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Study on human elements in the application of automatic identification system (AIS)

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STUDY ON HUMAN ELEMENTS IN THE APPLICATION OF AUTOMATIC IDENTIFICATION SYSTEM (AIS)

By

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The people's Ruplic of China

A dissertation submitted to the World Maritime University in partial Fulfillment of the requirements for the award of the degree of

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(MARITIME SAFETY AND ENVIRONMENT PROTECTION)

2006

Dedicated to:

My beloved wife, Peng Min

and

My dear daughter, Lu Jiayuan

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Title: **Study on Human Elements in the Application of Automatic Identification System (AIS)**

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Abstract

Shipboard Automatic Identification System (AIS) represents a technological development that has the potential to offer tangible assistance to both mariners and shore-based authorities in enhancing navigational safety through identifying vessels, assisting in target tracking, simplifying information exchange and providing additional information to assist situation awareness (IMO, 2002).

However, the current status of AIS usage and application is far from initial expectations and, according to a recent survey and statistics carried in the Port of Shanghai and a research undertaken in Dover channel, quite a number of shipboard AIS equipment is either being improperly used or displaying inaccurate information. Erroneous or incomplete data, ineffective ergonomic designing, unfriendly interface, mental stress and additional workload induced during the usage, various human errors, etc. considerably impede AIS to perform all the potential capabilities.

Based on the identification of human elements involved in the application and usage of AIS, this dissertation tries to analyze how those elements affect the performance and reliability of AIS. Ergonomic designing and human-machine interface, mental stress facing automatic devices, workload increased or reduced and, various human errors will be discussed during the analytic process.

Having analyzed human elements affecting the full capabilities of AIS, this dissertation urges these concerns to be incorporated in the application and development of AIS. Recommendations will be given for the effective combination of human elements and the better use of this navigational aid.

Key Words: AIS Human Element Ergonomics Interface Workload Stress Human Error

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Abbreviations

AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
CPA	Closest Point of Approach
COG	Course Over Ground
COLREGs	International Regulations for Preventing Collisions at Sea, 1972
DGNSS	Differential Global Navigation Satellite System
ECDIS	Electronic Chart Display and Information Service
ECS	Electronic Chart System
ENC	Electronic Nautical Chart
GPS	Global Positioning System
GT	Gross Tonnage
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IBS	Integrated Bridge System
IMO	International Maritime Organisation
INS	Integrated Navigation System
MMSI	Maritime Mobile Service Identification
MAIB	The UK Marine Accident Investigation Branch
OOW	Officer of the Watch
ROT	Rate of Turn
ROTI	Rate of Turn Indicator

SAR	Search and Rescue
SOG	Speed Over Ground
SOLAS	International Convention for the Safety of Life at Sea
STDMA	Self-organised Time Division Multiple Access
TCPA	Time to Closest Point of Approach
T.R.B.	Transportation Research Board of the National Academies (U.S.A)
U-AIS	Universal Automatic Identification System
VHF	Very High Frequency (30 – 300 MHz)
VTS	Vessel Traffic Service

Chapter One Introduction

1.1 Importance of the Study

As for the maritime safety, Ma (2005) states that "⋯seafaring was and remains one of the most dangerous professions measured in the number of people injured or killed⋯" and "⋯if shipping is already a safety and environmental concern today, it will be more so in the future".

Modern technology is one of the efforts to enhance the maritime safety and has revolutionized the traditional way in which the officer of the watch (OOW) maintains a safe navigational watch. In particular, the birth of Automatic Identification System (AIS) technology has improved the way in which radar images can be identified with clear static, dynamic and voyage related information. AIS technology is revolutionizing surveillance and control of shipping, and as introduced by Berking (2003), AIS has the potential to become the key element for information exchange and will play an important role for the efficient and smooth flow of information among all parties concerned.

According to International Maritime Organization (IMO) Resolution MSC.74 (69) (IMO, 1998),

> The AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:
>
> .1 in a ship-to-ship mode for collision avoidance;

.2 as a means for littoral States to obtain information about a ship and its cargo; and

.3 as a VTS tool, i.e. ship-to-shore (traffic management).

It is argued that although the equipment used on ships is becoming more and more sophisticated, it is not correct to say the technology would provide a solution to certain problems, because unless properly used technology could make the problem worse (O'Neil, 1999). Recognized generally, the contribution of AIS to navigational safety and shore-based services is principally based on the correct usage and full application. Bailey (2005) argues that making effective decisions on the basis of AIS data requires that the data transmitted is correct and that those receiving the information are able to interpret it correctly. Chang (2004) believes the effectiveness of VTS service depends heavily on the quality of AIS information and intelligent applications for information processing, integration, and presentation.

However, the current status of usage and application of AIS is far from initial expectation and, according to a spot check in 2005 August at Shanghai VTS center, the author found that at least one third of AIS-fitted ships were displaying, more or less, incomplete and improper information[1]. Similarly, the research undertaken at Dover channel in 2005 showed that from 84 vessels, there were 122 discrete items of discrepant data, many of which consisted of wrong names or spelling mistakes, empty data fields, unintelligible abbreviations and wrong information of destination (Bailey, 2005). As the shipping industry are worried about the risks brought by AIS and "waiting for" the AIS-assisted accidents (Nautical Institute, 2003 and Belcher, 2004), the first collision between the Hyundai Dominion and the Sky Hope, mainly caused by misunderstanding of AIS messages, occurred in the East China Sea on June 21, 2004 (Speares, September1, 2005).

The improper use of AIS and the AIS-assisted accident have clearly presented the fact that human elements involved, to which less attention was paid at the beginning, are decisive to the development of AIS. Human elements including ergonomic

[1] See Appendix One

designing, machine/human interface, mental stress, increased/reduced workload, various human errors, etc. should be substantially addressed to reduce negative effects of AIS and to realize as much potential as possible.

Furthermore, this study is aimed to help prepare for the implementation of the compulsory installation of AIS before the deadline prescribed in SOLAS Convention. From 30th April 2006 on, AIS equipments have to be installed on domestic-route ships with 500 GT or more in China[2]. Hopefully, this dissertation will offer some guidance for shipping companies, classification societies and the Administration in China.

1.2 Objective of the Study

-To identify human elements concerned in the usage and application of AIS;

-To examine and evaluate the impacts of those human elements on the effectiveness of AIS;

-To explain why those human elements are related and how they impact the effectiveness of AIS; and

-To give recommendations to minimize negative affects through incorporating the consideration of human elements in the application of AIS.

1.3 Order of Presentation

The order of presentation is arranged in a logical sequence to focus and attain the desired objectives of this dissertation. In Chapter II, the basic functionalities as well as potential benefits are briefly introduced to give readers a general idea about AIS. Meanwhile, the need for the study on human elements in the implementation is to be analyzed and explained. Meanwhile, this chapter overviews the role of human elements in the domain of maritime safety and also, defines human-related items in the application of AIS.

[2] Refer to the Document No. 406 issued on Oct.14, 2005 by China Maritime Safety Administration

Chapter III firstly defines "ergonomics" as the study and design of working environments and their components, work practices, and work procedures for the benefit of worker's productivities, health, comfort and safety. Proper ergonomics generally promises higher productivity, more comfort and less risk. To obtain an objective comment on AIS ergonomics, this chapter overviews and evaluates the effectiveness of current AIS ergonomic design. After that, Chapter III focuses on the current AIS interface—MKD. Beginning with introduction of definition and components of human/machine interface, the author, based on a practical survey, evaluates how reasonable and effective the MKD is. Having discussed the significance of AIS-related ergonomics and interface and identified the existing obstacles, the author raises recommendations for the development and evolution.

Chapter IV begins with the discussion of impacts derived from new technology, implying the effects of AIS as a new technology should be fully considered. Bearing in mind the two sides of new technology, the author look at the initial expectations of reducing bridge workload through the implementation of AIS and discuss the question whether the AIS DOES reduce seafarer's workload or NOT. Workload reduced by AIS includes reduction of VHF communications, avoiding blind verbal communication, assisting the situational awareness and releasing stress. At the same time, seafarers are suffering from altered patterns of workload, such as interpretation and correlation of information and various stresses. In this chapter, reasons for the increased workload are overviewed and analyzed. Some recommendations are also raised to alleviate the workload induced during the usage.

Based on the basic types of human error, Chapter V tries to identify a variety of human errors related to the usage of AIS, analyze the apparent and underlying reasons, and discuss the measures to minimize the probability as well as the consequence of those human errors. Skill-based, rule-based, knowledge-based errors and violations involved in the operation of AIS are discussed. In addition, Chapter V analyzes the potential hazards brought by those human errors to navigation safety. Explanation is given why human errors may lead to failure to make quick and precise decisions, confuse the vicinity ships and undermine the effectiveness of AIS technology. In the last part of this Chapter, the author analyzes the reasons for the occurrence of those human errors and presents some recommendations.

Chapter VI concludes the whole paper and gives general suggestions for the achievement of AIS full capabilities and future development.

1.4 Scope and Methodology

Visits to Wusong VTS and Yangshan VTS in the Port of Shanghai were made to spot-check the current status of AIS usage. Statistics were also made there to get an objective picture of the accuracy of AIS information sent from ships. Interviews were conducted not only to a few of VTS operators, but also to some PSC officers to get sufficient first-hand information. A panel of AIS technical experts were contacted to obtain some advices and important technical materials that both greatly contribute to the study. A literature search was extensively undertaken to examine what findings have been got by current AIS trails and other research. IMO relevant resolutions, AIS trail reports and AIS related papers, as well as some AIS-related proposals submitted by IMO Party States during IMO Subcommittees' meetings were collected and examined to support the study.

The author also used his personal experience as a Port State Control officer to conduct a survey[3] to collect practical data from current seafarers. During the practical survey, the author boarded twenty container vessels and interviewed ten duty officers to seek opinions and perspectives on AIS application. Questionnaire[4] was designed and disseminated to facilitate the interview. The author also has got an opportunity to view how AIS works on board. Detailed notes were made after the interviewing in order to reflect the objective and complete facts. These experiences helped to identify main issues relevant to the objectives of the research.

[3] For detailed information, refer to Appendix Two
[4] See Appendix Three

To get a comprehensive knowledge of human elements in maritime domain, the author undertook an extensive research on human error, ergonomics, stress, workload, human-machine interface, organizational management, etc. to facilitate the analysis and support the recommendations.

The author also studied the report[5] on AIS-assisted accident took place on June 21, 2004 in the East China Sea and incorporated the lessons into this dissertation.

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[5] Report on the investigation of the collision between *Hyundai Dominion* and *Sky Hope* in the East China Sea on 21 June 2004, retrieved from the website of MAIB.

Chapter Two Overview of AIS and Human Elements Involved

2.1 General Introduction

The Automatic Identification System (AIS) technology, which has been under rapid development for two decades, is driven by at least three forces. Firstly, mariners are seeking effective, reliable and automatic vessel identification to minimize the verbal effort in calling blindly a vessel on VHF and to "reduce the hazard of making collision avoidance arrangement with the wrong vessel" (T.R.B., 2003, p.15). Secondly, this technology satisfies the needs of Governments to conduct effective traffic management through more powerful VTS integrating AIS. "Government agencies of coastal states…are interested in vessel identification as well as monitoring certain vessel activities and movements" (T.R.B., 2003, p.15). Last but not least, the event of "9/11" is a catalyst for the acceleration of mandatory carriage.

