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船舶自動識別系統使用心得及意見

AIS: From the Deck Officers' Perspective

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摘要

自 2002 年以來，船舶自動識別系統 AIS 已陸續成為客、貨、油輪駕駛台之必須裝備，大部份製造廠商及法律規範者多來自西方國家，然而海事從業人員卻多以亞洲國家為主，對此新裝備之操作及定位難免有認知及解讀的出入，若將其應用於海上避碰時，更突顯國際統一規範的迫切性。AIS 應以提高船員海上航行安全為首，增進船舶航行效率為輔，且以不增加當值工作負荷為前提。此學術研究調查之目的，是探訪及收集海事工作者對 AIS 的看法及使用經驗，藉以傳達海事工作者對 AIS 普遍觀點，以期對海上人命與航安能有正面之貢獻。期待能近身觀察遠東地區海事工作者對船舶自動識別系統 AIS 的使用心得及意見。

關鍵字: 船舶自動識別系統，避碰雷達，問卷調查

Abstract

The AIS has been approved by IMO and has become a mandatory carriage requirement on board SOLAS vessels. It is capable of sending and receiving navigational data via a designated VHF data link under two operation modes of ship-to-ship and ship-to-shore. The idea of giving merchant ships an identity came from a similar use in aircraft. By enhancing target identification at sea, AIS are known to be capable of assisting traffic, improving VTS service and protecting the environment. As a result of the 911 Event, the time schedule for fitting AIS was moved forward due to concerns about possible terrorist attack from the sea. As a consequence, the time for adopting shipborne AIS in was dramatically reduced leaving most mariners with an AIS device without knowledge about the applications and AIS training is not mandatory. Therefore, the accelerated implementation schedule of AIS carriage requirement could cause concern to navigation and ship manoeuvring. The objective of the paper is to discuss the potential for using AIS for navigation. It is based on the feedback from interviewed respondents who are mainly qualified 1st Class deck officers from Taiwan. The opinions and experiences of these end-users were obtained in order to present opinions on AIS applications at sea.

Keywords: Shipborne AIS, ARAPA RADAR, Questionnaire Survey

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I　Introduction

The Class A Automatic Identification System (AIS) is defined by the International Maritime Organisation (IMO)[4] and has been made a carriage requirement by the latest revision of Safety of Life at Sea Convention (SOLAS) Chapter V [1]. Shipborne AIS contains transceivers (two receivers and a transmitter) for broadcasting and receiving data via the Very High Frequency (VHF) maritime radio bands. With the advanced technology of Self-Organised Time Division Multiple Access (SOTDMA), the system is capable of handling over 4,500 reports every minute in its two designated radio channels (AIS One 161.975 kHz and AIS Two 162.025 kHz). The availability of connecting Global Navigation Satellite System (GNSS) (and Differential GNSS) makes transmitted data more accurate and reliable than Automatic Radar Plotting Aid (ARPA) RADAR, and furthermore GNSS gives synchronised data in real-time to all AIS receivers. Potentially, AIS can improve the current bridge systems where operators' workload and the safety of navigation will be enhanced.

During the 1990's, AIS was originally conceived as a traffic management and collision avoidance tool that would widely broadcast vessel positions [2]. After the 911 Event, maritime security was considered in addition to AIS intended purposes, thus the United States (US) Department of Homeland Security described AIS as an awareness tool in its “Secure Seas-Open Ports” pamphlet. According to the amended SOLAS convention in December 2002, all SOLAS ships shall be fitted with AIS no later than 31 December 2004 (see revised Regulation 19 Chapter V SOLAS). In addition, the AIS Minimum Keypad and Display (MKD) was then introduced as an interim measure to fulfil the requirement of AIS carriage. Apart from enabling prompt identification, the application of AIS/navigation was overshadowed by the greater concern of coastal security. For instance, a guideline based on the use in collision avoidance was only

[4] AIS was included in IMO as a carriage requirement in the revised SOLAS Chapter V with the IMO Performance Standard, the ITU-R Technical Characteristics Standards, and the IEC Test Standard.

mentioned briefly in Annex 3 Maritime Safety Committee (MSC) 74(69) and Resolution A.917 (22), IMO. To be able to pinpoint the use of AIS on the bridge, a thorough study of consensus among the mariners will be required. The aim of this paper is to reveal the survey results from the end-users regarding the current operation of shipborne AIS and concerns for using AIS in ship navigation and manoeuvring.

1.1 AIS Overview

According to the IMO Resolution A.917 (22), Guidelines for the onboard operational use of shipborne AIS, AIS is to enhance: the safety of life at sea; the safety and efficiency of navigation; and the protection of the marine environment [3]. The Annex 3 MSC.74 (69) Recommendation on Performance Standards for UAIS further stated that AIS should be capable of providing information automatically and continuously to a competent onshore authority and vessels without necessary manual interference from personnel [4]. The AIS has interfaces (configurable as International Electrotechnical Commission (IEC) 61162-1 or 61162-2) for position, heading and rate of turn (ROT) sensors [1]. Additionally, Course over Ground and Speed over Ground (COG and SOG) supported by GNSS input are also available and presented in real time. In terms of service range, AIS is able to detect ships within a VHF/Frequency Modulation (FM) range. Normally, a 20 to 30 nautical miles (nm) range would be expected and the actual range varies by the height of AIS/VHF antenna. In particular, a signal carried by VHF transmission can travel around the physical landmass and will not be affected much as the weather conditions deteriorate. Theoretically, AIS can provide extra information in terms of wider coverage of target detection. Clutter effects and blind sectors on RADAR can also be reduced by AIS.

1.2 Concerns about the AIS operation

The operation of AIS at sea also has a number of disadvantages that shall be borne in mind Officer of the Watch (OOW) before taking AIS into consideration of bridge lookout. Firstly, there are certain objects at sea that might not be available and displayed on the AIS display. For example, groups of non-SOLAS ships (e.g. small fishing boats, leisure craft, etc) are exempted from the compulsory AIS carriage requirement. Otherwise, objects like floating ice, containers, etc. will not be detected either. Additionally, there are also possibilities that AIS end-users, mainly the master, will be able to switch off the AIS transmission in certain areas where piracy is common. Thus, AIS target monitoring is unable to provide a complete picture in the current working reality. In order to prevent approaching these undetected targets at sea, it is highly recommended that AIS can only be used to back-up bridge operations such as lookout and RADAR. Despite the potential giving wider coverage and target identity to the OOWs, AIS data should not be relied solely and should always be used with caution when navigating and manoeuvring.

The AIS should be capable of providing positional and manoeuvring information at a data rate adequate to facilitate accurate tracking by a competent authority and other ships[5] [4]. It is essential that the information provided by AIS be reliable because information may be used for the navigation of the ship. In theory, an internal GNSS receiver is installed in the shipborne AIS not only to provide dynamic data but also to keep the data transmission at synchronised time frame. The data from gyro or ROT indicator are also available for precise heading and rotation rate displays. If there is a navigational device capable of executing and displaying data from AIS, the AIS system shall be connected to that system via the AIS Presentation Interface (PI[6]) [1]. So far, RADAR, Electronic Chart Display and Information System (ECDIS), RADAR and

[5] See Annex 3 MSC.74 (69).
[6] The PI (input/output) should meet the IEC 61162-2 requirements.

Integrated Bridge System (IBS) are made compatible by a number of AIS manufacturers. The contribution from all sources of navigational devices to the AIS working platform will provide mariner data in real-time and GNSS based dynamic data. In spite of the current shortcomings of AIS, the potential to access more accurate and reliable data shall have a role in improving situation awareness at sea.

In short, AIS should become a useful source of supplementary information to that derived from navigational systems (including RADAR) and therefore an important 'tool' in enhancing situation awareness of the traffic confronting users [3]. The idea is mentioned in one of the functional requirements for onboard AIS in Annex 3 MSC.74 (69):

> ‘AIS should improve the safety of navigation by assisting in the efficient navigation of ship, protection of the environment, and operation of VTS, by satisfying in a ship-to-ship mode for collision avoidance;’

No doubt, the use of ARPA RADAR has been approved by the marine public and remains one of the important devices in collision avoidance. The advantages of AIS are its ability to enable real-time COG, SOG, gyro heading and ROT to be considered in the decision making in ship manoeuvring. However, a unique element to evaluate developing risk with another vessel is the Speed through the Water (STW), Course through the Water (CTW) which is not available from AIS. In fact, taking visual bearings and continuing RADAR monitoring remain the most useful function to determine the collision risk by means of relative motion observation when two ships are at an encounter situation. Thus, AIS based dynamic information will need a transformation into water based information if OOWs are taking AIS into anti-collision manoeuvring. Today, AIS based information can only be treated as an additional source of navigational information to evaluate the aspect with the vessel with collision risk. Above all, the Collision Regulations (COLREGs) shall be the most important discipline in collision avoidance with or without the use of advanced navigational devices. The purposes of this paper are to reveal the current use of AIS by OOWs, to assess the possible use of AIS in navigation.

