fundamental research for considering the establishment of routeing measures and ship reporting systems in Sunda Strait has been conducted by Sunaryo et al. [18] and Sobaruddin et al. [19]. Moreover, the official document of the proposal for the establishment of the routeing system has been submitted to IMO through NCSR 5th session [20]. Though, the research with a focus on everyday performance to highlight the service contribution to the safe navigation of vessel traffic within VTS approaches has not been conducted yet. That is why this study is significant and helping to understand better, how the optimal design, installation, and operation of Merak VTS potentially can more efficiently contribute to safety, efficiency, and sustainability of maritime traffic.

Establishing a VTS is usually a multiple process of implementing, optimizing, adapting and tuning technical components and the human element. The development and implementation of operational procedures specifically drafted to ensure smooth interactive functioning of these elements are essential for this. Using the VTS for Sunda Strait in Merak and South Baltic VTS Centre in Warnemünde as a baseline, the ongoing study is to compare the operations of the two VTSs. The study aims at identifying potentials for improvement and optimization of operations in Merak VTS.

2. Methodological Approach
The preliminary study was done by benchmarking the guidance of IMO Resolution A.857(20) and IALA Guideline 1111 into the implementation of Merak VTS to monitor the vessel traffic in Sunda
Strait. After figuring out the level of compliance with rules and regulations, the further study discusses the preliminary outcome of empirical investigations and elaborates on a case study, similarities, and differences between Merak VTS and Warnemünde VTS to find potential areas for improvement.

For the research in this study, data are collected from both primary and secondary sources. The primary data were collected through own participating observations and interviews. Meanwhile, the secondary data used are Standard Operational Procedures of Merak VTS by DJPL [14], VTS Guide Germany by BSH [17], the IMO Resolution [5], the IALA publications [3, 21], and Praetorius [6].

2.1. Survey of Compliance with Rules and Regulations
The rules from each regulation were categorized into three aspects to gain preliminary study and do further study afterward on the developed essential issues. The defined aspects are explained as below:

- Technical aspect contains all rules from chosen regulations in terms of technology and equipment.
- Human element’s aspect contains all rules from chosen regulations in terms of staff recruitment, skills, and training.
- Administrative work’s aspect contains all rules from chosen regulations in terms of procedures and responsibilities of Competent Authority.

The benchmarking has been accomplished by analyzing Standard Operational Procedure (SOP) of Merak VTS, doing study visits, also conducting informal conversational interviews with Head of Merak VTS and the experts in the same VTS. The compliance with regulations was studied by providing implementations level within three categories and criteria, whether each of the rules has been “fully complied”, “partially complied”, or has “not been complied at all”.

2.1.1. Compliance with IMO Resolution A.857(20) ‘Guidelines for Vessel Traffic Services’ (even though under revision, but valid at the time the research has been conducted). The Merak VTS has adopted this guidance on its Standard Operational Procedure (SOP) since 2015. The authors are aware that this resolution is under revision by IMO and about to be replaced by a new resolution. However, for the purpose of this study, the original basis for the installation of the VTS was used. Meanwhile the regulated rules subtracted for each of the three aspects are presented in Table 1, the procedures from SOP of Merak VTS with the concern of this guidance are listed as below [5, 14]:

- Procedure #1 consists of the general introduction, goal, purpose and objectives of Merak VTS;
- Procedure #1.1.1 consists of the operational coverage area of Merak VTS in the 1st phase with information of equipment and provided services; and
- Procedure #1.1.3 consists of the job description, training and certification for staff Merak VTS with procedures of monitoring and shift work.

**Table 1. Overview regulated rules of IMO resolution A.857(20).**

| Technical | Human Element | Administrative Work |
|-----------|---------------|---------------------|
| General consideration for VTS | - General consideration for VTS | - General consideration for VTS |
| - Objectives and authority | - Objectives and authority | - Guidance for planning and implementing VTS |
| - Framework | - Framework | - Determining skill and knowledge requirements |
| - Prerequisites for the system | - Prerequisites for the system | associated with VTS functions |
| - System parameters: Recruitment and selection, qualifications, training, certifications | - System parameters: Recruitment and selection, qualifications, training, certifications | |
| (Covered 4% of all rules) | (Covered 54% of all rules) | (Covered 42% of all rules) |
2.1.2. Compliance with IALA Guideline 1111 ‘Preparation of Operational and Technical Performance Requirements for VTS Systems’. This guidance has not been mentioned nor adopted by Merak VTS on its SOP. Meanwhile, the Ministry of Indonesia adopted the IALA Recommendation V-128 as the standard of equipment for all VTS in Indonesia [22]. Nevertheless, this recommendation recognizes and refers to the IALA Guideline 1111 as the updated version and information for VTS systems. The guideline addresses the relationship between operational and technical performance requirements for VTS equipment. It presents system design, sensors, communications, processing, and acceptance, without inferring priority of VTS equipment [21]. The regulated rules subtracted for each of the three aspects could be seen in Table 2.

