

Training and Technology Onboard Ship: How seafarers learned to use the shipboard Automatic Identification System (AIS)

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Executive Summary

This report is the first of a series which will focus upon seafarer training in relation to the introduction of shipboard technology as, and when, it occurs. The report focuses upon the universal introduction of AIS in December 2004 which provided the ideal opportunity to observe the extent to which training accompanies the introduction of new onboard technology. Prior to the conduct of interviews with seafarers about the training which accompanied the introduction of AIS, we attempted to ascertain the level of errors identified in relation to information transmitted using AIS and we treated this as an indicator of the competence of seafarers in relation to its use.

The report is based on data collected at three time points over a four year period (October 2004, October 2005 and October 2007). The report indicates the levels of errors in the use of AIS and how these levels varied over time. It also considers the extent to which AIS appears to encourage the “improper” use of VHF radio for collision avoidance and the implications of this for training. The use of VHF radio to negotiate collision avoidance between ships has long been held to be a problem by many agencies concerned with navigation, such as, the UK Maritime Coastguard Agency (MCA).

Errors in data transmission

- During the 2007 research period 3.5% of vessels transiting the South West (SW) lane of the Dover Strait transmitted errors in their AIS data. This was down from 7.9% in 2005, which in turn was down from 10.4% in 2004. These figures represent a statistically significant year on year improvement¹.
- The number of errors reduced in relation to all major categories of information transmitted in the period 2004.
- Of the errors transmitted, in each of the three years 2007, 2005, and 2004, the majority were in destination and draught data.

¹ At the 95% confidence level.

- Errors in identification data, i.e. MMSI number, call sign and ship name, increased between 2004 and 2005, but fell below the original 2004 levels in 2007.

AIS and VHF Radio

- Increased use is being made of VHF radio, and specifically for collision avoidance. In 2004, 11.5% of ships transiting the Strait initiated inter-ship calls, in 2005 this figure had increased to 17% and in 2007 this was up to 20.8%. This represents a statistically significant change from 2004.
- In 2007, 94.2% of inter-ship calls were for the purpose of collision avoidance, up from 89.4% in 2004.

Other findings

- There have been procedural changes in the way in which Coastguard operators take information from reporting vessels, which emphasises the use of AIS.
- An increased use of the AIS text facility was recorded.
- Ships were spontaneously indicating errors to each other via the AIS text facility and occasionally by VHF radio.
- Ships' officers were using the AIS text facility to conduct AIS self-test procedures.

Conclusion

Our data suggest that there has been a slow but clear learning process taking place in relation to the use of AIS. Vessel Traffic Services (VTS) operators further reported that ships' officers appeared to be more responsive to correcting errors when these were detected and brought to their attention. This was further borne out by analysis of text messages that indicated that many ships were pro-actively engaging in AIS self-test procedures. Moreover examples were identified of ships' officers spontaneously pointing out detected errors by radio and text message to other ships. The learning that has taken place has not only been limited to those onboard but is also reflected in the practice of Channel Navigation Information Service (CNIS) operators and the response of maritime authorities such as the MCA.

As part of this developmental process we have also witnessed the emergence of unanticipated practices, the ultimate significance of which remains unclear. Firstly,

the introduction of AIS has led to a significant increase in the use of VHF radio for the purpose of collision avoidance. This phenomenon has become significantly more common, despite the reissue of advice, by the UK MCA in 2006, that VHF radio should not generally be used for collision avoidance. Secondly, there is evidence of growing and widespread use of the AIS text facility, especially for inter-ship communication. The full significance of the emergence of this form of communication is still to be determined.

Further research needs to be undertaken to fully assess the learning process that appears to have taken place. This is the aim of the continuing over-arching project investigating training and technology. In particular, the ongoing research will seek to determine whether ships' crews have, through a process of use and informal learning, developed an enhanced appreciation of the system and developed ways of utilising its various features, or whether they have received formal structured training on board or ashore. Consideration will also be given to the external drivers of the process, i.e. those forces which have led to individuals and/or companies to enhance their performance.

Introduction

The application of new technology has long been utilised to achieve safety and or efficiency improvements. This is very much the case in the maritime industry with ships' bridges and engine control rooms regularly being fitted with new pieces of equipment, many of which seek to improve safe and efficient operations. Recent introductions have included ARPA radar, digital electronic charts, GMDSS, stability programmes, dynamic positioning systems and remote engine machinery monitoring and operating systems. Much new equipment is voluntarily introduced on board. In December 2004, however, an Automatic Identification System (AIS) was made mandatory for all merchant ships over 300 gross tonnes undertaking international voyages.

The effectiveness of such systems depends upon the competence of those who operate them. Nevertheless anecdotal evidence suggests that crews are often inadequately trained in the use of equipment installed aboard ships.² Indeed, in January 2008 it was reported that the severe listing of the passenger ship *Crown Princess* and the subsequent injury of 298 passengers in 2006, was due to “the inadequate training of crewmembers in the use of integrated navigation systems” (NTSB)³.

This report is based on research undertaken as part of a larger study to determine the extent to which crews receive appropriate training when new technology is introduced aboard ships. In particular, the study focuses on the case of AIS. In so doing, it raises questions in relation to maritime training more generally.

The AIS is an electronic system originally intended to improve the safety of navigation. Under the auspices of the International Maritime Organization (IMO) Safety of Life at Sea (SOLAS) convention a planned timetable was in place for the gradual and phased introduction of AIS to be fully implemented by 2007. However after the terrorist attacks of 9/11 the focus of attention changed and the system

² Pelecanos, S. (2004) 'The Human Element in Pilotage', *Alert*, Issue 3 April, p6.

³ NTSB News. January 10, 2008 SB-08-01 'CREW MISTAKES CAUSED HEELING OF CROWN PRINCESS CRUISE SHIP' <http://www.nts.gov/pressrel/2008/080110.html>

became more greatly valued in terms of its security benefits.⁴ Consequently the implementation date was brought forwards, with full implementation to be achieved by December 2004. Whilst maritime authorities have, in general,⁵ tended to focus on the technical issues of implementation and equipment design,⁶ less attention appears to have been given to the issue of operator training in the rush towards implementation.

⁴ Other uses for AIS have been advocated by different parties. For instance Sjöfartsverket promoted AIS at the IMO as necessary for the operation of Archipelago VTMS. Likewise the possibility for owners to track their vessels via the internet has been expounded as a benefit. Thanks to J.Earthy for pointing out these references.

⁵ The need to consider training is mentioned in MSC/Circ.1091, 6 June 2003.

⁶ See for example, *Fairplay Solutions* (2003) February, 24-25; International Maritime Organization (IMO) (2001) *Interim Guidelines for the presentation and Display of AIS Target Information*. London: SN/Circ 217. 11th July 2001; Transportation Research Board of the National Academies (2003) *Shipboard Automatic Identification System Displays: Meeting the Needs of Mariners*, Special Report 273, Washington DC.

AIS the System

The fundamental function of AIS is the automatic transmission of information by VHF radio between ships and between ships and shore stations. As a ship comes within range of another ship, or a shore station, the AIS automatically identifies the vessel on which it is stationed. This facilitates the earlier, and easier, identification of vessels than is possible using radars alone. The range of AIS is currently determined by the height of radio antennas, but the system could potentially be integrated into satellite systems to provide global coverage.

Figure 1: A typical AIS unit



The benefit of the 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 inventor, Dr Hakan Lans, identified the system's contribution to collision avoidance as the main

benefit to the maritime industry.⁷ 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. In order to achieve either objective the system needs to be effectively operated. In this report particular attention is given to its contribution to safer navigation via improved on-board situational awareness.⁸

The shipboard AIS system is basically a means for automatically and repeatedly transmitting differing types of information. These are:

1. Static information entered into the system when the AIS unit is installed.
 - MMSI number
 - IMO number
 - Call sign
 - Ship name
 - Length and beam
 - Type of ship
 - Location of position fixing antenna on the ship

2. Navigational data which principally derive from the onboard electronic navigational systems.
 - Position time stamp (UTC)
 - Course over ground
 - Speed over ground
 - Heading
 - Navigational Status
 - Rate of Turn

3. Voyage related information which must be entered at the start of each voyage.
 - Ship's draught
 - Hazardous cargo
 - Destination and ETA
 - Route Plan

AIS therefore has the capacity to improve situational awareness via the production of information that allows a clearer picture to emerge of which ships are in the vicinity,

⁷ *Digital Ship* (2004) October, 21

⁸ The contribution of AIS to navigation is becoming increasingly prominent, as demonstrated by a recent article in *Practical Boat Owner*, (June 2005, Issue No 462) a yachting magazine, which highlights the ready availability and benefits of AIS radar for small boat owners. See also Andrew Perry (2005) *Automatic Identification System (AIS) vs Radar*, The Journal of the Honourable Company of Master Mariners. Spring 2005, p.214-5. More importantly the International Maritime Organization (IMO) have recognised the potential of AIS for navigation and collision avoidance: see resolution A.917(22) as amended by A.956(23). For a recent update see MSC 80/3/7 (March 2005).

where they are heading, and what they are doing at any given moment. This is obviously important for both shore side authorities and ships' officers.

