



THE NAUTICAL INSTITUTE



THE USE OF VISUAL AIDS TO NAVIGATION

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OVERVIEW

The Council of The Nautical Institute has commissioned this report into the use of visual aids to navigation (ie buoys, beacons, leading lines/ranges) by modern mariners. The study was conducted internationally, and from the perspective of all maritime users including commercial mariners, fishermen and leisure users.

The study was commissioned because some authorities were questioning the value of visual aids to navigation, in an environment where heavy reliance is placed on accurate and affordable electronic navigation systems. This report has been designed to document how visual aids to navigation are being used, so as to provide a valuable contribution to any process of assessing risk, evaluating costs, benefits and training requirements.

The report looks at the historical development of visual aids to navigation and current navigational techniques, and examines the niche requirements of different maritime users. It is based on literary research, examination of incident and accident reports, and a consultation exercise based on user focused meetings held throughout the world. The report builds on documentation from IALA, IMO, and industry best practices.

It concludes that visual aids to navigation continue to be vital tools for mariners to assess and verify their position, provide situational awareness and orientation, indicate current flow, afford redundancy for electronic systems which can be faulty or inaccurate, and highlight individual dangers such as wrecks, rocks and shoals. There will thus be a continuing need for visual aids to navigation, not so much for the purpose of ***position fixing*** but increasingly so for ***visual reference***, and to ***alert the mariner*** to the fact that he may be standing into danger.

October 2002

Commodore David Squire, CBE, JP, FNI, FCMI

1. INTRODUCTION

- 1.1. The Council of the Nautical Institute is aware that the development of, and the reliance on, visual aids to navigation have changed with the advance of technology, which has raised questions as to the future role and disposition of traditional aids. While it is clearly the duty of Lighthouse Authorities and national administrations to determine the right mix of aids to navigation to satisfy the needs of the mariner, through meaningful risk assessment,¹ such assessment should include consultation with a wide cross-section of mariners to establish the way in which mariners use them in an age of increasing electronic technology. To this end, the Nautical Institute embarked upon a project to review past, current and likely future navigation policies and practices in coastal waters and port approaches worldwide.
- 1.2. The purpose of this report is to determine current, and future, navigational practices in order to provide a better understanding of the full value of aids to navigation today and in the foreseeable future, in order to aid that Risk Assessment process.
- 1.3. Consultation has comprised of a series of presentations to Nautical Institute members and invited guests in Bristol (UK), Antwerp (Belgium), Houston (USA), Manila (Philippines) and Limassol (Cyprus) with a further presentation to the Houston and Galveston Navigational Safety Committee (HOGANSAC).
- 1.4. Passages have been undertaken in:
- A coastal tanker, from Avonmouth to Barry Island (Bristol Channel). Pilot assisted.

¹ In the context of IALA Guidelines on Risk Management, December 2000, Part B

- A 38991gt container vessel, from Flushing to Antwerp (River Scheldte). Pilot assisted.
 - A 59925gt Passenger/RORO ferry from Hull to Rotterdam.
 - A cargo RORO from Purfleet (River Thames) to Zeebrugge.
 - A Supercat 6 High Speed Ferry from Manila (Philippines) to Orion.
- 1.5. Other information has been compiled from accident investigation reports during the periods 1999 to 2001 and Nautical Institute Marine Accident Reporting Scheme (MARS) reports, and from the anecdotal evidence of some 220 mariners, including deep sea and coastal masters, pilots, yachtsmen harbourmasters and representatives of a number of Lighthouse Authorities.

2. VISUAL AIDS TO NAVIGATION - DEFINITION

2.1. For the purpose of this study, **Visual Aids to Navigation** are defined as *visual devices, external to a vessel, which are provided to help mariners determine their position and course, to warn them of dangers or obstructions or to advise them of the location of the best or preferred route*².

2.2. These comprise of **Fixed** and **Floating** aids, as follows³:

- **Fixed:** Lighthouses (including light platforms and structures, leading (range) lines, sector lights and beacons.
- **Floating:** Light-vessels, light floats, LANBYS, buoys, and spars.

² Adapted from the Canadian Coastguard definition of an Aid to Navigation

³ For description of each type of ATON see IALA Navguide (4th Edition), Chapter 3

3. PHASES OF NAVIGATION

3.1. The two phases of navigation that relate to this study are:⁴

3.1.1. **Coastal:** Coastal navigation is generally regarded as navigation within 50 nautical miles from land or within the outer limit of offshore shoals or other hazards, or where navigation is subject to restrictions.

3.1.2. **Harbour Approaches and Harbour/Inland Waterway:** In general, these are waters inland from the coastal phase, where freedom to manoeuvre may be limited, and where pilotage techniques may be applied, even though a Pilot may not be embarked.

⁴ IALA Navguide, 4th Edition, Chapter 2, pp 19-21

4. THE USERS OF AIDS TO NAVIGATION

- 4.1. The users of aids to navigation can broadly be described in four main categories, namely **Commercial**, **Fishing**, **Leisure** and **Specialist**. However, within each of these categories can be found an even more diverse range of users depending upon the nature of their trade or business.
- 4.2. **Commercial.** The commercial user will normally follow a well-defined and recognised route. The size and speed of vessel can vary greatly, from the deep draught and less manoeuvrable VLCC to the relatively shallow draught, fast and very manoeuvrable High Speed Ferry (HSF).
- 4.3. SOLAS Chapter V requires that all ships should carry shipborne navigational equipment appropriate to their size, in accordance with Regulation 19⁵. However, Administrations have the freedom to decide to what extent the provisions of this Regulation do not apply to ships below 150 gross tonnage engaged on any voyage and those ships below 500 gross tonnage not engaged on international voyages.⁶
- 4.4. Bridge manning, skills levels, standards of maintenance and reliability of onboard navigational equipment, and commercial pressures may affect the way in which the vessel is navigated, and how visual aids to navigation are optimised (if at all). The degree of accuracy of position fixing will therefore be dictated by the level of shipborne navigational equipment carried, and such factors as the vessel's speed, beam, draught and manoeuvrability, the depth of water or, in the case of harbour or inland waterway navigation, the width of the navigational channel.
- 4.5. **Fishing.** Fishing vessels can range from modern deep-sea trawlers with state of the art control and navigation systems, to the single

⁵ As amended by Resolution MSC.99 (73)

⁶ Regulation 1(4)

manned inshore vessel. The requirements of the deep-sea fishermen, although in some sense the same as those of the commercial category, differ in that not even the larger vessels are likely to be constrained by their speed, beam, draught or manoeuvrability on a normal passage. They do, however, require a high level of repeatable accuracy to locate fishing grounds, and to avoid obstructions on the seabed that will damage their fishing gear and perhaps more importantly, may cause the vessel to capsize and founder.

4.6. Administrations have the freedom to decide to what extent the provisions of Regulation 19 of SOLAS Chapter V (Shipborne Navigational Equipment) do not apply to fishing vessels⁷. It cannot therefore be assumed that all fishing vessels are fitted with even the most basic of electronic position fixing equipment. Indeed, a vast majority of the estimated 1,258,200 fishing vessels in the world⁸ are under 25gt, and are manned by small-scale or artisanal fishermen⁹. While the former may use the most advanced fishing technology and electronics on board, the latter are mostly poor fishermen, who make their living by operating low-investment boats and fishing equipment.

4.7. Despite efforts by the International Maritime Organisation (IMO) to make standards of safety for crews of fishing vessels mandatory, through STCW-F, 1995¹⁰, as yet only three states have accepted the Convention.¹¹ In many countries, skippers of small fishing vessels are not required to obtain certification, undergo mandatory marine training, nor pass examinations. Artisanal fishermen lack an understanding of the limits of modern technology and hence take unheeded risks, which is often compounded by inadequate maritime training in navigation and the use of electronic aids. Many artisanal fishermen sail without

⁷ Regulation 1(4)

⁸ FAO: *Bulletin of Fishery Statistics*, No. 35 (Rome, 1998).