| Technological | Human Element | Administrative Work |
|---------------|---------------|---------------------|
| - Core operational and technical requirements | - Core operational and technical requirements | - Core operational and technical requirements |
| - Radar | - AIS | - Environmental monitoring |
| - Environmental monitoring | - Electro-optical systems | - Radio direction finders |
| - Long-range sensors | - Data processing | - VTS Human/Machine Interface |
| - VTS Human/Machine Interface | - Decision support | - External information exchange |
| - Data processing | - Verification and validation | |

(Covered 92% of all rules) (Covered 2% of all rules) (Covered 6% of all rules)

2.2. Participating Observation

The study visit in Merak VTS at the beginning of this research was conducted based on findings from the literature, the discovery of available data sources, and the identification of research problems. The unstructured observation by applying open-ended questions was intended to have a deeper understanding of the VTS system, operational procedures, technical equipment, and the operators providing the service.

On the second study visit in Merak VTS, the research problem has been set and prepared. The checklist form containing the listed regulation also has been developed and brought on-site visits. This observation was structured and aimed to fulfill the information, which can identify the gap of compliance between the implementation of Merak VTS and guidance from selected international guidelines. This observation resulted in the preliminary case study.

The latter observation was done in Maritime Simulation Centre Warnemünde (MSCW) and Warnemünde VTSC in Germany. This study visit can be categorized as direct observation and participant observation, which is aiming to know how the VTS Operators provide the service through simulation training and real operation. This observation added information about the operation and the training scheme of VTS in Germany.

2.3. Interview

Texting was made to the participants of Merak VTS to establish contact for interview and time to be arranged. The interviewee was humbly asked whether they would prefer to be interviewed on the phone or receive a link that would lead them to Google Docs. Meanwhile, the interviews with participants at MSCW and Warnemünde VTS were done with face to face meetings.
The participants of VTSs were introduced to the research aims and objectives and were also informed that all collected data would be treated with confidentiality. The consent form was also introduced, in detail, can be seen in the research project of the authors [23].

Apart from the introduction, the primary investigation was structured into 15 questions. The interview questions were carefully designed to cover the objectives of the study and particularly developing essential issues from the conducted preliminary study. The study intended to investigate how is the implementation level of VTS by compliance with rules and regulations; to identify training scheme and operational procedures; to identify VTS capabilities in increasing maritime safety through navigation in the area, and derive recommendations for the identified potentials of the system.

The main questions that were used for the interviews in both VTSs and the detailed version of the questions, which is guided by a questionnaire form, were provided and elaborated in the frame of this research project [23]. Questions ranged from participants' backgrounds up to available technical equipment and its use. The following chapter provides an exemplary selection of gained results.

3. Results and Discussion

3.1. Compliance with Rules and Regulations
In this preliminary study, the implementation level of rules and regulations by Merak VTS can be visualized through the compliance of the three selected aspects (see Figure 3). The compliance in terms of existing technical, the human element, and administrative work were figured out, verified by an expert and discussed in the following sub-section.

![Figure 3](image_url)

**Figure 3.** Graph of implementation level as compliance with rules and regulations.

3.1.1. Compliance with IMO Resolution A.857(20). The rules of this guidance mostly covers administrative work and human element aspects of VTS. From the study, some implementations of Merak VTS have fully complied with the rules, as illustrated in Figure 4, which are 50% of all rules in the technical aspect, 55% of all rules in administrative work aspect, and 54% of all rules in human element aspect. Despite the full compliance status, some implementations of Merak VTS have partially complied with the rules, which resulted in 50% of all rules in the technical aspect, 45% of all rules in administrative work aspect, and 46% of all rules in human element aspect.
3.1.2. Compliance with IALA Guideline 1111. Contrary to IMO Resolution A.857(20), the rules of this guidance are clearly linked to VTS for most of the technical aspects. From the study, the graph compliance of the technical aspect in Merak VTS presented several levels of implementation. However, Figure 5 shows that most of the implementation of the technical aspect has fully complied with the rules, as much as 61% of compliance. It is followed accordingly by 33% and 6% of the rules have been partially complied and not complied at all. Besides the technical aspect, implementation of administrative work and human element aspect in Merak VTS have 13% and 50% of full compliance with all rules in each aspect accordingly. Despite the lower full compliance compared with another aspect, the aspect of administrative work has 88% of partial compliance.

