Information Requirements for Vessel Traffic Service Operations

Fan Li, Chun-Hsien Chen, Li Pheng Khoo

***Abstract*—**Operators of vessel traffic service (VTS) center provides three different types of services; namely information service, navigational assistance and traffic organization to vessels. To provide these services, operators monitor vessel traffic through computer interface and provide navigational advice based on the information integrated from multiple sources, including automatic identification system (AIS), radar system, and closed circuit television (CCTV) system. Therefore, this information is crucial in VTS operation. However, what information the VTS operator actually need to efficiently and properly offer services is unclear. The aim of this study is to investigate into information requirements for VTS operation. To achieve this aim, field observation was carried out to elicit the information requirements for VTS operation. The study revealed that the most frequent and important tasks were handling arrival vessel report, potential conflict control and abeam vessel report. Current location and vessel name were used in all tasks. Hazard cargo information was particularly required when operators handle arrival vessel report. The speed, the course, and the distance of two or several vessels were only used in potential conflict control. The information requirements identified in this study can be utilized in designing a human-computer interface that takes into consideration what and when information should be displayed, and might be further used to build the foundation of a decision support system for VTS.

***Keywords*—**Vessel traffic service, information requirements, hierarchy task analysis, field observation.

I. Introduction

VTS plays an important role in improving the safety and efficiency of vessel traffic [1]. In a VTS center, operators analyze the information integrated from multiple sources, including AIS, radar system, and CCTV system. And then, operators provide services according to situation. There are three kinds of service may be provided, namely information service, navigational assistance and traffic organization to vessels. Operators have to make decisions based on overload information. Therefore, information is crucial in VTS operation. In accordance with this importance, researchers have conducted much research in obtaining required information. Cairns and Sollosi [2] suggested to integrate information of Navigation Satellite System into VTS center; Razzano et al. [3] proposed an enhanced AIS which can provide additional information on buoys and lights; Lapierre et al. [4] recommended the use of Electro-Optical (EO) imagers to provide uncooperative vessel information. However, multiple new technology provides large amount of information as well as challenges like information overload and redundancy [5].

Vast amount of information may lead to human fatigues which is one of the major factors of maritime accidents and incidents [6]. Therefore, what and how much information VTS operator is actually needed to offer service, when and how this information to be displayed are the most important questions facing designers of human-computer interface in designing a traffic management system [5].

Oser et al. [7] proposed a methodology to structure and guide investigations of aircrew information requirements. They applied this methodology to elicit information requirements and outlined the implications of information requirements for future interface design. Endsley and Rodgers [8] conducted goal-direct task analysis to elicit situation awareness information requirements for en route air traffic control and figured out the important factors of operator decision making. Duley et al. [9] investigated the information requirements of 58 en route air traffic operators to design an interface between air traffic manager and airspace system. They studied the importance of information and operators' preferences of information presentation frequency. However, to the authors' knowledge, the issues concerning the information requirements of a VTS operator have not been well addressed. To reduce the potential for information overload and better assist VTS operators in managing the safety and efficiency of vessel traffic, an investigation into information requirements of VTS operators should be carried out.

In this study, information requirements of current VTS operators working at MPA (Maritime and Port Authority of Singapore) were investigated. The daily work of operators was observed to generate a task overview and elicit information requirements over different tasks [10]-[11]. The objective of this study is to determine what and how much information is needed for VTS operators to complete different tasks.

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TABLE I
VESSEL TRAFFIC INFORMATION ATTRIBUTES

Information Attributes			Information Frequency		
			PCC	VAR	AVR
1	Vessel category	The classification of vessel into commercial, militrary, and general vessel.			
2	Vessel name	The classification of vessel into a specific make and/or basic model of vessel that define its handling characteristics.			
3	Vessel callsign	A unique designation for a vessel.			
4	Intentions	All possible indications of any planned or unplanned changes in a vessel's route of sailing.			
5	Location	A simple designator that specifics the current controlling sector for the vessel in potential conflict.			
6	Destination	The place vessels proceeding to, i.e. the location in the port or bound for sea.			
7	Draft	The vertical distance between the waterline and the bottom of the hull (keel).			
8	Neighbors	The proximity in distance between vessel pairs in potential conflict and other vessel within some parameter distance or time.			
9	ETA	Expected arrival date and time.			
10	Infolinked status	Associating or connecting a track with information in a database. Infolinking is automatically initiated for AIS tracks, else initiated by an operator.			
11	Pilot boarding time	All vessels proceeding to the anchorages in the port need pilots to guide to berth. Pilot boarding ground means the time for pilot boarding vessels in need.			
12	Pilot boarding ground	All vessels proceeding to the anchorages in the port need pilots to guide to berth. Pilot boarding ground means the place for pilot boarding vessels in need.			
13	Hazardous cargo	Vessels carrying with dangerous goods.			
14	CPA	Closest point of approach.			
15	Course	The direction of the vessel route is called the course.			