⁹ Small-scale fishermen who catch mainly for their own consumption but also sell the surplus for commercial gain.

¹⁰ International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995

¹¹ IMO Summary Of Status Of Conventions as at 30 June 2002

navigation instruments, often even without a magnetic compass.¹² They therefore rely significantly on their local knowledge and on natural conspicuous features of the coastline or visual aids to navigation when traversing to and from their fishing grounds.

- 4.8. **Leisure.** There are an estimated 34 million leisure craft of all sizes worldwide and this number is increasing;¹³ in the United States alone, there are approximately 12.8 million numbered boats. One senior professional mariner and leisure yachtsman in Houston commented that many leisure users in the US are pure amateurs who know little about the rules of the sea, albeit they are aware that buoys mark some form of navigable channel, while there are others who believe in operating to the basic principles of navigation and will not invest in modern technology.
- 4.9. US Coastguard Boating Accident Statistics¹⁴ reveal that of the 7,740 recreational boating accidents reported in 2000, 12% were caused by operator inattention, 12% through inexperience and 8% through lack of a proper lookout. That is not to say that all leisure users are not properly educated in the ways of the sea - there are many organisations worldwide that are dedicated to the training of yachtsmen and boat users. For example, one million people have completed Royal Yachting Association (RYA)¹⁵ courses in the last ten years, and the RYA Yachtmaster is accredited by the UK Maritime and Coastguard Agency (MCA), which is emulated throughout the world. Leisure users can therefore range from the well trained to the basic amateur.

¹² Sectoral Activities Program Working Paper *Risks And Dangers In Small-Scale Fisheries: An Overview*. (International Labour Office, Geneva, August 2000)

¹³ UK Marine Industries World Export Market Potential – a report for the Foresight Marine Panel, October 2000

¹⁴ U.S. Department of Transportation, United States Coast Guard *Boating Statistics – 2000* (COMDTPUB P16754.14)

¹⁵ <http://www.rya.org.uk/Training/>

- 4.10. The leisure craft is generally less well equipped with onboard instrumentation; the navigation suite can vary from nothing to the very basic fit of compass, log, echo-sounder and, perhaps, handheld satellite navigation system, then to the more sophisticated, comprising of radar, fitted satellite navigator, chart plotter and integrated instrumentation. The leisure sailor will navigate more by reference to visual aids to navigation when in sight of land, or in shipping lanes or when approaching a fairway, or harbour, or when navigating within harbour limits or on an inland waterway.
- 4.11. **Specialist.** Users in the Specialist category are those such as warships and auxiliaries, hydrographic vessels, lighthouse tenders and vessels engaged in dredging, cable laying, research and offshore exploration. They may, at times, require a high level of positional accuracy for the tasks in which they are engaged, but it is probable that each will be provided with the appropriate mix of satellite and terrestrial systems, having the required degree of accuracy, to allow them to undertake those tasks. That is not to say, however, that they will have any disregard for the traditional principles of good seamanship by any one of them using fixed and floating aids as reference points. The very nature of the business of warships or auxiliaries is such that any one unit may be required to deploy to an area where both fixed and floating aids are, at best rudimentary.

5. HISTORY OF AIDS TO NAVIGATION

- 5.1. Mariners have relied on visual aids to navigation since they first put to sea. In the dark ages, these comprised of crude, but effective devices, relying heavily on landmarks (sometimes referred to as seamarks) such as church spires, conspicuous trees and buildings, prominent headlands etc. One of the earliest lighthouses was the Pharos, built in about 280 BC, off the coast of Alexandria. It was over 130 metres high, used a fire of burning wood and was visible to a distance of about 67 miles. The development of lighthouses around the world continued throughout the ages; wood and coal fires were progressively replaced by more efficient means of illumination, and some were fitted with foghorns to give further position and warning information, in the event of poor visibility. The lighthouse served a number of purposes such as to mark the position of promontories and of dangerous shoals, and to provide a means for mariners making a landfall, from some distance, by observing its visible range (through its high structure by day and its light by night). In the 15th century, the Portuguese established giant navigational beacons ("padrões") along the coasts to allow ships' navigators to check their coordinates at sea; they did not have a light nor did they warn of danger. Other Fixed Aids to Navigation followed, these having specific purposes, such as leading lines and sector lights.
- 5.2. Simple buoys and beacons were known to be in use from the Middle Ages, to guide mariners through estuaries and up and down rivers. There was no system, as such, until the late 19th century when a uniform system of buoyage was introduced on a worldwide basis. This was refined, by international agreement at the League of Nations, in 1936 and again in 1983, with the introduction of the International Association of Lighthouse Authorities (IALA) Maritime Buoyage System. The functions of buoys and other Floating Aids to Navigation have not changed significantly over the years (but for the fitting of Racons), in that they are used for marking dangers, channels, points of

convergence and other significant positions offshore. By their very nature, they are not infallible aids to navigation.

6. CURRENT NAVIGATIONAL TECHNIQUES

- 6.1. **Traditional.** The traditional methods of position fixing, through visual observation of fixed aids, natural charted features and conspicuous objects, complemented by radar ranges and parallel indexing, and by the use of the echo sounder, have stood the test of time, and are still used by many mariners both in coastal and harbour navigation. Direct visual reference to buoys or beacons readily provides the mariner with an indication of leeway, set and tidal flow, while the use of transit bearings on fixed or floating aids and/or natural conspicuous features can provide him with an indication of whether the vessel is stopped when approaching an anchorage. Visual references to transits (ranges), or leading lines, clearing bearings or headmarks from fixed aids, or from natural conspicuous features of the coastline, such as promontories, chimneys etc, and from floating aids are considered essential for the safe conduct of a pilotage.
- 6.2. A Pilot or a Master holding a Pilotage Exemption Certificate (PEC) will have an intimate knowledge of the area in which he is navigating and he relies heavily upon a variety of visual aids, both fixed and floating, and natural features, either directly or through the use of radar, to monitor the passage of a vessel, to indicate wheel-over positions and to provide him with a lead towards a berth, dock or lock. In clear visibility, reliance would generally be placed on headmarks, leading (range) lights or sectored lights for lateral positioning, backed up as necessary by visual observation of floating and/or fixed channel markers, in the immediate vicinity, as reference markers, and supported by the echo sounder. In poor visibility, where the headmark or leading or sectored light may not be visible (except possibly in the case of high precision directional lights)¹⁶, he would resort to radar parallel indexing from fixed points along the route, again using the fixed and floating channel

¹⁶ A light visible over a very narrow angle to indicate a direction to be followed

markers for visual confirmation of his position relative to the channel, again supported by the echo sounder.

6.3. Current Problems. There are areas where aids to navigation may not be adequate, for a variety of reasons; for example:

6.3.1. Many of the aids to navigation around Papua New Guinea do not work. In September 2000, a press release from the Asian Development Bank, announcing a loan towards the rehabilitation of maritime navigation systems in Papua New Guinea¹⁷ conceded that navigating through the many islands could be hazardous because 70 out of 166 aids to navigation were not working as a result of vandalism, deterioration, or damage caused by ships or volcanic activity. Two of the aims of the project were to restore defective aids to international standards, and to install new ones. As yet, there is no evidence of this having occurred.

6.3.2. Philippine Notices to Mariners advise Masters of vessels to exercise great care when navigating in Philippine waters because of the low visibility and occasional failure of some temporary lights and because buoys and beacons are sometimes lost or destroyed especially after typhoons. One amateur yachtsman, with a vast experience of sailing around the 7,000 islands of the Philippines reports (See Annex D) that the Philippine Coast Guard has circulated a document to mariners stating that at any one time up to 50% of all main buoys and lights in Philippine waters may not be operational.