Some elements which detected to be not complied with this guideline are the environmental protection system, long-range identification and tracking (LRIT), satellite-based synthetic aperture radar (SARSAT), few of inter-system data exchange as part of the VTS data management, and track warning for air draught clearance as a function of decision support tools.

The environmental protection system requires the early detection sensors or software processing of the VTS radar signal to detect any pollution incidents that may be caused by visiting vessels. Meanwhile, the LRIT and SARSAT are the long-range sensors for locating or detecting vessels that have not arrived on schedule, arrive unannounced or even in case of an incident. According to this guideline, the tracking function and other data processing functions may need to be considered within the VTS design. Data processing is the collection and extraction of data to provide information. This VTS data management may include information such as voyage data, vessel data, incident data, and equipment fault records. The identified missing elements are the information of the data of berths and capabilities, traffic analysis data, and VTS spares and consumables stock.

The mentioned elements in this preliminary study were found to be not yet installed and were identified as not complying with the rules of IALA Guideline 1111. However, the upgrade and installation of such technical equipment to improve the compliance were on progress.
3.2. Implementation Level of VTS by Compliance with Rules and Regulations

According to the preliminary study, Indonesia, through the services of Merak VTS, has a relatively high compliance in the terms of human element and administrative work. However, the technical aspects have shown the lowest compliance compared to others. This section interprets the preliminary outcome of empirical study and discusses the three core aspects of rules and regulations governing the system of Merak VTS.

3.2.1. Human Element Aspects. All the participants involved in the interview from Merak VTS are coming from different backgrounds. Most of the personnel were coast radio station operators who had worked for one to seven years, while others were ranging from an operator of another VTS, software developer, programmer, or new officer who was entering the job following formal education. Almost all of them are civil servants. Nevertheless, there was also a contracted employee at Merak VTS.

The interviews found that the Merak VTS operators are trained according to the basic course for navigating vessel traffic through VTS area, which is the basic training as VTS operators according to the IALA VTS 103 Modules, the communication competency training according to the IMO Standard Marine Communication Phrases (SMCP), as well as the maritime radio communication training of GMDSS’s General Operators Certificate (GOC) in accordance with the IMO. Though, the personnel who is a contracted employee had only been formally taken through the training of GMDSS GOC.

The personnel who is a contracted employee is recruited and trained purposely to work at the monitoring stations. They did not have training on VTS operation as required by IALA and IMO regulations, because they are responsible for manning the stations for merely monitoring purposes and could not intervene with the traffic. However, they had the basics of GMDSS GOC for operating all radio equipment during the activities of vessel monitoring.

All the participants stated that the training in which they have participated are beneficial, and most of them believed they have adequate skills and knowledge to perform their tasks as VTS operator. During on work duties, half of the personnel agreed that they are experiencing confusion to make decision making, especially if emergency navigational situations happened. The grounding, collision, and man overboard are to mention a few. Most of personnel realized that their work is affected by continuously growing work pressure. It is to be noted that all of the personnel wish to have refresher training or further course for sharpening their skills and knowledge. Working hours in Merak VTS are mostly in accordance with its SOP [14], but it could be more than 9 hours on some occasions. Nevertheless, they stated that they have enough time to take a short break during the working hours. Some personnel strongly agree that their working area is not safe in terms of the location site. The Merak VTS is located close to the sea and therefore received the perceived vibration from vessels. The office is surrounded by some units of power plants and located relatively close to the active Krakatau Volcano. The possibility of being impacted by accident in some nearer area made some of the personnel not feeling safe at work.

The present structural position of Merak VTS personnel does not yet fit properly to the elaborated structure, which is mentioned in its SOP. The ideal structure would probably consist of a head of VTS, supervisors and operators. As a substitute for the absence of a VTS supervisor, the senior personnel who has a longer experience period in Merak VTS are taking charge to monitor and accompany other personnel during their working hours. All of the participants strongly agreed to have more VTS operators available in a team. They claimed that additional personnel would be very helpful for their monitoring duties, especially when Merak VTS enhances its service to facilitate and support TSS in Sunda Strait.

All of them are fully aware that TSS has been adopted and will demand higher skills and attention from VTS personnel through its implementation soon. This aspect could further be developed to improve the present situations and is discussed under the training scheme of VTS staff in the proceeding section.
3.2.2. Administrative Work Aspects. The Merak VTS is expected to be regulated by the requirements of the IMO. The IMO legislations such as in SOLAS Chapter V in regulation 12, guidelines contained in the Resolution A.857(20), MARPOL, and COLREGs. To carry out the duties as VTS personnel, they refer to the SOP of Merak VTS as the operational guide.