2.1.1 Introduction of AIS

AIS is a shipboard broadcast data link system that acts like a transponder, operating in marine VHF band. It automatically provides or receives ship's identification, location and other data to/from other vessels and shore stations through the Self-Organizing Time Division Multiple Access (SOTDMA) technology. It can be stated that in general, AIS provides a means of exchanging a precisely defined range of data between ships, and between ships and shore facilities under the oversight of competent authority (T.R.B., 2003, p18).

In an ideal case, vessels fitted with AIS broadcast their identifications, navigational status and intentions to other AIS devices (mobile and shore-based) within the radio coverage of their own cell. Identifications including ship's Maritime Mobile Service Identity (MMSI), call sign and name, particulars including vessel type, dimension reference for position, type of electronic position fixing device, as well as voyage related information such as maximum present static draught, cargo type, destination and ETA (estimated time of arrival) are broadcast every 6 minutes. MMSI tagged position reports including position accuracy (indicating whether DGNSS is used), navigational status, course over ground (COG), speed over ground (SOG), true heading (HDG), and rate of turn (ROT), are broadcast every 2-180 seconds, depending on ship's speed and rate of turn.

AIS is a new system that can be seen as the most important revolution in maritime safety and security since Radar and GPS were introduced. If full potential is developed, AIS capabilities can be summarized as follows.

(1) Supplement the information from radar to provide officers of watch with situational awareness (Pettersson, 2004), through

--Looking behind the bend in a channel or behind an island in an archipelago, to detect the presence of other ships and identify them;

--Predicting the exact position of a meeting with other ships in a river or in the archipelago to avoid meeting in e.g. a narrow river bend;

--Knowing which port and which harbor a ship is bound for;

--Getting aware of the size and the draft of ships in the vicinity;

--Detecting a change in a ship's heading almost in real time; and

--Identifying a ferry leaving the shore bank in a river.

(2) Assist the coastal states to monitor ship's movements and activities; and

(3) Facilitate Search and Rescue operation and provide methods to anti-pollution from ships (Pettersson, 2004, Bao and Zhou, 2005).

As a new technology with inadequate experience in usage, AIS inevitably has some limitations and needs improvements, which will be discussed later in this chapter.

2.1.2 Carriage Requirements

Perceived as a promising technology of enhancing maritime safety, AIS equipment was initially to be implemented as a mandatory carriage requirement under a planned time schedule through which the gradual and phased introduction of this technology were to be fully achieved by 2007. However, after the event of "9/11", the focus of attention changed and the system became more greatly valued in terms of its security benefits. As the consequence, the implementation date was brought forwards. According to SOLAS Regulation 19, all ships of 300 GRT or upwards would have been fitted with AIS by 1 July 2004 (IMO, 2004).

At present, all ships subject to the SOLAS Convention and of 300 gross tons (GT) and upwards engaged on international voyages have been fitted with AIS. Cargo ships of 500 GT and upwards and passenger ships irrespective of size not engaged on international voyages must fit AIS not later than July 1, 2008.

2.2 Need for Research on AIS-related Human Elements

International Chamber of Shipping (ICS) argues AIS is a new and untried system, with no accumulated operational experiences (Hinchliffe, 2002). Meanwhile, the schedule of mandatory carriage has been tremendously put forward due to the event of "9/11", leading to an embarrassing compromise between developing performance and satisfying SOLAS requirements. "It was hijacked by the security agenda after September 11 and has been too rapidly to be an effective tool for collision avoidance" Andy Norris commented in a seminar held in Amsterdam in 2004 (Warner, March 26, 2004).

Undoubtedly, human operators are playing the pivotal role, either in current period or in the coming stage for developing AIS technology. Human elements are to be identified for better use of this "untried" technology for the time being and more significantly, to strengthen the base of evolution in the future.

In simple, need for consideration of human elements is based on three reasons:

(1) Byproducts are emerging from the accelerated schedule;

(2) Inaccurate AIS-data and the existence of various human errors not only hamper the full application of AIS, but also bring new risks to navigation safety; and

(3) Inherent limitations should be emphasized and recognized to achieve full capabilities of AIS.

2.2.1 Byproducts Emerging from the Accelerated Schedule

2.2.1.1 Less Attention Paid to the Human Elements

Under the pressure of implementation schedule, neither the ship-owner nor the manufacturer has sufficient time to produce a better AIS equipment by incorporating human considerations in the design. Less attention has been focused on the effective use of AIS equipment, but on how the equipment can be installed as simple and as soon as possible. Bailey (2005, p.109) adds that whilst maritime authorities have, in general, tended to focus on the technical issues of implementation and equipment design, less attention appears to have been given to the issue of operator training in the rush towards implementation.

2.2.1.2 Deviation from the Initial Purpose

The benefit of AIS system as originally conceived is its potential to contribute to improved situational awareness for both those ashore (monitoring shipping) and for those on the ship's bridge concerned with collision avoidance.

The United States government, by contrast, has focused on the capacity for shore side identification and tracking of ships and the potential for improved security awareness. This transfer of focus, although diversifies its inherent functions and develops more benefits, might inevitably undermine the initial purpose as an assistant tool for situational awareness, and attract more attention to the technological development which leads to less consideration of factors affecting human performance.

Therefore, for the purposes of safety and security achievements, AIS system needs to be effectively operated through paying more attention on human elements which influence considerably the full potential.

2.2.2 Inaccurate AIS-data and Human Errors

The navigation safety lies in good seamanship which describes the broad sense of knowledge needed to navigate in a safe manner. Dodds (1995, p.1) believed that modern seamanship requires an understanding of the natural world of ocean and sky, and of the unnatural world of electronic and mechanical devices and it requires good judgment and sound decision-making.

Assisting situation awareness, conceived as the main benefit of AIS, depends on the reliable and accurate data transmitted and received. However, the current status of usage and implementation is far from initial expectation. In the spot check[1] in August, 2005 at Shanghai VTS center, at least one third of ships with AIS equipments on board were found displaying, more or less, incomplete and improper information. Similarly, in the research undertaken at Dover channel in 2005, it was found that from 84 vessels, there were 122 discrete items of discrepant data, many of which consist of wrong names or spelling, empty data fields, unintelligible abbreviations and wrong information of destination (Bailey, 2005). More interestingly, speaking at the 17th International Maritime Pilots Association convention in Istanbul, Captain Tuncay Cehreli, director-general of the new Vessel Traffic System, overseeing the Turkish Straits estimated that some 80% of ships passing through the straits had mistakes in the data that was electronically presented when the AIS was interrogated by the VTS operators (Grey, July 1, 2004). In the observation in a Dutch VTS station, Dr Norris found that 136 vessels from a total of 196 registered a speed of 0 knots. However, only 65 of the vessels had anchored or moored status (Warner, March 26, 2004).

More seriously, human errors occurred in the usage of AIS are sometimes disastrous for navigation safety. The first AIS-assisted collision between the Hyundai Dominion and the Sky Hope in the East China Sea on June 21, 2004 has highlighted the danger of human errors when using AIS text facilities in situations requiring prompt action. The report by the UK's Marine Accident Investigation Branch (MAIB) found that AIS text messaging for collision avoidance was “unsuitable” and that time spent by the Hyundai Dominion's officer of the watch (OOW) sending the text “was obviously time lost to him for taking more relevant action” (MAIB, 2005).

2.2.3 Inherent limitations of AIS

IMO Resolution A.917 (22) (IMO, 2002) has warned OOW of limitations at least as follows:

--Not all ships are fitted with AIS and not all AIS equipments are switched on.

--Information received might be erroneous due to the shortfalls of the technology and relevant sensors.

--Incorrect information might be transmitted and could be dangerously confusing.

Hinchliffe (2002) stated that the imminent arrival of AIS was not viewed with unreserved joy by the mariner simply because it brought with it problems, for which answers must urgently be found.

Considering the existence of inherent limitations, OOW is the only one who could overcome those shortfalls and to visualize all the potential benefits of AIS technology, using his/her competence (Pertterson, 2003). In this sense, the emphasis of human elements seems to be essential.

2.3 Overview of Human Elements in the Domain of Maritime Safety

Historically, the international maritime community has approached maritime safety from a predominantly technical perspective. Accordingly, safety standards have primarily addressed ship design and equipment requirements. Despite these technical innovations, significant marine casualties and incidents have continued to occur. After investigation and analysis, the maritime community is getting aware that nearly 80% of maritime accidents are attributable to a variety of factors related to human beings (Fotland, 2004). In light of IMO resolution A.884 (21), human elements include design, manufacture, management, operations and maintenance (IMO, 2000). In general, the following are examples of these factors in the domain of maritime safety: culture, competence, communication, experience, fatigue, health, situational awareness, stress and working conditions.

2.4 Human Elements to Be Highlighted

Introduction of new technology can be advantageous but sometimes it does not properly consider human needs such as capabilities and limitations of operators (Mokhtari, Moghadam, Brooks, Wall and Wang, 2005). Lack of attention paid to the operators at the centre of the safety-critical systems such as marine navigation may create weak points in the whole system and reduce the effectiveness and interactivity of new technology. Despite the high diversity of operations in the marine industry, there is less evidence of use of applied human factors research in marine navigation than in aviation industry. Unforeseen and unnecessary properties in new technologies may hamper the OOW, especially in emergencies.

Human elements related to AIS span a particular range that includes ergonomics, interface between machine and operators, additional workload and stress incurred during the usage, various human errors resulting in negative effects, training and certification issues, organizational management and so on.

Studying human element related to AIS is ought to improve the safety of marine navigation. Issues such as improper presentation of information may cause misunderstanding, misinterpretation, and overload of information to the OOW. Over-reliance on the systems, inadequate skills, and abilities of the OOW are also matters that can amplify the danger to safety of marine navigation. Effective ergonomics, proper training and good equipment design can overcome the identified difficulties. In the subsequent chapters, those specific issues will be discussed with both theoretical principles and practical examples or experiences.

Chapter Three Ergonomics and Interface Relating to AIS

Poorly designed ergonomics and unfriendly AIS interface can be argued to impose negative effects to the full capabilities of AIS. In the light of relevant research and survey, OOW is suffering from the separated location of AIS equipment from radar screen, and also from an unfriendly interface including complicated menus, unnecessary data display, inconvenient operation, error-prone interpretation, etc. In this chapter, ergonomics and interface relating to AIS in current status will be discussed and in addition, some of shortfalls concerning AIS will be presented for further consideration and debate.

3.1 Ergonomics relating to AIS

3.1.1 Definition and Role of Ergonomics

The terminology ergonomics refers to peculiar meaning in the maritime domain. The IMO definition of ergonomics is the study and design of working environments (e.g., workstations, cockpit, ship bridges) and their components, work practices, and work procedures for the benefit of worker's productivities, health, comfort and safety (Squire, 2004). It can be argued that the meaning of "human element" is similar with that of "ergonomics", and "…any distinctions are arbitrary and that, for all practical purposes, the terms are synonymous" (Sanders and McCormick, 2002).