6.3.3. The Canadian Coastguard warns mariners¹⁸ that most aids to navigation are not under continuous observation and that failures and displacements occur because they are subject to damage,

¹⁷ ADB News Release No. 089/0012 dated September 2000, *Shipping To Be Made Safer in Papua New Guinea Waters*

¹⁸ Canadian Coastguard Annual Notice to Mariners

failure or dislocation by ice or storms, to being struck by vessels or tows, and to power failures. They further caution mariners that buoys may fail to exhibit their advertised characteristics and that lights may be extinguished or sound signals may not function due to ice, collisions and mechanical failure, and that the shape of a buoy may be altered by ice formation or damage or its colour altered by freezing spray, marine growth or fouling by birds.

- 6.3.4. Approaches to many harbours fronting towns or cities are susceptible to light pollution, such that the lights of visual aids are not easily discernable.

7. SATELLITE, RADIO AND RADAR NAVIGATION

- 7.1. The development of satellite, radio and radar navigation techniques has revolutionised the way in which mariners establish the vessel's position.

These include:

- 7.1.1. Global Navigational Satellite Systems (GNSS), such as the US-owned Global Positioning System (GPS) (accuracy 13 metres), the Russian-owned Global Navigation Satellite System (GLONASS) (45 metres) and Differential Global Navigation Satellite Systems (DGNSS) (3-5 metres) utilising MF maritime radio beacons for the broadcast of differential corrections to users of GPS and GLONASS, ostensibly to provide integrity monitoring of the raw signal.
- 7.1.2. Area Terrestrial Systems, such as Loran C (± 100 metres) or Chayka (± 100 metres).
- 7.1.3. Shore-based radars, racons and marine radiobeacons.
- 7.1.4. Shipborne navigation aids including Integrated Bridge Systems designed to automate the collection, processing and display of the ship's navigation and other sensor data, and electronic navigation charts and the Electronic Chart Display and Information System (ECDIS) such that it is now possible to provide real-time displays of a vessel's position, as well as anti-grounding and anti-collision warnings when interfaced with the radar.
- 7.1.5. Portable Pilotage Units.

- 7.2. **Current Problems.** As yet, there is no internationally accepted GNSS and there is still a question mark over the integrity, availability, control

and accuracy of the existing systems for other than general navigation. Indeed, in the case of GPS, the Volpe Report¹⁹ acknowledges that:

- 7.2.1. GPS systems in the maritime environment can be affected by unintentional interference from other electronic devices now in regular and increasing use on a vessel. For example, shipboard radar can degrade GPS performance, and mobile and fixed VHF transmitters have the potential to interfere with marine GPS receivers on inland waterways.
- 7.2.2. The GPS signal is subject to degradation and loss through attacks by hostile interests. Potential attacks include jamming and spoofing of GPS signals and/or disruption of GPS ground stations and satellites.
- 7.2.3. The GPS service is susceptible to unintentional disruptions from ionospheric effects, blockage from buildings, and interference from narrow and wideband sources.
- 7.3. The report further recognizes that while augmentations (such as DGPS) may improve basic GPS accuracy, reliability, availability, and integrity, the system is vulnerable to interference that can be reduced but not eliminated, and it identifies the need for independent back-up systems or procedures.
- 7.4. Furthermore, while in May 2000, it was announced that the US would discontinue the use of Selective Availability (SA)²⁰ by 2006, such that civilian users of GPS would be able to pinpoint locations up to ten times more accurately than hitherto, the President's statement also alluded to a capability to selectively deny GPS signals on a regional basis when national security was threatened.

¹⁹ *Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System*. Final Report 29 August 2001 – John A Volpe, National Transportation Systems Center

²⁰ Statement by the President regarding the United States' decision to stop degrading Global Positioning System Accuracy, 1 May 2000 (http://gpshome.ssc.nasa.gov/press_release.htm)

- 7.5. It would therefore be reasonable to suggest that these same vulnerabilities could apply to GLONASS.
- 7.6. Many administrations warn against over-reliance on the quoted accuracy of such systems, particularly when referred to the World Geodetic Reference System of 1984 (WGS84). For example, the UK Hydrographic Office, in a Notice to Mariners, warns against *'over-reliance on the quoted accuracy of GPS and DGPS referred to WGS84, when using large and medium scale admiralty charts, including charts on which it is stated that WGS84 positions can be plotted directly.'* It advises that *'when closing the coast or in the vicinity of dangers, which may have been fixed relative to the coastline, vessels should always verify their GPS position in relation to the charted detail by using alternative methods of position fixing.'*
- 7.7. It also warns mariners that, *'in all cases, prudent positional clearance should be given to any charted feature, which might present a danger to their vessel.'*
- 7.8. SOLAS Chapter V, Regulation 16(2)²¹ warns that the malfunction of certain shipborne navigation equipment *'shall not be considered as making the ship unseaworthy or as a reason for delaying the ship in ports where repair facilities are not readily available'*, but any such malfunction, if not detected early could be disastrous, as is borne out by the following incidents:
- 7.8.1. January 1995: The loss of a speed sensor caused the passenger/car ferry SILJA EUROPA to ground in the Stockholm Archipelago.²²

²¹ As amended by Resolution MSC.99 (73)

²² Accident Investigation Board, Finland, Investigation Report 1/1995

- 7.8.2. June 1995: An unexpected loss of the position sensor (GPS) resulted in the grounding of the passenger ship ROYAL MAJESTY on the east coast of the United States.²³
- 7.8.3. April 2, 2000: The RORO passenger vessel FINFELLOW ran aground near Överö in Aland, as a result of a gyro compass malfunction through radio frequency interference.²⁴
- 7.9. It therefore follows that there may be ships at sea with defective navigational aids. It must also be borne in mind that many shipborne navigational aids depend for their operation on reliable power supplies, which could be interrupted at any time. Furthermore, Administrations that control position-fixing systems, do not accept responsibility for the consequences of inaccurate positions being obtained by means of such systems.
- 7.10. **Future Developments.** The present satellite navigation systems are expected to be fully operational until at least the year 2010. Future GNSS is expected to improve, replace or supplement the present satellite navigation systems, which have shortcomings in regard to integrity, availability, control and system life expectancy.²⁵ IMO requires that future GNSS should meet the maritime user's operational requirements for general navigation, including navigation in harbour entrances and approaches and other waters where navigation is restricted. The designated minimum horizontal absolute accuracy maritime user requirements for general navigation are:
- **Ocean.** 10 metres.
 - **Port Approaches and Restricted Waters.** 10 metres.

²³ National Transportation Safety Board Marine Accident Report NTSB/MAR-97/01

²⁴ Accident Investigation Board, Finland, Investigation Report B 2/2000 M

²⁵ IMO Resolution A.915(22) – *Revised Maritime Policy For A Future Global Navigation Satellite System* (GNSS)

- **Coastal.** 10 metres.
- **Port.** 1 metre.
- **Inland Waterways.** 10 metres.

7.11. Future developments include²⁶:

7.11.1. **GPS.** The system will undergo a modernisation programme between 2002 and 2010, when the performance of the system will be improved.

7.11.2. **GLONASS.** Although the future of GLONASS remains uncertain, there are still six healthy satellites and further launches are planned.

7.11.3. **GALILEO.** The European Programme for Global Navigation Services, and the first satellite positioning and navigation system specifically for civil purposes, is currently under development with a view to commencing commercial operations from 2008.

7.11.4. **Space Based Augmentation Systems.** Space Based Augmentation Systems using geo-stationary satellites to provide integrity warnings, additional ranging signals and differential corrections, are likely to become fully operational in 2004.

7.11.5. **Terrestrial Systems.** The future of the United States-controlled LORAN-C networks is under consideration. However, the Russian Federation-controlled CHAYKA networks will not be considered for phasing out until at least the year 2010. Civil-controlled LORAN-C and LORAN-C/Chayka networks are in operation in the Far East, north-west Europe and other parts of the world, with plans for extension in some areas. A number of Loran-C and Chayka

²⁶ Compiled from IMO Resolution A.915(22) and XVth IALA Conference Papers

stations are transmitting differential GPS correction, on an experimental basis.