The participants of Merak VTS were all able to give a general structure of the nature of vessel traffic in the Sunda Strait area. Merak VTS covers one sector for the entire area of Sunda Strait from Java Island to Sumatera Island. Merak VTS monitors all vessels, the crossing route for the ferries and passing routes for all vessels. The ferries across the strait and connect the port of Merak with port of Bakauheni in a day. The operation of the ferries had been monitored by the ferries company, namely ASDP Indonesia Ferry. Nevertheless, Merak VTS keeps on this monitoring. Although there is an available VTS near Bakauheni, namely Panjang VTS, communication between the VTSs had rarely been made.

All participants had been continuously made the coordination with some government agencies, which are port state control, port company, sea and coast guard, water police, Navy, search and rescue team, a port operator and agent, as well as the pilotage. The coordination has been done cooperatively and right in time to minimize the consequences of danger and prevent such an accident from being happened.

The core activities of Merak is to monitor and inform the traffic, as provided in the INS service of VTS. The VTS personnel can not actively organize the traffic and needs to rely on support from other services, such as the pilot service. It seems like no strict enforcement or fine being charge to the particular vessel when there is any non-compliance shown into the VTS regulatory requirements.

3.2.3. Technical Aspects. The interviews revealed that the Merak VTS staff has the basic infrastructure necessary for conducting decent surveillance on safety and maritime security in the Sunda Strait area. The communication devices installed in Merak VTS is VHF radio for communicating with vessels. The sensors available consisted of long-range camera, radar, and radio direction finder. These devices were installed on Merak VTS, Cipala Hill, Tempurung Island, and Cikoneng Lighthouse.

Currently, there are several types of equipment are planned to be installed for the operation, which are AIS base station, long-range CCTV surveillance, weather sensor, additional workstation units, VHF radio, and generator. At the time of the study, the weather forecast is taken daily from the Indonesian Weather Forecast. Some of the existing equipment would also be changed or upgraded, such as the VTS software with alert systems, radar, medium-range CCTV surveillance, and power supply. This equipment is intended to repair or maintain the quality of existing equipment and to fully support the implementation of TSS in Sunda Strait in 2020.

3.3. Potential for Further Development and Improvement of Merak VTS

3.3.1. Training Scheme for VTS Staff. According to the Resolution A.857(20), the competent authority should specify the level of skill and knowledge a VTS operator must have based on the background and prior experiences and should also consider the training requirements regarding the tasks to be performed. Authorities should be aware of the provided training by considering the prior qualification, skills and knowledge of the VTS staff in order to reach an equivalent skill and knowledge.

The applicable minimum qualification when entering the Merak VTS is having a formal education background in high school degree or equal, having two years of work experience, and able to communicate in the English language before entering the field of VTSO. All of the participants have a high school or a higher degree, such as diploma degree or bachelor degree, and also have taken GMDSS’s GOc before becoming a VTSO. Based on the interview, all participants of Merak VTS had not had a mariners background. Most of them had a qualified civil servant background which is Civil Servant Echelon II/b. In case of not having work experience prior to the recruitment process, this
qualification is compensated as long as the person has graduated from a higher degree and been accepted as a civil servant.

On the contrary, the Warnemünde VTS Centre set higher qualifications for its personnel to become the operator. All of the VTS staff had to have a mariners’ background, have taken GMDSS’s GOC and show their certificates prior to the recruitment of VTS staff. Therefore they have experiences sailing on board as the deck officer or equivalent according to the STCW. They also had to have graduated from a technical college for becoming an operator. Meanwhile, they had to have a university of applied science degree to become a supervisor. As for the language, the VTS staff had to have a basic command of the English language for VTSO and good command of the English language for becoming a VTS supervisor.

The study in Germany shows that having a mariner’s background is essential for any VTS staff. The personnel would have the intuition to the best practice of operation on board of a ship, what is needed in a specific sit, and how to manage such a situation in the monitored navigational area. Therefore, they have better focus and more goal-objective oriented to achieve the safety of the maritime traffic.

As has been recommended by IMO A.857(20), the VTS staff shall be trained in accordance with IALA VTS 103 modules consists of VTS Operators Training (V-103/1), VTS Supervisor Training (V-103/2), VTS On the Job Training (V-103/3), VTS On the Job Training Instructor (V-103/4), and VTS Revalidation Process (V-103/5).

Through the interviews, the training system level in Indonesia is quite different from the IALA VTS 103 modules and could be provided by the government agency or the third party. Most of the time, the training offered to Merak VTSO is part of the BP2TL program, which was established by the Ministry of Research, Technology and Higher Education in Indonesia. The training for VTSO consists of a maritime English course, basic VTS course for 30 days, and a VTS operator course for 40 days. However, the VTS staff has to come into the selection phase to participate in such trainings.