II　Survey findings

The survey aimed to gather the opinions and experiences of the OOW regarding the operation of AIS. With an insight from these respondents, issues and suggestions could be obtained for further contributions and improvements in the use of AIS. The survey took place from October 2005 at which time AIS would have been on every SOLAS ship for more than one year, according to the International Ship and Port Facility Security (ISPS) Code requirement. The survey also looked at impact on respondents' attitude measurement where statistical analysis were run by Statistical Product and Service Solutions (SPSS) version 11.5 and Microsoft Excel.

The first stage of the analysis was to reveal the percentage of every item from the respondents. Secondly, the Likert Scale was used to measure the attitude in parts of the survey questionnaire. The five degrees of agreement, moderate and disagreement gives more choices to respondents and provides more precise result than a simple agree/disagree question [5]. Follow the finding of attitude measurement by the Likert Scale [6], a Cross-sectional design was adopted to discuss the items over four different groups of ranking officers[7]. Next, the items were checked by the Kruskal-Wallis test (significant level at 0.05; the found significance could conclude different ranking officers hold different point of view). The items affected by the difference of OOW's ranking were reported in this paper. The test statistic and its degree of freedom (DF) and its significance were reported. Finally, a few *post hoc* tests follow up the Kruskal-Wallis test were run by using Mann-Whitney tests [7] in order to complete six comparisons among the ranking officers. The *Bonferroni correction* (significant level was then reduced/adjusted to 0.0083) was adopted in order to reduce the inflation of a Type I

[7] The research was interested in groups of masters, chief officers, second officers and third officers.

error by the application of a number of Mann-Whitney tests. The comparison that is significant was shown in figure and discussed.

2.1 Demographic data

There were seventy four questionnaires returned in the end of 2005[8]. The distribution of the serving years and the respondent's rank are shown below, where nearly half of the respondents were officers with one to five years sea experience (Figure 1), and two two-tenths of respondents were officers with six to ten years and more than fifteen years sea experience. In terms of the current ranking, the respondents are evenly distributed from third officers to master (Figure 2).

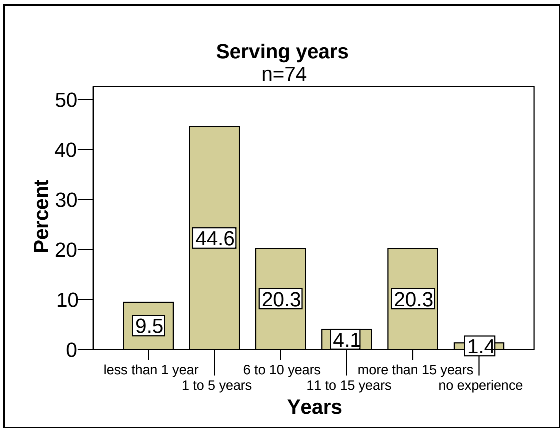

Figure 1 Serving years

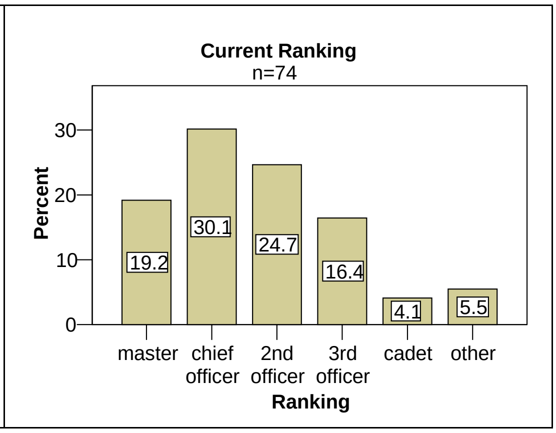

Figure 2 Officers' ranking

As the survey questionnaires were mainly distributed to the major liners in Taiwan, a large proportion of respondents have experienced working on container ships (see Figure 3) in their marine careers. When the survey took place, more than half of the respondents (55.4%) were working on container ships and more than one quarter of the respondents (32.4%) were working ashore or on leave (4.1% on bulk carriers; 1.4% on tankers; 6.8% others).

[8] The survey period was 60 days.

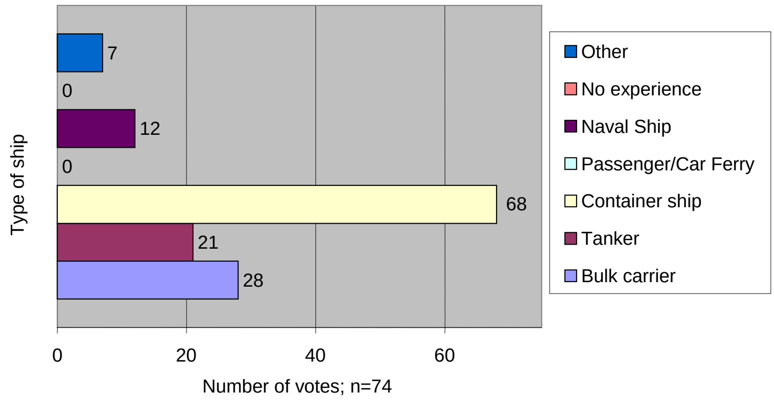

Figure 3 Served ship types

2.2 General view

The questionnaire began by asking for some general opinions on AIS. Firstly, more than three quarters of the respondents had already operated AIS on board. Of the thirteen respondents who had not operated AIS before, eleven had heard of and knew about shipborne AIS. In particular, more than half of the respondents (60.8%) had used AIS data in manoeuvring for collision avoidance. Next, the OOWs' opinions on AIS next were mainly based on the 72 respondents who were aware of the AIS operation.

Consequently, the respondents were asked to give opinions on four possible onboard AIS applications in ship manoeuvring, ship navigation, ship reporting and security measure (see Table 1 & Figure 4). There were nearly eight tenths of respondents felt AIS could be applied in communication assistance where over six tenths of respondents would like to see AIS applications in collision avoidance and security enhancement. Nevertheless, there were only three tenths of respondents agreed AIS would be useful in navigating ship by the positioning data where nearly a quarter of the respondents disagreed (41.66% neither agreed nor disagreed).

Table 1 Opinions on AIS applications

	Level of usability	Very useful	Useful	Neither/Nor	Not useful	Least useful	N
Collision avoidance	**66.66%**	22.22%	44.44%	27.78%	5.56%	0.00%	72
Position fixing	**36.11%**	8.33%	27.78%	41.66%	16.67%	5.56%	72
Communication	**79.17%**	38.89%	40.28%	16.67%	4.16%	0.00%	72
Security	**63.38%**	35.21%	28.17%	23.94%	9.86%	2.82%	71

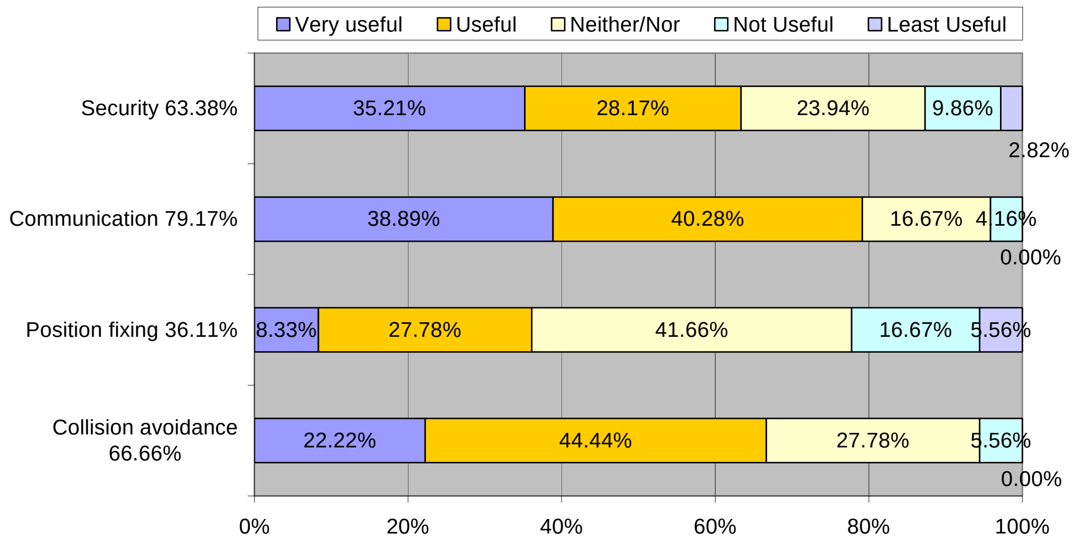

Figure 4 Mariners' opinions on four AIS applications

In terms of officer's ranking (see Table 2), apart from the group of masters, the rest of the groups showed the most support of AIS in communications application, chief officers (90%), second officers (77%) and third officers (100%). Nevertheless, the group of masters showed the most support in collision avoidance and security measures where only a quarter of the masters (28.57%) believed AIS assisted position fixing is useful. The remaining groups of OOWs also showed the least support in position fixing among the four applications.