7.11.6. **DGNSS.** Further deployment of DGNSS via radiobeacons is envisaged. Some 40 countries worldwide now have systems in operation or on trial.

7.11.7. **AIS.** The application of AIS Technology is being developed to identify and monitor aids to navigation.

7.11.8. **Portable Pilot Units.** The introduction of Portable Pilot Units, through the Innovative Portable Pilot Assistance (IPPA) Project,²⁷ will provide the pilot (or master) on vessels operating in confined waters access to the most accurate and up to date information available, to provide, among others, fairway information on electronic navigation charts, better situational awareness during the navigation process and improved passage planning execution.²⁸

7.11.9. **Laser Light Technology.** The use of laser light technology to replace conventional range lights and to indicate a channel's side, central and dividing lines is being developed.

7.12. **Possible Future Developments.** In his speech to the 2002 IALA Conference, the Secretary General of IMO offered his thoughts on a number of possibilities for the future, including:

²⁷ IPPA Synopsis v1_0.doc dated 26-Mar-01 www.ippa.dera.gov.uk

²⁸ *Pilotage and new technology, an alien or.....* Capt. Harry W. Tabak Vice-president – chairman VTM Taskforce. XXXVth General meeting EMPA By

- 7.12.1. The further development of the concept of the Marine Electronic Highway, which is currently focused on the Straits of Malacca and Singapore. He suggests that this is a thought provoking and far-sighted programme with enormous potential to shape the way information technology can be used in the future.
- 7.12.2. The extension of mandatory VTS, currently only allowed in territorial waters, especially in congested waterways.
- 7.12.3. The concept of a global traffic management system, based on long-range AIS, feeding information into local traffic control systems responsible for ports, coastal sea-lanes or straits.
- 7.12.4. A system of positive control for selected high-risk areas, which would substantially enhance the safe movement of vessels.

8. THE PERCEIVED NEED FOR VISUAL AIDS TO NAVIGATION

- 8.1. Despite the increase in technology, IALA recognises that lighthouses, buoys and beacons still comprise the greatest number of aids to navigation and that this is likely to remain the case for many years to come. Some Aids to Navigation Authorities, however, are examining the need for the traditional aids to navigation. The Canadian Coast Guard, for example, argue that there have been significant advancements in new technologies, particularly the availability of GPS, such that large landfall lights and offshore buoys can be downsized or discontinued. The investigation report of a passenger vessel grounding in Lake Saint-Louis, Quebec, in May 1999,²⁹ notes that aids to navigation had been reduced in the previous four to five years prior to the incident, such that leading lights in small craft channels had been discontinued and there were fewer buoys.
- 8.2. That is not to say that any Authority is advocating the total removal of aids to navigation, but the Northern Lighthouse Board argues³⁰ that at some indeterminate stage in the future, most of the traditional aids to navigation probably will have been made redundant by evolving satellite-based radionavigation systems and the associated onboard systems. In particular, they suggest that Authorities adopt a policy of reducing the maximum range of their more powerful lights, and question the need for big landfall lights and for every isolated rock to be marked.
- 8.3. The UK General Lighthouse Authorities, however, acknowledge that the widespread availability of GPS and DGPS receivers, at low cost, is increasingly encouraging mariners of all classes to navigate not only closer inshore but to do so in conditions of darkness and reduced visibility where they would not have previously ventured. In order therefore to mitigate the risk of any leisure or fishing vessel grounding,

²⁹ Transportation Safety Board of Canada Report Number M99C0016

³⁰ XVth IALA Conference Papers - March 2002, p42 et seq

or colliding with a buoy at night they have recently increased the number of buoys around the coasts of England and Wales, and fitted lights to over 50 hitherto unlit buoys.³¹

8.4. A selection of comments from accident reports and from mariners around the world demonstrates that there is overwhelming support for the continuance of visual aids to navigation (extracted from Annexes A, B & C):

- *Had there been something such as a beacon to mark the reef it may have stimulated the mate from his reverie so that he may have reacted to save the situation.*
- *While every electronic aid was onboard the ship, a simple visual marker on that pinnacle would have alerted their attention*
- *The more visual aids - the happier the yachtsman.*
- *The worldwide marine leisure industry is huge, from giant powerboats down to small yachts. It is the small yachtsman who uses the lights. If navigational lights were reduced, it would be a problem for the small craft sailor.*
- *Leading lights and buoys etc are especially useful to yachtsmen where the channel may be changing.*
- *It is good to have lights (lighthouses), as they give reassurance.*
- *Visual aids are needed and will continue to be so; visual aids at night must be efficient despite background lights.*

³¹ Anecdotal evidence from Director of Navigational Requirements, Trinity House Lighthouse Service

- *What is perfectly possible on a merchant ship is probably unacceptable on most leisure vessels.*
- *If you use buoys, you need a lot of them to be certain that one is out of position.*
- *The exit channel takes you between 2 buoys...he was not happy until he visually saw the markers on these 2 items. He wanted to see them to make sure he was going through there rather than rely on any electronic navigation aid.*
- *Visual aids to navigation should be maintained because they are very useful especially when you are navigating, piloting in places with strong currents.*
- *When it comes to landfall and when entering shallow waters and dense traffic areas, we should start using our traditional pilotage and close water techniques and visual aids.*
- *The pendulum of choices swings very much towards 'traditional' aids with the 'A1 eyeball' as the primary source of safe navigation in Philippine Waters.*
- *No electronic device can fully replace visual navigational aids in shipping.*
- *Visual aids are, at any time, much more reliable than electronic aids and are relatively easy to use for an amateur navigator. This is also true for coastal fishing communities who have limited resources to afford electronic aids and many are not trained as navigators.*
- *If we are looking for safer ships and cleaner seas, then visual navigational aids should stay. The cost of keeping these is*

negligible compared to the enormous cost of accidents caused by ships due to lack of aids in terms of life, resources and clean ups after pollution, and this is applicable to all sectors of shipping.

- *I cannot see, at any time in the foreseeable future, a situation where electronic aids can safely take the place of traditional visual methods of navigation.*
- *My gut feeling as a Master Mariner with some 26 years service at sea is yes we need the visual as well as the electronic system.*
- *Nothing is simpler and safer, than to look at a buoy or leading lights, and keep your ship on the correct course, making due allowance for currents.*

9. TRADITIONAL VERSUS ELECTRONIC

- 9.1. While Para 47 of Chapter VIII of the STCW Code requires that, in vessels of 500 gross tonnage or more, fixes be carried out *by more than one method whenever circumstances allow*, it does not stipulate that one of those methods should be by visual means, albeit Para 48 requires the officer in charge of the navigational watch to *positively identify all relevant navigation marks*. This could either be visually or by cross reference to a satellite/terrestrial or radar position fix.
- 9.2. The traditional method of making a landfall by recognising and then obtaining lines of position from lighthouses or natural features of the land, is becoming past practice, even though one would wish to believe that no self-respecting mariner would make a landfall without a cursory glance at that lighthouse or feature, to confirm that he is where he should be.
- 9.3. Even for close-in coastal navigation, the use of a differential GNSS as the primary method of position fixing, backed up by radar ranges and bearings, instead of position lines taken from the traditional visual aids, should be acceptable, provided that the maximum margin of error is taken into consideration when establishing the optimum safe passing distance from any hazard.
- 9.4. But, this method may not be acceptable in, say, congested and restricted traffic separation schemes, such as the Singapore Strait or Dover Strait, where the size of a vessel and its manoeuvrability may dictate a position accuracy of considerably less, and where visual or radar reference to, and the need to properly identify, fixed or floating aids may be appropriate, to ensure that the correct and safest route is being followed.