For the navigator on the ship's bridge, the ability to positively identify surrounding vessels by name and type, combined with the availability of voyage information and real time vessel movement information (such as course and speed), provides for an improved awareness of the developing navigational situation within which to make collision avoidance decisions. However, to make effective decisions on the basis of AIS data requires that the data transmitted are correct and that those receiving the information are able to interpret it correctly. This requires that the system has been correctly installed and is fully functional, and that additional equipment like the ship's compass and rate of turn indicator are operational and correctly integrated with the AIS unit. A failure of these systems could lead to incorrect navigational information being transmitted. Likewise, operator entered data must be correct. With reference to the latter, there are two points at which data entry errors can occur: firstly, at the time of installation when the technician enters static information such as IMO number; secondly, when voyage data is entered at the beginning of each voyage by the bridge officer.

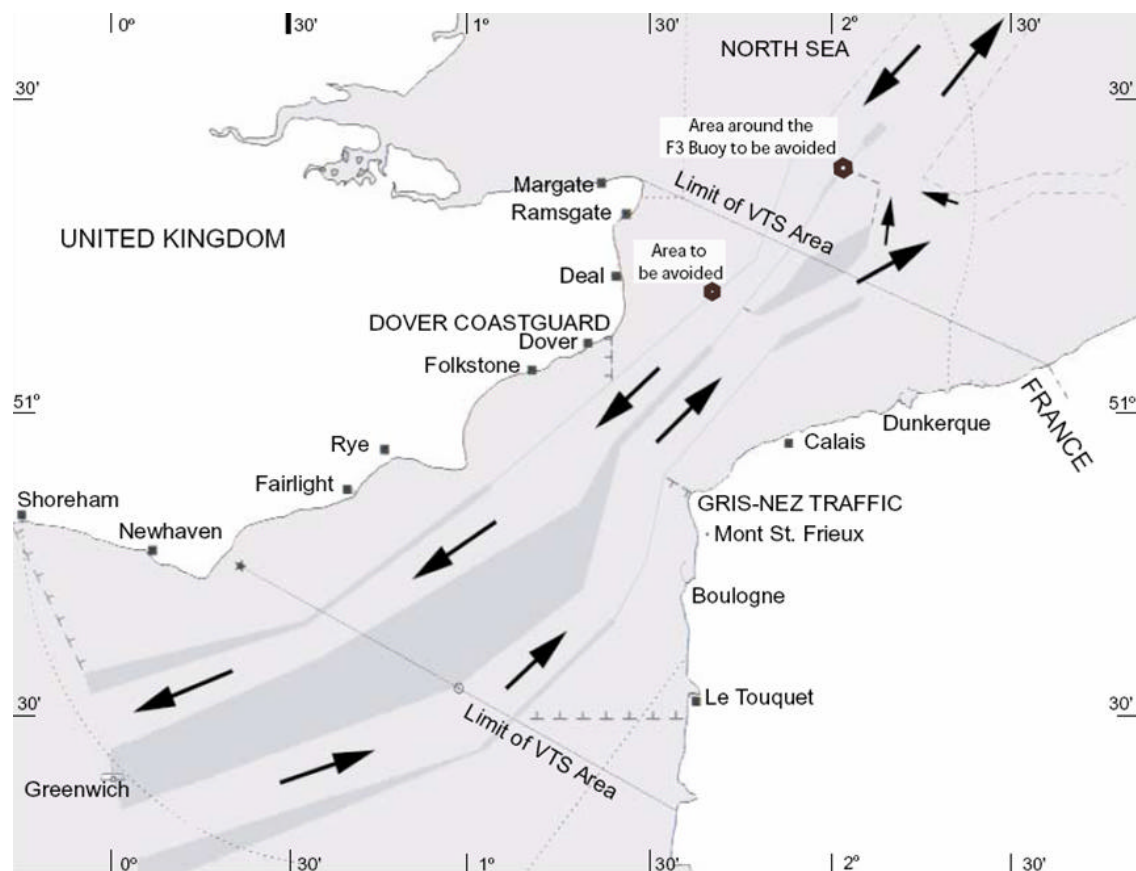
Assuming the data transmitted and received are correct, a navigator needs to know how best to utilise the information. To do so requires a basic understanding of the system and the basis of the information presented. In particular, the bridge officer requires an appreciation of potential errors, in order to appropriately assess any risk and to develop a suitable level of trust and confidence in the system. Moreover it is necessary for ships' officers to know how best to utilise the information received for the purpose of collision avoidance. None of these elements are intuitively obvious, but rather, we would argue, they need to be explicitly taught. Indeed there is growing evidence to suggest that there are problems emerging related to AIS, in terms of both equipment design and operator use.⁹ Hence, there may be a need for further training in this area.

⁹ For example, *Seaways* (2004) April, 24-25

The Research Site

The research was undertaken over a period of seven days at Dover Coastguard Channel Navigation Information Service (CNIS). Dover is one of the busiest shipping lanes in the world with up to 500 vessel movements a day. The Dover Strait consists of a relatively narrow body of water between the United Kingdom (UK) and France (Figure 1). It is principally demarcated by two shipping lanes which serve to separate vessels depending on the direction in which they are heading. Those ships proceeding South West stay on the UK side of the Strait, and those heading North East stay on the French side. All South West bound vessels transiting the Dover Strait report to Dover Coastguard. North East bound vessels report to the French authorities. The reporting area for the Dover Strait consists of a bounded area labelled “limits of VTS Area” on the map below (Figure 2).

Figure 2: The Dover Strait



The CNIS is operated 24 hours a day, 7 days a week, by four teams of 6/7 persons per watch. The watch team members are all highly trained maritime specialists. They

monitor vessel movements, provide navigational information and co-ordinate emergency response operations for vessels operating in the Strait. To facilitate the performance of these functions, all vessels operating within the South West bound lane of the Dover Strait are required to report to Dover Coastguard and to pass them specific information, including information which is also transmitted by AIS. Dover CNIS also operate radar tracking which is integrated with their AIS receiver and allows AIS data to be displayed on the radar screen.

Data Collection

The first phase of the research was undertaken between 16-23 October 2004 and a second data sweep took place in 2005. Following the introduction of new guidance on the use of VHF radio and AIS by the UK Maritime Coastguard Agency (MCA) in July 2006, a third round of data collection was carried out in 2007. For consistency, the data sweeps in 2005 and 2007 were conducted as close as practically possible to the 2004 dates.¹⁰

Data collection consisted of two distinct activities.

Firstly, with the availability of both AIS data and information transmitted verbally by VHF, as ships reported to Dover Coastguard (CNIS) it was possible to create a record of discrepancies between the two sets of information to ascertain the type and extent of errors that were being produced. This data was collected by the CNIS operators for a period of seven days as they spoke to each vessel in turn.

Secondly, two researchers, working 12 hours on / 12 hours off, provided 24 hour a day monitoring of VHF transmissions for a period of 7 days, between ships operating within the vicinity of the Dover Strait. The aim was to determine the extent to which ships' officers were using VHF to negotiate collision avoidance and to ascertain whether and how AIS was influencing behaviour. Inter-ship calling was monitored on VHF channel 16, the international calling channel, and calls were followed across working channels. Details of conversations were noted and later categorised according to their purpose. A radar set and computer were also made available for use by the researchers to aid the identification of vessels and to facilitate access to a database of ship details. Where vessels could be clearly identified, their details in terms of type of vessel and flag were also recorded. Because of a lack of clarity in the pronunciation of names and / or the quality of the signal and background noise, these details were not always available.

¹⁰ 4-11 October 2005 and 17-24 October 2007.

During each of the data collection periods, vessels were heard making calls where the proceedings were all conducted in a language other than English¹¹. These were not included in the data set. Likewise the researchers heard various survey and fisheries protection vessels regularly calling other ships. The decision was made not to record these calls, as they did not constitute typical examples of routine inter-ship calling and would have distorted the findings. Calls between fishing vessels and between yachts were similarly excluded. Hence the prevalence of inter-ship calling was actually more extensive than the data reported here.

Field-notes (written notes) recording discussions with operators and observations relating to procedure were also made during the period of the study.

¹¹ Most frequently these sounded like Eastern European languages.

Discrepant Information

An Overview

Dover CNIS produce a daily record of vessels operating in the South West (SW) bound traffic separation lane.¹² In 2004, during the week-long period of the study Dover operators recorded 806 SW bound and crossing ships. Of these, 84 vessels, i.e. approximately 1 in 10, were recorded as presenting differences between the data transmitted by AIS and that conveyed by VHF radio. From these 84 vessels, there were 122 discrete items of discrepant data transmission recorded.¹³ A year later, in 2005, the number of vessels recorded using the SW lane during the period of the research had increased from 806 in 2004 to 901. Of these 901 vessels, 71 (7.9%) transmitted errors in their AIS data. This consisted of 99 discrete items of discrepant information. Notably in 2007, there were over a hundred more ships (n=940) recorded using the SW lane than on the previous two occasions, but the percentage of ships transmitting errors was substantially lower at just 3.5% (Table 1).