Proper ergonomics generally promises higher productivity, more comfort and less risk, and on the contrary, if the ergonomics has got right, overall ship performance might be compromised (Squire, 2004). An expression of "ergonomic nightmare" (Squire, 2004) is often heard emanating from mariners, reflecting their opinions on the layout of ship's bridge, or engine room. Human beings are generally inclined to have implicit faith in those who have conceived, designed and built things and seafarers are no exception. However, ships will never be prefect due to the compromise between what is needed to satisfy the regulations, what is absolutely necessary to fulfill the operational role, and what is affordable. Nevertheless, the ergonomic design must be fit for purposes and enable the master and his/her crew to fulfill their duties to ensure all safe operations on board. In other words, for any ship or system to operate safely and effectively, it must be designed to support the people who operate it, without detriment to their health, safety and overall performance.

3.1.2 Overview and Evaluation of the Current Ergonomics Relating to AIS

Ergonomics relating to AIS mainly refers to the location of Minimum Keyboard Display (MKD), if not integrated into other devices such as radar or Electronic Nautical Chart (ENC) system. Guidelines (IMO, 2003) for AIS installation suggest:

> The functionality of the Minimum Keyboard and Display (MKD) should be available to the mariner at the position from which the ship is normally operated. This can be by means of the AIS' internal MKD (integrated or remote) or through the equivalent functionality on a separate display system.

To interpret this suggestion, we conclude that when using MKD units, sufficient consideration should be given as to the placement of the display for effective use, such as its proximity to radars and VHFs.

During the survey[6] from twenty vessels, seven set MKD close to radar or ARPA, five are installed in the chartroom, the rest eight are installed at the front edge of bridge windows.

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[6] See Appendix Two

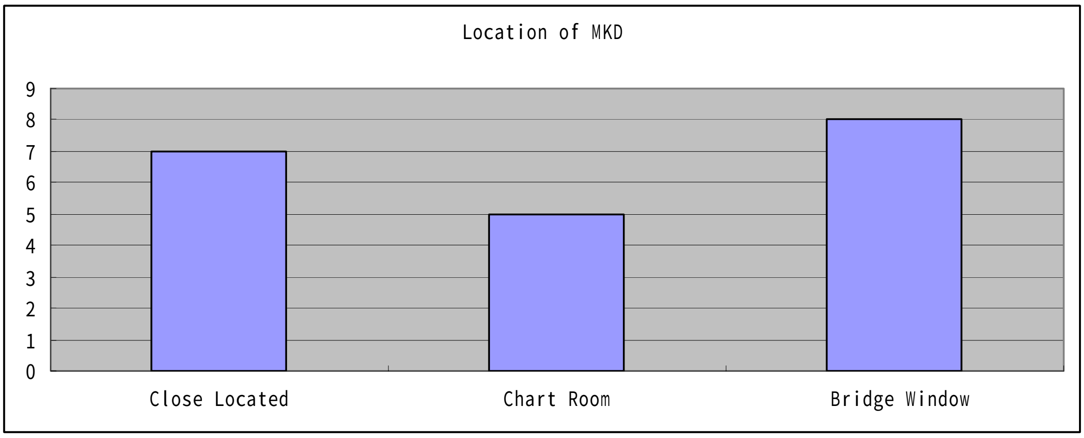

Table One: Location of MKD

Figure One: MKD close to Radar

The separated installation makes the correlation between an AIS target and an ARPA target tricky, particularly when the targets are close in range/bearing and where other targets exist. During the survey, all the interviewees believe the MKD and radar screen should be closely located and one of the interviewee strongly complains that the separated location makes AIS time-consuming and even useless when in heavy traffic areas.

Figure Two: MKD in the front of bridge

Figure Three: MKD in the chartroom

In practice, the stand-alone display must find a place on the bridge and unfortunately, this has the potential to increase the workload for the OOW on the bridge (Hinchliffe, 2002). A dedicated display demands the undivided attention of the OOW for a percentage of his time on watch. In busy traffic situations, where time is always at a premium, there may be a need to scroll up and down the screen of the minimum display to find the ship of interest. More significantly, the information AIS yields will require mental correlation with radar information and visual observation. Even in good traffic conditions, the OOW will be required to maintain a very high degree of spatial awareness to ensure that he/she understands which of his/her visual contacts is also held on radar or AIS or both.

During the interview with ten OOWs, the author found the different locations of installation result in opposite reactions and opinions on the effectiveness and usefulness of AIS. Two interviewees serving on the ships where the MKD is located in the chart room state that during the target-correlation, they have to write down the range and bearing information from the radar, and then go to the chart room to check MKD and ideally, to identify the proper ships. They think it is boring to do so, and feel frustrating if they identify the wrong ship. To avoid mistaking the identification, they have to write down the bearing and range from the radar, and then correlate them with AIS data. One Russia chief officer complains that the target-correlation like this will cost too much time which is of great importance in congested waters and it is unwise to install MKD in the chart room. By contrast, two officers using MKD situated beside the radar screen think highly of the usefulness of AIS. They are accustomed to correlate AIS information with what they observe with their eyes or radar. They believe it is convenient to check AIS data when they are keeping watch with radar, sitting in the chair in the middle of radar screen and MKD. One Chinese second officer argues that to some extent, this kind of installation encourages him to use AIS more frequently.

Based on above discussions, it can be concluded that the ergonomics relating to AIS mainly refers to the distance that MKD is located from the radar screen. The willingness of OOWs to use AIS and the effectiveness of AIS application vary greatly according to the remoteness of MKD. OOWs are inclined to use AIS installed close to radar more frequently than those who have to go back and forth from the bridge to the chart room. High probability of making mistakes and consumption of more time are the contributable factors to the reluctance from OOWs, which is quite opposite to the initial purpose of AIS technology.

3.2 AIS Interface

The efficiency and effectiveness of new equipment or technology greatly depend on the interaction or interface with operators. Grabowski (2005) believes that problems can arise from unanticipated interactions between technology, human operators, and other systems in the environment. How effective and productive the AIS will be depends on whether the interface is user-friendly or not. As for the significance of human/machine interface in shipping industry, IMO resolution A.884(21) states that poor design of the ship, its subsystems, its environment controls, engineering or its human-machine interfaces, which results in an increased difficulty to perform shipboard tasks (IMO, 2000). It is argued that for AIS to meet its stated objective of promoting safe vessel navigation, an effective onboard interface with the vessel's operator is essential (T.R.B., 2003, p. 7)

In the last part of this chapter, the terminology of "interface" in AIS will be defined; elements will be identified and evaluated; potential hazards or negative affects brought by unfriendly interface will be discussed; and also, recommendations will be given on the base of above analysis.

3.2.1 Definition of interface

From the perspective of the human operators, the "interface" of AIS can be defined as "the display and control mechanisms that enable the exchange of information between the person and the AIS" (TRB, 2003, p.105).

Displays are the means by which AIS data are converted into useful information for the proper decision-making while controls are the ways through which OOWs could input, or edit, or process the information subject to different needs.

3.2.2 Elements in AIS interface

The interface includes not only the display of information, such as cathode ray tube graphics and auditory warnings, but also data entry and control elements, such as the keyboard or switches.

AIS interface generally refers to what data will be presented, how they are displayed and produced, how to control the display, how to consult and process the data, how to input and edit the data, how the display affects the interpretation, so on and so forth. In short, all the interactions between the operator and AIS equipment can be generalized as elements on the interface.

3.2.3 IMO Guidelines Regarding AIS Interface

In IMO SN/Circ.227 (IMO, 2003a), the recommendation in terms of AIS display system says:

> If there is navigational equipment capable of processing and displaying AIS information such as ECDIS, radar or an integrated system available on board the ship, the AIS Class A mobile system may be connected to that system via the AIS Presentation Interface (PI). …The display system can also include the functionality of an MKD

Over the past years, a variety of technical, operational and installation standards have been established and published by IMO, ITU and other organizations. However, these standards do not particularly address how the information should be displayed on board, excerpt for a minimum alphanumeric presentation. Also, little has been done to define the information needs and priorities that would establish display parameters. The document submitted to IMO by the United Kingdom in 2003 states that "… other than at the most basic level, it has not yet been agreed how best to display information. In itself, this might inform the decision as to the use to which received information is put…" (IMO, 2003b). They also present the question "to what extent should it address the overlay/underlay/interlay situation? Presently, there is no requirement to display AIS information on radar or ECDIS but the capability to do so exists" (IMO, 2003b).

3.2.4 Current AIS Interface

On the IMO/IALA seminar on AIS, the ICS (Hinchliffe, 2002) conveys their worries concerning the AIS interface.

> There is a risk that AIS evolution may well stall on the day that the last carriage requirement becomes effective; as once AIS equipment is bought and fitted, there is no incentive to buy an upgrade for many years. The accelerated introduction will arguably delay the introduction of integrated

display systems and make it likely that the minimum display will be the most common display system at sea for many years.

After conducting the practical survey and interview[7], the author found almost the same conclusion as ICS's worries. From twenty ships actually boarded and a panel of OOWs and Port State Control officers interviewed, the author has not seen or heard any AIS integrated into radar or ENC or ECDIS system.

In short, the MKD represents the current status of AIS interface. It is estimated that over 80% of owners are opting to fit the minimum requirement of an alpha numeric unit similar in size (Nautical Institute, 2003), although AIS is now appearing on an increasing number of vessels and there are many companies offering full integration of AIS into ECDIS and radar displays.

3.2.5 Overview and Evaluation of MKD

Since the MKD dominates in the current status of AIS interface, it is meaningful to insight this small box to get an objective picture of AIS interface. The overview and evaluation of the MKD is mainly based on the interview with ten OOWs and also referred to findings from PSC officers.

From the perspective of operators on board, the MKD is generally considered unfit for the AIS technology. All of the interviewees complain the MKD is too small in size. They feel inconvenient to input, edit and check the data when necessary. One second officer confess that he suffers a lot from the MKD because the small screen could not display all the targets he need. He has to scroll up and down to identify the target ship several miles away since the targets are displayed according to their distances.

One interviewee complains too many items are displayed on the small screen. Three pages are needed to display all the items whereas some of them like call sign, length, and width are not necessary. He selects ship's name, CPA, COG and destination as four of the mot useful items.

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[7] See Appendix Two

One chief officer does agree that there are too many sub-menus that need to shift for reading messages or inputting data. As far as the design of menu is concerned, he thinks it depends on different manufacturers. Take the MKD installed on his ship as an example. Three items including target's course, distance and MMSI are displayed on the first page. The chief complains a lot about this type of display and describes it as "the worst thing" because it is extremely inconvenient and inefficient to use ship's MMSI as the identifier[8].

Most of the interviewees criticize the keyboard which is described as "neither convenient nor efficient" way. One chief officer recommends the input device should be designed in the same way as a personal computer's keyboard.

Some Port State Control officers who received interview reflected that over 60 percent of deficiencies related to AIS are operational problems. Most deck officers who are not familiar with the operation of data-input or displaying attribute the reason to the complicated procedures and menus, or unfriendly displaying mode.

