TECHNOLOGICAL PERCEPTIONS ON HUMAN TECHNOLOGY INTERACTION (HTI) IN NAVIGATION OPERATION OF MERCHANT SHIPS

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ABSTRACT: This paper highlighted the perception of seafarers on Human Technology Interaction (HTI) in the navigation operation of merchant ships. From the review of the literatures, weaknesses related to HTI in the current practice of navigation were found. Most common errors found were over reliance on technology, misinterpretations of data and careless usage of technology. Due to these weaknesses, a survey titled 'The Technological Perception on Human Technology Interaction (HTI) for Navigation of Merchant Shipping' was conducted focusing on the perception of officers in handling the technological equipment during the navigation operation. The survey involved 97 officers of merchant ships from two major shipping companies in Asia. Among the findings were 56% officers agreed that accident happened frequently due to misinterpretation of data provided by the technological equipment. About 67% of officers agreed that logic diagrams should be provided for equipment. Recommendations were made such as to provide logic diagrams showing the relationship between the equipment and the system. A clear policy on the use of technology particularly for navigation operation should be developed especially the trend of future ships are more technologically inclined. Lastly, there is a need to explore the ergonomic compatibility for effectively eliminating the HTI errors.

KEYWORDS: *Human Technology Interaction; Merchant Shipping*

1.0 INTRODUCTION

The maritime transport industry (shipping) accounted for more than 90% of global trade [1]. The trend in shipping operation is less manpower and more on automation. More shipping liners have shown an increasing interest in using large-sized ships for the foreseeable future because of their scale advantages since a bigger size ship generates a corresponding increase in cargo and passengers; but this may lead to catastrophic consequences in terms of human life loss [2]. In contrast, even though the implementation of number of measures aimed on improving its safety level (such as new regulations or new forms of team training), shipping accidents, and particularly collisions and groundings [3-6] and foundering [5], remain as the most frequent types of accidents that happened. On board ship, the manoeuvring and steering of the ship are performed on the bridge by the watch keeping officer or Officer on Watch (OOW). Occasionally, the OOW will be assisted by the Bridge Resource Management (BRM) team when entering and leaving port as well as navigating through congested areas such as narrow canals and busy ports. The manoeuvring and steering are also known as the navigation operation. The bridge is considered as the brain of the ship because any wrong decision or judgement made during the navigation will lead to the risks of either collisions or groundings. Due to the serious consequences involved, the goal of this paper was to assess the perception of OOW in interacting with the technological equipment during navigation operation. The Research Objectives (RO) are as follows:

RO1 – To assess the general perception on the use of technology on board ships
RO2 – To assess the impact of technology on the officers
RO3 – To determine the improvement that can be made to the current practices in handling the technological equipment during navigation

The scope of the study was the Officers on Watch (OOW) comprises of Captains, Chief Officers, Second Officers, Third Officers and Fourth Officers of two leading shipping companies in Asia.

1.1 The Current Practices of Officer on Watch (OOW) During Navigation Operation

There are several human technology interaction required in order to perform the navigation on board ships by the OOW as shown in Figure 1.

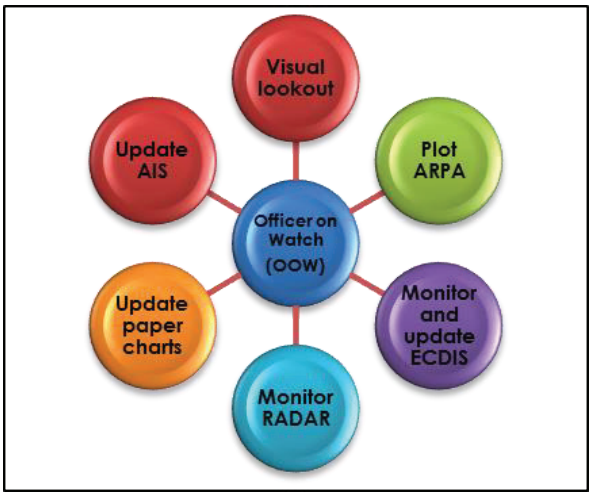

Figure 1: The current navigation practices on board merchant ships

The tasks are carried out on the bridge of a typical merchant ship. In the four hours of duty, the OOW is required to perform the tasks such as monitor and update the Electronic Chart Display (ECDIS), plot the position of the ship using Automatic Radar Plotting Aids (ARPA) as well as monitor the Radio Detection and Ranging (RADAR), update the Automatic Identification System (AIS) and monitor the position of the ship visually.

1.2 Errors Related to Human Technology Interaction (HTI) in Navigation Operation

Human errors due to Human Technology Interaction (HTI) in navigation were identified as lack of situation awareness [7-8], fatigue [7, 9], complacency [8], over reliance on technology [8, 10], and inadequate training [10]. Besides, communication issues [8] were also identified as human error in navigation operation. Errors related to collisions and groundings involve the technological equipment ranges from information overload, over reliance and lack of understanding of the equipment [5].