Table 2 Ranking officers’ opinions on four applications

CA application	Ranking	Usability	N	Positioning	Ranking	Usability	N
	Master	78.56%	14		Master	**28.57%**	14
	Chief officer	68.17%	22		Chief officer	31.82%	22
	2nd officer	44.44%	18		2nd officer	38.89%	18
	3rd officer	75.00%	12		3rd officer	41.67%	12
	Total	65.15%	66		Total	34.85%	66
Communication	Ranking	Usability	N	Security	Ranking	Usability	N
	Master	50.00%	14		Master	78.57%	14
	Chief officer	90.91%	22		Chief officer	54.55%	22
	2nd officer	77.78%	18		2nd officer	64.71%	17
	3rd officer	**100.0%**	12		3rd officer	58.33%	12
	Total	80.30%	66		Total	63.07%	65

2.3 Lookout and manoeuvring

The survey questionnaire also asked about general bridge watch keeping as the research is also interested in attitudes of OOWs to the use of AIS. Due to its prompt identification, AIS could assist the OOW in identifying the targets’ details if needed, which could mean an implication of frequent use of VHF. Apart from the majority of respondents approving the use of VHF, more than three quarters of the respondents pointed out that there are difficulties in calling another ship on VHF channels. Moreover, 58 OOWs suggested the difficulties of VHF calling were because of busy traffic (n=40), vessel identification (n=29) and language barrier (n=13).

Despite the difficulty of using VHF calling, most respondents (88.9%) actually use VHF voice radio during collision avoidance where in contrast, less than one tenth of officers do not use VHF in ship manoeuvring. Furthermore, three quarters of the respondents still use VHF to assist manoeuvring in a close-quarter situation. There is a slightly increased proportion among the respondents (from 9.7% to 22.5%) who do not use VHF in this situation. The survey concludes that two parts of the VHF calling are a problem, that which may appear when the VHF voice radio is deployed and using combined VHF and AIS. In order to determine how exactly these respondents would like AIS to combine with VHF calling, a hypothetical question was asked “After AIS is fully implemented, will AIS text message be used in preference to the use of verbal communication for collision avoidance?”. This gave the implication that an AIS message could be sent ship-to-ship in ship manoeuvring. However, more than three quarters of the respondents do not agree that an AIS text message should replace verbal communication for collision avoidance. Therefore, the relation between AIS and VHF suggests that frequent use of VHF in collision avoidance is likely to happen after AIS gives target’s identity promptly. Next, the focus will move from the AIS assisted communication to AIS assisted RADAR operation.

As there are advantages and disadvantages associated with the use of ARPA RADAR on the bridge, the questionnaire asked about experience of external elements such as weather effect, offshore navigation, etc. In fact, more than three quarters of the respondents were not satisfied with their ARPA RADAR detection while proceeding in bended channel or if an obstructed landmass is between target and own ship. Most respondents (93.1%) feared that smaller boats may not be detected and shown properly by RADAR due to the clutter effect (mostly caused by rain or sea). The two issues need to be taken into consideration when operating RADAR in collision avoidance.

Apart from the natural and inherent limitations of RADAR, there is also concern for the man machine relationship. The view on how respondents normally operate RADAR was paid attention to. Firstly, the modes of RADAR stabilisation were asked. RADAR provides sea or ground stabilised display according to the speed-input mode to own ship's RADAR [8]. There were nearly six tenths of respondents who normally use Sea Stabilised function as log data (see Figure 5). In addition, more than three tenths of respondents (34.3%) use Ground Stabilised setup as speed input is manually maintained.

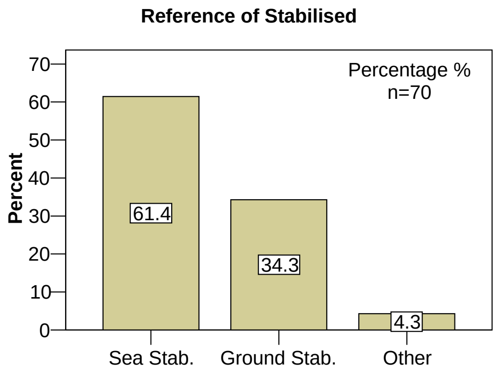

Figure 5 Stabilisation modes of RADAR[9]

When assessing the risk of collision especially in sea areas that experience significant tidal streams and currents, it could be dangerous only to rely on ground stabilized display throughout the event of anti-collision. Relevant to this is the collision case of *Ever Decent* and *Norwegian Dream* in the English Channel, the OOW on board the *Norwegian Dream* was mistakenly using manual speed input based on an estimated SOG throughout his watch duty [9]. There were a few collision cases indicating the concern of ground stabilisation display. To be able to evaluate the encounter situation with other vessels, OOWs should be required to switch back to sea stabilised mode on ARPA RADAR.

Half of the respondents agree that ships nearby will take action if they use shapes, lights, and sound signals. Nevertheless, more than one quarter of the respondents (36.6%) did consider that some ships do not act properly when the signals are deployed. Therefore, the survey examined what the traffic situation is by asking respondents to give score on seven types of vessels in COLREGs observance. It turns out more than three quarters of the respondents were satisfied with both cargo ships and VLCC as the best at complying with COLREGs (Table 3 & Figure 6). In the third place, a quarter of the respondents were satisfied with High Speed Crafts (HSC) followed by naval ships (15%), ferries (14%). Lastly, only two percent of respondents felt satisfied with the way

[9] The respondents who answered others were switching between two modes.

leisure boats and fishing boats were obeying the rules. In fact, nearly eight tenths of respondents were actually dissatisfied with the fishing boats, and more than half of the respondents were not happy with the leisure vessels. Hence, a controversial status between asymmetrical types of ships at sea could be seen as a problem for the merchant mariners when considering difficulties in detecting fishing boats and leisure boats, and the conflict in obeying the rule of the road at sea, not to mention that these types of ships are likely not to have AIS identity on board.

Table 3 Opinions of COLREGs observance on vessel types

COLREGs	**Level of Satisfaction**	Very satisfied	Fairly satisfied	Neither/Nor	Fairly dissatisfied	Very dissatisfied	n
Cargo Ships	**75.00%**	9.72%	65.28%	22.22%	2.78%	0.00%	72
VLCC	**83.33%**	19.44%	63.89%	16.67%	0.00%	0.00%	72
Fishing boats	**2.77%**	0.00%	2.77%	18.06%	43.06%	36.11%	72
Naval ships	**15.28%**	0.00%	15.28%	48.61%	29.17%	6.94%	72
Leisure boats	**2.78%**	0.00%	2.78%	36.11%	44.44%	16.67%	72
HSC	**26.40%**	1.40%	25.00%	45.83%	19.44%	8.33%	72
Ferries	**13.89%**	1.39%	12.50%	41.67%	36.11%	8.33%	72