In short summary, as the interface, MKD has basic functionality to display the targets' information and enable OOWs to achieve necessary operations. However, due to inherent deficiencies, MKD impose the following inconveniences to the operators on board:

--The screen is too small in size and unable to display all the items, which results in more time and efforts to search for data needed.

--Too many items (including static, dynamic and voyage-related information) are displayed. Some of them can be omitted, or at least, debatable.

--The menus are complicated and confusing. Some functions like "undo" and "redo" should be added.

--Considerable inconvenience is caused when correlating AIS data with radar information because the course and speed given by AIS is "over-ground".

[8] According to Bailey (2005), ship's name is the most effective identifier and around 86% ships manage to make VHF communications via calling names of each other.

--The problem of inputting or editing data is noticeable. It costs time to input static and voyage-related data.

Although AIS technology is generally acknowledged useful in assisting seafarers to get situation awareness, the current interface should be considered responsible for the universal complaining, workload and stress induced, and failure of implementation of good seamanship in the collision between Hyundai Dominion and Sky Hope.

Coupled with a user-friendly interface, the AIS information should allow OOWs "to focus more time on the navigation situation around them thus increasing situational awareness and safety" (Edwards and Pietraswski, 2000).

3.3 Approaches to Mitigate the Negative Effects from Ergonomics and Interface

3.3.1 Incorporating Ergonomic Consideration into the Designing Process

Since ships' life span will probably last twenty years and more, it is important that ergonomic efficiency is taken into account as new equipment is retrofitted. Ergonomic considerations regarding AIS should never be neglected. The different locations of MKD might become one of the critical factors affecting the potential capabilities of AIS technology. In addition, the ergonomic design would be better if some room is left for the future integration into other equipments. Clearly, where AIS information is fused with the radar picture, such continuous monitoring will be relatively easy. In other cases, the MKD should be in close proximity to the radar screen that is likely to be used in restricted visibility.

3.3.2 Integrating AIS with Other Equipments

Integrating AIS with other equipment in the bridge system is almost the consensus of the whole shipping industry. However, when AIS displays are integrated with other equipments, the information must be presented to the OOWs in such a way that it is clear, unambiguous, and accurate. Additional work is also required to determine how to best integrate the existing and new systems, which will affect the entire process of introducing AIS displays aboard vessels.

3.3.3 Reinforcing the Emphasis on Human-centered Interface

We should always bear in mind that advanced technology can increase errors and risks even when appearing to be beneficial. In the context of AIS, the ways for OOWs to input, edit and consult and methods for displaying should be defined and evaluated sufficiently. Although several researchers have investigated mariner collision avoidance and navigation strategies and information needs, no one has systematically evaluated how AIS can support these and other information needs (Hutchins 1990; Laxar and Olsen 1978; Lee and Sanquist 1993; Lee and Sanquist 2000; Schuffel et al. 1989). Therefore, when we are designing an effective human-centered AIS interface, a systematic process should be required to consider the capabilities of the users and the demands of the operational environment.

3.3.4 Putting More Focus on Designing

When establishing the cause of an accident, any approach focusing solely on the personnel on board will reduce the possibility of identifying the underlying cause. There must also be some focus on errors in design, poor ergonomics and technical solutions, and routines and procedures incorrectly implemented.

Considering the designed purposes of AIS, more efforts should be put on shore-to-ship data relating to traffic management. At present, most of AIS reported information has focused on target data in ship-to-ship use for identification or collision avoidance. This hampers the complete achievement of AIS benefits.

3.3.5 Paying More Attention to Trivial Considerations

Information displayed on the MKD, wherever possible, should be those considered as most important to obtain situational awareness. The information should be listed in an appropriate order of visual priority. As Taylor argues (2003) that there is a need to filter the data so that the mariner gets presented only with the essentials and the “kiss” (keep it simple, stupid) principle is a good one to follow on ships’ bridges as elsewhere in life.

Besides modification of displaying approaches, some items related to controlling means, although seem trivial, are actually playing significant roles in the process of usage. OOWs are discouraged, to some extent, to use this equipment if the screen is small, the menu appears complicated and keyboarding remains time-consuming.

Chapter Four Workload Reduced and Induced by AIS

4.1 Impact of New Technology

Undoubtedly, new technology is often introduced in systems as way of reducing workload and improving human performance in the system. Technology can be designed in an attempt to remove the source of error and improve system performance, often by automating functions carried by a human operator (Grabowski, 2004). It is often assumed that technology will simplify the operator's job and reduce the errors and costs (Wickens et al. 1997, p. 265).

Problems can arise not only because of the technology itself but also because of the way the technology is implemented in practice. Technology can also introduce new human error forms (Wiener, 1988), and "automation surprises" can puzzle the operator (Sarter and Woods, 1995). These effects can reduce system efficiency or compromise safety, negating the other benefits that technology provides. One of the ironies of technology is that automation designed to reduce operator workload sometimes increases it (Bainbridge, 1983 and Rochlin, 1997). In addition, the introduction of technology can lead to manual skill deterioration, alteration of workload patterns, poor monitoring, inappropriate responses to alarms, and reductions in job satisfaction, (Wiener and Curry, 1980).

The introduction of AIS technology is no exception. Moore (2002) states that the AIS's overall benefits to the mariner will provide him/her timely and accurate information, in a form immediately applicable to decision-making, and in a manner that minimizes the bridge workload. By contrast, Ramsvik (2004) believed that too much of the OOW's time would be required to interpret and assimilate AIS target information presented on MKD and then associate it with visually observed targets and with ARPA target information presented on other screens.

Bearing in mind the two sides of the introduction of new technology, we look at the initial expectations of reducing bridge workload through the implementation of AIS and discuss the question whether the AIS could reduce OOWs' workload or not.

4.2 Workload Reduced by AIS

4.2.1 Reduction of VHF Communications

One of the designed benefits of AIS is path prediction. The large potential of transmitting the rate of turn of the ship, together with all the other movement parameters including ETA, destination, draught and etc. enables both the VTS and approaching ships to make a rather accurate prediction of the path a ship is taking, some 30-90 seconds ahead (Petterson, 2003). This gives more time and better information for all the other navigators in the traffic environment to plan their moves.

The functionality of path prediction facilitates the reduction of VHF communications. Stitt (2004) argues that AIS should provide sufficient additional information to determine whether a risk of collision exists without the problems of different languages, accents and cultures that are inherent in any VHF communications.

VHF Channel 16 communications, especially within congested waters, not only intervene OOW's normal operations, but also distract his/her attention from keeping proper watch-out. Those unnecessary conversations which can be eliminated by proper use of AIS bring additional workload as well as mental stress to the bridge personnel. Ramsvik (2004) adds that Bridge Teams feel that it is desirable to minimize VHF traffic because it reduces the number of things the OOW has to focus on. Thus, an AIS-equipped ship should not be required to report its particulars, nature of its cargo, destination, position, etc. because AIS was designed to do this without Bridge Team involvement.

Therefore, if proper use is made of AIS information, it is arguable that the prediction of target's path may be achieved and pass arrangements may be made in silence. Since fewer VHF conversations are needed, the time involved in making a call would often be better spent in considering what action is required by the Rules, taking that action and then monitoring the position.

Nevertheless, although the potential reduction in VHF communications following the implementation of the AIS carriage requirements is welcome among navigators and shore VTS operators, the means of the information displayed is equally concerned. It is suggested that the information displayed should be only that which is necessary for the safe and effective operation in anti-collision mode (Tailor, 2002).

4.2.2 Avoiding Blind Verbal Communications

The fundamental function of AIS is to achieve the target's identification. Ambiguous calls, with a stressed voice at night, described as: *"Ship on my starboard side, Ship on my starboard side, this is M/S XXX, I am turning to port"* have made many OOW's wishing for an AIS to identify the called target and to get the information about when and how much M/S XXX is turning and to whom she is directing her call (Petterson, 2003).

This blind calling is particularly frustrating and tiring when proceeding in waters with complicated situations. In addition, to avoid the occurrence of urgent situation when the communication becomes essential, the OOW has to identify the target with alternative ways such as marking it with accurate GPS positions or with specific bearing and range away from some known lighthouse, and then try to call the target with diversified ways. This process significantly burdens the OOW with workload as well as fatigue. It can be imagined that if all the passing arrangements are made in the way discussed above, the workload will be tremendous and dangerous.

With the identification of target, both the effort of marking the target with onerous approaches and the verbal repeat of calling can be minimized and accordingly, the workload brought to the OOW is alleviated. A similar result from the survey undertaken among numerous Masters and Mates is that AIS significantly reduces workload in the effort of physical reporting (Grabowski, 2004).

4.2.3 Assisting the Situational Awareness

According to IMO Resolution A.917 (22), AIS is intended to provide additional information to assist situational awareness (IMO, 2002).

"Situation awareness" has been used in the Aviation Industry for some time to describe the top-level requirement of the instrument navigational aids to the user. The definition most commonly used is that given by Endsley (1995): "Situation awareness" is the perception of the elements of the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.

The elements of the navigational environment may embrace:

(1) Natural elements, like tide, wind, current and etc.;

(2) Conditions of the waterways, including the Aids to Navigation, depth, width of the channel or waters; and

(3) Movement or intended movement of the target.

The first two elements are beyond the functionality of AIS while the third one is what AIS focuses on. Without the help of AIS, the OOW might seek information either from radar or his/her visual observation. However, it is recognized that radar has its inherent limitations and blind sectors which can be supplemented by AIS technology (Berking, 2003). The visual observation would be ineffective when the visibility is poor in foggy weather. Thus, situational awareness brought by AIS greatly facilitates OOWs to get aware of the elements of navigational environment in case the radar or visual observation offers little help. Stitt (2004) argues that where the AIS information is integrated with ARPA or ECDIS displays, there is undoubtedly and improvement in situation awareness.

4.2.4 Releasing Stress

Mental stress is one of the contributors to fatigue which is the underlying cause of marine casualties. More stress will be generated when an OOW is put under more workload caused by unknown situation. As Petterson (2003) states:

> All the OOWs, within the radio range, will be put under severe stress due to this inaccurate and incomplete information. The stress will last the APAR radar equipped ships, after two or three minutes, will direct that one of the targets on the display is turning and might be M/S XXX.

During the interview with OOWs, some interviewees believe AIS makes them feel more relaxed and confident when making pass arrangements, especially after identifying the right target.

In short, the stress induced by additional workload and unclear situation is argued to decrease through the usage of AIS. However, other types of mental stress might be generated from a variety of resources, which will be further discussed in 4.3. 3.2.

4.3 Workload Induced by AIS

Before discussing the workload induced by AIS, mariners should be reminded of the impacts of automation. If impacts of automation from positive as well as negative aspects have been considered, the reasons and sources for workload induced by AIS will become understandable.

4.3.1 Impacts of Automation

Automation is often introduced with the goal of reducing operator workload. However, automation sometimes has the effect of reducing workload during already low-workload periods and increasing it during high-workload periods. In this way, clumsy automation can make easy tasks easier and hard tasks harder. For example, a flight management system tends to make the low-workload phases of flight (such as straight and level flight or a routine climb) easier, but it tends to make high-workload phases (such as maneuvers in preparation for landing) more difficult; pilots have to share their time between landing procedures, communication, and programming the flight management system (Cook et al. 1990b; Woods et al. 1991).