On the other hand, the VTS staff in Warnemünde VTS Centre had to have participated in a maritime English course, On the Job Training and VTS Operators Training according to IALA 103 modules. All personnel also had to participate in the refresher training of V-103/5 once every two years to memorize the knowledge, especially the necessary skills during unusual operation situations. In addition, the VTS staff has to take part in VTS Supervisor Training of V-103/2 for upgrading a level into the supervisor. The training scheme of VTS staff in Germany could be seen in Figure 6.

![Figure 6. Training scheme of VTS staff in Germany (graphic adapted from [23]).](image-url)
3.3.2. Comparison of the Operational Procedures in Merak VTS and Warnemünde VTS Centre.

According to the IALA VTS Manual, a control system that is approved by the competent authority and properly implemented can ensure the consistently maintained standards to provide safe and effective services. Operational procedures are then defined as an integral part of the verifiable system, which contains all internal and external procedures within a VTS.

The study identified the similarity and differences between the operational procedures of both VTS. They have a similar principle structure though the “title” written in each section is different. However, there is a fundamental difference in the operation of both VTS. It became obvious when referring to the operational procedures of Merak VTS laid down in the “Prosedur Operasi Standar (SOP) VTS Merak” and the rules and guidelines for the operation of Warnemünde VTS Centre laid down in the “Verwaltungsvorschrift VV 24-08” and “Verwaltungsvorschrift VV 24-9”.

The implementation of Merak VTS, so far, is dedicated to providing INS and NAS. Meanwhile, the Warnemünde VTS Centre provides all the three services of VTS, including TOS. Consequently, operational procedures for pro-active avoidance of accidents, such as collisions and groundings, were not yet included in the SOP of Merak VTS. Besides, there was no active traffic planning and traffic regulation in terms of active controlling encounters of departing and arriving vessels. The study would not refer to the discussion about accident avoidance of VTS because both of the procedures were not comparable. However, the study of the operational procedures of both VTSs was presented on the research project of the authors [23].

Regarding the division of sector, the Merak VTS covers the whole area of operation as one sector and is mainly to interact with participating vessels in the time of extreme weather or rough sea situation by giving a warning, in time when the Indonesian Navy is doing training or in time of installing process to protect the cable or pipeline within a particular area by giving information. On the other hand, the Warnemünde VTS Centre is divided into five sectors to ensure intense monitoring, which are covered within three workstations and monitored by three operators. Also, there is one more workstation specialized as the centre of all three sectors and monitored by a VTS supervisor. The divisions are made from the entrance into the port approach and different berths at ports, because each sector has their characteristics, such as the existence of fishing and diving activities, the existence of wind farm, various ports, fairways and channels, the existence of ship routeings—which are TSS, precautionary area, inshore traffic zones, and deep water routes.

The interviews revealed that the Merak VTS and the Warnemünde VTS Centre staff had taken appropriate procedures during their duties. Though, both VTSs have different levels of participation from vessels sailing within the coverage area. The vessels were showing voluntary participation in the Merak VTS. Meanwhile, the Warnemünde VTS Centre was receiving mandatory participation. In case of voluntary participation, the VTS shall be more active in establishing communication with vessels through VHF Ch.20.

Moreover, since the vessels have not been informed or have no idea of such services or designated channels of VTS, this kind of participation created difficulties to the VTS for communicating with the particular vessel through VHF Ch.16 and coordinating with other vessels or allied services. The Warnemünde VTS Centre strongly believed that mandatory SRS in dense traffic situations is significant for the sake of her safety, as well as another vessel around her. The regulated speed limit is also to be noted by all participating vessels and the VTS can take any further action if it is deemed necessary. The mandatory participation could only be given to international waters as long as it has been adopted by IMO and established in a particular area.

3.3.3. Usefulness of VTS in ensuring maritime safety, efficiency, and sustainability of maritime traffic.

The Merak VTS has strong contributions to the Sunda Strait area to increase the safety level by reducing collisions and grounding accidents, more effective of time by fast responding in case of fire or explosion, as well as lessening of casualties, such as man overboard or dying at sea. The presence of VTS could give particular information to the vessel and prevent unintended physical contact of her with navigational markings, such as offshore or fix objects at sea. Like the Merak VTS, the existence
of Warnemünde VTS Centre has strongly corresponded with the function of VTS described by the IMO. For instance, there is another VTS in Germany which has 1,000 ships reported to the VTS in a month. The accident of fire or explosion was happening one and eight years ago, as well as the reported two cases of grounding. Recently, there are almost no collisions happening in the water area.