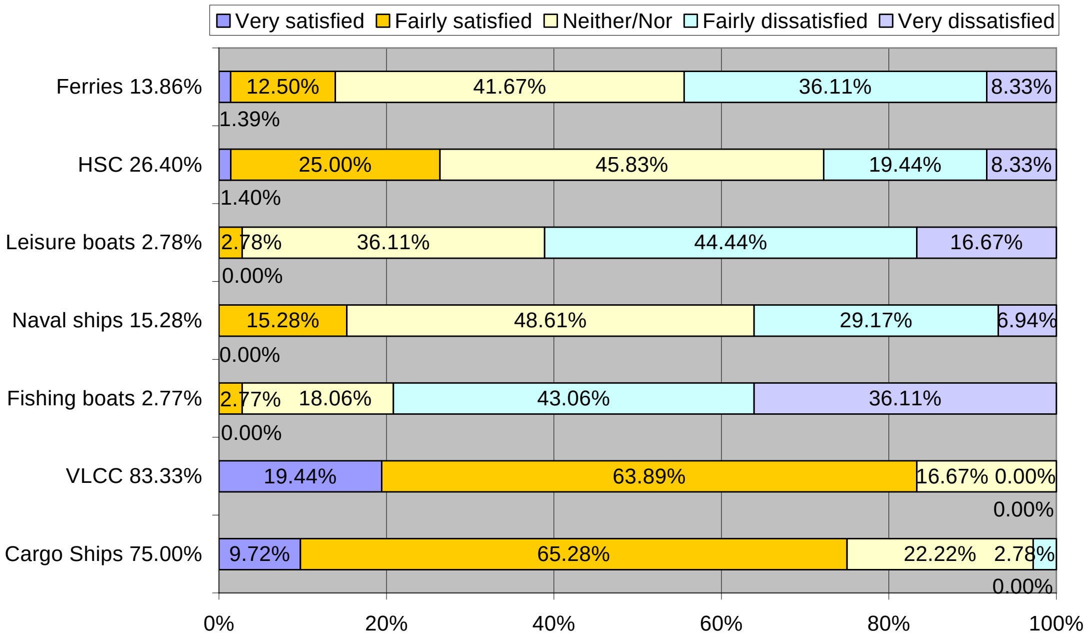

Figure 6 Mariners' opinions on COLREGs observance

In Table 4, the group of third officers showed the most support (91.67%) among the groups of ranking officers in two types of vessels, one is cargo ship and the other is the VLCC. Similar to the rest of the ranking groups, masters showed the most support in VLCC (78.57%) as well as chief officers (90.91%) and second officers (72.22%). The groups of masters, chief officers and third officers were not satisfied with the fishing boats (0.00%) and leisure boats (0.00%) in COLREGs observance where the third mates were also not satisfied with the ferries (0.00%).

Table 4 Ranking officers' opinions on COLREGs observance

Cargo	Ranking	Satisfaction	N	VLCC	Ranking	Satisfaction	N
	Master	71.43%	14		Master	78.57%	14
	Chief officer	72.73%	22		Chief officer	90.91%	22
	2nd officer	66.67%	18		2nd officer	72.22%	18
	3rd officer	**91.67%**	12		3rd officer	**91.67%**	12
	Total	74.24%	66		Total	83.33%	66
Fishing	Ranking	Satisfaction	N	Navy	Ranking	Satisfaction	N
	Master	**0.00%**	14		Master	28.57%	14
	Chief officer	**0.00%**	22		Chief officer	13.64%	22
	2nd officer	5.56%	18		2nd officer	11.11%	18
	3rd officer	**0.00%**	12		3rd officer	16.67%	12
	Total	1.52%	66		Total	16.67%	66
Leisure	Ranking	Satisfaction	N	HSC	Ranking	Satisfaction	N
	Master	**0.00%**	14		Master	50.00%	14
	Chief officer	**0.00%**	22		Chief officer	27.27%	22
	2nd officer	5.56%	18		2nd officer	27.78%	18
	3rd officer	**0.00%**	12		3rd officer	8.33%	12
	Total	1.52%	66		Total	28.79%	66
Ferry	Ranking	Satisfaction	N				
	Master	42.86%	14				
	Chief officer	9.09%	22				
	2nd officer	11.11%	18				
	3rd officer	**0.00%**	12				
	Total	15.15%	66				

According to the Kruskal-Wallis test, there was a significant difference between the compared pairs in item fishing boats (H= 10.269, DF= 3, P= 0.016). Further *post* *hoc* (Bonferroni correction, if P<0.0083, reject null hypothesis) shows significant difference between the groups of masters and chief officers (P= 0.001, Z= -3.254). In Figure 7, the majority of the chief officers clearly showed dissatisfaction on fishing boat complying to COLREGs at sea. There were 6 out of 14 masters answered moderate (neither/nor) opinion in this question.

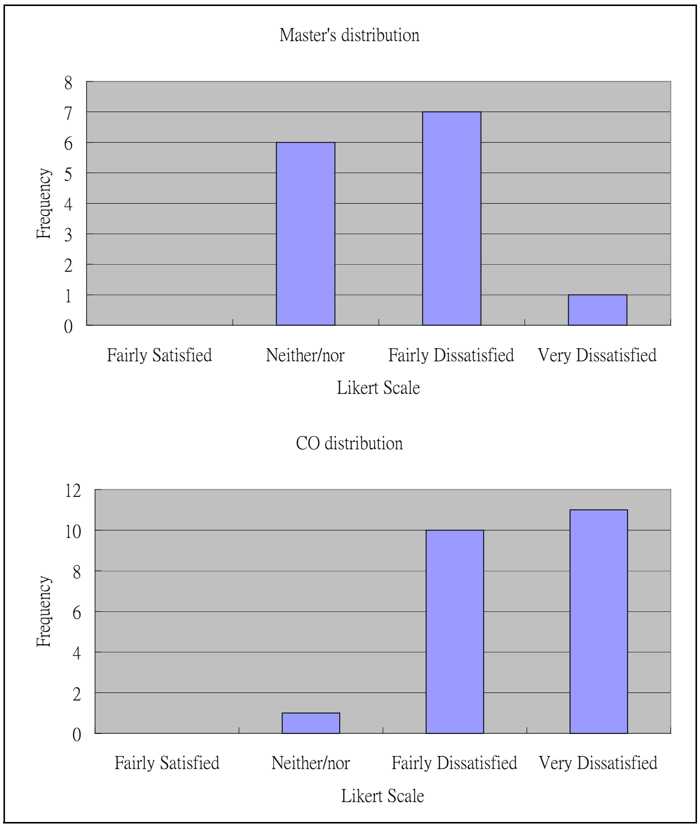

Figure 7 Frequency of view on fishing boat/COLREGs in masters and chief officers

2.4 Layout of navigation equipment on the bridge

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 [1]. The MKD provides no less than three lines of data consisting of bearing, range and name of a selected ship [3]. In fact, the MKD was not considered very helpful to bridge operation lately and might only be seen as an interim solution at the current level of AIS development. Without links to the other navigation equipment, MKD could end up as a standalone device providing AIS data and unfriendly to operate. In addition, there was no guidance as to where specifically the AIS MKD should be located on the bridge apart from Annex 17 IMO Resolution A.917(22) [1]: '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'. For the convenience of the technician who fits MKD on the bridge, the location of MKD can easily be found in some places like chart room (see Figure 8).


Figure 8 Photos of AIS MKD taken from a chart room (Source: Author)

On one hand, AIS MKD can be seen as an interim option to fulfil the carriage requirement. On the other hand, the AIS MKD would deter ships from fitting an integrated display that would be more expensive [10]. Thus, concern for time and cost could result in AIS MKD, being installed in an isolated location. Moreover, a lack of concern for putting AIS into the right location could make the OOW's job of reading the data more difficult. In many cases, AIS MKD have been criticised for being too far from the bridge's main console. From the opinions given on the layout of the navigational equipment, which can be found in the Table 5 and Figure 9, respondents were more satisfied with their ARPA RADAR location. AIS MKD and the overall bridge layout had the least satisfaction in terms of location among the bridge navigational devices. In particularly, nearly two tenths of respondents (16.9%) felt dissatisfied with the AIS MKD especially.