1.3 Weaknesses of the Technology on the Bridge

Technology on the bridge existed in the form of Radio Detection and Ranging (RADAR), Automatic Radar Plotting Aids (ARPA), Electronic Chart Display (ECDIS), Automatic Identification System (AIS) and several others. These equipments were designed with the intention to reduce human workload during navigation operation. For example, ARPA was designed for the purpose of plotting an intended course during the ship's voyage. IMO proposed the use of ARPA in order to improve the standard of collision avoidance at sea [11]. Unfortunately, the need to plot the course on ARPA has created another workload for the watch keeping officer besides monitoring other automation. Equipment like ARPA still relies on officers' skills and experiences to make decision which unfortunately has resulted in careless use and creating serious errors due to their inadequate skills and insufficient experience [12]. On the other hand, the Automatic Identification System (AIS) has reliability issues because of its poor performance and transmission of erroneous information [10]. Thus, it is not reliable to be used as equipment for anti-collision operations. This situation can easily reduce the situation awareness of the watch keeping officer thus, affecting the decision-making process. Therefore, higher risk of accident is possible.

1.4 Ergonomic

Ergonomic is defined as the scientific discipline concerning the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [13]. Ergonomic was highlighted in many areas of industries from manufacturing, healthcare as well as transportation. For example, Advance Manufacturing Technology (AMT) is a relevant resource that has been extensively used in modern industries around the world with the aim of being competitive and maintain high level of quality and performance with tools such as cost, speed, time and precision for selection and evaluation processes; however, aspects such as human factors and ergonomics characteristics are commonly neglected in AMT [14]. Thus, Ergonomics Compatibility Main Attributes (ECMA) methodology was developed to assess the ergonomics issue [14]. In terms of ergonomic

of the technological equipment on the bridge of merchant ships, given the risk involved, ships bridges should be organized and designed in a way that offers maximum safety and efficiency – not only under normal circumstances but also under conditions of rough seas, in emergencies, and during operations by stressed, fatigued or overloaded mariners [15]. Mismatch between intentions of system designers and operators were commonly observed as a causal factor in many complex engineered system and the subsequent accident sequences [7, 15].

1.5 Important issues related to errors in HTI for navigation operation

Based on the discussion above, issues such as reliability of technological equipment, inadequate skills and experience of the officers in handling technological equipment, lack of ergonomic design of technological equipment due to mismatch between intentions of system designers and operators were the causal factors which resulted in errors of HTI. These issues can be summarized into the compatibility of technological equipment to fit into the human mental model as reflected in Ergonomics Compatibility of Advance Manufacturing Technology (AMT) [16]. According to the authors [16], the main attributes of Ergonomic Compatibility can be classified into Human Skills and Training Compatibility, Physical Work Space Compatibility, Usability, Equipment Emission Requirements and Equipment Design Organizational Requirements. Each main attribute has sub-attributes that detailed out every element related to the respective main attribute; making the analysis of HTI more comprehensive yet easy to follow. AMT has addressed the ergonomics compatibility of the interaction between human and technology quite comprehensively as compared to other models such as the Human Factors Analysis and Classification System (HFACS) which is widely used in shipping industries for analysing the risk of accident and incident at sea [17]. However, the HTI aspect in HFACS is addressed in a very general manner under the 'Technological Environment' comprises of equipment and controls, automation reliability/complexity, task and procedure design, manuals and checklist design [18]. The assessment of each element will depend on the experts who conduct the investigation or the analysis. As such, the result of the analysis has the tendency to reflect an incomplete and

possibly deviates from the actual result affecting the entire analysis. Thus, the Ergonomics Compatibility of the AMT seems to be more accurate in reflecting the actual problem of HTI on board ships.

1.6 Motivation of the paper

The absence of risk analysis models that comprehensively assessing the HTI aspects in the maritime industry has motivates the authors to assess the perception of OOW in handling the technological equipment during navigation operation as the first step to understand the actual problem the officers are facing in interacting with the technological equipment. The results from the survey will be used to become the input for the development of a HTI model for risk analysis or accident analysis of navigation operation following the Ergonomic Compatibility Main Attributes (ECMA).

2.0 METHODOLOGY

Based on the objectives of the paper and the weaknesses discussed above, a survey titled 'The Technological Perceptions on Human Technology Interaction (HTI) for navigation of merchant shipping' was conducted. In the survey, technology is referred to the typical electronic equipment used in navigation operation namely Radio Detection and Ranging (RADAR), Automatic Radar Plotting Aids (ARPA), Electronic Chart Display and Information System (ECDIS) and Automatic Identification System (AIS).