In marine navigation, bridge automation can reduce operator workload during some voyage phases, but can increase workload in other phases of the voyage, perhaps during arrival or departure, particularly if the operator is unfamiliar with the technology (Grabowski and Sanborn, 2001). As a result, the anticipated workload reduction of the automation may not be realized.

AIS is a typical new technology with functionalities of automation and "may be prone to the same problems of clumsy automation, particularly if there is a high level of text messages during the already high-workload periods associated with transiting restricted waters or coming into a port" (T.R.B., 2003, p.122).

Therefore, due to the existence of negative effects of automation, the workload induced by AIS should be never ignored.

4.3.2 Reasons for New Patterns of Workload Induced

Safe navigation is achieved through the clear identification of the tasks required of the OOWs and the effective and efficient use of all available tools to fulfill such tasks. Woods (2002) believes that today's watchkeeper is required to absorb and process a considerable amount of information and data to achieve the desired result of the overall safe navigation of the vessel, and the retrieval of information can be time-consuming because of the large number of stand-alone instrument displays, which in some cases, are distributed in an illogical and irrational manner.

Troubles can also stem from unanticipated interactions among new technology, human operators, and other systems in the environment. These can be problems inherent to the technology, as well as to the technology's behavior in a larger, more complex system, Tenner (1996). This can be seen in integrated ship's bridge systems, where system performance can be determined by the interaction of multiple sensors, systems, people, and technologies (Grabowski and Roberts, 1996; Grabowski and Sanborn, 2001).

As Stitt (2004) states, one of the similarities between the introduction of AIS and the period when radar, and the later ARPA, were first widely used is that new technology is involved and the related equipment is being brought into use with only limited experience of the practical effects of that technology.

To summarize, reasons for new patterns of workload induced by AIS embrace three aspects, namely, correlation information between AIS and other equipments, interaction among technology, human operators and other systems, and limited practical experience.

4.3.3 Types of Workload Induced

4.3.3.1 Correlating Information between AIS and Other Equipments

In practice, over 80% of MKD is a stand-alone display which is set either on the bridge or even worse, in the chart room (Nautical Institute, 2003). A dedicated display demands an undivided attention of the OOW for a percentage of his time on watch. In busy traffic areas where time is always limited, the OOW always has to page up and down to find the ship of interest.

Despite these efforts and assuming the identification of target is smoothly done, the work of OOW is far from over. Navigational data AIS yields will require mental correlation with radar information and visual observation. Even in good conditions, the OOW will be required to maintain a very high degree of spatial awareness to ensure that he/she understands which of his/her visual contacts is also held on radar or AIS or both. In conditions of poor visibility the problem is compounded and there is a chance of human error, when the OOW cannot be sure that all contacts will be detected by radar or by AIS. In addition, due to the master’s discretion to switch off the AIS if he/she perceives the status is beneficial to the security and the fact that not all the ships are equipped with AIS, the OOW can never be completely ensured that the ship of interest is the target displayed on the MKD.

This problem is further complicated by the fact that some displays are effectively ground stabilized through reliance on GPS whilst others present a relative picture. It seems inevitable that there will be an irresistible temptation to use VHF in an attempt to resolve traffic situations simply because AIS will provide the identity of some of the ships involved. The possibility for confusion can be more readily understood when it is appreciated that not all ships will be fitted with AIS or not all switch on the AIS.

In short summary, generated from interpreting and correlating information between AIS and other equipments such as radar or ENC or ECDIS, this pattern of workload is the biggest one among the induced. Lee (2001) stated similarly:

> The information provided by navigational aids on the bridge of a typical ship is currently distributed over a number of 'stand-alone aids'…Distributing the information is not in itself bad design. But too often the task requires multiple instrument viewing and holistic comprehension by the mariner of multiple information sources. The difficulties are compounded by there being, currently, no consistency in the manner of operation or of symbology between the various display surfaces.

4.3.3.2 Types of Mental Stress Induced

Mental stress alleviated AIS through enhancing situational awareness has been discussed in 4.2.4. Nevertheless, other types of mental stress may be generated mainly due to the unfamiliarity with the operation as well as interpretation.

The "unfamiliarity" generally consists of unfamiliarity with AIS menu operation, incomprehension of AIS information, uncertainty with the correlated information and interrupting alarms from MKD.

Stress from menu-operation is the stress originated from the complicated and poorly designed AIS menu. This kind of stress is low-level because it can be eliminated by better designing or more practicing. Usually, younger OOWs have a culture of using information technology and the elder seafarers seem more likely to upset when using menus to input, edit or consult AIS information.

Stress from incomprehension is the primary one in AIS usage. Assuming all AIS information transmitted and received is correct, the OOW needs to know how best to utilize those information. To do so, it requires a basic understanding of AIS system and the basis of the information presented. If the OOW is not competent enough, he/she might be unable to understand AIS information well and, say nothing of correlating them with those on radar. Hinchliffe (2002) states that the appreciation of the complexities associated with ground stabilized and sea stabilized displays and the effect on true vectors makes it doubtful how those OOWs with insufficient knowledge will cope with AIS. Moreover, in case the navigation situation becomes complicated and the use of AIS seems necessary, the stress from incomprehension will be tremendously increased.

Stress from uncertainty is generally derived from tricky situation where the OOW is not certain whether the ship of interest is the one he/she identifies on the MKD. When the careful OOW bears in mind the fact that not all ships are equipped with AIS and not all AISs are switched on, he/she may suffer the mental stress from uncertainty. This kind of stress is likely to be magnified if the uncertainty lasts for quite a long period.

Stress due to alarms arises when OOW feels overloaded or doubtful with AIS. Alarms added to this equipment could also be source of mental stress. In terms of the alarm-related stress, Tailor (2003) stated: "I have on many occasions witnessed the frustration of a master in the middle of the night, seeking to track down the source and level of importance of one or more alarms…" and "I have listened and watched the levels of stress rise to unreasonable levels as one or more of the officers on a bridge wrestled with a set of controls which performed a subtly different function⋯"

Thus the stress, although released a little bit during the course of getting situation awareness, might be generated for a variety of reasons and should not be overlooked. Too much mental stress raised may cause reluctance to use, occurrence of human errors and reduction of self-confidence in maritime navigation. All of these are opposite to the initiatives of AIS development.

4.4 Approaches to Reduce Workload and Stress as a Whole through AIS

Embracing both promises and shortfalls, every new technology imposes considerable impacts on the users. If properly developed, technology will be definitely beneficial while on the contrast, it may also become catastrophic.

As a new and untried technology, AIS introduces new pictures on bridge automation which is conceived crucial to the reduction of OOW's workload and stress. The workload and stress reduced through the application of AIS is obvious because of the designed function. However, other patterns of workload and stress derived from the same equipment should never be ignored.

Thus, the question whether AIS, as a whole, truly reduces human workload and stress or not becomes somehow complicated. The ultimate answer varies case by case, person by person and, situation by situation. The only issue can be definitely right is to amplify the benefits of AIS and to mitigate various workload and stress induced by AIS.

In summary, approaches to reduce workload and stress as a whole though AIS should include the followings:

--Fully appreciate the impacts of new technology, and exert potential benefits while avoiding clumsy development.

--Get familiar with the path prediction by use of AIS information and shrink VHF communications.

--In case verbal communication is necessary, avoid blind verbal calling and mistaken targeting through accurate identification of the ship of interest.

--The selection of the presented information should be filtered by the 'need to know principle' to enable the user to reduce cognitive workload.

--Get accustomed to the correlation between AIS and other navigational aids. Situational awareness can not be ensured unless information available is correctly interpreted.

--Before substantial improvement on MKD is achieved, training and practicing should be encouraged to promote OOWs’ skills and competence in the usage of AIS. All the types of stress induced by AIS can tremendously decrease with improvement of OOWs’ competence.

Chapter Five AIS-related Human Errors

It is commonly agreed among the shipping industry that approximate 80% of marine accidents are rooted in human error (Fotland, 2004). The trend also indicates that there are fewer accidents caused by technical failure of a piece of equipment, and an increasing number that can be explained by human errors. The problem is complex; human error may very well be due to an error in design, improper follow-up of the building process, or lack of proper routines on board. Some studies also indicate that a majority of the accidents due to human error may be traced back to factors where the ship's management has a strong influence, and in some cases direct control.

If we recall the situation when radar and ARPA were first introduced, marine accidents happened occasionally due to various human errors and Wei (2004) suggests that the lessons learned the hard way when radar and ARPA were first used should not be forgotten.

As the whole shipping industry were waiting for the first "AIS-assisted" maritime accident, it did happen in the East China Sea on June 21, 2004 (Lloyds List, September 1, 2005,) and unsurprisingly, it is subject to a typical human error (MAIB, 2005).

Based on the application of three basic error types, this chapter tries to identify a variety of human errors related to the AIS usage, analyze the apparent and underlying reasons, and to discuss the measures of minimizing the probability as well as the consequence of those human errors.

5.1 Basic Errors Types

Senders and Moray (1991, p.21) defines the human error as a human action that fails to meet an implicit or explicit standard. They add that an error occurs when a planned series of actions fails to achieve its desired outcome, and when this failure cannot be attributed to the intervention of some chance occurrence (1991, p.21).

Rasmussen divided human error into three basic error types, namely: *skill-based slips (and lapse), rule-based mistakes* and *knowledge-based mistakes* (Reason, 1990, p.53). According to UK P&I CLUB (2003), unintended errors stem from informational factors and the likelihood is reduced by improving information. In addition to three basic error types, *violation* is a unique type of error that reflects intentional purposes.

In short, sources of human error can be summarized as the followings (UK P&I CLUB, 2003)

Skill-based Human Errors

Skill-based human errors consist of:

(1) memory failures, referring to omission or repetition of planned or intended action; and

(2) attentional failures, referring to unintended deviation from a correct plan of action.

Memory failures are subject to change in nature of task or change in task environment whereas attentional failures are contributable to distraction from task or preoccupation with other things. Routine and highly practiced tasks are carried out at the skill-based level, in a largely automatic fashion.

Rule-based Human Errors

Rule-based human errors are those intended action inappropriate to circumstances or sound rules applied in inappropriate circumstances. When there is a need to modify our largely pre-programmed behavior in line with some change in the situation, we should switch to the rule-based level. It is called rule-based because we apply stored rules of the kind: if (this situation) then do (these actions).

Knowledge-based Human Error

Knowledge-based human error refers to erroneous judgment in situation not covered by rule because of insufficient knowledge or experience-immaturity. Given time, human beings are often able to produce good solutions but, in an emergency, are not. Only when we have repeatedly failed to find a solution using known methods, do we resort to the slow, effortful and highly error-prone business of thinking things through on the spot usually at their best.

Violations

Besides three types of unintended errors, violation is considered as an intended error which stems mainly from motivational factors and is reduced by changing attitudes or culture.