Table 1: Numbers of vessels transmitting errors by year

Year	Total Number of Ships	Vessels Transmitting Errors	Percentage of Vessels Transmitting Errors	Number of Errors
2004	806	84	10.4%	122
2005	901	71	7.9%	99
2007	940	33	3.5%	44

Thus it is apparent that there has been a notable reduction in the overall number of errors transmitted. This would seem to suggest that ships' officers have become increasingly proficient / diligent in ensuring that information is entered correctly and that their equipment is kept updated. Based on the time spent in the control room listening to calls and from talking to the CNIS operators, the authors believe that this does indeed reflect the actual trend. However, a word of caution must be added in

¹² It also includes crossing vessels and some of the vessels using the NE bound lane.

¹³ Due to the varying workload of the operators the data collected probably represents a slight under recording of the actual instances of discrepancies.

relation to the 2007 data. From discussion with the CNIS operators it became apparent that the excitement of detecting errors had undergone a transformation. In 2004 operators were keen to point out even small errors in the AIS data, however in 2007 they were much more interested in technical anomalies in the system, such as ‘target swap’. Moreover it was noted that the form of communication between operators and ships had evolved to take account of the fact that the ships details were now readily available to the CNIS operators from the AIS. Thus, for instance, instead of asking a ship for its draught, the operator would state that ‘I see your draught is xx metres’. The onus would then be on the ship’s officer to confirm this or to point out the error. From the perspective of the CNIS operators the aim of this is to facilitate information transfer while also helping to make ships aware that the information is being used and thereby to encourage them to keep their systems up to date. However it does raise the issue of whether some ships’ officers may simply agree with the CNIS operator rather than draw attention to an error or lack of understanding¹⁴. Thus we have to accept that the figures may to some extent under-represent the actual number of errors transmitted.

To summarise, we can say with confidence that there was a clear fall in the number of errors transmitted in 2005 from 2004 and the data suggest that this trend continued in 2007. While the extent of the improvement in 2007 may be slightly exaggerated, evidence derived from analysis of VHF conversations and AIS text messages will be presented in the following sections to further support the claim that ships’ crews have become increasingly aware of the system and the need to keep it updated.

In the next section we will look in detail at the types of error transmitted.

¹⁴ We would like to thank Mike Toogood for drawing our attention to the latter point.

Types of Error Transmitted

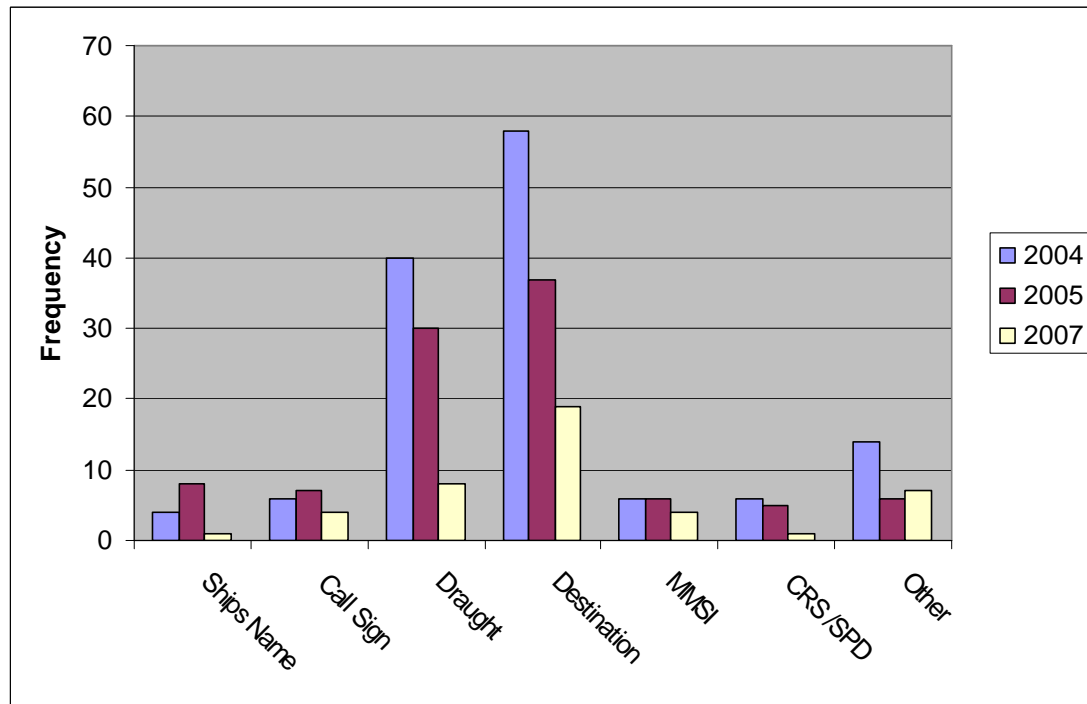
The types of discrepancies recorded related to the following types of information:

MMSI	A unique 9 digit number that is assigned to a ship's radio station.
Call sign	A unique combination of letters and numbers that identifies the ship and is assigned by the flag state. Call sign is often used during verbal communication for identifying a ship, MUP2, would be said over the radio as "Mike Uniform Papa Two".
Name	Every ship is given a name by its owner / operator. It is possible for several ships to have the same name.
Draught	The depth of water measured vertically from the waterline to the underside of the ships keel.
Destination	The place the ship is bound for.
Course / Speed	The ship's course and speed measured over the ground as input from a compass and global positioning system (GPS).
Other	This included comments inappropriately added to the 'ship' dialogue box, information in the wrong dialogue boxes, and missing or partial information.

The assumption made for the purpose of the study was that where information was discrepant, the verbally transmitted data was correct and that the AIS information was in error. Critical navigational information such as the vessel's draught and destination 'ought' to be readily available to the navigating officer when reporting to Dover and it is reasonable to assume that they 'should' communicate this accurately. Moreover, many of the discrepancies consisted of incorrect names or spelling, which clearly located the error as being with the AIS.

Figure 3 shows the actual numbers of each type of error for each of the three years when data were recorded.

Figure 3: Relative frequency of errors transmitted by year



It can be seen that in each of the three years the greatest number of instances of discrepant information transmission related to 'destination' data. Errors included: misspelling, empty data fields, unintelligible abbreviations and reference to the previous, rather than to destination, ports. Some of these apparent errors appeared to be due to lack of clear guidance as to the format in which destination information should be specified, i.e. should it be port name, country name or both, or should UN lo-code be used? Equally there seemed to be confusion as to what to do when the spelling of the destination requires more characters than were available on the AIS display. This latter point equally applied to the entry of ship name.

The second largest category of errors, again across all three years, related to draught data. The majority of discrepancies consisted of a difference of 1 metre or less, but there were cases where the difference was 3 metres or more. Indeed, in one case, a

tanker displayed a draught of 7 metres on their AIS but verbally reported a draught of 11 metres, which represents a significant difference in navigational terms. It is not clear whether these cases were indicative of a failure to update the system or of wrongly entered information. Either way, the fact that vessels were transmitting such critical navigational information in error must raise concerns.

Examples of errors relating to call sign, name and MMSI number consisted of misspelling and blank spaces. It was also pointed out by the operators that it was not unusual to see lewd comments appearing where these details should be. As one operator stated:

The information is often wrong; you see 'call signs' like 'f**k' or 's**t'. The technicians that set them up just enter crap.

(2004 Fieldnote)

It is perhaps surprising that there were any instances of error relating to ship identification, i.e. call sign, name and MMSI number, as this information is generally entered at 'set-up' when the system is installed. The fact of such errors thus raises further questions regarding the integrity and professionalism of those who installed the equipment and / or the access that others have to this level of data input. The fact that basic identifying information may be incorrect is clearly significant for shore-side authorities concerned with issues of security but also for any ship's officer seeking to establish contact with affected vessels.

A possible explanation for the initial level of errors in these categories of information is that with the rush to implement the AIS, installation technicians were not always as careful or proficient as they should have been in setting the systems up. Alternatively it could be that companies were relying on untrained ship staff to install the systems¹⁵ and so consequently errors were made. Notably, however, in 2005 the number of errors in the identification information showed a slight increase over 2004; this was at a time when the errors in the other categories of information were declining. This level of data may only be modified by password entry, which is generally unavailable to ship officers on board. Thus an explanation for the increase in discrepancies between 2004 and 2005 could be that as ships changed owner, flag or name, such details were not modified or updated. We should not make too much of this, however,

¹⁵ Evidence from shipboard field work provides support for this.

as the numbers are small and the variations are not statistically significant and indeed, numbers fell off again in 2007.