There is a strong relationship between the technology used in the VTS with the ease operational by personnel to ensure the safety of navigation. The technologies that could help to avoid the unwanted situations are such as a broader range coverage of land-based radar for reaching long-distance vessels as well as in rough weather and distress conditions, more Aid to Navigations as navigational marking following the need of the particular area and an advanced system of VTS software to provide alarms or warnings management. Nevertheless, the access to internet connection 24 hours a day, the existence of CCTV along the water area and the well-equipped communication devices are also necessary to support and facilitate the services of VTS.

3.3.4. Areas for Potential Improvement of Merak VTS. The study of Merak VTS noted that the system is basically to monitor and report activities of vessels and has a shortage of the power to enforce regulations. Instead of eight message markers defined in SMCP, most of the information was provided with the soft message, which is “information” or “advice”. In addition, the communication or recommendation to vessels were given in case of unusual activity informed by the allied services. After taking reactive actions, the Merak VTS was not received further notice of this usual behavior at a later time, except the allied services asked VTS again to do further communication with the vessel, or the situation takes quite a long time to be completed. There is no speed limit regulated to vessels. Furthermore, there has not been a clear prejudice set as violating behavior from vessels to the national and international regulations. The closer collaboration among government agencies would enhance the effectiveness of monitoring and reporting. Therefore, the usefulness of the system would be improved.

Regarding the coordination in VTS, the Warnemünde VTS Centre has one different party. There is one headquarter of command, namely Central Command Maritime Authority, consisting of Navy to be in charge in a time of emergency happened in all Germany coasts. Besides, VTS in Germany is also mainly in contact with water police and tugboat for controlling the traffic situation. Their foremost contributions are to give information, to give support if deemed necessary and the final is to give force. Still, the Warnemünde VTS Centre is trying not to involve too much to the mariner’s operation.

The other potential is related to the recruitments, qualifications, and training of VTS staff. During operational, the Warnemünde VTS Centre believes the personnel plays a key role in the implementation of VTS and therefore is trained periodically. First, the personnel will have a one year contract and provided by the Authority to get their first basic training. This training consists of a basic course about the authority, advanced course about theory and practice for four weeks, sector area course for approximately four until six months and official instruction. The personnel is facilitated to get on board in a short time in order to familiarize themselves with their navigational area. The On the Job Training for becoming a VTSO lasts for four until six months, and meanwhile, for becoming a VTS supervisor, it lasts for one year. When they are passed the training for over this period, they can officially be the VTS staff. For all active personnel, they will participate in cyclical training, which consists of a seminar on selected topics based on demand and seminar on maritime traffic safety to gain practical exercises and simulations for one week in the VTS Simulator of MSCW.

The number of VTSOs assigned depends on the size of the area, volume, density of traffic, and the geographic conditions. The Merak VTS assigns 3 VTS staff in a shift of 11 VTS staff in total Meanwhile, the Warnemünde VTS Centre assigns 4 VTS staff in one shift of 24 VTS staff in total. The Warnemünde VTS Centre projected that it is necessary to have a minimum of 16 VTS staff for the total operation. This number is considering the implementation of three shifts to monitor the 24 hours operation and considering the days off or unpredictable situations, such as sickness of the personnel.

Another potential for improvement is the coverage ranges of the sensor equipment in Merak VTS. The coverage areas of land-based Radar and AIS are currently 48NM and 30 to 200NM, respectively. These could be extended by installing and integrating the equipment on patrol boats and is especially
needed in rough weather conditions. Moreover, if the VHF radio could reach longer nautical miles, it would be possible to establish communication with another VTS centre, which is Panjang VTS.

One aspect of achieving the most effective VTS contribution to safe and efficient vessel traffic flow in their areas of concern is the provision of sound training of the personnel and permanent adaptation of technical equipment. The ongoing process of digitalization in the frame of IMO’s e-Navigation initiative will certainly result in substantial changes in the daily routine work for VTS operators ashore [7]. The introduction of new equipment in VTS centres will need to be coordinated with navigational, communication and other equipment on-board. VTSs, however, have to take into account the traffic in its comprehensive composition of vessels, from the most modern (highly digitized and ready for automation) to most conventionally equipped vessels [24, 25]. In relation to the VTS operators, this requires well-defined and profound training programs covering the VTS services supporting all types of vessels [26].

4. Conclusion

Comparative studies of Indonesian Merak VTS in the Sunda Strait and German Warnemünde VTS in the South Baltic Sea have been carried out, in order to identify potentials for improvement and further development of VTS operation to address the challenges of increasing traffic density and ship dimensions. The focus of the studies was the technical and organizational aspects of VTS operations.