There are five types of violation

(1) Routine violations, the Habitual deviation from required practice;

(2) Optimizations violations, involving thrill seeking while getting from A to B, or indulging in aggressive instincts;

(3) Situational violations, referring to problems that are not specifically covered in the procedures;

(4) Exceptional violations, Ad hoc infringement of regulated practice in unforeseen or undefined situations; and

(5) Acts of sabotage, deliberate violation for malicious reasons.

5.2 Human Errors related to AIS

Detection of target by AIS totally depends upon the full cooperation of the target vessels within detection range. Human errors occurring in the routine operation definitely reduce the reliability of AIS information, limit its usefulness and effectiveness for collision avoidance, and ultimately, put the ship into a substantial danger. Issues such as improper presentation of information may cause misunderstanding, misinterpretation, and overload of information to the OOW (Bailey, 2005). AIS problems will be more noticeable and potentially dangerous in areas of restricted visibility and radar blind areas and they might cause AIS assisted collisions or incidents. Over-reliance on the systems, increase in mental stress in busy traffic areas, inadequate skills and abilities of OOWs are also issues that can amplify the risk to the navigational safety.

Studying AIS-related human errors may help to identify and eliminate the errors which often occur and impose potential or apparent hazards to marine navigation. Identifying those errors makes navigators more aware of the inherent limitations of AIS technology and current design, and more cautious about AIS routine operation. To achieve this goal, we will concentrate more on the various human errors found in the operation than in the designing course.

5.2.1 Skill-based Errors

Skill-based errors related to AIS operations are relatively simple. They can be easily prevented through effective bridge procedure and more practicing. Basically, there are three types of skill-based error in the routine usage of AIS.

The error stemming from memory failures or attention failures is the primary one. In Bailey's research (2005), two major categories of error are related to ship's draught and destination, which are included in the scope of voyage related data and should be updated each voyage. This founding reflects the phenomenon that OOWs often fail to update the information of new voyage and remain the data of previous trip, or even that of long time before.

Another common error is connected with the transmission of navigation status. Since it is optional and that it will usually rely on manual input, OOWs often find ships under sail presents the status under "moored" (Warner, March 26, 2004). Stitt

(2004) argues that especially in emergencies, making a change in the status could be overlooked.

The third typical type of skill-based error is misspelling. Bailey (2005) finds, in his research that it is surprising that there are any instances of error relating to call sign, name and MMSI number as these are initially entered when the system is installed. Due to the limitation of input device, OOWs are probable to make spelling mistakes during the data-input if some distractions appear and result in attentional failures.

5.2.2 Rule-based Errors

Although some operational guidelines have been provided by IMO Resolution A.917 (22) (IMO, 2002) for OOWs to effectively apply AIS technology, rule-based errors still prevails in four aspects.

Firstly, the unintelligible abbreviations regarding “destinations” bring a lot of confuse to OOWs. This situation leads to confusion and inefficiency in data interchange (IMO, 2003). Although it is recommended that OOWs enter the ship’s destination into the AIS at the start of each voyage, and to keep this information updated (IMO, 2002), there is no clear provisions or standards in terms of the abbreviation of destinations. Therefore, “evidence shows that mariners are using different names for the same location when entering destination data in their AIS units” (IMO, 2003). It may be confusing and misleading when OOWs use the destination data to predict the possible route of the targets.

The Master’s discretion of switching off the AIS equipment is the second big problem related to rule-based errors. The operation of AIS is governed by international legislation allowing the Master to switch the AIS ON and OFF at the Master’s discretion. In light of the statistics by Auxiliary (2004), 47% masters ***consider*** switching off their AIS off, and 19% ***definitely*** switch it off when passing through a known piracy area. Auxiliary (2004) also draws the conclusion from his research that there remains significant misunderstanding with respect to the authority of the Master and its use. All these are indicative of the shortage of unambiguous rules regarding the conditions under which AIS is allowed or not allowed to be switched off.

The third typical rule-based error concerns with the receiving/transmitting safety related information. There are no internationally accepted standards for messages describing safety-related or environmental conditions. It is problematic for OOWs, especially for non-English speakers to edit and interpret information quickly and precisely without sacrificing proper watch-out. The first AIS-assisted accident, the collision between Hyundai Dominion and Sky Hope, is caused by lack of necessary communication which was considered by one of the watchkeepers, had been replaced by the exchange of a text message (MAIB, 2005).

Finally, examples from the ‘other’ category include: the inappropriate addition of comments such as ‘not under command’ in the *ship type* field, and the transmission of a ‘Mayday’ message via the text facility when there was no distress.

5.2.3 Knowledge-based Errors

Currently, what the shipping industry concern is whether OOWs are changing information and, if so, to what extent they are knowledgeable about what they are doing. The technical specification for AIS is well documented whereas the knowledge required by the operator is not (IMO, 2003).

The most probable knowledge-based error may be found in the interpretation of AIS information. Ramsvik states (2004):

> That is a main part of the problem; most navigators are today not familiar with the AIS technology and its pros and cons partly mentioned above, and may use the AIS information uncritically and trust the AIS information in disfavor of the ARPA/ Radar information.

The probability of knowledge-based error is extremely high when the OOW is not so knowledgeable with the correlation with the radar target. This problem is further complicated by the fact that some displays are effectively ground stabilized through reliance on GPS whilst others present a relative picture. Thus, the OOW is ought to remember to alter the displaying mode to make the information consistency. In some cases where the alteration is not convenient, he/she has to bother to calculate the alteration manually. All these operations need relevant knowledge.

If AIS is integrated into ARPA, the OOW should also be reminded that he/she may experience two information sources with different data for the same target vessel. In this aspect, Ramsvik (2004) conveys his worries:

> We may also foresee situations where the position of the AIS target and the ARPA target for the same vessel are different due to position error from the AIS···. The navigator may then perceive the situation as there are two vessels and react wrong if he/she should do in the actual situation.

Therefore, OOWs who read AIS information should never forget the limitations of this technology. They ought to bear into mind the fact that the information presented might be erroneously input. The knowledge of the pitfalls, the awareness of the possibility of conflicting and confusing information, either imposed on the radar or independently displayed, will absolutely benefit the prevention of potential for disastrous consequences.

5.2.4 Violations

Violations here refer to failing to comply with good seamanship and generally embrace three types:

The first violation is to break COLREGs. Evidences show some OOWs are more likely to violate COLREGs due to the introduction of AIS. It is reported that the primary use of AIS by some OOWs is to identify other vessels and contacting them by VHF either to confirm or contravene the COLREGs (Nautical Institute, 2003). Similarly, Petterson (2004) states that It has been argued that OOWs, on board equipped ships, sometimes will actively agree on actions in conflict with COLREG, due to their knowledge about names of other ships.

The second category of violation is to misuse AIS information. Availability of information notwithstanding, IMO acknowledges that AIS information will be available for the coast safety agencies and authorities and could equally be available for ill-minded people. AIS itself is a tool used in an information collection system and we can not prevent people from misusing that information. As Ramsvik (2004) suggests that we may also note that it's possible to set up a "ghost AIS" sending false data.

The last kind of violation is somewhat of controversy. Is the OOW violating his/her good bridge practice when he/she inputs text message for collision avoidance when visual observation is argued to be more useful? Nautical Institute (2003) states that as the overwhelming majority of OOWs have not received any information or training in their use and the sending of text messages to other ships will contravene good bridge practice.

5.3 Potential Hazards

AIS is intended to assist OOWs to get situation awareness and it can be easily understood that potential hazards will be caused by various human errors during the operation. If summarized, the hazards to navigational safety can be elaborated as the followings:

5.3.1 Failing to Make Quick and Precise Decisions

AIS enables OOWs to make decisions in line with the data provided by other sources. In other words, OOWs may make decisions or predictions with reference to the AIS information. Thus, Bailey (2004) states where the information displayed is incorrect there is clear scope for an officer to make a poor decision on the basis of what is presented. In addition, transmitting incorrect data brings into question the levels of confidence that can be placed in the information received by both those ashore and those on board ship.

For those who do not appreciate the necessary knowledge of proper use of AIS technology, this hazard might be amplified. Wrong interpretation leads to wrong decision-making more easily.

The consequence of violating COLREGs can be considerable. Where ships start negotiating actions contrary to COLREGs it becomes increasingly difficult for surrounding ships to plan ahead. The effect of such action is to undermine situational awareness rather than improve it as intended. These findings highlight a range of issues pertinent to the use of AIS in the context of decision making and collision avoidance.

5.3.2 Confusing the Vicinity Ships

Human errors, especially skill-based errors might cause very confusing and embarrassing situation. For instance, wrong installation type data, such as an incorrectly spelled 'name' may cause confusion should a vessel need to contact another. Erroneous voyage data such as 'destination' could lead a vessel wrongly to anticipate a maneuver by another in close proximity, say one being overtaken or running alongside, while the appearance of incorrect navigational data, such as course or speed vector introduces a serious risk into the decision making frame.

When OOWs are confused, they usually seek confirmation with an alternative approach, which makes time more limited in congested waters.

5.3.3 Undermining the Effectiveness of AIS technology

Each of these instances of erroneous data undermines the confidence that can be placed in the AIS system and hence its contribution to improved situational awareness. Neither *mistrust* nor *over-trust* is beneficial to the effective use of AIS.

Insofar as access to a vessel's name makes it easier to use VHF to establish contact with other vessels, there is an increased risk that VHF traffic and, specifically, negotiation of collision avoidance will be promoted. Ironically, the original intention of AIS is to reduce VHF verbal communication which is believed to add more workload and misunderstandings to OOWs.

5.4 Reasons for the Occurrence of Human Error

5.4.1 Lack of Training Programs

It is probable that, initially, many of the shortcomings of AIS will not be properly appreciated. Stitt (2004) states that in many cases, OOWs will not be properly trained in the use of AIS and its potential benefits and shortcomings. Moreover, because of the accelerated timetable and increased emphasis on anti-terrorist and ship-to-shore applications, there is a danger that the operational requirements of AIS applications will form a substantial part of the syllabus, to the detriment of training in the effective use for collision avoidance.

5.4.2 Unawareness of the Limitations

Knowledge-based human errors mainly result from unawareness of AIS limitations. In the information technology age, OOWs tend to put more faith in electronic aids than is really warranted. They are likely to neglect the fact that AIS will provide yet another distraction, and it could become a further excuse for reduced attention for keeping a proper visual lookout. Stitt (2004) argues AIS generated information, whether on stand-alone displays or shown on ARPA or ECDIS displays is also likely to divert attention away from CPAs and TCPAs derived form one's own ship's radar/ARPA if only because of its novelty value.

5.4.3 Insufficient Bridge Procedures

It should be recognized that many AIS-related human errors can be avoided if anti measures are made and incorporated in bridge procedures. For instance, regular check and compulsory logging may remind OOWs of the entry and prevent inputting wrong information. If violating COLREGs is principally forbidden in bridge procedures, AIS would not be used as a catalyst for agreeing on a course of action which is in conflict with these rules. Memory failures, like failing to change the navigation status, destination and draught information will also be effectively eliminated if proper requirements are set and implemented.