II. METHOD

Observation-based methodology modified from [10] was used to observe the nature of the operation (i.e., information exchanges) executed by vessel traffic controllers. This observation-based methodology comprises four steps:

1. Collection of core tasks,
2. List of VTS information attributes,
3. Naturalistic observation, and
4. Collection of information requirements.

The "core tasks" refers to a set of frequent and important tasks completed by VTS operators when they provide the shore-side service. Three tasks were identified as core tasks based on literature review, users' and experts' opinions. They were named vessel arrival report (VAR), abeam vessel report (AVR) and potential conflict control (PCC). Both VAR and AVR belong to information service and PCC belongs to navigational assistance. VAR refers to messages vessels give to VTS upon their arrival of Singapore. To handle VAR, operators of VTS should update the Port Traffic Management System (PTMS) and provide arrival vessels with the traffic information within Singapore Strait. During sailing in Singapore Strait, vessels would report to VTS through report channel when abeam of "reporting point" (e.g. abeam of Raffle's Lighthouse). When receive these report, operators may make some remarks and instruct them a right reporting channel, reporting point. These works are defined as task AVR. For RPC, operators monitor the traffic situation, identify potential conflict, and provide related vessels with navigational advice.

An initial list of information attributes was derived from VTS manual handbook, and other related research documents. The list was reviewed by several highly experienced controllers, who made some recommendations to modify the contents. Accordingly, a list of 15 information attributes was obtained. These information attributes cover most of important and frequently used information. Table I shows the resultant list of information attributes.

Given the core tasks identified in the first step, the naturalistic observation was carried out to capture the behaviors of operator completing these tasks. The observation was performed in two months during daytime. Ten VTS operators participated in the field observation. All of them have decades of working experience in VTS. For each operator, two 1-hour tapes were recorded to capture the work dynamics of VTS operations. During observation, the normal operating procedures of VTS controllers and communication between VTS and vessels was recorded. Due to safety-critical work environment, the observation was naturistic and passive, i.e. the researcher stood aside a VTS operator in silence without interrupting the operator's work.

A 15-minute span was chosen as a sample interval to elicit information requirements of specific tasks [12]. Thirty (30) video samples (ten samples per task) were selected as input for collection of information requirements after naturalistic observation. To generate a reliable form of information requirements, these 30 video samples were viewed to identify how operators completed tasks, and what information was exchanged and required. A form (Table I) modified from [8] was used to record the information requirements. Frequency means how many times the information was required to complete tasks.

III. RESULTS

Information requirements of task PCC, VAR, and AVR are presented in Figs. 1-3. As shown in Fig. 1, vessel name, vessel category, vessel location, neighbor and CPA were the top 5 types of information required in task PCC. ETA and infolinked status were rarely required. Unlike information requirements of task PCC, destination, vessel draft, and infolinked status were the top types of information required in task VAR (as Fig. 2

shows). What's more, compared with Figs. 1 and 3, Fig. 2 shows relatively high frequency of most types of information. As can be seen in Fig. 3, there were only four types of information, namely vessel category, vessel name, location and destination were required in task AVR.