- 9.5. Nor may it be entirely acceptable in the one-man bridge situation, where the officer of the watch may be so pre-occupied with a busy traffic situation that he could become disorientated, because he is unable to plot his position on the chart as frequently as may be prudent. The real-time position information provided by ECDIS (if fitted) will, of course, alleviate this but better still would be visual or radar reference to both fixed and floating aids.
- 9.6. When operating in port approaches or restricted waters, visual reference to aids to navigation and natural features is essential to ensure that the vessel is correctly positioned in the channel. During pilotage, the conduct of navigation is best monitored through a combination of visual reference to leading lines, headmarks and buoys/beacons, together with radar parallel indexing, and by plotting the vessel's position either manually on the paper chart or automatically on the electronic chart. The traditional method of obtaining three lines of position by visual observation or by radar ranges is, however, both time consuming and manpower intensive, particularly in minimum manned, broad beam vessels. But, those lines of position when transferred to the paper chart serve to confirm the vessel's position, albeit it may not be as 'real-time' as that provided by a DGNSS derived position on an electronic chart or ECDIS.
- 9.7. It has been suggested that the use of modern systems may be to the detriment of the traditional principles of good seamanship. In an article, published in the Royal Institute of Navigation's Navigation News³², the author observes that the use of *landmarks* is:

'navigation in its traditional form, and it is a navigation which we are still expected to carry out to confirm positions which have been established by electronic means. With modern GPS fixing, which can give position to within a few metres, this idea of

³² RIN Navigation News, March/April 2001

confirming the position by means of compass bearings seems a little old-fashioned, and it is suspected that very few navigators use it. Modern electronic navigation systems have transformed navigation to the point where visual references may not be considered necessary any longer...As electronic systems develop we could get to the stage where buoys and lighthouses become obsolete and we place total reliance on the electronic systems to get us to a destination.'

- 9.8. Furthermore, the Chairman of the North Sea Pilots Association, in a discussion document³³, makes the point that:

'whilst G.P.S. is a very useful tool for the mariner, it appears that it is superseding the need for navigators to monitor their position relative to channels, banks, buoys and other marks.'

- 9.9. The Chief Inspector of the UK Marine Accident Investigation Branch (UK MAIB) observes³⁴ that misidentifying navigational marks, especially by day, is a common feature in many grounding incidents. He adds:

'We live in the age of the GPS, a very accurate, very reliable and very easy system to use. We use it all the time to fix our position and we all have come to rely on it. The younger generation will have been brought up on it, and will invariably assume that the position given on the read out, or the marker on the automatic chart plotter, will be correct. Everything else must, by definition, be relative to where our own ship is. But there is one big problem.'

³³ 'Area of Concern ', a discussion document Presented by The North Sea Pilots Association, taken from the Europilots website

³⁴ Department for Transport MAIB Safety Digest *Lessons from Marine Accident Reports 2/2001*

What happens if, on rare occasions, it isn't working for some reason? Can we spot when it isn't functioning correctly, and can we still navigate safely if it isn't available? The ancient mariner will be in his element, but the younger one may find he is not as familiar with the traditional methods of navigating as he should be.'

- 9.10. The various accident investigation reports, summarised at Annex A, MARS reports (Annex B) and anecdotal statements from mariners around the world (Annexes C and D) would appear to support these views. Some typical comments are:

9.10.1. Accident Reports (extracted from Annex A):

- *Not making "basic navigation checks".*
- *A proper passage plan was not being executed by the navigation personnel, and the progress of the vessel was not being plotted on the chart. The vessel was being steered by DGPS...the navigation instruments and the technique used by navigation personnel did not permit precise navigation in the restricted channel. The route and waypoint features of the DGPS were not used to help monitor the vessel's progress along her intended track.*
- *The progress of the vessel was not being monitored effectively. The vessel had adequate navigational equipment operating to safely navigate the vessel but it was not being used to good effect.*
- *The collision resulted mainly from the failure of the Master to monitor the position of the vessel.*

- *The skipper was totally reliant on a video plotter for the safe navigation of the vessel in confined waters. The skipper's assessment of the vessel's position, based upon the plotter, was inaccurate. The plotter, primarily used for fishing purposes, was not adequate for safe navigation. The skipper was apparently unable to utilise positional information from the degraded radar picture.*
- *DGPS and GPS positions were not plotted on the paper chart.*
- *The grounding of the vessel resulted from a gross error in the navigation of the vessel. There was a lack of appreciation of the danger of approaching too close to the hazard, and a lack of any sort of passage planning. Laying off courses to pass safely down the middle of the channel and to give passing distances of salient points and pre-planned turning points would have prevented this grounding.*
- *The skipper clearly anticipated following a line of buoys until he thought it was safe to alter course to starboard. As they passed close down the line, they realised they had not been counting them. As they passed what they thought was either the third or fourth buoy, course was altered to starboard to round up for the eastern channel. It is possible the skipper thought he had reached the most westerly buoy in the line and had clear water to run up to the eastern channel. Soon afterwards the vessel had grounded. Throughout this period the GPS was functioning correctly but was not being used. The echo sounder was switched off. No positions were being plotted on the chart.*

- *The vessel ran aground, due to the inattentiveness of the officer of the watch, who allowed himself to become distracted from the navigation of the ship, for a period of about 15 minutes such that he did not hear the waypoint arrival alarm on the GPS...The ship was travelling towards a featureless horizon with no visual cues to mark the reef, which was largely submerged. Fixing was by GPS onto a paper chart. The report of the investigation suggests that had there been something such as a beacon to mark the reef it may have stimulated the mate from his reverie so that he may have reacted to save the situation.*
- *The skipper was alone in the wheelhouse and navigating, mostly by eye but with the aid of GPS and radar. The radar was set on the 3-mile range and the GPS on large scale. He was not using the navigational chart of the area... The skipper's navigation methods were not appropriate for the area being transited. The skipper did not know the precise location of the vessel just before it grounded.*
- *Individuals in the bridge team were independently monitoring the progress of the ship, but the low standard of bridge resource management resulted in poor communication of information and an eventual loss of situational awareness. The number and disposition of navigation marks in the channel, particularly as some were unlit, made it unsuitable for transiting in darkness.*

9.10.2. Anecdotal Reports (extracted from Annexes B, C &D):

- *One of the major problems we have now is trying to combine ancient style built ships with modern navigation techniques – maybe not everybody knows perfectly well*

how to use modern navigation systems. I know from my seafaring days that some of the youngsters were not able to combine the different modes of navigation.

- *I teach ages 16 – 21 and I teach the ECDIS and the ARPA...I put them into the Dover Strait...I put on the ECDIS, I put on the ARPA - they don't have any sight, there is no panoramic view and I put a lot of targets in it so they have to manually plot the vessels, otherwise they take automatic plotting and everything goes straight on to the ECDIS, so I take manual plotting, they have to choose their own targets. They put them onto the ECDIS and what happens for them it looks like a video game and after 50 minutes I put on some extra vessels or some extra targets and what happens they forget to look at the ARPA, they are only looking at the ECDIS because they see all the targets are on the ECDIS - that is not true of course. I have to say that 90% of them make the same mistake, always a collision, every time so they really think it's a video game, that's why now in our Institute we have chosen to go for panoramic view also so they really see that if there is a buoy out there but it isn't on the ECDIS that doesn't mean there is not a buoy out there*
- *He turned to the second mate and said 'is that this light on the chart?' The second mate said 'oh yes' and he said 'how do you know that it is the right lighthouse'; the second mate responded 'the lighthouse is always there and the GPS puts us here, so therefore it must be the right lighthouse.'*
- *It boils down to one basic lesson, which is to look outside the window*