5.5 Approaches to Cope with AIS-related Human Errors

Reason (1990, p.1) argues that modern technology has now reached a point where improved safety can only be achieved on the basis on of a better understanding of human error mechanisms. Human errors are very difficult to be eliminated due to the complexity. Fu (2004) recommended that human error should be controlled through three aspects:

(1) Control and minimize the factors might cause human error;

(2) Prevent the occurrence of accidents in case of human error; and

(3) Control and minimize the consequence if case accidents happen due to human error.

To effectively cope with various human errors regarding AIS, recommendations are listed as the followings:

--Consider AIS nothing more than one of the tools assisting navigational safety and never let the attention be distracted. ICS urges seafarers to use AIS equipment as an aid, not as an excuse for failing to look out of the bridge window. It has been suggested mariners not to use AIS information alone for critical decisions such as collision avoidance (Patraiko, 2004 and Hinchliffe, 2002).

--Operational training is necessary. It can not be acceptable to put AIS onboard to achieve full capabilities only with an hour or two instructions form the manufactures. The training syllabus should at least embrace (1) basic knowledge and operation; (2) limitations; and (3) how to interpret and correlate information with other sources.

--Bridge procedures should consist of requirements concerning proper AIS operation. For instance, OOWs should be advised to make an entry in the log after data updating (Stitt, 2004), and to routinely check the accuracy of own ship’s static, dynamic and voyage-related data being transmitted.

--Passing arrangements should not be made through AIS messaging. COLREGs should prevail at all times. Making private passing arrangements would be dangerous because other nearby ships, even if they were equipped with AIS, would not be aware of the arrangements.

--Harmonize the input of information such as destinations, by adopting an available universal protocol to unify the presentation of navigation information in such a way as to avoid confusion in the display of such information. When using MKD graphical display in conjunction with radar, it is important to use similar orientation (heads-up, course up) to avoid confusion.

Chapter 6 Conclusions and Recommendations

6.1 Better Understanding of AIS

Automatic Identification System (AIS) technology, providing a means of exchanging a precisely defined range of information between ships, reduces the number of near-misses and collisions because it will significantly improve the OOW's ability to anticipate and avoid potential collisions. It holds the promises of minimizing VHF communication by clearly identifying targets.

Due to various reasons such as an accelerated time schedule and limited experience, more efforts are focused on meeting the minimum requirement of AIS in terms of its performance, leaving less address on human elements involved. Thus, there are the possibilities of misuse and unintended negative consequence, which makes it impractical to achieve AIS full capabilities and facilitates the future development.

The human elements ought to be emphasized basically to embrace ergonomic designing, machine/human interface, workload, mental stress and human errors.

Recommendation 1: The whole shipping industry should attach more importance to a better and more comprehensive understanding of AIS while enjoying its apparent promising benefits. To acquire necessary lessons from first AIS-assisted maritime accident, it is imperative for all stakeholders of AIS technology to put more address on the considerations of human elements.

Recommendation 2: In China, more attention should be paid to OOWs' competence and qualification regarding AIS operational issues since domestic-route ships are required to carry AIS gradually[9]. A systematic implementation plan and schedule for AIS carriage might be needed.

6.2 The Critical Role of Ergonomics and Interface

Ergonomics is greatly related to human performance because it is the study and design of working environments and their components, work practices, and work procedures for the benefit of worker's productivities, health, comfort and safety. In the context of current AIS, ergonomics mainly refers to the location of Minimum Keyboard Display (MKD).

The poorly designed ergonomics can be argued to impose negative effects to the full capabilities of AIS. The separated installation makes the correlation between targets reported by AIS and ARPA more detrimental, particularly when they are close in range/bearing and where other targets exist.

From the perspective of OOWs, the AIS interface can be defined as the display and control mechanisms that enable the exchange of information between the person and the AIS. This interface represents an opportunity for significant improvements in available knowledge and awareness of waterways and vessel traffic situations for all mariners.

It is argued that for AIS to meet its stated objective of promoting safe vessel navigation, an effective onboard interface with the vessel's operator is essential. How effective and productive the AIS will be depends greatly on whether the interface is user-friendly or not. As the dominant interface, MKD has basic functionality to display the data needed. However, due to inherent deficiencies and clumsy designing, MKD imposes tangible inconveniences to OOWs.

Recommendation 3: The ergonomic consideration should be settled in the designing stage. It is believed that address needs to be given as to the placement of the display for effective use, such as its proximity to radars and VHFs.

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[9] See Document No. 406 issued on Oct.14, 2005 by China MSA

Recommendation 4: AIS displays should be introduced carefully and thoughtfully so that the needs of OOWs are met without overburdening them with inessential information and inconvenient operations.

Recommendation 5: In China, more considerations should be given to the fact that most OOWs in domestic routes have inadequate capabilities of English language. What they need from AIS and how the information is displayed must be defined and evaluated sufficiently well. Developing appropriate requirements for the minimum information display of AIS is essential for domestic route ships.

6.3 Workload Reduced and Induced by AIS

As a new technology, AIS is introduced as an approach of reducing workload and improving human performance in the navigational system. Within the element of understanding is the notion that AIS can increase workload and mental stress if it is used properly.

It is of great value to analyze as a whole the workload reduced and induced by the introduction of AIS. Four categories of workload are decreased after the usage of AIS. OOWs enjoy less VHF communication, less effort in identifying targets, more situation awareness and less stress from judging the situation. Nevertheless, new patterns of workload are triggered at the same time due to the unique nature of AIS. Interpreting and correlating the information between AIS and other resources, various stresses from menu-operation, incomprehension, uncertainty and interrupting alarms are typical types.

The answer to this question whether AIS really reduces OOWs' workload or not varies case by case due to a number of reasons. In general, the workload induced relates considerably with OOWS' competencies and skills. They need to be able to control the menus with skills and to interpret and correlate the information in the appropriate way. Sometimes these problems can be solved by more effective operator training.

Recommendation 6: Amplifying the benefits of AIS and reducing various workload and stress induced by AIS should be always born into minds. AIS technology must evolve in a manner meeting the needs of active seafarers and incorporating the consideration of reducing workload as a whole.

Recommendation 7: In China, training and practicing should be encouraged to promote OOWs' skills and competence in the usage of AIS, regardless of the revolutionary improvements on AIS displays may be achieved.

6.4 Human Error Triggered by AIS

Identifying those errors makes navigators more aware of the inherent limitations of AIS technology at current status and helps to avoid apparent or potential hazards.

Basic levels of human error including skill-based error, rule-based error and knowledge-based error are also applied in the implementation of AIS. Skill-based errors embrace those stemming from memory or attentional failures, connected with the transmission of navigation status and misspelling. Rule-based errors, resulted from the lack of clearly defined rules, are found in the unintelligible abbreviations regarding destinations, master's discretion of switching off the MKD and addition of inappropriate comments. Knowledge-based errors, considerably related to OOWs' competence, are mainly derived from the interpretation of AIS information.

Violations are also found in the implementation course. Evidences show that OOWs are more likely to violate COLREGs due to the introduction of AIS. Also, AIS information might be misused for illness purposes.

The potential hazards to navigation safety are tremendous if these human errors are not attached sufficient importance in the application of AIS. Hazards include failing to make quick and precise decisions, confusing the vicinity ships and undermining the effectiveness of AIS technology.

Recommendation 8: Reasons for the occurrence of human errors should be carefully analyzed, especially after the first AIS-assisted accident has happened. Efforts should be further made to clarify training programs and standards, to ensure OOWs' awareness of AIS limitations and to incorporate operational requirements in the bridge procedures.

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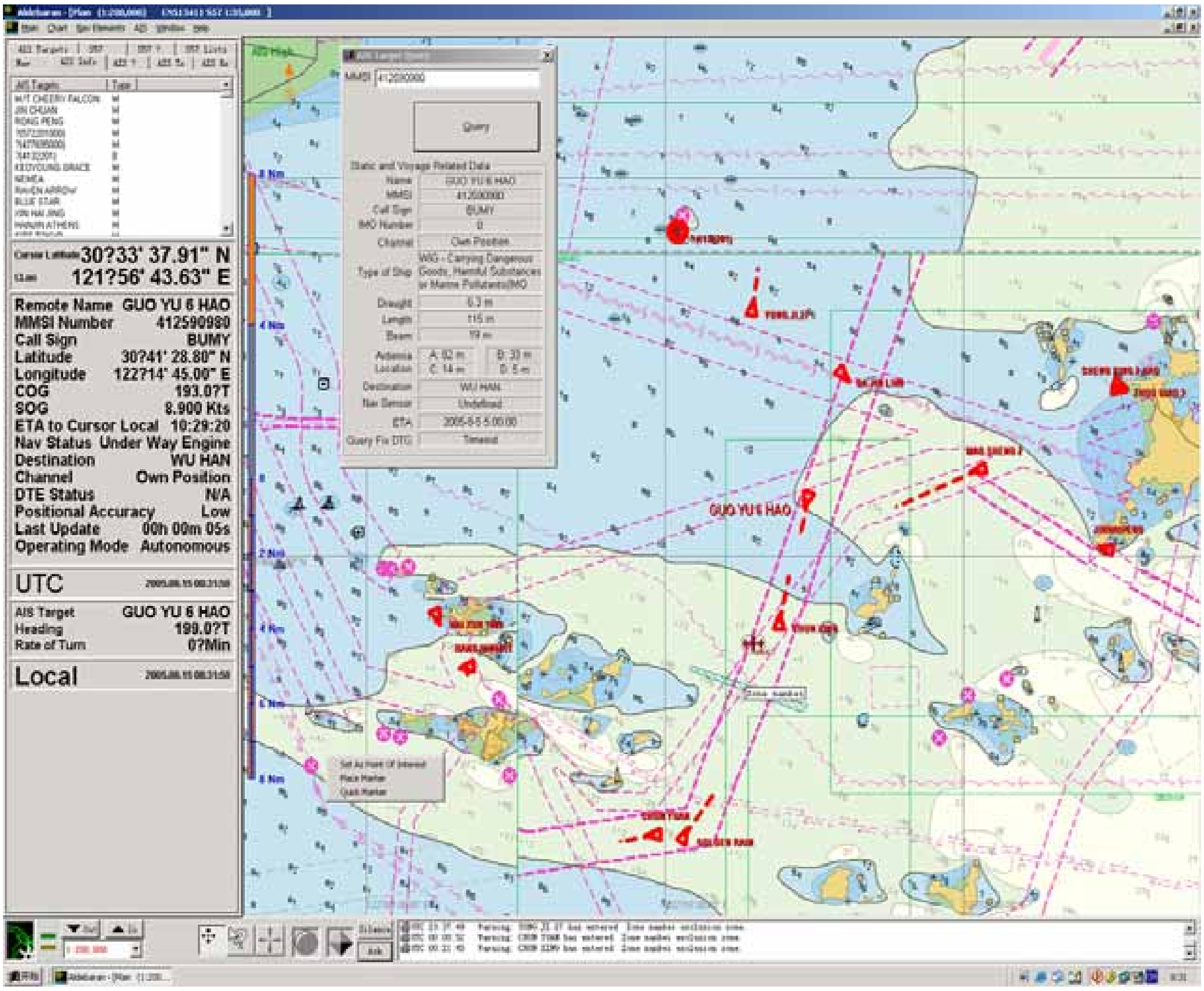
Appendix One　Example of Improper Information



Notes: The M/V GUO YU 6 HAO, shown in VTS screen, is proceeding in the route off Shanghai port. The route is in an opposite direction of WU HAN that is indicated as her destination from the AIS.