From the point of view of improved situational awareness and collision avoidance, it is significant that there were instances of course / speed information being incorrect. This information can be overlaid on a radar screen to produce a vector indicating a target ship's course and speed. 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 the instances observed the vector was 180 degrees out. Thus a vessel could have appeared to be going away from an observing ship, giving a bridge officer the sense that the target was not an immediate cause for concern, when in fact two vessels were proceeding towards each other. While these types of problem are now well documented and have been linked to interface problems with certain types of older Gyro compass,¹⁶ the inherent risk posed continues to exist as long as instances occur.

Finally, examples from the 'other' category included: the inappropriate addition of comments such as 'not under command' in the *ship type* field. In 2004 there was a case of a ship transmitting a 'Mayday' message via the text facility when there was no distress. Even after Dover Coastguard had responded to the latter message, the vessel continued to transmit it. This may suggest that the crew were insufficiently competent in the use of the system to know how to stop the transmission. Interestingly in 2007, the very first conversation the researchers heard was Dover Coastguard dealing with a ship inappropriately transmitting a 'Mayday' by the text facility. The ship's captain when contacted by the coastguard claimed the equipment had experienced an 'electrical' problem.

In summary, from Figure 2, it can be seen that errors in draught and destination information constituted the largest groupings in each of three years. However Figure 2 shows a clear trend, with the numbers in each of these categories reducing for each of the three years. Ships' officers are responsible for the entry of this information, updating it each time the vessel leaves port. Thus it could reasonably be argued that the officers have become more competent / diligent in performing this task as a result

¹⁶ See for example UK, MCA MGN 324 (M+F) *Radio: Operational Guidance on the Use of VHF Radio and Automatic Identification Systems (AIS) at sea. UK, MCA July 2006.*

of a process of learning either due to (1) having received training in the operation of the equipment or (2) through increased familiarity with the equipment. Likewise greater awareness of the need to correctly enter the data due to modified bridge procedures or from publicity surrounding research into this issue and prompts from the coastguard and other authorities, may have led to increased diligence and reduced numbers of errors.

Additional Issues

In 2004, discussions with CNIS operators identified several other problem areas, and these and additional problems were found to persist in 2005 and 2007.

A problem associated with radar derived data is a phenomenon known as ‘target swap’. When two vessels pass close to each other it is possible for the symbology (and associated information) relating to one vessel, e.g. the vector indicating course and speed, to swap to the passing ship. This can introduce an element of confusion into decision making processes. An advantage of AIS is that this should not happen, yet CNIS operators reported witnessing this taking place. In the reported example, the AIS symbology and information from a car carrier, presented on the CNIS radar screen, was seen to have attached itself to another vessel of a different type, while also continuing to be displayed in association with the car carrier. Several instances of this phenomenon were pointed out by the CNIS operators and observed by the researchers in 2007.

A further possible source of confusion was identified by the CNIS operators. At installation the co-ordinates of aerials are entered into the system in relation to GPS units. Although password protected, it is possible for authorised personnel with access to a password to change these settings. By changing the offsets it is possible (accidentally or intentionally) to create the effect of locating the displayed ship AIS symbology at a distance from the ship itself. Such cases had been observed by the CNIS operators; in one instance the symbology was a distance of 2 miles from the ship. The effect of such an offset could lead an observer to believe that another vessel

is present but not detected by radar. Such an effect could be particularly problematic in poor weather conditions.

In 2007 the operators drew the researchers' attention to the case of a ship's AIS that was continually polling between two different positions, locating the ship alternately in a south coast port in the UK and in the port of Dunkirk, France. A further reported case involved a ship that suffered a power loss to its AIS unit. When the power was restored the system reportedly reverted to former settings including prior name and other identification details.

These findings from the first part of the research demonstrate that there are ongoing technical issues associated with the data transmitted by AIS, and that many of these might be resolved with better use of training.

AIS and its impact upon the use of VHF Radio

To ascertain the extent to which VHF radio was being used for the purpose of collision avoidance activity and whether this was influenced by the introduction of AIS, the researchers monitored VHF radio channel 16 (the calling channel) continually for 7 days and followed inter-ship conversations to working channels.¹⁷ The coverage area was determined by the range of the VHF antennae and coincided, more or less, with the whole of the 'VTS Area', including both traffic lanes, demarcated in Figure 2.¹⁸

We calculated the numbers of vessel movements in the Dover Strait during the research period¹⁹ in each of the years 2004, 2005 and 2007. We then compared these figures with the numbers of recorded inter-ship VHF calls during the same periods to determine the percentage of ships initiating calls. The results can be seen in Table 2.

Table 2: Numbers of ships and frequencies of calls by year

Year	Number of ships	Number of calls	Percentage of ships calling
2007	2808	583	20.8%
2005	2754	519	18.8%
2004	2634	329	12.5%

As can be seen from the table, in 2004 12.5% of ships operating within the vicinity of the Dover Strait were found to have initiated inter-ship VHF calls. By 2005 this figure had risen to 18.8%, representing a statistically significant increase in the number of

¹⁷ It was not always possible to hear the content of conversation on working channels due to the range of the aerial in use.

¹⁸ The area of coverage of the radio array at Dover CNIS coincides closely with the VTS Area identified.

¹⁹ We have arrived at these estimates as follows. Taking 2004 as the example, 806 vessels were recorded by Dover proceeding through the SW lanes departing the Southern North Sea. We assumed that similar numbers of vessels were proceeding in a North East direction entering the Southern North Sea, giving a figure of 1612 vessels transiting the Dover Strait during the week of the study. In addition, ferry movements which were not recorded by Dover needed to be included. There were approximately 146 ferry (including catamaran) movements per day within Dover or 1022 vessel movements a week. Thereby we arrived at an approximation of 2634 vessel movements in the Strait during the week of the study.

ships using VHF for inter-ship calling. The figures for 2007 showed a further increase, with 20.8% of ships making an inter-ship VHF call.

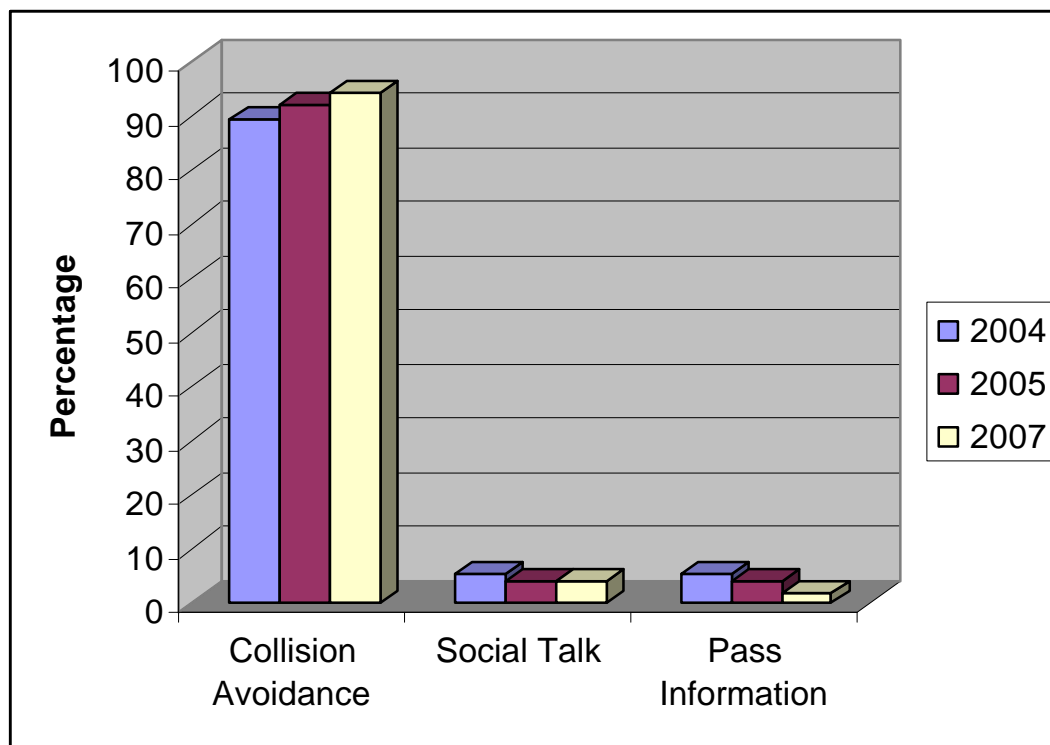
As far as possible the VHF calls were recorded by the researchers and categorised according to their main purpose. The three categories to emerge from the data were ‘collision avoidance’, ‘social talk’ (i.e. to talk to friends), and ‘passing information’ (e.g. that a navigation light was out). For each year the purpose of the calls was determined in approximately 75% of cases. As a corollary, for each year in approximately a quarter of cases the purpose was not determined. The reason for this varied, but included such factors as: no response to the initial call, that the follow-up conversation was not heard, and that the speakers changed to a language not understood by the researchers. The numbers of each type of call and the relative percentage by year are shown in Table 3.