Table 5 Opinions on bridge layout

Bridge Layout	**Level of Satisfaction**	Very satisfied	Fairly satisfied	Neither/ Nor	Fairly dissatisfied	Very dissatisfied	n
AIS MKD	**50.71%**	7.04%	43.67%	32.39%	15.49%	1.41%	71
ARPA RADAR	**77.78%**	5.56%	72.22%	19.44%	2.78%	0.00%	72
VHF	**69.45%**	5.56%	63.89%	20.83%	9.72%	0.00%	72
Electronic chart	**71.01%**	10.14%	60.87%	24.64%	4.35%	0.00%	69
Overall Bridge layout	**51.39%**	5.56%	45.83%	40.28%	8.33%	0.00%	72

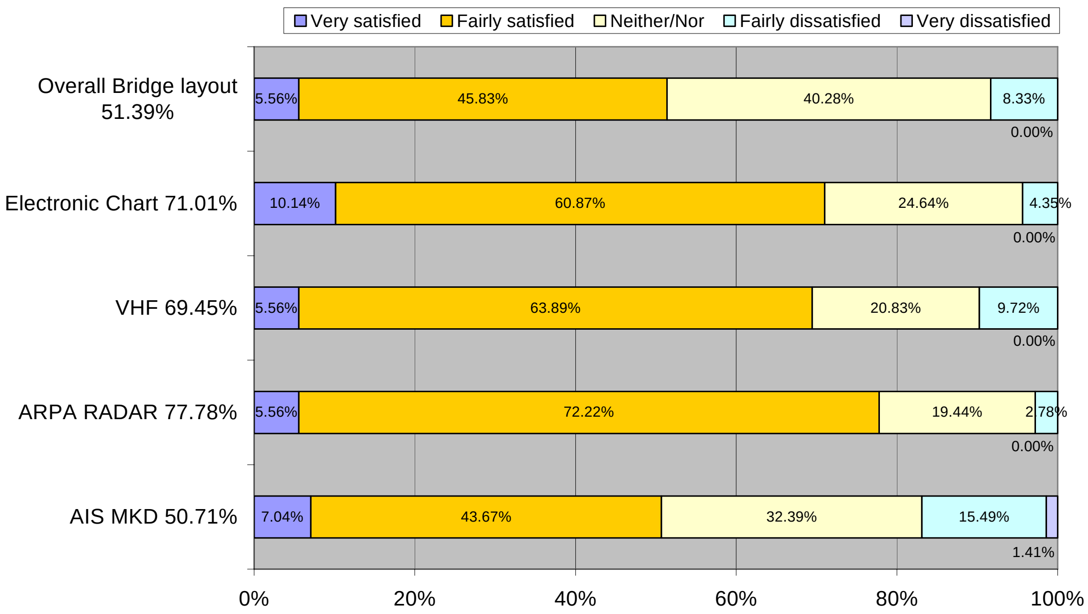

Figure 9 Officers' view on bridge layout

In Table 6, the group of masters showed the most satisfaction (85.71%) with the location of RADAR and VHF being set up. Among the rest of the groups, chief officers were mostly satisfied with the location of RADAR (81.82%), both RADAR and ECDIS for second mates (66.67%), and both VHF and ECDIS for third mates (83.33%). The group of second mates were showing the least satisfaction of bridge layout on AIS (35.29%).

Table 6 Ranking officers' opinions on bridge layout

MKD	Ranking	Satisfaction	N	RADAR	Ranking	Satisfaction	N
	Master	71.43%	14		Master	**85.71%**	14
	Chief officer	45.45%	22		Chief officer	81.82%	22
	2nd officer	**35.29%**	17		2nd officer	66.67%	18
	3rd officer	58.33%	12		3rd officer	75.00%	12
	Total	50.77%	65		Total	77.27%	66
VHF	Ranking	Satisfaction	N	ECDIS	Ranking	Satisfaction	N
	Master	**85.71%**	14		Master	76.92%	13
	Chief officer	63.64%	22		Chief officer	70.00%	20
	2nd officer	55.56%	18		2nd officer	66.67%	18
	3rd officer	83.33%	12		3rd officer	83.33%	12
	Total	69.70%	66		Total	73.02%	63
Overall	Ranking	Satisfaction	N				
	Master	57.14%	14				
	Chief officer	40.91%	22				
	2nd officer	38.89%	18				
	3rd officer	75.00%	12				
	Total	50.00%	66				

The location of AIS MKD on the bridge raises the issue as to whether data displayed by the MKD can give OOW prompt information. More than three tenths of respondents do consider reading data from the AIS MKD influences their decision on collision avoidance. Six tenths of respondents do not think reading AIS MKD data would delay their decision for collision avoidance (30.6% do think so). On the influence of operating AIS on the bridge, the survey would suggest there is still area needs to be studied whether the end-users do consider taking AIS into their anti-collision operation and how much percentage the AIS will be involved in the navigational operation.

Although the location of AIS MKD did not win the respondents' support, there is another means to define the value of AIS as if AIS data can be presented on certain graphical displays. AIS can provide information based on ground movement, rate of turn, identity of targets, etc, most respondents (93.2%) would like to see AIS data integrated with the other electronic devices on board. Furthermore, among the respondents who would like to see integration of AIS data, integration with ARPA and

ECDIS were particularly favoured (Figure 10). From the sample of 29 masters and senior chief officers, 22 of them would like to integrated AIS with ARPA RADAR where only 14 of them chose integration with ECDIS (n=14). Despite the concern for the minimum display by the MKD, the paper suggests respondents were seeing AIS as an extra data system capable of assisting the existing bridge systems.

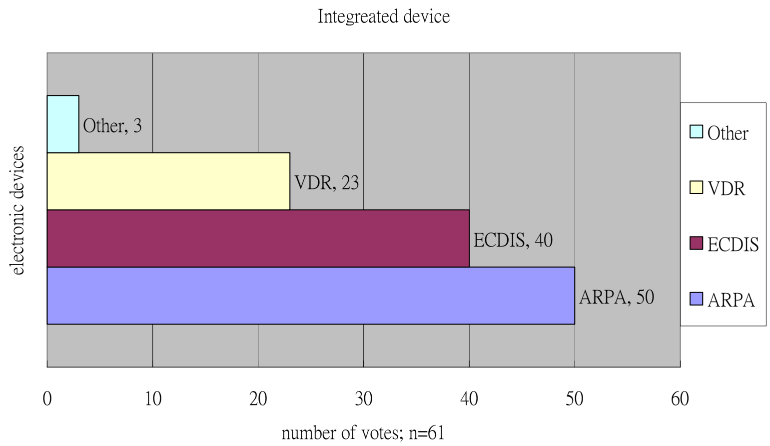

Figure 10 Preferable integrated devices

2.5 AIS implementation issues

The process of implementing AIS raises training, implementation and installation issues. 18.6% have experienced difficulties due to the implementation date being moved forward, though half of the respondents did not have difficulties. Although the result did not have a strong indication as to the problem caused by the changed time schedule, over four tenths of respondents (43.1%) agreed the cause was more about security measures than improving navigation.

On the issue of training requirements, half of the respondents (50.7%) knew that there was no training requirement for operating AIS. Yet, more than three quarters of the respondents (85.7%) believed proper training is needed if OOW to operate AIS in collision avoidance. Among the respondents who supported training, most answers lead to an onshore organisation (n=21) or the shipping company (n=22) as the best place to hold AIS training (see Figure 11). The remainder were 13 respondents who wanted self-training on the bridge and 7 respondents advocating tutorial by technicians whilst calling in harbour. Here, less than three quarters of the respondents do not think there is difficulty in communication with technicians.

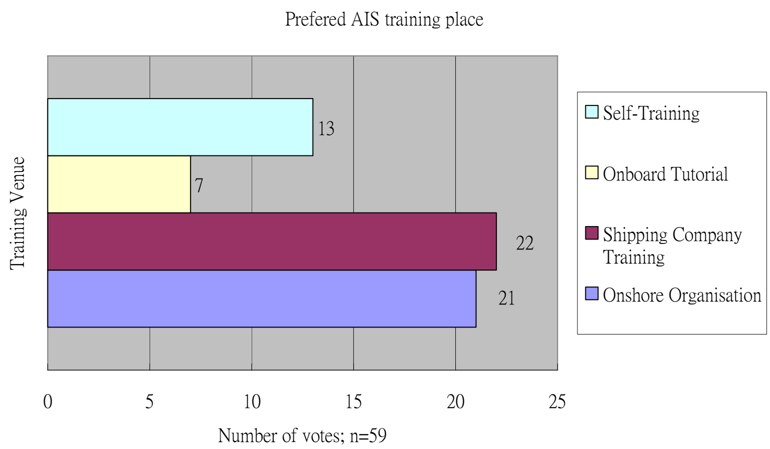

Figure 11 Preferable places to hold AIS training

Inevitably, if there is an optional or mandatory requirement for AIS training, the training cost would also be an issue for consideration. From the seafarers' point of view, it is understandable that they would not want to be responsible for training cost. The results in Figure 12 shows the suggesting authorities to bear the cost are Shipping Companies (n=39), Government (n=36) and the AIS manufacturers (n=16).