- *People just forget to look outside the window*
- *They were plotting the ship from the GPS...they only fixed the minutes and didn't check the degrees on the GPS...they were one degree of longitude out, so when they changed the course to enter the channel, they went aground – for 32 hours they only checked the minutes and seconds and they were 60 miles out.*
- *The 3/0 did not fix the position for about 30 minutes and the vessel went aground... the GPS correctly indicated the vessel was on the bank!*
- *A panamax size bulk carrier fully loaded...very clear day, state of the art equipment, 2 GPS, master on the bridge, second officer and 2 lookouts...echo sounder running, course line properly laid off on the chart, passage plan and relevant sailing direction books out. The master was familiar with the area, but on a vessel of only 5000t; he decided to cut the corner...there is a pinnacle reef that's referred to on the chart and also in the sailing directions...he hit the pinnacle at full sea speed...while every electronic aid was onboard the ship, a simple visual marker on that pinnacle would have alerted their attention.*
- *Two ships touched at anchor...young boy on the bridge...although only 800-1000 metres off the breakwaters, he was using guard range rings set up on the GPS to alert him. It was the sterns of the ships that had touched – if he had got up and walked onto the bridge wing and looked aft he may have been able to see what was happening, but the first he knew of it was when he was thrown off the pilot's chair.*

- *With some of the young cadets ... if the ARPA was saying that something was going to pass at 0.16 they believed that was what it was going to be and with blind faith they believed what a digital display says.*
- *We have to convince the young navigators that they have to learn also to use landmarks, buoys and paper charts... they refuse even to go into the chartroom and they like to play with their 'trains'.*
- *Officers were often so absorbed by their task of sending or receiving signals by GMDSS that they appeared to forget, for significant periods, their prime role of looking out of the bridge window.*
- *They love to play with ECDIS and ARPA, and need constant reminders that their primary duty is to look out of the bridge window at what is happening around them.*
- *Young officers, who have grown up with computers, have implicit faith in them and all computer controlled electronic equipment. They would, on occasion, rather believe the equipment than what their own eyes tell them. At sea, the Mark 1 eyeball and the brain are still the optimum computer system.*
- *There appears to be an inability for today's navigator to be able to deal with taking three visual bearings and a radar range, plotting the position on the chart while maintaining an overview of the traffic situation and, if necessary in port approaches, keeping the Master informed too; this is not specific to one nationality, it's across the board, but it may*

explain why the navigator is reluctant to leave the security and continuity of the radar display.

- *Today's navigators seem to be reluctant to go outside into the marine environment when they can simply plot a GPS position, or obtain a position from the radar, or simply put an "x" on top of the Nautoplot light. Also, they certainly do not move themselves from the centre of the wheelhouse to the bridge wing and back to the chart table at anything like the speed we ancient mariners used to do when we were lads. Nor do they look out of the window to compute the movements of other ships with their eyes and brain nearly as much as their predecessors did.*
- *The 2/O had plotted the position of the buoys and channel limits into the basic radar mapping programme, linked to the GPS. I was aware that he rather resented my insistence on fixing the ship's position primarily using visual lighthouse bearings and radar distances. That was until he saw that the radar map graphics placed the channel clearly across the nearest rocky patch, even when account was taken of the half mile correction to WGS datum.*
- *I frequently sail with officers who need training in education in the rules and their application, how to take bearings, how to look out of the bridge window and how to use and interpret a basic radar display... we need to remind ourselves that our systems and equipment are worth little unless the people are fully competent and grounded in the basics. Will they cope at all times, especially when the fuses fail, as they must?³⁵*

³⁵ Captain A Ian Hale MNI – Letters *Seaways* April 2002

- 9.11. In his article in the July 2002 edition of *Seaways*³⁶, the Navigating Officer of the MV Aurora asserts that certain 'young navigators' may be over-reliant on electronic charts because of their perceived accuracy. His reflections on this subject effectively sum up the importance of cross checking positional information both visually and by the use of radar:

'We have increasingly realised...that the charts we use in many areas of the world are, in many cases, less than accurate...electronic chart systems have a certain reliance on satellite navigation systems...but at the same time are not totally reliant on them. Full regard must be had for cross checking the satellite positioning. This can easily be done using the radar maps and radar interlay. When passage planning using the ECDIS/RCDS, it is very easy to align the planned track precisely to any leading marks, lights and sectors. When making an approach these marks make an exceptional crosscheck of the integrity of the GPS position and horizontal datum of the chart.'

...we have made arrivals into ports where a GPS position has not been available – particularly notorious are Italian waters – or into ports where on the approach it has been apparent that datum irregularities in comparison with WGS84 datum exist. In these circumstances we have been able to navigate using the electronic chart with only radar and visual means.'

³⁶ *Electronic Charts at Sea* – Andrew Hall MNI. *Seaways* July 2002, page 13

10. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- 10.1. Visual aids to navigation including buoys beacons and shore-based lights are useful to modern mariners.
- 10.2. In contravention of good practice, many small craft do not carry charts or adequate navigation aids; mariners in these vessels therefore rely on visual aids to navigation to check the position of their craft when in coastal waters.
- 10.3. Large ships need to be navigated with greater accuracy due to limited sea room both in coastal waters and during pilotage. The economic and environmental consequences of a navigational accident generally increase in proportion to ship's size. Fixed and floating aids to navigation are utilised in many different ways in coastal regions, such as to mark channels, to identify hazardous wrecks, to delineate safe water around shoals and to provide orientation for safe landfalls, albeit there is a lesser need for long range landfall lights.
- 10.4. Most modern deep-sea ships have alternative electronic navigation systems, but some navigators tend to rely solely on one type of navigational aid. In this context, buoys provide a valuable check both visually and on Radar for evaluating situational awareness.
- 10.5. During pilotage, reliance is still placed on visual aids to navigation, both fixed and floating, for an indication of lateral positioning, for verifying progress towards alter course positions and safe channel limits, and in the case of floating aids, for early detection of set and drift.
- 10.6. Buoys form a valuable check to all mariners when operating in fog or reduced visibility, where the use of buoys can verify scanty information.

- 10.7. Electronic navigation aids can fail or become downgraded.
- 10.8. Mariners are becoming increasingly dependent on information from electronic systems, but the interpretation of such information by some is occasionally in error.
- 10.9. Visual aids to navigation reduce the frequency of navigational accidents, thus limiting consequences to the environment.
- 10.10. Buoys should not be used as fixed points for navigation purposes as their positions can be subject to shifting in bad weather and ice. They can also disappear due to collision. However, used with other aids to navigation, the correct identification of buoys provides reassurance and orientation.
- 10.11. Navigational practices are as diverse as the categories of operator, as is the manner in which visual aids to navigation are used.
- 10.12. There is an increasing tendency for some mariners to become over reliant on electronic systems with scant regard for the vulnerability of those systems in terms of their accuracy, reliability, availability, and integrity. While future developments in GNSS, Space Based Augmentation Systems, Terrestrial Systems, DGNSS, AIS, Portable Pilot Units, and Integrated Bridge Systems will inevitably reduce these vulnerabilities, they cannot mitigate against the tendency for the modern mariners to forget to make visual checks of the external environment, and to familiarise themselves with the area in which they are operating, by reference to visual aids.
- 10.13. It is inevitable that, for the majority of mariners, the introduction of new and more accurate satellite navigation systems coupled with the increasing availability of existing or new, and reliable, electronic position fixing devices and electronic chart systems, at affordable prices, will eventually supersede the need for some of the traditional methods of

position fixing. There will, however, be a continuing need for visual aids to navigation, albeit not so much for the purpose of ***position fixing*** but increasingly so for ***visual reference***, and to ***alert the mariner*** to the fact that he may be standing into danger.