Table 3: Purpose of Calls by Year

Year	Total calls	Purpose determined	Collision Avoidance	Social	Pass Information
2007	583	76.3% (n=445)	94.2% (n=419)	4.0% (n=18)	1.8% (n=8)
2005	519	74.8% (n=388)	92.0% (n=357)	3.9% (n=15)	4.1% (n=16)
2004	329	74.5% (n=245)	89.4% (n=219)	5.3% (n=13)	5.3% (n=13)

The numbers of recorded calls rose significantly over the three years, and the vast majority were for the purpose of collision avoidance. Although there were only relatively small numbers of ships calling to pass information and to engage in social talk, there was a statistically significant variation in the overall distribution of calls between 2004 and 2007. What we saw was an increase in the number of calls for the purpose of collision avoidance and a reduction in those concerned with passing information. This can be seen graphically in Figure 4.

Figure 4: Purpose of Inter-ship VHF Calls by Year



The distribution of calling between the hours of daylight and darkness can be seen in Table 4.

Table 4: Distribution of calls between Day and Night

Year	Purpose of Call	Day	Night	Total
2004	<i>Collision avoidance</i>	44.7%	55.3%	100%
	Pass information	30.8%	69.2%	100%
	Social call	53.8%	46.2%	100%
	Overall Distribution of Calls	45.3%	54.7%	100%
2005	<i>Collision avoidance</i>	46.8%	53.2%	100%
	Pass information	37.5%	62.5%	100%
	Social call	66.7%	33.3%	100%
	Overall Distribution of Calls	49.9%	50.1%	100%
2007	<i>Collision avoidance</i>	42.5%	57.5%	100%
	Pass information	62.5%	37.5%	100%
	Social call	38.9%	61.1%	100%
	Overall Distribution of Calls	42.4%	57.6%	100%

There tended to be more calls made at night and, in particular, a greater proportion of calls concerning collision avoidance (see Table 4).

The availability of ship's name

Traditionally, when a vessel needed to contact another, seafarers would usually call by giving the position of the vessel to be contacted either in geographic terms or by reference to a landmark or to themselves. Such calls would typically take the following form, as demonstrated in this example recorded during the research period.

North East bound vessel, North East bound vessel, your approximate coordinates are fifty one degrees thirty eight minutes north, longitude zero zero one degrees, forty seven minutes east; I repeat, zero zero one degrees, forty seven minutes east; approximately steering zero four five degrees; speed fifteen knots. This is the vessel on your port bow, distance three point four miles. Do you copy? Over.

This is clearly a long and laborious process, especially as a caller may well have to repeat this information several times before getting a response. By contrast, being able to positively identify another vessel by name is clearly much easier and more succinct, for example:

Gloria Estefan, Gloria Estefan, this is the Bruce Springsteen. Do you copy?

Initially, the instances where one ship could call another by name were limited to those situations where they were close enough to visually read the name of the other ship, or where they were calling a known ship. With the advent of AIS such 'name information' has become readily available to ship officers even when the vessel itself is not in sight, which has made calling other vessels by VHF more precise and much easier. In the case of the research it was found that the majority of vessels using VHF for inter-ship communication were using *vessel name* as the primary means of identification.

In 2004, just prior to the deadline for full implementation of AIS, in the majority of the cases which came to our attention (88.3%), calling vessels identified others by name. Moreover calling took place during the hours of darkness more often than in daylight when it would not, in general, be possible to read another ship's name. Hence it is safe to conclude that ships were deriving this information from AIS. Ships'

officers appeared to be utilising the AIS information to identify ships in their vicinity to call up.²⁰ In 2005 this figure had increased, with 95.3% of ships using ‘name’ to identify the ship being called. While in 2007 the practice of using ship names to identify other vessels had become almost universal with 98.6% of callers using name. This represents a statistically significant change from 2004.

This suggests that AIS has had a considerable impact upon behaviour, insofar as individuals when attempting to contact another vessel no longer make long broadcasts referencing their relative or geographical position. In this respect it can be seen as having a positive effect in reducing the length of transmissions and potentially keeping the airwaves free for essential calls.

When we considered the success rate of calls we found that the overall rate had not significantly changed between 2004 and 2007. Moreover there was no significant change in the level of success achieved in making contact using name. However, interestingly, where name was not used there had been a marked decline in the level of successful contact observed, as can be seen in Table 5.

Table 5: Rate of successful VHF contact by year

Rate of successful VHF contact	2004	2005	2007
Overall Rate	83.4%	81.6%	84.9%
Using name as identifier	84.9%	82.6%	85.3%
Not using name	70.3%	54.5%	50.0%

The observed decline in success rate, when name was not used, could possibly be due to ships’ officers anticipating hearing their ship’s name and no longer being as well attuned to listen for someone calling them by reference to their position. As a consequence it is conceivable that a ship could miss an urgent call from a small vessel not fitted with AIS, such as a yacht or fishing boat, or other vessel with a non-

²⁰ There are no records of numbers of ships calling each other before the introduction of AIS for comparison with our data. A follow up study to this research is intended to determine whether AIS and VHF usage change over time as officers become more familiar with the equipment.

operational AIS unit. We need to bear in mind however that the number of callers not using name is small and so we should not read too much into these figures.

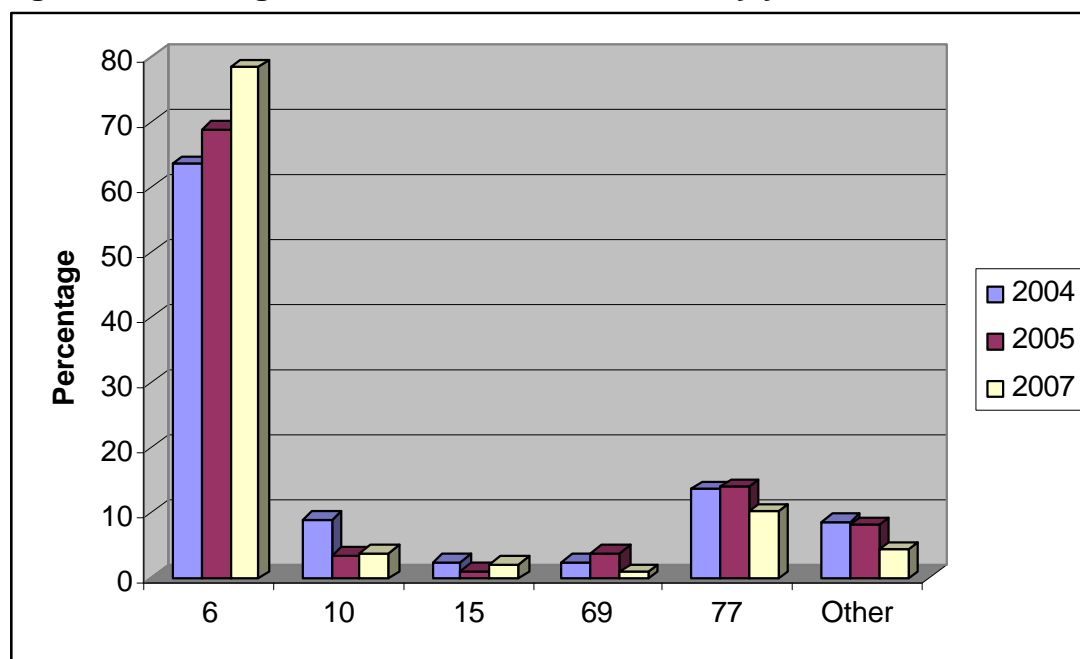
Once contact had been made, in 2004, 75.2% of callers moved to a working channel. In 2005, this figure had improved slightly with 80.6% changing to a working channel, and in 2007 was better still with 85.7% of callers conducting their conversation on a working channel. The most frequently used channels were channels 06 and 77 (see Table 6).

Table 6: Percentage of Calls per VHF Working Channel Used

Year	Ch06	Ch10	Ch15	Ch 69	Ch 77	Other
2004	63.6%	9.1%	2.5%	2.5%	13.6%	8.7%
2005	68.9%	3.6%	1.2%	3.9%	14.1%	8.3%
2007	78.4%	3.9%	2.2%	1.0%	10.2%	4.3%

Notably channel 06 became more popular over the three years considered, while the other main channels tended to be used less frequently in 2007 than in 2004. This can be seen more clearly in Figure 5.

Figure 5: Working channels used for VHF calls by year



With the increased use of a single channel, i.e. channel 06 there is clearly a greater risk that conversations will be over-spoken or broken due to interference from other stations. This is of significance when the majority of conversations are concerned with collision avoidance.