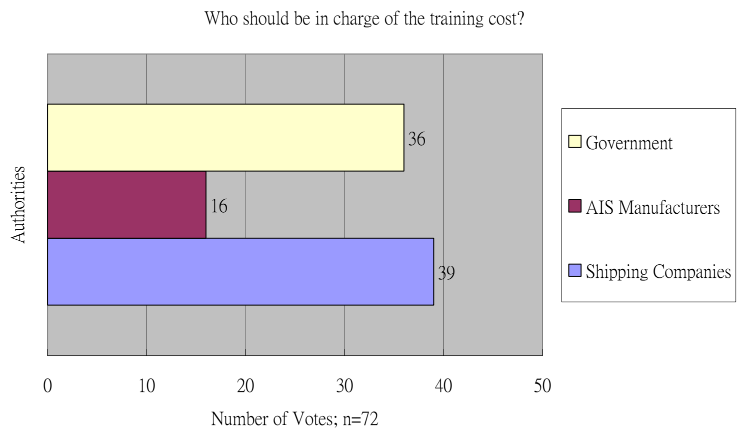

Figure 12 Responsible authorities for training cost

2.6 AIS and collision avoidance

The final series of questions related to the relation between the uses of AIS in ship anti-collision. In paragraph 2.2, six tenths of respondents have experienced operating AIS for collision avoidance, and a similar proportion (64.9%) also agree AIS is useful as one of the tools to avoid collision. In addition to the respondents' experiences and opinions, nearly nine tenths think AIS is currently suitable as an aid to collision avoidance. However, most respondents (91.7%) will not completely depend on the AIS data in the decision of collision avoidance. In short, the respondents would like to take AIS information into their decision if it is useful.

To gauge opinions on collision avoidance, respondents were asked about the importance of five navigational devices as navigation aids (Table 7 & Figure 13). ARPA RADAR and visual Watchkeeping were deemed to be the top navigational aids where Global Positioning System (GPS) and VHF were seen as important aids with over seven tenths of respondents' approving. AIS scored the last where six tenths of respondents felt AIS is important as a navigational aid.

Table 7 Opinions on collision avoidance with five methods

	Level of Importance	Very important	Important	Neither/Nor	Not important	Least important	n
ARPA	**100.00%**	76.39%	23.61%	0.00%	0.00%	0.00%	72
VHF	**79.16%**	34.72%	44.44%	20.84%	0.00%	0.00%	72
Watchkeeping	**97.23%**	79.17%	18.06%	2.77%	0.00%	0.00%	72
AIS	**63.88%**	19.44%	44.44%	31.94%	4.18%	0.00%	72
GPS	**73.61%**	29.17%	44.44%	25.00%	1.39%	0.00%	72

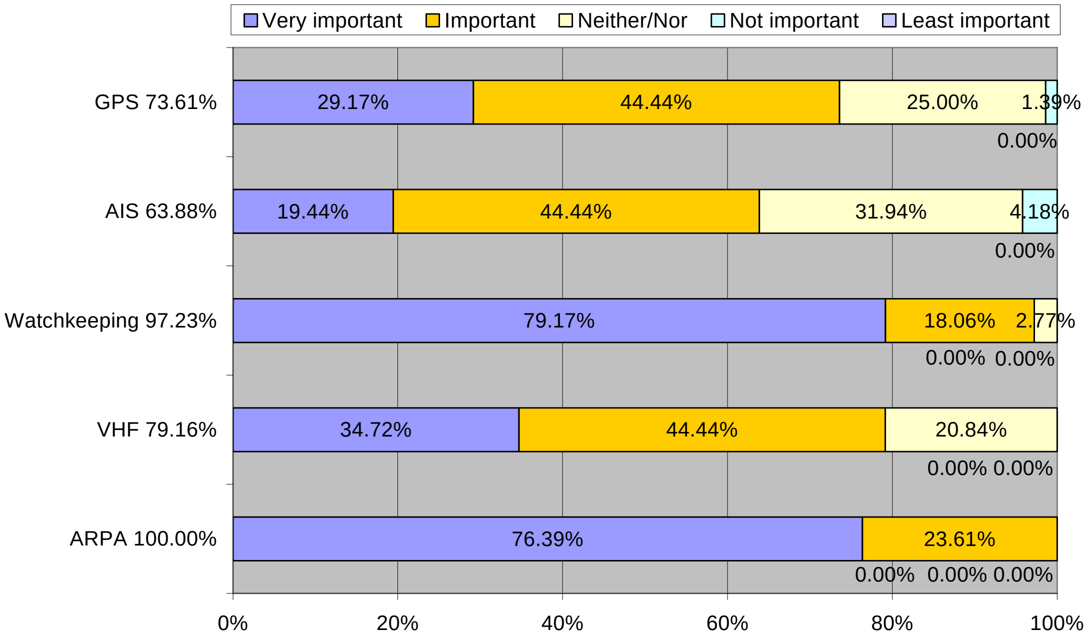

Figure 13 Navigational aids vs. collision avoidance

In Table 8, all ranking officers stated ARPA RADAR is the most important navigation aid. Besides, the groups of second mates and third mates also supported the visual lookout the most important. On the other hand, only half of the third mates believed AIS is important to be a navigation aid. In particular, the group of chief officers felt VHF is very important as a navigation aid for anti-collision manoeuvring. The group of masters particularly gave the highest score to use AIS in collision avoidance (71.43%). There were over eight tenths of group chief officers and second officers who considered GPS data important in ship manoeuvring.

Table 8 Ranking officers' opinions on navigational aids in collision avoidance

ARPA	Ranking	Importance	N	VHF	Ranking	Importance	N
	Master	**100.00%**	14		Master	71.43%	14
	Chief officer	**100.00%**	22		Chief officer	81.82%	22
	2nd officer	**100.00%**	18		2nd officer	77.78%	18
	3rd officer	**100.00%**	12		3rd officer	75.00%	12
	Total	**100.00%**	66		Total	77.27%	66
Visual	Ranking	Importance	N	AIS	Ranking	Importance	N
	Master	92.86%	14		Master	71.43%	14
	Chief officer	95.45%	22		Chief officer	63.64%	22
	2nd officer	**100.00%**	18		2nd officer	66.67%	18
	3rd officer	**100.00%**	12		3rd officer	**50.00%**	12
	Total	96.97%	66		Total	63.64%	66
GPS	Ranking	Importance	N				
	Master	57.14%	14				
	Chief officer	81.82%	22				
	2nd officer	88.89%	18				
	3rd officer	66.67%	12				
	Total	75.76%	66				

In terms of accuracy for position fixing (Table 9 &Figure 14), the overall result showed that respondents scored AIS the least accurate position fixing device even AIS is supposed to have GNSS connection. It is not difficult to find where only three tenths of respondents will apply AIS in position fixing (see above; Table 1 & Figure 4; paragraph 2.2). More than four tenths of respondents did not give opinions that could be deemed that mariners did not obtain AIS information for position fixing. In contrast, the respondents felt more accurate for GPS and ARPA RADAR accurate (nearly 95% of respondents agreed) in terms of position fixing. Visual lookout was also scored little compared to GPS and ARPA in terms of positioning accuracy.