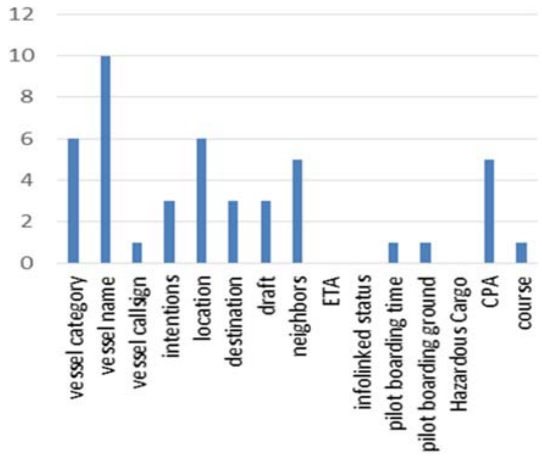

Fig. 1 Frequency of information required in PCC

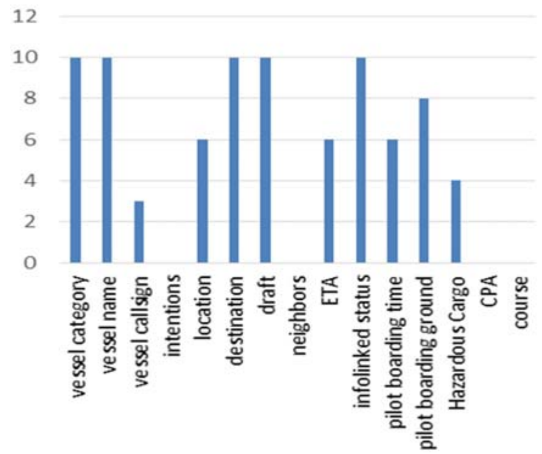

Fig. 2 Frequency of information required in VAR

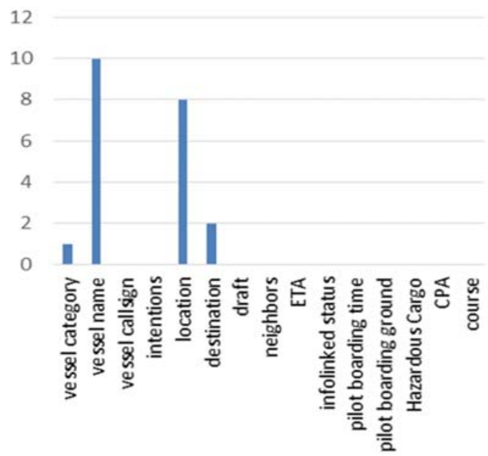

Fig. 3 Frequency of information required in AVR

Analysis was performed to identify the difference of information requirements across the three tasks. Compared the required information of any two tasks in the analysis below. This can give an indication of what information was more required in one task while less required in another task. Therefore, ΔA/B = the frequency of information was required in task A - the frequency of information was required in task B. This is interpreted as:

- ΔA/B > 0, information was more required in task A,
- ΔA/B < 0, information was more required in task B,
- ΔA/B = 0, information was required in task A and B.

Fig. 4 shows the ΔVAR/PCC results of task VAR and task PCC completed by experienced operator participants. Vessel name and vessel location were two types of information that required in both tasks VAR and PCC. Eight types of information stood out for mainly being required in task VAR. Information of infolinked status was required with highest frequency in task VAR, while rarely used in task PCC. Three other types of information were mainly required in task PCC. They were named neighbors, CPA, and intentions. Information of course was occasionally required in task PCC, rarely required in the other two tasks.