We have shown that AIS has had an impact upon shipboard behaviour with ships' officers making use of the availability of other ships' names when attempting to contact them by VHF radio. In addition, we have shown that there was a statistically significant increase in the number of VHF calls between the introduction of AIS, in 2004, and, 2007. Following the analysis of data in 2004 we argued the fact that 12.5% of ships initiated inter-ship calls was highly significant (see Bailey 2005), especially when the ships that responded to being called were also taken into account. In 2004 this amounted to 544 instances of a vessel operating within the Dover Strait, during the week of the study, participating in an inter-ship VHF call. In 2007, these figures had increased significantly with some 20% of ships in the vicinity of the Strait initiating 583 calls of which 491 were recorded as successful. Thus taking into account those vessels that responded to the calls in 2007 there were 982 recorded instances of ships participating in an inter-ship VHF call, 1.8 times as many as the same period in 2004. Importantly, the overwhelming majority of these calls were for the purpose of collision avoidance. Analysis of the conversational exchanges between ships was carried out, and some key points emerged in relation to the way in which AIS was actually utilised in collision avoidance situations.

AIS and Situational Awareness: An analysis of conversations

Knowledge of the destination and draught of nearby vessels may aid the bridge officer in making navigational decisions. Knowledge of another ship's destination can potentially be useful when considering which side to overtake. If, for example, an overtaking vessel is aware that the ship to be overtaken is liable to be making an alteration to starboard in the near future, then other things being equal overtaking on the port side may seem the prudent manoeuvre.

Further scenarios can equally be envisaged involving vessels approaching course alteration points within traffic routes, and between vessels following traffic separation lanes and those externally approaching the lane - where it is unclear as to whether they intended to join or cross the lane. In each case access to destination information could benefit the navigational decision.

Although draught information is less immediately connected to how a vessel will act, it is possible to construct scenarios in which draught information could equally aid decision making. For example, consider two or more vessels approaching a junction in a traffic scheme where the lane divides providing the option to follow a deep water route. In such a situation awareness of a vessel's draught, particularly when combined with knowledge of ship type and destination, could usefully serve as a guide as to whether a vessel is liable to use a particular route.

With AIS, this information is easily and readily available to the navigator directly from their onboard system. Nonetheless the research found in 2004 and 2005 that in exactly the scenarios described, navigators continued to use VHF to request such information, as demonstrated in the following recorded exchanges. However as will be shown, a transformation appears to have taken place between 2005 and 2007.

Example 1

Ship x: Where is your destination?
 Ship y: We are going to Rotterdam, we will alter course in a few minutes.
 Ship x: Roger, we will pass on your port side. (2004, # 272)

Example 2

Ship p: Good morning sir, right now what is your destination please?
 Ship q: Amsterdam, what is your intention sir?
 Ship p: I will overtake you on port side. (2005, #481)

Likewise, requests for routing information related to draught were also recorded, as the following two examples show.

Example 3

Will you use the Deep Water Route? (2004, #100)

Example 4

What's your intention sir, are you going to follow the Deep Water Route? (2005, #68)

In each of these cases knowledge of another vessel's destination and / or draught can serve to aid the decision process, as example 5 illustrates.

Example 5

Ship V: Can you tell me please will you be going straight or altering to starboard for Wandelaar?
 Ship M: I will be going to starboard, you will be going straight using the Deep Water Route?
 Ship V: Yes, I will be going straight
 Ship M: In that case I will go astern of you.
 Ship V: Yes it is better you alter to starboard now, so you can go astern of me and I will alter a little to port.
 Ship M: Yes that will be very nice.
 Ship V: Thank you very much. (2007, #77)

Clearly, then, the availability of this data has the potential to benefit the navigator through improved situational awareness and so reduce the need for VHF calling. In 2004 ships routinely called up and requested this information. In 2005 while it was still routinely requested, ships were clearly aware of the AIS information as the following extract demonstrates:

Example 6

I see on your AIS you are bound for Felixstowe, can you tell me where you will cross the SW lane? (2005, #394)

However, despite the confidence shown by the above caller, in general ships' navigators tended to adopt a more questioning or confirmation seeking form of discourse. This may suggest that they lacked some degree of confidence in the information available and so adopted a cautious approach to its use, as the following extract from a recorded conversation illustrates:

Example 7

I can see you are going to Antwerp, is that correct? (2005, #375)

Notably analysis of the conversations recorded in 2007 revealed a very different picture. While a few examples were still found of direct requests for destination

information in 2007, in general they were notable by their absence. Rather what we found was instances of officers using the information as in the following:

Examples 8 & 9

Ship M: What's your intention?

Ship P: I'd like to pass ahead of you; you're bound to Rotterdam according to your AIS, so you will join us to the East. (2007, #488)

And again,

Ship R: I am going to come a little to the right

Ship K: That's not a problem, I see you on AIS, so long as you don't come too close. (2007, #514)

What we see in these examples is that ships' officers are no longer requesting basic information that may be derived from AIS, but rather are incorporating AIS data as elements in their decisions making. This suggests that officers were both more aware of the availability of this information and had gained confidence in its reliability. The increasing awareness of the system further revealed itself in as much as in 2005, and 2007, a small number of instances recorded of ships' officers pointing out to each other that their AIS was not working, or that their destination information, for example, was incorrect, as the following examples illustrate:

Ship R: Just for information Zeebrugge is other side, you are going to Felixstowe on your AIS.

Ship T: Thank you. (2007, #322).

This type of instructional or corrective activity was found to be even more prevalent in 2007 when we examined the use of AIS text messaging, and will be discussed fully in the next section. Thus to summarise, the numbers of VHF calls in 2007 was up on 2005, and AIS was clearly the system that facilitated this process. However changes were noted in the way the types of calls being made²¹. Specifically, officers were no longer explicitly requesting destination information. This suggests that this information is now being taken directly from AIS and used with increasing confidence. Indeed, other recorded conversations clearly indicated that AIS is being used to inform situational awareness, and as a basis of navigational decisions.

²¹ Detailed examination of the use of VHF radio in relation to collision avoidance will be presented in a separate report.

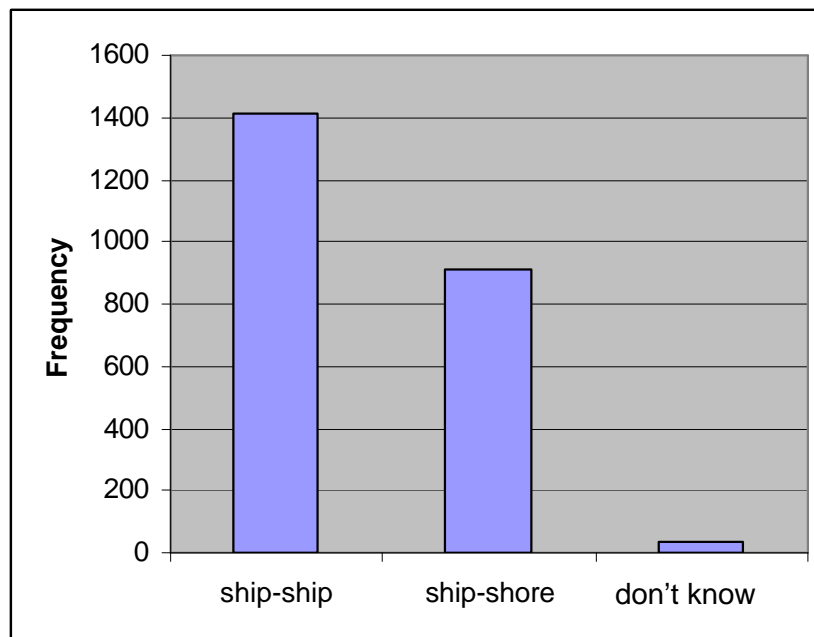
AIS and Texting

An additional feature of AIS is the facility to send text messages to other radio stations. In 2004 and 2005 although the CNIS operators mentioned that they occasionally saw text messages being transmitted, the researchers did not record any cases and it was perceived to be a rare phenomenon. However in 2007 the researchers became aware that there was a constant stream of text messages appearing on their radar screens. When the text history was later investigated the researchers were able to download the messages that had been received over a 10 week period. There were some 2357 texts messages stored that had been transmitted by ships and coastal stations in the vicinity of the Dover Strait. Although many of these messages were communications between ship and shore, the equipment at Dover Coastguard appeared to have been receiving inter-ship text messages. It is not known what proportion this represents of all inter-ship messages transmitted during this period, but the availability of these messages for the purpose of analysis provides valuable insight into how the system is being used.

The 2357 texts emanated from just 493 different stations. What was most notable in reading the messages was the high number of messages that were sent multiple times. Messages were commonly sent four or more times, with several sent 17 times and one sent 36 times. When we removed the (1118) repeated messages there were 1239 discrete messages, including replies. Thus almost half the messages were repeats.

From analysis of the message contents, the texts were categorised as to whether they were communications with a shore station or between two ships. The majority were seen to be inter-ship messages (Figure 6).

Figure 6: Frequency of ship-shore and ship-ship text communications



Further analysis of the contents of the texts was undertaken to identify how the messages were being used. From the analysis the following categories emerged.

1. Instructions / Queries.

These were generally messages giving an instruction to call a particular station, be it another ship or the coastguard.