Table 9 Opinions on positioning accuracy with four devices

	Level of Accuracy	Very Accurate	Accurate	Neither/Nor	Not accurate	Least accurate	n
ARPA	94.45%	29.17%	65.28%	5.55%	0.00%	0.00%	72
Visual Lookout	57.75%	12.68%	45.07%	38.03%	2.82%	1.40%	71
AIS	50.71%	4.23%	46.48%	46.48%	2.81%	0.00%	71
GPS	94.44%	31.94%	62.50%	5.56%	0.00%	0.00%	72

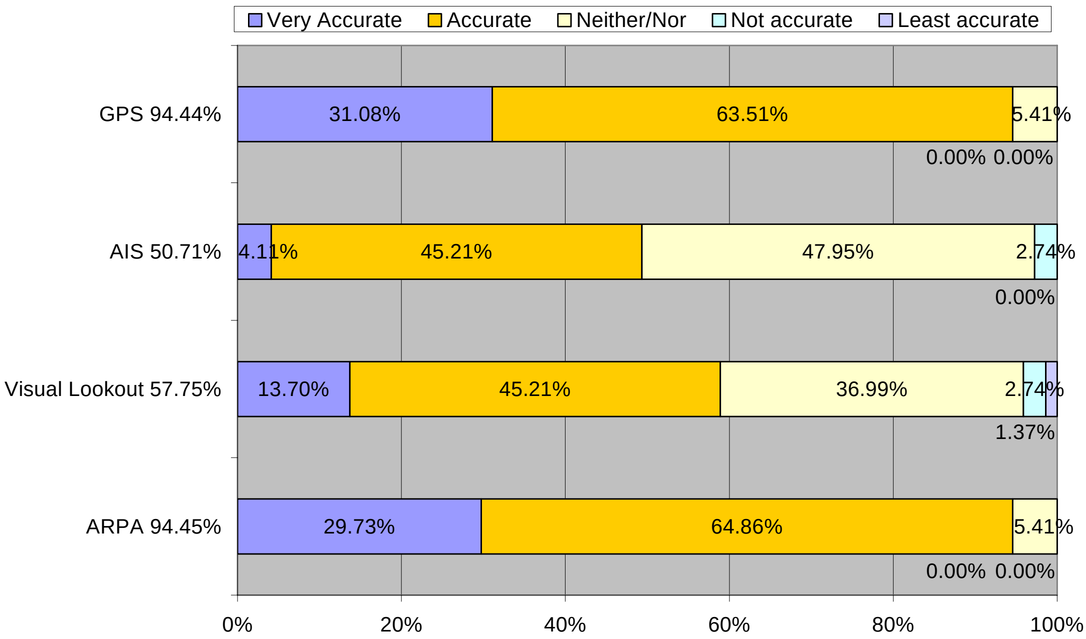

Figure 14 Navigational aids vs. accuracy of positioning

In Table 10, the groups of masters and third officers showed the most support in GPS regarding positioning accuracy (100.00%). The chief officers agreed accurate methods in positioning were RADAR (95.45%) and GPS (95.45%). The second officers agreed that RADAR is the most accurate method in position fixing (94.44%) where the same group of respondents showed the least support in AIS positioning (41.18%).

Table 10 Ranking officers' opinions on navigational aids in positioning accuracy

ARPA	Ranking	Accuracy	N	Visual	Ranking	Accuracy	N
	Master	92.86%	14		Master	57.1429	14
	Chief officer	95.45%	22		Chief officer	54.5455	22
	2nd officer	94.44%	18		2nd officer	55.5556	18
	3rd officer	91.67%	12		3rd officer	72.7273	11
	Total	93.94%	66		Total	58.4615	65
AIS	Ranking	Accuracy	N	GPS	Ranking	Accuracy	N
	Master	50.00%	14		Master	**100.00%**	14
	Chief officer	59.09%	22		Chief officer	95.45%	22
	2nd officer	**41.18%**	17		2nd officer	83.33%	18
	3rd officer	58.33%	12		3rd officer	**100.00%**	12
	Total	52.31%	65		Total	93.94%	66

Generally, the respondents are satisfied with the RADAR and GPS (Table 11) in terms of five gauging attributes (accuracy, integrity, coverage reliability and harmonisation). For Radar and GPS, over nine tenths of respondents were satisfied with the attribute in accuracy. The least score for RADAR was the concern of detecting coverage and the least score for GPS was the harmonisation. Similar to the results from the Figure 13, both visual lookout and AIS did not score better in the five-attribute question. For Visual lookout, coverage was the most concern for respondents. For AIS, only half of the respondents thought AIS is good for the five attributes in navigation.

Table 11 Attribute measurement of four aids to navigation

RADAR	**Support**	Very good	Good	Fair	Not very good	Poor	**Against**	N
Accuracy	**94.44%**	22.22%	72.22%	5.56%	0.00%	0.00%	**0.00%**	72
Integrity	**86.11%**	15.28%	70.83%	13.89%	0.00%	0.00%	**0.00%**	72
Coverage	**70.83%**	8.33%	62.50%	27.78%	1.39%	0.00%	**1.39%**	72
Reliability	**79.17%**	11.11%	68.06%	20.83%	0.00%	0.00%	**0.00%**	72
Harmonisation	**70.83%**	8.33%	62.50%	27.78%	1.39%	0.00%	**1.39%**	72
Support =Very good +Good; Against= Not very good+ Poor								
AIS	**Support**	Very good	Good	Fair	Not very good	Poor	**Against**	N
Accuracy	**63.38%**	5.63%	57.75%	33.80%	2.82%	0.00%	**2.82%**	71
Integrity	**54.93%**	7.04%	47.89%	39.44%	5.63%	0.00%	**5.63%**	71
Coverage	**53.52%**	5.63%	47.89%	43.66%	2.82%	0.00%	**2.82%**	71
Reliability	**56.34%**	8.45%	47.89%	38.03%	5.63%	0.00%	**5.63%**	71
Harmonisation	**58.57%**	11.43%	47.14%	35.71%	4.29%	1.43%	**5.72%**	70
Support =Very good +Good; Against= Not very good+ Poor								
GPS	**Support**	Very good	Good	Fair	Not very good	Poor	**Against**	N
Accuracy	**90.14%**	32.39%	57.75%	9.86%	0.00%	0.00%	**0.00%**	71
Integrity	**78.57%**	21.43%	57.14%	21.43%	0.00%	0.00%	**0.00%**	70
Coverage	**84.51%**	30.99%	53.52%	15.49%	0.00%	0.00%	**0.00%**	71
Reliability	**83.10%**	33.80%	49.30%	16.90%	0.00%	0.00%	**0.00%**	71
Harmonisation	**72.86%**	21.43%	51.43%	25.71%	0.00%	1.43%	**1.43%**	70
Support =Very good +Good; Against= Not very good+ Poor								
Visual	**Support**	Very good	Good	Fair	Not very good	Poor	**Against**	N
Accuracy	**56.34%**	7.04%	49.30%	38.03%	5.63%	0.00%	**5.63%**	71
Integrity	**53.52%**	9.86%	43.66%	38.03%	8.45%	0.00%	**8.45%**	71
Coverage	**35.21%**	1.41%	33.80%	39.44%	25.35%	0.00%	**25.35%**	71
Reliability	**63.38%**	21.13%	42.25%	29.58%	7.04%	0.00%	**7.04%**	71
Harmonisation	**56.34%**	8.45%	47.89%	38.03%	5.63%	0.00%	**5.63%**	71
Support =Very good +Good; Against= Not very good+ Poor								

According to the Kruskal-Wallis test, there was a significant difference among the ranking officers determined in the item accuracy of visual watch keeping (H= 9.827, DF= 3, P= 0.020). Further *post hoc* (Bonferroni correction, if P<0.0083, reject null hypothesis) shows the significant difference between the groups of chief officers and third officers (P= 0.006 Z= -2.725). In Figure 15, the majority of the third officers showed a distinct positive view on visual accuracy where the majority of the chief officers were reluctant to give a distinct view with moderate opinion instead.

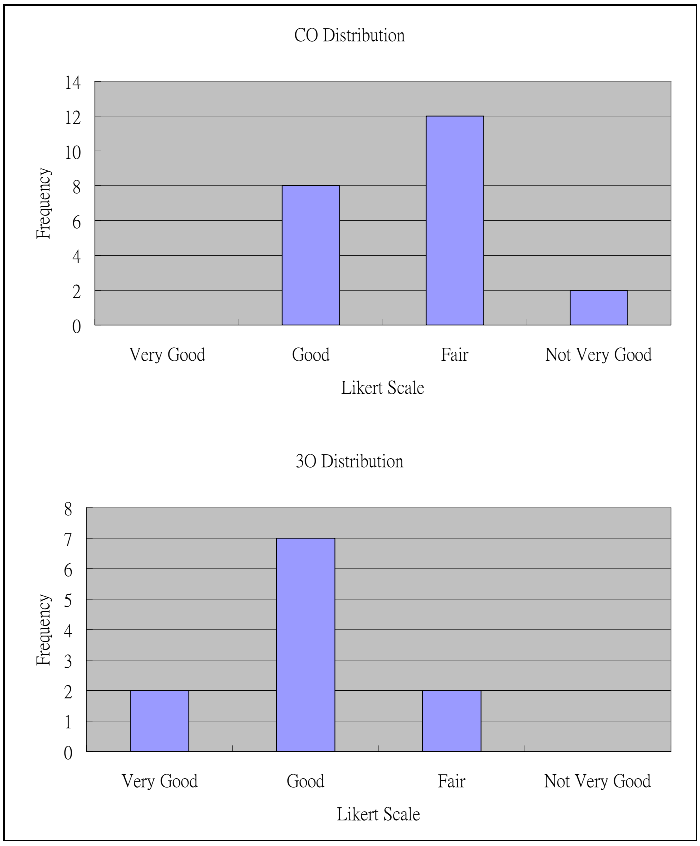

Figure 15 Frequency of view on visual/accuracy in chief officers and third officers

As there are a number of results showing connection between communication and AIS, most respondents (93.1%) thought they will take advantage of AIS identity to call for collision avoidance via VHF communication. In sight of the previous findings where 89% and 75% will use VHF in collision avoidance and in close quarter situation respectively, it is likely these interviewed respondents will deploy VHF more often to assist their manoeuvring mainly by means of prompt identification available from the AIS network.