The main outcomes of the studies are the implementation level of Merak VTS in terms of human element aspects and administrative works aspects in high compliance with IMO Resolution A.857(20). However, the technical aspects showed rather low compliance with IALA Guideline 1111. The provided services of Merak VTS and Warnemünde VTS Centre are in accordance with the need of each navigational area. The Merak VTS staff were trained according to IALA VTS 103 modules, but it has not been fully obtained by all personnel yet. The period of trainings as has been provided by the Warnemünde VTS Centre is significantly increasing the skills and knowledge of personnel. There is some lack of power to enforce regulations effectively and can be enhanced. The expansion in the range and coverage area of the equipment is necessary for better and broader monitoring and reporting. The additional number of staff and closer collaboration among government agencies will probably expand the usability in enhancing effective monitoring and reporting in the Sunda Strait area, especially when a new system such as TSS and mandatory reporting system are coming into force.

The study very well recognizes that the comparison is made between a long-term operating VTS in Warnemünde, which has undergone several phases of optimization during its course of existence. In comparison to this, Merak VTS is at an earlier stage of operation. Therefore, the recommendations are derived based on the research carried out so far, and none of the following recommendations are meant as criticism but intended to contribute to the potential improvement of existing VTS operation in the Sunda Strait.

- The results of the study suggest further assessment of the human element aspects in Merak VTS. The planning and establishing of systematic training and education for all categories of personnel will be beneficial for all the involved parties, which are VTS operators, domestic and international ships, as well as waterway and shipping administrations. It might also be beneficial to have additional employment of Merak VTS staff, especially the VTSO, to increase productivity and provide a better working environment. The higher employment also has to be in line with the appropriate training provided by IALA VTS 103 module course for the operator doing the required tasks, which may help resulted in a further contribution to maritime safety.

- The integrated collaboration of VTS and ferry companies seems to may utilize the system of monitoring and communication, not only to manage the traffic and the vessels in the time of accidents but also to take prior action in preventing potential accidents from happening and maybe even contribute to efficient traffic flow without delays and supporting navigation regimes that minimize emissions from ships.
• For future developments, a higher level of services from Merak VTS seems to be possible and is recommended. Since TSS and mandatory SRS have been adopted by IMO, upgrading the services into NAS and TOS would greatly support the system’s implementation.

• IMO regulations mandate the vessels to comply with regulations of VTS areas that are recognized by the organization. Therefore, Merak VTS is suggested to shall take action to contribute to more strictly enforce navigational regulations in the Sunda Strait area. Enforcing regulation is one of the best practices to create a deterrent effect for the offenders to ensure safe and efficient vessel traffic in the future.

• The study further recommends more regular communication between adjacent VTSs, such as Merak VTS with Panjang VTS, to significantly increase monitoring and reporting across the area. The distribution of information is also recommended to be done, for example, the automatically integrated database between adjacent VTSs or even all VTSs in Indonesia.

• The provided technical equipment is already enhanced monitoring function, such as for triggering warning for potential collisions or groundings. Extending the services and training of staff on how to make use of such functions efficiently may also contribute to improve future VTS operation of Merak VTS and increase maritime safety.

• The study recommends the Indonesian Directorate General of Sea Transportation to continuously update all necessary information to mariners applying e-Navigation concepts, especially for the electronic version of nautical publications related to navigational areas in Indonesia. It could be in part or a whole “VTS Guide Indonesia”, by the gradually accessed information from online or web-based publications, or by providing information in World VTS Guide. These seem to be significant to ensure the crew on board are familiarized with the procedures and regulations in a particular area.

The results gained from the baseline studies indicate that there is room for improvement. It is expected that the technical and technological developments in the field of shore-based monitoring, including e-Navigation and rapid digitalization, as well as more enhanced traffic organization, will soon allow or even requiring more pro-active traffic control in the sense of managing and coordinating vessel traffic. Consequently, operational procedures need to be further developed, and shore-based operators will have to be trained adequately to be well prepared for addressing their complex tasks to ensure the safety and efficiency of maritime transportation.

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References
[1] George R 2013 Ninety Percent of Everything: Inside Shipping, the Invisible Industry That Puts Clothes on Your Back, Gas in Your Car, and Food on Your Plate (New York: Metropolitan Books/Henry Holt and Co.)
[2] United Nations Conference on Trade and Development 2018 Review of Maritime Transport 2018 (New York: United Nations)
[3] IALA 2016 Vessel Traffic Service Manual 6th edn (Saint-Germain-en-Laye: International Association of Marine Aids to Navigation and Lighthouse Authorities)
[4] IMO 2015 Ships’ Routeing 2015 Edition (London: International Maritime Organization)
[5] IMO 1997 Resolution A.857(20) Guidelines for Vessel Traffic Services Assem. 20th Sess. Agenda item 9 (London: International Maritime Organization) pp 1-22
[6] Praetorius G 2014 Vessel Traffic Service (VTS): a maritime information service or traffic
control system? PhD Thesis Chalmers University of Technology, Gothenburg