2. The Passing of Information.

This category of message primarily communicated operational information, such as the number of persons onboard.

3. General Exchange.

General exchanges often involved a simple “OK”, “THANKS” or “RECEIVED” or “HAVE A GOOD VOYAGE”, “GOOD WATCH”, etc.²² Others were more involved and included requests about the nationality of the crew, whether a particular person was onboard or involved conveying greetings and salutations, as for example: “WHAT IS

²² Many responses in this category took the simple form of “OK” or “received” and may have been in response to test messages, but where the content of the message being acknowledged was not apparent they were categorised in this section rather than under 4 –test message.

NAME OF CH MATE” or “GUD PM TO 3M (NAME) & 2M (NAME)! RGARDS (NAME)”.

4. Test Messages and their Acknowledgements.

Test messages were used to ensure that AIS data was being received by other stations and were typically of the form “THIS IS AIS TEST PLS REPLY THKS BRGS” or “AIS TEST! PLS ACKN! THANKS!” while acknowledgements took the form of “ALL RECEIVED” or “TEST MSG RECVD WELL, TKS”.

5. AIS Related Errors.

There were several instances of ships and shore stations calling up to inform a ship that their AIS details were incorrect or incomplete. The following represent the sort of message sent – “TRY CHECKING YOUR AIS DATA...WRONG INFO” or most commonly “CHECK YR NAV STATUS BRGRDS”. Others were slightly more sarcastic such as “WHERE RU GOING. ZEEBRUGGE IS TO STBD”.

6. Collision Avoidance

Messages relating to collision generally took several forms as the following examples illustrate. Some messages alerted others to action to be taken: “GD EVENING I LIKE TO OVERTAKE YOU ON PORT SIDE. PLS KEEP CURSE AND SPEED. THANKS /BON VOYAGE”. Messages relating to overtaking manoeuvres were the most common, but there were also references to other types of situation as in this example: “GOING TO CROSS YOUR BOW”. Other messages were in a more tentative form suggesting the wish to agree a course of action, as these two unrelated examples show: “HI! WHAT IS YR INTESION?” or “GREEN TO GREEN PLS”. There were several instances of messages intended to alert another vessel to the fact that they were in close proximity. For example: “YOU ARE COMING TOO CLOSE. WILL ALTER 255 IN FEW MIN.” and “KEEP SAFE DISTANCE!!!” Others were more critical and expressed annoyance at perceived inappropriate action, as the following examples illustrate, in increasingly strong terms: “WHAT ABT COLREG”; “STUDY UR REGULATION”; “CONGRATULATION. WHERE DID YOU FOUND YOUR LICENCE.”; “IDIOT!”; “YOU ARE AN ASS*****”.

7. Emergency Messages

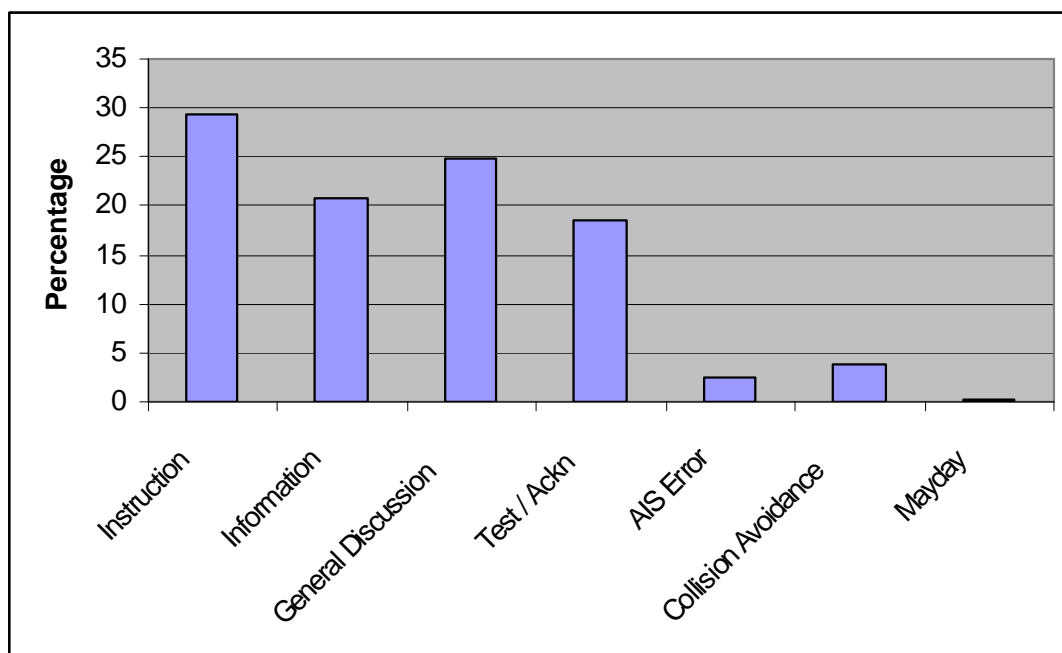
Additionally a couple of cases were recorded of ‘Mayday’ messages being transmitted.

8. Undetermined

This category included messages that made no obvious sense and a large number that were in a language other than English and so could not be readily understood by the researchers. Some foreign language messages had key words or phrases that the researcher took as indicative of the general meaning such as ‘AISTest’, where this was the case they were included in the appropriate category.

In Figure 7, we can see the relative proportions of the different categories of message where the content was determined. There were some 536 messages where the content was not understood of which 499 were in a language other than English.

Figure 7: Types of message sent by percentage

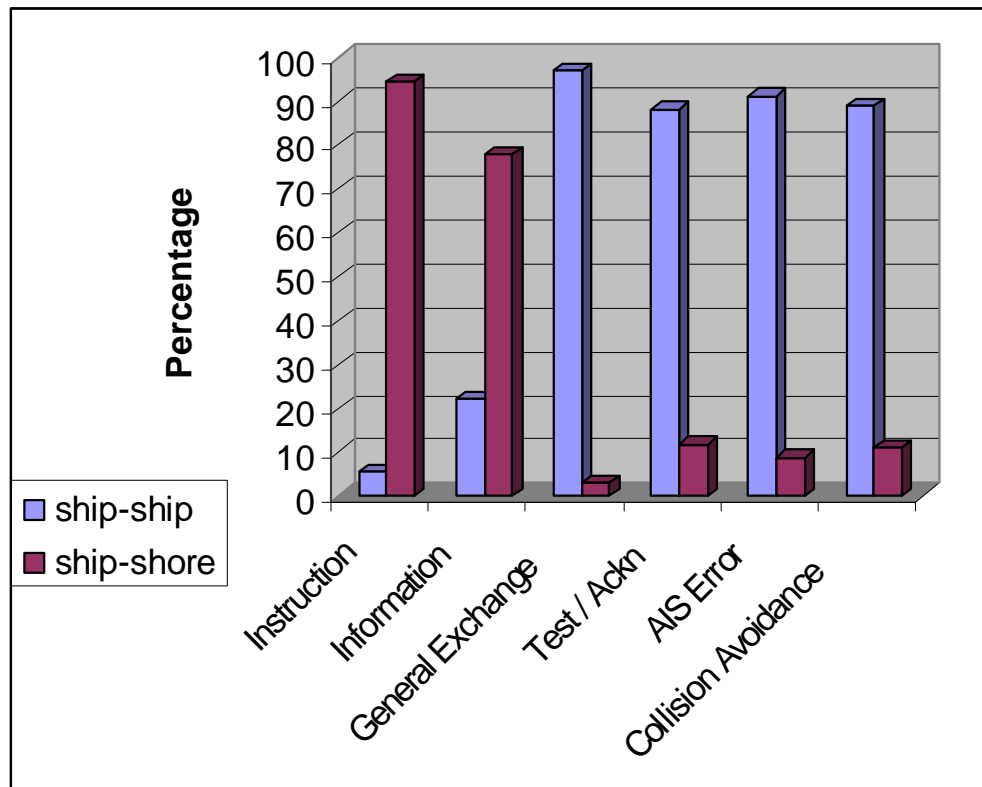


From Figure 7, it can be seen that those messages conveying instructions constituted the largest category and represented almost a third (29.3%) of all message types. As noted above, these messages tended to take the form of: “call station (A) on VHF channel (Y)”. Those categorised as general discussion represented almost a quarter

(24.8%) of the total messages transmitted, while those specifically concerned with the transmission of information made up a further 20.7%. The remaining 25% of messages consisted primarily of test messages (18.5%), with individual reports of errors in AIS data making up (2.5%), collision avoidance messages (3.9%) and two emergency 'Mayday' messages (0.2%).