Today, ships are under the guidance of the COLREGs with more advanced electronic equipment to provide more accurate information than before. Experience from the modification of COLREGs to take account of the important use of RADAR in collision avoidance indicates that AIS will have to prove its role good enough in ships navigation and manoeuvring if it is to be considered in a possible modification of COLREGs. No doubt, this will need a great consensus among the law makers, mariners, etc. In the survey, a hypothetical question was asked as to whether mariners would like to see COLREGs changed because of the use of AIS. More than half of the respondents thought the potential use of AIS will trigger the modification of the COLREGs. Among the respondents who gave answers (Figure 16), Rules 7, 8, 9 and 19 were voted (n>15) to be most likely to be affected.

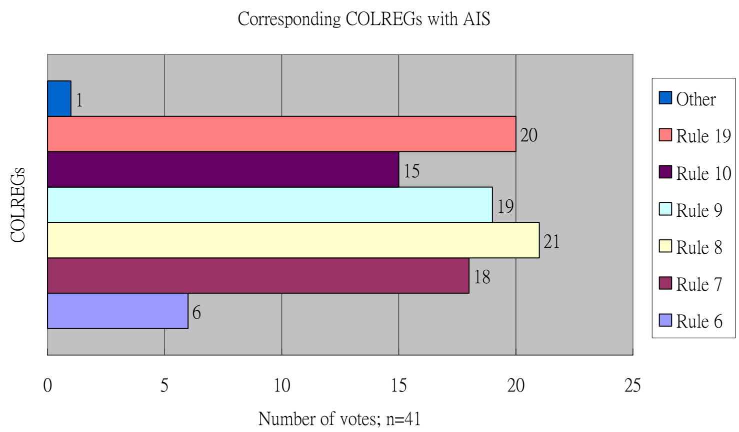

Figure 16 Polls for AIS corresponding rules in COLREGs

III　Summary of the survey result

The interviewees were diverse in their backgrounds and experience thus the survey gave widely differing opinions on the use of AIS for navigation. The survey was also timed to take place when AIS had been a carriage requirement on board every SOLAS ship since December 2004. It was found that the majority of respondents have operated AIS and most respondents have used or considered AIS in assisting collision avoidance. In the degree of useful of AIS applications on board, the respondents have seen AIS security measures as the most useful application from the other three possible functions, i.e. an aid for collision avoidance, position fixing and communication.

Before discussing the role of AIS as part of the lookout operation, there were a number of questions about the use of existing navigation aids, the use of VHF and the use of ARPA RADAR. Firstly, most respondents feel there are difficulties when using VHF calling to another ship in the vicinity. Moreover, respondents indicated that busy traffic and vessel identification are the two issues that cause most concern. Nevertheless, most respondents see AIS positively in assisting with communication and are therefore willing to use VHF voice radio to assist ship manoeuvring. Secondly, the ARPA RADAR has been recognised as the most important navigation aid for navigation and collision avoidance. Nevertheless, ARPA RADAR does have its limitations. The survey showed that the majority of respondents have a concern that there are limitations to target detection by RADAR especially sailing around a bend or meeting with a smaller boat or object at sea. Therefore, the extra identification and confirmation from AIS could be considered and applied to improve RADAR’s target detection and classification.

The meeting of asymmetrical types of ships at sea is another issue whilst on lookout. There is the alarming result that most respondents had concerns with the fishing boats regarding the COLREGs. In fact, many fishing boats are much smaller compared to the merchant vessels. Furthermore, a fishing boat exempted from the SOLAS Convention does not need to have AIS on board. The benefit for fitting AIS onboard non-SOLAS ships could be an alternative to increase target detection for boats with smaller size at sea.

The majority of ships that respondents were working on were ships built before the mandatory AIS carriage requirement. It is inevitable that MKD was the device displaying AIS information. The criticism arrived for the AIS MKD being user-unfriendly. An idea of overlaying AIS information into other bridge systems, such as RADAR and ECDIS was approved by the respondents. Besides, a number of literature had similar view on the operation of MKD on the bridge [10-13] Therefore, the AIS information should be made available on advanced and graphical display and the MKD at present should be treated as an interim device only.

As the original AIS carriage requirement was not due to have been accomplished on every SOLAS ship until 2008, the respondents have also taken part in the bringing forward of the latest carriage requirement. The longer/original time schedule would have left more time for the preparation of AIS fitting on board. Concern for national security regarding the maritime sector was fundamental to the plan for bringing forward AIS carriage requirement. Hence, more respondents believe that the reason to implement AIS earlier was due more to concern over maritime security measure than the application in navigation. Despite the focus on security, most respondents approved of the idea of training OOW in AIS use in ship manoeuvring and navigation.

Apart from the focus on maritime security and interim AIS displays, most respondents have started to take AIS into their daily work when on duty. Most respondents thought AIS is currently suitable as a navigational aid in collision avoidance. There are the disadvantages that not all vessels and objects on the sea carry

AIS[10]. AIS should not be relied on as a sole data source for the whole decision making of ship manoeuvring. By saying that, AIS can be an extra data support in order to improve situation awareness on the sea while working with ARPA RADAR.

With regard to situation awareness at sea, reading information from AIS was positively supported by respondents. The survey starts from an overview of AIS along with opinions on the present bridge operation. In the results, the respondents were generally familiar with the characteristics of AIS and also noticed advantages and disadvantages from operating AIS in navigation and ship manoeuvring. Theoretically, AIS can be a useful tool to enhance target detection, target tracking and target classification. Based on the findings, the clutter effect and blinding sector from RADAR detection do raise concern for OOWs. AIS can be applied to back RADAR up especially when the weather is deteriorating or where a target may be undetected behind a landmass by RADAR alone. Furthermore, AIS identification can also prevent target swapping on RADAR scanning which normally appears when two targets are very close to each other. As a result, there is a better chance of identifying an ambiguous target at sea with the assistance of AIS.

IV　Conclusion

There are a number of points which have been raised for consideration in AIS operation, and the following suggestions were addressed next,

1. AIS could promote more use of VHF voice radio;
2. Implication of AIS being focused on security measure than any other applications;
3. There are considerations for the use of AIS for navigation;
4. Different views were found in ranking officers;
5. Difficulties in understanding the intention of non-SOLAS ships;
6. AIS could build better situation awareness for the OOWs;

[10] AIS can be switched off by a master in some circumstances.

7. Idea of modification of AIS/COLREGs was not objected;
8. Integration of AIS into ARPA RADAR and ECDIS was recommended.

There are a number of messages sent by the OOWs from the survey results. Firstly, the respondents support AIS for the improvement of the navigation operation. However, the current carriage requirement and corresponding provisions have given an ambiguous message to the users. In fact, OOWs are simply handed a new bridge device without further mention of instruction or training. From Rule 5, COLREGs, any valuable information that can assist officer to clear doubts when manoeuvring shall be considered. So far, the role of AIS reaches no further than the provision of Rule 5, Look-out. Furthermore, the finding of a direct relation between AIS identification and VHF calling for collision avoidance should also be kept under review. Briefly, COLREGs shall be obeyed at all times and AIS/VHF voice radio shall not be abused in ship manoeuvring. In fact, the result reflected that officers would like to use VHF communication to sort out their difficulty in a close-quarter situation. Therefore, a balance between AIS providing more information and timing for AIS-VHF calling, need thorough discussion. AIS has gained consensus for navigational application among the OOWs despite the confusion on regulation and installation. AIS will be used as an improvement in situation awareness and future studies should aim to examine how AIS can contribute to safety at sea and navigation efficiency.

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