[7] Baldauf M, Fischer S, Kitada M, Mehdi R A, Al-Quhali M A and Fiorini M 2019 Merging conventionally navigating ships and MASS – merging VTS, FOC, and SCC? TransNav 13 pp 495-501

[8] Southall T 2019 Seminar on the Revision of IMO Resolution A.857(20) Guidelines for Vessel Traffic Services (Saint-Germain-en-Laye: International Association of Marine Aids to Navigation and Lighthouse Authorities)

[9] Aylward K, Johannesson A, Weber R, MacKinnon S N and Lundh M 2020 An evaluation of low-level automation navigation functions upon vessel traffic services work practices WMU Journal of Maritime Affairs pp 1-23

[10] IMO 2017 NCSR 6/3/3 Routeing Measures and Mandatory Ship Reporting Systems (London: International Maritime Organization) NCSR 6th session Agenda item 3 Online: IMODOCS

[11] HELCOM 2016 Baltic Sea Clean Shipping Guide 2016 ed H Backer (Helsinki: HELCOM)

[12] Kuma J A 2015 Vessel traffic service as a maritime security tool: vessel traffic management information systems (VTMIS) in Ghana Dissertation World Maritime University, Malmö

[13] Hydrography and Oceanography Centre, Indonesian Navy 2018 Chart IDN400170 Indonesia, Sunda Strait – Merak to Bakauntheni (Jakarta: Pusdihosal Sales and Distribution Units)

[14] Directorate General of Sea Transportation of the Republic of Indonesia 2015 Decree Number NV.101/118/DIPL.15 on The Enforcement Standard Operational Procedures for Merak Vessel Traffic Services (VTS) (article in Bahasa)

[15] National Transportation Safety Committee (KNKT) 2020 Accident Reports Online: http://knkt.dephub.go.id/knkt/ntsc_maritime/maritime.htm

[16] Federal Bureau of Maritime Casualty Investigation (BSU) 2020 Investigation Reports Online: https://www.bsu-bund.de/EN/Publications/Unfallberichte/Unfallberichte_node.html

[17] Federal Maritime and Hydrographic Agency (BSH) 2018 VTS Guide Germany 12th edn BSH-No. 2011 (Germany: Bundesamt für Seeschiffahrt und Hydrographie) pp 88-105

[18] Sunaryo S, Priadi A A and Tjahjono T 2015 Implementation of traffic separation scheme for preventing accidents on the Sunda Strait International Journal of Technology 6 6

[19] Sobaruddin D P, Armawi A and Martono E 2017 Traffic separation scheme (TSS) model of archipelagic sea lanes (ASL) I in Sunda Strait for actualizing regional resilience Jurnal Ketahanan Nasional 23 1 pp 104-122 (article in Bahasa)

[20] IMO 2017 NCSR 5/INF.24 Routeing Measures and Mandatory Ship Reporting Systems: (London: International Maritime Organization) NCSR 5th session Agenda item 3 Online: IMODOCS

[21] IALA 2015 IALA Guideline 1111: Preparation of Operational and Technical Performance Requirements for VTS Systems (Saint-Germain-en-Laye: International Association of Marine Aids to Navigation and Lighthouse Authorities)

[22] Ministry of Transportation of the Republic of Indonesia 2011 Regulation Number PM 26 of the Year 2011 on The Maritime Telecommunication (article in Bahasa)

[23] Claresta G 2019 Optimization vessel traffic service – a comparing case study of Merak VTS in Sunda Strait Indonesia and Warnemünde VTS in Baltic Sea Germany Bachelor Thesis Hochschule Wismar University of Applied Sciences – Institut Teknologi Sepuluh Nopember

[24] Kitada M, Baldauf M, Mannov A, Svendsen P A, Baumler R, Schröder-Hinrichs J U, Dalaklis D, Fonseca T, Shi X and Lagadami K 2019 Command of vessels in the era of digitalization Advances in Intelligent Systems and Computing vol 783 (Cham: Springer) pp 339-50

[25] Sari N K, Baldauf M and Kitada M 2018 E-Navigation or autonomous navigation – quo vadis? 1st Maritime Safety International Conference (Bali: Clausius Scientific Press)

[26] Baldauf M, Kitada M and Mehdi R 2018 E-navigation, digitalization and unmanned ships: challenges for future maritime education and training INTED2018 Proceedings vol 1 (Valencia: IATED) pp 9525-30