2.1 Questionnaire Design

The questionnaire was designed based on the three research objectives described previously. Each research objective was translated into the following three research questions (RQs):

RQ1 – What is the general perception on the use of technology on board ships?
RQ2 – How does technology gives impact to officers?
RQ3 – What kind of improvement can be made to the current practices in handling the technological equipment during navigation?

The survey comprised of three sections namely Background, Demographic and twenty-seven (27) Survey Questions (Statements). The survey questions were designed based on the findings from the review of literatures done previously. 5 points Likert Scales were used starting from Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree. The survey was distributed to ships through emails and to the local Maritime Education and Training (MET) institutions that conducted courses for the officers.

2.2 Sampling

The author has adopted the Purposive Sampling technique. The target respondents were the officers performing the navigation operation on board merchant ships who are also known as Officer on Watch (OOW). As such, the questionnaires survey was sent to the shipping companies through emails for distribution to their ships. A total of 87 surveys were returned from ships and another 10 surveys were collected from the MET. Data was extracted and analysed using SPSS 19.

3.0 RESULTS AND DISCUSSION

3.1 Findings - Demographic data

Demographic data for the survey is displayed in Table 1.

Table 1: Number (N) of officers involved in the survey

Current rank	N
Second Officer (2/O)	37
Third Officer (3/O)	32
Fourth Officer (4/O)	2
Chief Officer (C/O)	10
Master (Captain)	16
Total	97

3.2 Section 2: Statements focusing on the weaknesses of technology on the bridge

Based on the survey, Table 2 shows the statements with highest scores relate to the research questions (RQs):

Table 2: Number (N) of officers involved in the survey

Research Question	Findings
RQ1 – What is the general perception on the use of technology on board ships? Statement 1.1: The purpose of technology is to assist me in navigating the ship safely.	58.8% respondent Strongly Agreed
RQ2 – How does technology gives impact to officers? Statement 1.13: Automated bridges require more verbal communication between crewmembers Statement 1.14: Automated bridges require more cross-checking of officer's action Statement 1.19: In my opinion, navigation accident frequently happened because of misinterpretation of information provided by the automation. Statement 1.27: Miscommunication is always a problem on board ships	55% respondent Agreed 59.8% Agree 56% Agree 45% Agree
RQ3 – What kind of improvement can be made to the current practices in handling the technological equipment during navigation? Statement 1.19: My training on the bridge equipment is normally differ from the actual bridge equipment on board Statement 1.21: Automated system should be accompanied by logic diagrams showing the relations and interactions between equipment and system.	43% Agree 67% Agree

As for the reliability analysis of the survey, Cronbach Alpha is computed as 0.708.

3.3 Section 3: Concerns and/or Recommendations

Feedbacks recorded were such as:

i. To maximize the effectiveness of automated system on board ships, clear and systematic policy should be introduced by the company.
ii. Automation should be limited. As best practice, seamanship is the best solution to avoid risk of collision.
iii. There is a tendency that young navigators rely on automation system too much. It is strongly recommended that more communication shall be carried out between experienced and young navigators both at shore and on board.

iv. The officers should be trained often to get used to the automation system and procedures.

v. The officers should know the limitations and errors of the equipment, should interpret data correctly.

3.4 Discussion

From the findings above, it was observed that majority of OOWs agreed that the technological equipment were provided to assist them in navigation operation. This statement has also met the goal of the International Maritime Organization (IMO) in terms of providing the technology on the bridge to assist navigators in performing their job. However, majority of the officers also agreed that technology requires more verbal communication between crew members and more cross checking of their actions. So, another type of workload existed for the officers. Other than that, many officers agreed that the navigation accidents frequently happen due to misinterpretation of information provided by the automation. Besides that, the highest percentage was recorded for Statement 1.19 My training on the bridge equipment is normally different from the actual bridge equipment on board. Training given in Maritime Education & Training (MET) institution is fixed on one specific model of equipment which normally differs with the one installed on board ship as the training provided in MET use specific equipment for specific training. For example, a training on how to operate RADAR will be conducted for three days whereas for Automatic Radar Plotting Aids (ARPA) will take another 3 days [19].

4.0 CONCLUSION

As a conclusion, an improvement to the current practice of HTI in navigation operation, logic diagrams showing interrelationship between equipment and system should be provided. Next, verbal communication between one OOW to another should be increased to acknowledge the changes made to the equipment. A clear policy on the technology usage particularly in the navigation operation should be developed since the future trend of merchant ships is technologically inclined. Furthermore, there is a need to explore the ergonomic compatibility to effectively eliminate the HTI errors in navigation operation of merchant ships. The risk analysis on board

ships will be more meaningful and effective when more focus is given to the Ergonomics Compatibility issues of the technological equipment during navigation operation since 90% of the navigation operation relies on the interaction of human with technological equipment as aids for decision making.

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