When we looked in detail at how the different categories of message were distributed by the types of station involved in the exchange, we saw that there were clear differences in the messages going back and forth between ships and shore stations as compared to those being sent between ships. As can be seen (Figure 8), of the messages concerned with communicating instructions or the passing of information the majority were between ships and shore stations. This is not really surprising given that the area in which the ships were operating was covered by a mandatory reporting zone and also included several ports. Hence these two categories of messages predominantly related to the need to make official reports to VTS centres and local port control authorities and to pass information such as draught and numbers of persons onboard etc. By contrast, it can be seen (Figure 8) that the majority of 'AIS tests' were conducted between ships rather than between ships and coast stations and it was other ships that tended to report instances of errors in AIS to each other – although VTS stations would also generally do this by VHF radio as ships reported in to them. Notably a small percentage of messages relating to collision avoidance were initiated by coastal stations that were monitoring ship movements.

Figure 8²³: Types of message sent ship-shore and ship-ship by percentage



A final observation from the analysis of the text messages which may have already struck the reader is that many of the authors of the messages made use of an abbreviated text language which varied between individuals. What is not apparent to the authors is the extent and nature of the variability. That is, is this entirely an individual matter or do certain groups, e.g. do those within the same company or of the same nationality abbreviate in similar ways? Equally, do those messages composed in languages other than English similarly contain abbreviated forms? This is a topic that may bear further investigation.

In summary, we have seen that text messaging has increased significantly over the period of the study. This facility is clearly being used as another means to transmit basic voyage and ship information messages to shore-side authorities, but it is also being used for general non-essential communication between ships. Equally however, the fact that test messages are being sent between ships and individuals are

²³ The instances of Mayday are all generated by ships and have been left out of this table for reasons of space and clarity.

spontaneously pointing out errors in others AIS data to them, points to an increased awareness of the system and a level of pro-active self monitoring. Moreover increased use of this facility demonstrates growing confidence in, and awareness of, the system as a whole.

On the downside, there is clearly an issue as to whether ships' navigators should be spending their time writing text messages, especially when they are simply for personal communications, as presumably this is taking place while they are on watch in one of the world's busiest stretches of water. Moreover, while the number of messages being sent relating to collision avoidance is small, the fact that ships are using this form of communication for such activity at all must be cause for concern. Interestingly analysis of the messages revealed that two cross channel ferries were texting other merchant ships asking them to call on channel 16. In the context of crossing busy shipping lanes, it can be asked whether this is the most appropriate way for these officers to be spending their time.

Finally, within the sample of messages analysed, there were several ships that transmitted messages referring to incorrect AIS heading information, including one with the following content: "CHECK YOUR AIS HEADING. IT IS VERY DIFFERENT FROM YOUR COG". This message was followed with the reply "COG IS WIND AND TIDE". As the response indicates, a ship's course over the ground may indeed be different to its compass (AIS) heading, because of the influence of wind and tide. Thus the respondent appears to be suggesting that the author of the original message lacked an appropriate understanding of this basic navigational concept.

Conclusion and Recommendations

For the inventor of AIS, the intended purpose of the system was to contribute to improved situational awareness for shore-side authorities and ships' officers. The usefulness of the system, however, is dependent upon operator competence, technical adequacy and the transmission of accurate information. The data that has been presented is pertinent to each of these issues. Between the implementation of AIS in December 2004 and our latest data sweep in October 2007, we have seen a process of change, learning and improved awareness in relation to the operation and use of the system.

In 2004, we identified relatively high levels of error in the data being transmitted. The different types of errors detected raised questions about the level of competence of those operating the system and also the technical adequacy of the system. As such, this brought into question the level of confidence that could be placed in the information received by both those ashore and those on board ship. From a shore-side perspective it is important to know who is operating in the authority's waters for both purposes of security, traffic management and emergency response. However, our original finding that identification information was frequently incorrect highlighted the problem of reliance on the system. Likewise, from a shipboard perspective we have seen how different forms of information (e.g. destination, draught and manoeuvring data) were often erroneous. It was shown that the availability of such information could aid the situational awareness of ships' officers, but that frequent errors in these categories again meant the information could not be relied up to inform situational awareness and consequently navigational decisions. 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 manoeuvre by another in close proximity, say one being overtaken or running alongside, while the appearance of incorrect navigational data, such as course /speed vector introduces a serious risk into the decision making frame. This is particularly the case in heavily congested waters where the navigator places greater reliance on electronic aids.

The nature of these errors was seen to be due to a combination of operator input, technician input, and electronic interfacing. Furthermore, from observation and discussion with the operators at Dover CNIS, it became apparent that some ships' officers lacked awareness of, and competence in, the use of the system. The researchers witnessed instances of CNIS operators reporting to ships that they were transmitting erroneous information, and those onboard clearly indicating that they had no idea what to do about it. In one case an individual denied that they even had an AIS unit onboard. Similar cases have been reported by VTS (Vessel Traffic Services) operators in Singapore.²⁴

Importantly, however, over time we have seen a reduction in the numbers of errors transmitted. Equally CNIS operators have reported that ships' officers appear to be far more responsive in correcting any errors detected. This suggests a growing awareness of the system and of the need to keep it updated. Indeed analysis of VHF conversations and AIS text messages revealed that ships' crews were routinely and pro-actively checking their transmissions with those on other ships and with shore-stations. Moreover there had been changes in the form of conversations recorded. In 2004 and 2005 ships officers routinely called each other by VHF radio and asked for the destination of the other vessel. However in 2007, despite a much large number of recorded VHF calls, hardly any such examples were recorded, but examples were identified of ships' officers making explicit reference to AIS. This again suggests that seafarers have undergone a process of learning and have developed a greater awareness of the system.

Changes have also been recorded in relation to other parties involved in the operationalisation of AIS as a shipboard system. For instance, the Coastguard operators appear to have become de-sensitised to minor errors and have modified their form of exchange with reporting ships. Now when communicating with reporting ships instead of requesting ship's name, draught, and destination, etc., they specifically refer to the ship's AIS information and simply ask for verification. This change in operational practice both facilitates the ease of the information exchange, but also alerts ships' officers to the need to keep the system up to date. Similarly the

²⁴ Jackson (2004) *Seaways* (2004) April, p24.

UK, MCA has responded by publishing a new guidance notice²⁵ that explicitly refers to the use of AIS. Arguably this learning process is ongoing; there is still room to further reduce the number of operator entered errors transmitted, to eliminate technical anomalies and for finding the best way to monitor the system and enforce compliance.

Looking beyond the immediate operation and use of AIS for the purposes of improved situational awareness, we have identified that the introduction of the system has additionally induced unintended changes in the behaviour of ships' officers with respect to the use of VHF radio and the developing use of the AIS text facility. Other, as yet unidentified, changes may still emerge. We have seen that the use of VHF radio has greatly increased year on year since the introduction of AIS which facilitates ship identification. Moreover VHF calling is widely being used for the purposes of collision avoidance which runs contrary to current MCA advice.²⁶ Furthermore the use of the AIS text facility is increasingly being used as a form of communication between ships, and ships and shore. Each of these communicative activities has the potential to distract ship navigators from the business of the watch. Moreover there are wide differences in the forms in which communications are expressed both verbally by VHF radio and in writing by text message. This lack of consistency itself potentially introduces an extra element of risk into the navigational situation.

In terms of the future development of AIS, certain specific solutions may suggest themselves in terms of enhanced regulatory monitoring, the codification of different forms of communication exchange and the need for further research.

Enhanced regulatory monitoring by:

- Incorporation of AIS into the Ship's Radio Survey could do much to ensure that the equipment is properly installed, set up and operational.
- Port State Control inspections provide an opportunity to identify appropriate procedures within shipboard Safety Management Systems.

²⁵ MGN 324 (M+F) *Radio: Operational Guidance on the Use of VHF Radio and Automatic Identification Systems (AIS) at sea*. UK, MCA July 2006.

²⁶ Anecdotal evidence collected during other studies undertaken by the authors suggests that the problem of negotiated collision avoidance is also becoming an issue in open waters at deep-sea. This is an area that clearly requires further investigation.

- Other forms of inspection, such as International Ship and Port Facility Security (ISPS) audits, and ship vetting inspections offer the potential for monitoring AIS systems aboard ship.

The data presented here have illuminated serious issues concerning the introduction of new technologies aboard ship. Specifically we have discussed developments around the implementation and use of AIS within the context of shipboard navigation. When considered in the round, what has emerged from the range of issues identified is that a learning process has taken place in conjunction with the introduction of AIS, with the consequent development of unanticipated practices and problems. While this process of learning has led to greater awareness and increased competence, it is unclear what the essential drivers are behind these developments. Are the developments identified, the result of an informal process of increasing familiarity with the equipment and awareness of the need to keep the system up to date, or are the changes observed due to officers undergoing formal instruction and training? Moreover there are questions to be asked about the role and influence of changes in practice by the Coastguard, the issuance of advice by maritime authorities, the role of port state inspectors, the development of company procedures, and the effect of media publicity and the reporting of research findings, etc. Furthermore, if the changes detected have emerged as a result of officers having undergone formal training, then given the emergence of what may be described as unintended behaviours, there are questions to be asked about the adequacy of the training available.

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