RECOMMENDATIONS

- 10.14. Authorities when carrying out their risk assessment for safe navigation should bear these conclusions in mind, with particular respect to soliciting further feedback from all sectors of local area users.
- 10.15. Training should continue to emphasise the importance and use of visual aids during passage planning and simulation exercises, with particular regard to the use of leading lights, sector lights and buoys/beacons.
- 10.16. Passage planning should take into account the value of relevant visual aids to navigation, for fixing and verifying the vessel's position (fixed aids) and early detection of set and drift.
- 10.17. The Nautical Institute should support the continued provision of visual aids to navigation to minimise the risk of stranding in coastal waters.
- 10.18. Visual aids to navigation should continue to be used to reduce the risk of navigational errors and thus minimise the frequency of accidents and therefore the consequences to the environment.
- 10.19. Visual aids to navigation should continue to be used to mark navigational hazards, such as wrecks that may not be visible on the surface.
- 10.20. Visual aids to navigation should continue to be used as a means of verifying the vessel's position providing essential redundancy to electronic navigation systems.

Annexes:

- A. SUMMARY OF GROUNDING INCIDENTS 1999 - 2001
- B. NAUTICAL INSTITUTE MARS REPORTS 1999 - 2002
- C. NOTES FROM NAUTICAL INSTITUTE PRESENTATIONS
- D. WRITTEN SUBMISSIONS FROM MARINERS
- E. PRESENTATION TO NAUTICAL INSTITUTE BRANCHES

ANNEX A - SUMMARY OF GROUNDING INCIDENTS 1999 - 2001

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
1.	Apr 1999	USCG	Fishing Vessel	N/K	Foundered on reef	<i>The skipper set the wrong course on his satellite-based autopilot. He did not aim toward a specific waypoint, and never checked his position again. Twelve hours later the vessel went aground. The mate said just before going aground he couldn't see out of the windows on the bridge because of the rain, all that the radar showed was rain clutter, and the alarm on the radar that should have sounded as he approached shore failed to go off. He had no idea he was anywhere close to land. The grounding was primarily due to the skipper's negligence in not making "basic navigation checks" that would have made him realize he was on a collision course with the island. It is suspect whether the radar alarm was set or whether the radar was even turned on prior to the grounding.</i>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
2.	May 1999	Transportation Safety Board of Canada	Passenger Vessel	463gt	Bottom Contact	<i>A proper passage plan was not being executed by the navigation personnel, and the progress of the vessel was not being plotted on the chart. The vessel was being steered by DGPS. The vessel came into contact with the bottom because the navigation instruments and the technique used by navigation personnel did not permit precise navigation in the restricted channel. The route and waypoint features of the DGPS were not used to help monitor the vessel's progress along her intended track. Also, the water level was unusually low, leaving little room for error. The elimination of a range light and the absence of a buoy contributed in reducing the situational awareness of the navigation team. Aids to navigation had been reduced in the past four to five years prior to the incident, such that leading lights in small craft channels had been discontinued and there were fewer buoys.</i>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
3.	Oct 1999	UK MAIB	Yacht	28ft	Grounding	<p><i>The navplan involved keeping to seaward of a number of yellow firing range buoys, of which there were seven in almost a straight line, three of which were lit. The skipper clearly anticipated following them until he thought it was safe to alter course to starboard. As they passed close down the line, the skipper and the one member of the crew who was with him in the cockpit realised they had not been counting them. As they passed what they thought was either the third or fourth buoy, course was altered to starboard to round up for the eastern channel. It is possible the skipper thought he had reached the most westerly buoy in the line and had clear water to run up to the eastern channel. For the approach, he used the eastern breakwater sector light as the head mark. It was identified as 'a red light'. He did not take a bearing of it or check his position by any means. He continued to navigate by eye. Throughout this period the GPS was functioning correctly but was not being used. The echo sounder was switched off. No positions were being plotted on the chart. The vessel grounded. The investigation report highlighted the importance of using pre-planned clearing lines on known dangers, the use of the echo sounder, identifying buoys correctly and verifying the vessel's position by other means such as GPS, and by using available navigation aids to advantage.</i></p>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
4.	Apr 2000	Transport Accident Investigation Commission New Zealand	Passenger Charter Launch	12gt	Struck rocks	<p><i>The vessel struck rocks and sunk when the progress of the vessel was not being monitored effectively. Before the accident the skipper chose to leave the navigation of the vessel to a trainee, allowing him to navigate close to an area of known dangers with a minimum of supervision.</i></p> <p><i>The skipper gave the trainee verbal instructions on how to navigate around the rocks. The trainee was under the impression that a lighthouse was situated on the extremity of any dangers and was unaware of the rocks on which the vessel grounded.</i></p> <p><i>The vessel had adequate navigational equipment operating to safely navigate the vessel but it was not being used to good effect. It was a dark night, making navigating by eye difficult. The trip was the trainee's first in the area at night and the first time he had steered the vessel at night.</i></p> <p><i>The GPS-derived track was typical of the track expected when navigating by eye alone. The initial track headed straight for or slightly to starboard of the light. As the vessel closed on the point the vertical angle of the light would have increased, raising the trainee's awareness of how close to it he was. He appears to have responded by altering course away from the light but not far enough to avoid the rocks on which the vessel eventually grounded</i></p>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
5.	Aug 2000	MAIB Hong Kong	Jetfoil Passenger Ferry	303gt	Collision with unlit mooring buoy	<i>The collision resulted mainly from the failure of the Master to monitor the position of the vessel during the passage. Other contributory factors were the failure of the Chief Officer to report the vessel's position to the Master even though he had regularly checked the position of the vessel, particularly when the jetfoil was in the vicinity of mooring buoys, and the failure of the Night Vision Officer to detect and report the presence of the unlit mooring buoy.</i>
6.	Oct 2000	UK MAIB	Fishing Vessel	240gt	Grounding	<i>The immediate cause of the accident was that the skipper was unaware that his vessel was about 400m north of the intended track and heading towards an island. Heavy rain reduced visibility and degraded the radar picture. The skipper was totally reliant on the MPS 100 video plotter for the safe navigation of the vessel in confined waters. The skipper's assessment of the vessel's position, based upon the MPS 100 plotter, was inaccurate. The plotter, primarily used for fishing purposes, was not adequate for safe navigation. The skipper was apparently unable to utilise positional information from the degraded radar picture. DGPS and GPS positions were not plotted on the paper chart. Lookouts were not posted outside the wheelhouse when visibility reduced.</i>
7.	Oct 2000	Marine and Safety Tasmania (MAST)	Stern Landing Vessel	247gt	Grounding	<i>The grounding of the vessel resulted from a gross error in the navigation of the vessel. A lack of appreciation of the danger of approaching too close the hazard. A lack of any sort of passage planning. Laying off courses to pass at safely down the middle of the channel and to give passing distances of salient points and pre-planned turning points would have prevented this grounding.</i>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
8.	Nov 2000	Australian Transport Safety Bureau	Container ship	21,000gt	Grounding on unmarked reef	<i>The vessel ran aground, due to the inattentiveness of the officer of the watch, who allowed himself to become distracted from the navigation of the ship, for a period of about 15 minutes, by a telephone conversation being made by his wife, who was on the ship's bridge wing, such that he did not hear the waypoint arrival alarm on the GPS and therefore did not alter course at the appropriate time. The ship was travelling towards a featureless horizon with no visual cues to mark the reef, which was largely submerged. Fixing was by GPS onto a paper chart. Although the real cause of the grounding was through the inattentiveness of the officer of the watch, the report of the investigation suggests that had there been something such as a beacon to mark the reef it may have stimulated the mate from his reverie so that he may have reacted to save the situation.</i>