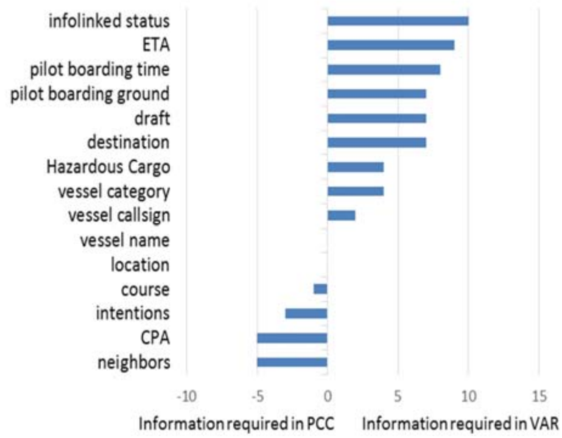

Fig. 4 Information requirements of VAR vs. information requirements of PCC

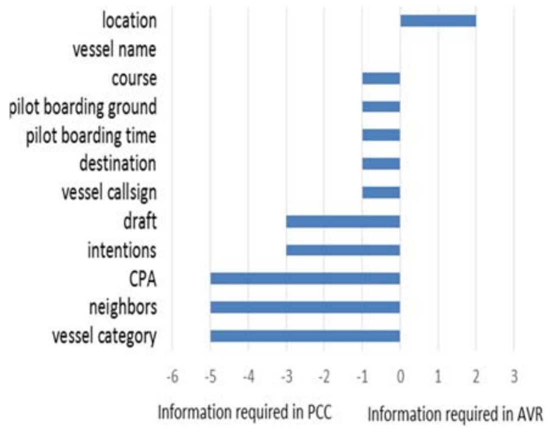

Fig. 5 Information requirements of AVR vs. information requirements of PCC

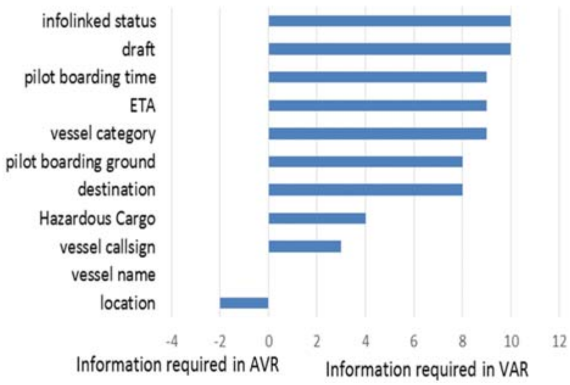

Fig. 6 Information requirements of AVR vs. information requirements of VAR

Unlike the results of ΔVAR/PCC, the difference of information requirements between PCC and AVR was much bigger. Fig. 5 presents the information requirements ΔAVR/PCC results of task PCC and AVR. As shown in the figure, much more information was required in task PCC, while only information of location was more required in task AVR. Vessel name was the only type of information required in both tasks PCC and AVR.

Similar to the ΔAVR/PCC results, the ΔAVR/VAR results of task AVR and VAR presented in Fig. 6 shows huge difference of information requirements between task AVR and VAR. Vessel name was still the only type of information required in two tasks. Moreover, the information of location was still the only one stood out for being more needed in task AVR.

IV. Discussion

The common most important information identified by observation and task analysis for all three tasks was only vessel name (Figs. 1-3). Operators have to connect to vessels when providing service, so vessel identities was required in all tasks. To our surprise, operators prefer to use vessel name rather than call sign to connect with vessels (Figs. 1-3). Call sign was used only in special circumstance. Most information just required in one task while rarely used in other tasks. For example, information of neighbors, vessel category and CPA were very important for PCC, while they were seldom used in VAR and AVR (Figs. 4, 5). The difference of information requirements comes from the nature of tasks. Based on the information of CPA, neighbor, and intentions, operators could know the future track of vessels and identify potential collision. Then operators could provide vessels under potential collision with the relative movement of another vessel to them in order to avoid collision. For handling VAR, operators have to know their pilot boarding time, pilot boarding place, and class of hazard cargos. Based on information of pilot boarding time and pilot boarding place, operators can predict when and where a vessel may make a turn. For AVR, operators have to know current locations of vessels to instruct them to stand by right channel. Therefore, information of location has the same frequency with vessel name in AVR (Fig. 3).

Results of this study show that different task requires different information and ascertain which information is most important for the three specific tasks (Figs. 1-3), and should be useful in developing automation tools. Drury and Prabhu [13] found that both incomplete and too much information would affect operators' performance. Therefore, utilizing these information requirements to design human computer interface which presents relative information at the appropriate time is necessary. In this study, only experienced operators were participated in the research. Therefore, the crucial question of utilizing these information requirements is "does experience affect information requirements of operators?" Yuan et al. [14] conducted a survey to study the effect of previous experience on information requirements of air traffic controllers. They found that gaining experience has little effect on the most important information types required by air traffic controllers. Based on this, the information requirements of VTS operators obtained here could be useful and credible reference for human computer interface design.

V. Conclusion

This study is the first step to address the information requirements of the VTS operators. First three most core tasks were figured out based on literature review and operators' opinions, namely PCC, AVR, and VAR. We found that in providing traffic vessel service, operators mainly provide advice and information for vessels while seldom provide instructions. Second, information requirements for each identified task was examined and compared with others to understand the difference across three tasks. With this context, we can create a knowledge-based interface where information displays vary with the information requirements of operators [9].

In this study, information requirements were obtained from field observation and literature review, no subjective view of VTS operators was included. In the future study, unstructured interview will be carried out to better understand the information requirements of VTS.

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