Appendix Two Notes of the Practical Survey

Notes of First Day's Interview

On January 23, 2006 the author boarded six container ships at Zhanghuabang Terminal. Four of them are from China shipping companies and two other ships are from Germany.

The author interviewed six deck officers (two third officers, two second officers and two chief officers). All of them are familiar with the AIS and the author did not find any wrong data in their respective equipment.

As recognized generally, AIS is helpful for navigational activities, i.e. identifying targets. They do not think it is a burden for deck officer to input the voyage-related information including destination, ETA, draught, cargo, etc. One of the interviewees believed that the entry of data could be done correctly within two minutes.

Three of the interviewees always use AIS as an assistant tool to conduct collision prevention activities. One third officer never consults AIS equipment because he thinks radar is more reliable and the time is limited. He states that if situation permitting, he prefers to use Radar or his eyes to judge the situation. He thinks, furthermore, it is not allowed to identify all the targets through AIS when proceeding in congested waters. However, he recognized that AIS is particularly helpful in foggy weather.

All of them complain the small size of MKD. They feel inconvenient to input and check the data when necessary. One second officer confesses that he suffers a lot from the small screen of AIS because the screen could not display all the targets he need in some time. He has to up or down the pages to identify the target ship several miles away.

One of the interviewees adds that it is likely to identify the wrong vessel when targets are close to each other. The third officer does not think so. He states that with the information of position and bearing from the APPA radar, the AIS target is easily identified. (On his ship, the MKD is set very close to the radar screen)

All of them feel accustomed to the operation of AIS although two of them mentioned a little nervous at the very beginning.

They always check the data before communicate with other ships.

None of them has taken a training program before. Three interviews believe it unnecessary to receive such a training program because the instructions on board are clear enough. One of the chief officers thinks it would be better to have a training course but it dose not matter whether there will be an examination or not.

All of them believe the AIS and radar screen should be closely located. One of the interviewees strongly complains that it takes time when two equipments are separated.

They all recommend the integration of AIS and radar or ECDIS.

Two interviewees (in the same ship) mention the poor signal that results in failing to receive information.

From the interview, there is no sign of over-reliance on AIS. On the contrary, two of them hint a little suspicion of the reliance of AIS information because so many ships are inputting wrong information or even ignore the usage of AIS.

They all mention that a number of ships are inputting wrong information or even ignore the usage of AIS. One of the chief mates estimated that in the past, about half of ships made mistakes in entering voyage related data, however at present, the quality of information is improved and the number of ships who make mistakes has been reduced to 20% approximately. He guesses the reason is the strictness from the Administration and company management.

One interviewee complains the number of items displayed on the small screen. Three pages are needed to display all the items whereas some of them like call sign, length, width and so on. He selected four of the mot useful items including name, CPA, COG and destination.

One interviewee intentionally set Zero as the alarming CPA. He explained that too many alarms in the bridge will confuse the OOW and if the CPA is set one mile, there will be too many alarms when proceeding in busy waters.

None of them has ever released the safety related information. The second officer even believes this function is useless.

There is a sign of reluctance of using AIS when situation is urgent or time is limited or the data is confusing.

One of the interviewees hints his worries of the performance of non-English speakers although he urges the implementation of AIS for all coasters.

Two ships' AIS equipments are installed about 1.5 meters away from the radar screen. One ship's AIS equipment is within the reach of OOW when he is watching the radar screen.

Notes of Second Day's Interview

On January 25th 2006, the author boarded four container ships at Waigaoqiao Terminal and interviewed one chief officer and three third officers. The chief officer who is from Russia, works for the APL shipping while the Chinese third officer works for China Shipping.

All of them are familiar with the AIS and the author has not found any wrong data in their respective equipment.

As recognized generally, AIS is helpful for navigational activities, i.e. identifying targets.

They do not think it is a burden for deck officer to input the voyage-related information including destination, ETA, draught, cargo, etc. One third officer believes that the entry of data could be done correctly within one minute. However, the chief officer has a great complain about the small size of keyboard. He considers it inconvenient and time-consuming for him to input all the data. He recommends AIS equipment should use a computer keyboard.

All of the interviewees always use AIS as an assistant tool to conduct collision prevention activities.

All of them do not think it is a problem to identify the targets through AIS when proceeding in congested waters. The chief officer thinks it is possible and simple. None of them thinks it is likely to identify the wrong vessel when targets are close to each other.

The chief officer complained the small size of MKD whereas two third officers believe it is all right. However, the chief officer is very accustomed with the AIS. As he says, the operation is like mobile phone. So he does not think it necessary for him to receive a training program. He does agree that there are too many sub-manus that need to shift for reading messages or inputting data. As far as the design of menu is concerned, he thinks it depends on different manufacturers.

During the interview, the author finds that his AIS displays ships with their course, distance and MMSI on the first page. The chief complains a lot about this because there are no ships' names on the first page, only with MMSI. However, the nearest three ships' names are displayed on the first page.

The chief officer who used to have experienced the radar system with an integration of AIS does not think the integration is a good thing because the real target may be reflected into two targets in the screen. The displayed information is confusing and misleading. However, he believes the integration of AIS into ECDIS is a perfect thing.

They always check the data before communicate with other ships.

None of them has taken a training program before and believes it necessary to receive such a training program.

All of them believe the AIS and radar screen should be closely located.

From the interview, two third officers seem a little over-relied on AIS. On the contrary, the chief officer does not think he is over relied on the AIS.

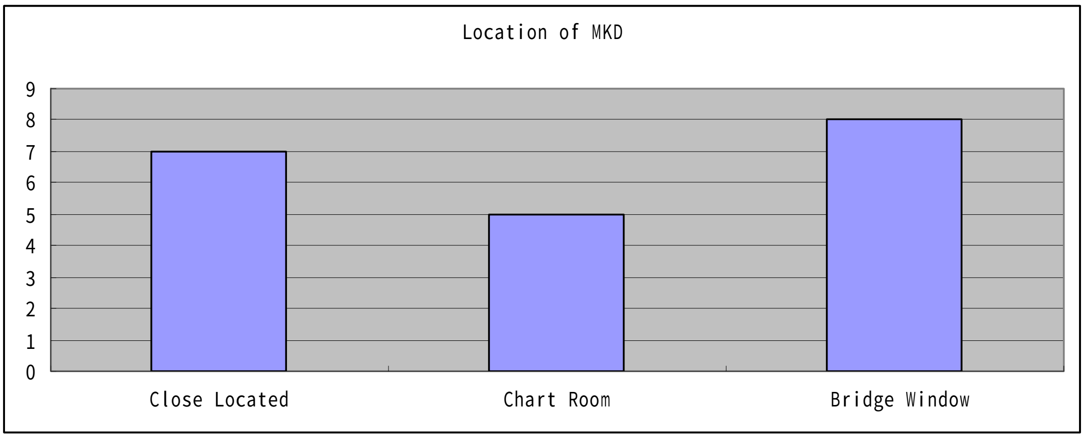
They all mention that a number of ships are inputting wrong information or even ignore the usage of AIS. One third officer estimates around 10% ships do not enter their names in the AIS. The third officers only consult the ship's name before communicating with the relevant ship. The chief officer will check other information before communication.

The chief officer switches off the alarming system to reduce the number of alarm on the bridge. He suggests the maximum number of alarms on the bridge should not exceed four.

Notes of Third Day's Interview

On January 26th 2006, the author boarded ten container ships at Waigaoqiao Terminal to get statistics of the location of MKD. No officers are interviewed in detail.

After three days' survey, the following table can explain the location of MKD in 20 ships:



Appendix Three Questionnaire about the Usage and Application of Shipboard AIS

Dear Sir:

This questionnaire is used for a recent research about the true situation of AIS usage and application. You are greatly appreciated if you choose the answer that you truly prefer. What you do may help us improve the effectiveness of AIS application in China. Therefore, we are so grateful for your frankness and cooperation.

The answers you choose have NOTHING to do with the results of PSC inspection or other formalities. This questionnaire is conducted voluntarily and anonymously.

1. What problems do you often meet when you are inputting static data, dynamic data or voyage related data, safety and security related messages?

☐A. No problems at all.

☐B. Only small mistakes, like slips (attention failure) or lapse (memory failure).

☐C. Sometimes I feel a little unfamiliar with the menu, but finally I can handle it.

☐D. It is difficult for me to input the data every time, because the time is so limited.

E. Others (Please specify) ____

____

2. How often do you use AIS as an assistant tool to prevent collision?

☐A. Always (More than 60% times).

☐B. Sometimes (Around 30% times).

☐C. Seldom (Less than 20% times)

☐D. Never, because I think Radar is more reliable or because I do not like to check the data in AIS within such a short time.

E. Others (Please specify) ____

____

3. What do you think of the Minimum Keyboard and Display?

☐A. It is too small. I feel inconvenient to input or consult the data.

☐B. It is O.K., but needs improvement.

☐C. It is a burden for deck officer.

☐D. It works well, and helps a lot.

E. Others (Please specify) ____

____

4. What do you feel when you are using AIS to avoid collision or to do other operations (i.e. communicating with other ships, receiving safety and security related messages)?

☐A. I feel very accustomed to it.

☐B. I feel a little nervous or excited because I am not very familiar with the operations.

☐C. I feel a little suspicious of the reliability of the AIS.

D. Others (Please specify) ____

____

5. Before you communicate with other ships, do you check the data in AIS to identify her name?

☐A. Always.

☐B. Sometimes, if there is enough time.

☐C. Seldom.

D. Others (Please specify) ____

____

6. Do you satisfy with the performance of AIS (only with the Minimum Keyboard and Display)?

A. Yes, because ____

____

B. No, because____

____

C. Others (Please specify) ____

____

7. What will you recommend to improve the friendliness of AIS interface? (You may have more than one choice)

☐A. Reduce the items in the static, dynamic and voyage information

☐B. Integrate the AIS data into the radar or ECDIS system

☐C. Set the Minimum Keyboard and Displayer beside the Radar

☐D. Redesign the complicated menu

E. Others (Please specify) ____

____

8. Have you taken a training program BEFORE?

- ☐ A. NEVER
- ☐ B. YES，if so，THEN
  - ◆ What kind of training program have you attended?
    - ☐Shore-Based Training program for MKD AIS
    - ☐On Borading CD training

9. Do you think the training program for use of AIS necessary?

- ☐YES
- ☐NOT

10. Does the Bridge Procedure on board your ship cover the proper use of AIS?

- ☐YES
- ☐NO

11. There are too many sub-menus that need to shift for reading messages or inputting data.

☐ I agree

☐ I don’t agree

12. The design of menu as well as submenu is not user-friendly.

☐ I agree

☐ I don’t agree

13. Anything else would you like to comment on the use of AIS?

____

____

____