	DATE	SOURCE	VESSEL TYPE	SIZE	NATURE OF INCIDENT	MAIN CONCLUSIONS
9.	Nov 2000	Transport Accident Investigation Commission New Zealand	Fishing Charter Vessel	12.35m	Grounding and foundering	<i>The skipper was alone in the wheelhouse and navigating, mostly by eye but with the aid of GPS and radar. The radar was set on the 3-mile range and the GPS on large scale. He was not using the navigational chart of the area. He left the wheel to get a pen from his briefcase, which was on the bunk behind him. About 2 minutes later, the vessel struck a charted underwater rock. The skipper's navigation methods were not appropriate for the area being transited. The skipper did not know the precise location of the vessel just before it grounded and the grounding probably would have occurred even if he had not left the wheel unattended.</i>
10.	Jul 2001	Transport Accident Investigation Commission New Zealand	Coastal Container Ship	4529gt	Grounding	<i>Vessel grounded when the pilot intentionally conned the vessel toward the starboard side of the channel to avoid reported shoaling near a beacon. The following ebb tide probably carried the vessel further to starboard unnoticed by the bridge team. Individuals in the bridge team were independently monitoring the progress of the ship, but the low standard of bridge resource management resulted in poor communication of information and an eventual loss of situational awareness. The number and disposition of navigation marks in channel, particularly as some were unlit, made it unsuitable for transiting in darkness.</i>

**ANNEX B - NAUTICAL INSTITUTE MARINE ACCIDENT REPORTING
SCHEME (MARS) REPORTS 2002 - 2002**

A Bridge Automation Too Far

Report No. 200012

I am in danger of entering into a passionate discourse about bridge automation and its evils but that would create the wrong impression and would probably brand me an old fashioned stick in the mud. Instead I shall comment about one particular item of automation which frightens the life out of me! In a recent MARS report one of two ships proceeding up channel mysteriously altered course towards the other whom she was overtaking and then, even more mysteriously, appeared to correct the error and sheared off to port, thus averting a collision. The officer in the overtaken vessel was probably somewhat shaken by the encounter.

The incident was similar to one I witnessed. I was on the bridge wing talking to the Second Officer when the ship mysteriously altered course. I immediately noticed the change but was rather disturbed at the officer's nonchalance in informing me, in response to my questioning, that the ship had reached a Waypoint and the GPS had altered course!!! The ship had recently been taken over from another company. We immediately ordered the disconnection of the GPS from the Autopilot. An incident on the eastern seaboard of the USA involving such equipment on a cruise ship was still fresh in our memories.

Returning to the original incident described, I wonder if the overtaking ship was similarly equipped and did a similar event occur? It is evident to me that shipyards are increasingly producing ships with "Fully Integrated" bridges as a standard item. If one reads the naval architecture, ship construction and even ship management magazines, such equipment is seen as something to be proud of. How many mariners have been consulted?

Is it too late to shout loud in protest at this premature introduction of a lethal weapon? Aircraft may have such systems but they also have the added dimension of altitude to help prevent collisions as well as a very strictly regulated oversight by not one, but two pilots. Driverless trains are a reality on the Docklands Light Railway and between airport terminals but again the regulatory environment is very strict indeed. We have no such safeguards on the sea. The separation aids which are in place are imaginary lines marked on charts, occasionally assisted by navigation aids. They are entirely dependent on humans ensuring their ships are correctly positioned. Unfortunately there are too many people both at the design stage and operating at sea who do not give enough thought to the possible disastrous results of their actions. One only has to read MARS to appreciate that.

When the next yachtsman or fisherman is run down; when the next catastrophic collision occurs between two leviathans, will the designers take any share of the responsibility? Human error extends much further than just the operator.

I read with interest the Mars report expressing concern over Bridge Automation. The author was rather disturbed when his ship 'mysteriously' altered course whilst he was on the bridge wing. Our vessel, a large 80 metre motor yacht has had the system he described installed since 1995. Whilst I am very aware of the limitations of the system I am also very aware of how useful a system can be. One distinct advantage of this is when crossing the North Atlantic on a Great Circle route. The ship, being guided by the GPS will follow the GC track from start to finish making small alterations as necessary. We do not, however, use this system in dense traffic situations nor whilst in close proximity to either land or other vessels.

Our systems, and all other approved systems, are not allowed to alter course unless this has been approved by the operator. Our particular system has a two tiered alarm. The first is a 5 minute to waypoint warning which must be accepted first before the second alarm which is the actual alter course can be activated. My standing orders dictate that a watchkeeper is forbidden to accept an alter course request unless the ships position has been confirmed first. It also has a course limit alarm which can be set in 5 degree increments, i.e. the ship is not allowed to alter course by more than 5 degrees without operator intervention. Now that the errors on GPS have been taken out, there will be less spurious GPS positions which cause the system to want to alter course unnecessarily. In conclusion, an automated bridge system is very helpful to the mariner as long as the limitations of the system are known. It can only be termed as a 'lethal weapon' is if it put into the wrong hands.

Reading the MARS reports lately concerning the maintaining of a good lookout and the loss of yachts, I was reminded of a recent discussion I had with the Master and Chief Officer of a handy sized bulk carrier. They were reiterating what I had also heard from other sources. Their observation concerned the way in which the maintenance of a good lookout at sea was adversely affected by GMDSS.

They observed that officers were often so absorbed by their task of sending or receiving signals by GMDSS that they appeared to forget, for significant periods, their prime role of looking out of the bridge window. If this practice is widespread at sea and carried out at times when a second man (if on watch) is also preoccupied in other duties, it is small wonder that yachts and small boats are knocked down.

I well remember during my days as watch keeping officer, taking frequent breaks from other mundane duties (such as correction of charts and publications or planning of cargo operations) to pace up and down the bridge. Looking out of the window is just one of the responsibilities of the officer of the watch. Not only did this frequent pacing keep me awake and break the tedium, it kept me continuously aware of the situation round the vessel, of the weather, of the course being steered and of the activities of the crew on deck.

Are today's watch keepers being seduced away from their prime duties as OOW by the techno-attraction of the GMDSS terminals?

GMDSS is primarily a Distress and Safety System with DSC for calling and Distress Alerting, other channels/frequencies are used for working, as has always been the way. If watchkeepers are playing with Ch 70, 2187.5 and so on, it might account for the large number of False Distress Alerts!!

Enough flippancy. Having spoken to several Masters of modern vessels within my branch of the Institute, I suspect that it is not the GMDSS equipment which is the greatest distraction to young watchkeepers today - Pilots all too often report it as being switched off when they board - but rather ECDIS and ARPA. They love to play with both, and need constant reminders that their primary duty is to look out of the bridge window at what is happening around them.

Young officers who have grown up with computers, have implicit faith in them and all computer controlled electronic equipment. They would, on occasion, rather believe the equipment than what their own eyes tell them. At sea, the Mark 1 eyeball and the brain are still the optimum computer system. Many a time you will see a sailing boat when it will not show on the radar.

I agree entirely with your correspondent that walking the bridge, looking at what is going on around you, keeps you alert. Today's ergonomic bridge, with the airline pilot's seat and displays all around you, is guaranteed to put you to sleep especially in an OMBO environment, where there is no one to give you the occasional nudge if you start to nod off.

I have often encountered two opposing views, one which "refuses to look away from the ARPA and out of the window", and the other which "refuses to look into the ARPA and looks only through the window". Very rarely have I seen people with a well balanced attitude who, so to say, "look at both the ARPA and 'out of the window'."

I belong to the so-called "GPS generation" - other than my first two ships, all the rest had GPS, though I have used the Decca, Loran, Satnav, even Omega, and still take sun and star sights on clear days and nights (Something which I continue to teach my cadets). A few years ago, we had some interesting voyages on 14 knot 30,000dwt ship sailing between Brazil and the entrance of the English Channel - the master would check our position on the Satnav every noon...just to be on the safe side, and then switch it off.

I often wonder, if it is not the slowness of seafarers to adapt to new technology which makes them either over dependent or foolishly independent. Do we practice shouting or, for that matter, using smoke signals, in the fear that the telephone lines or cell phone towers may be down sometime? Do we stop using the TV/heating/lights/electric appliances - preparing for the power shut down? Do we stop using computers and e-mails fearing a computer crash/virus attack (Something which happens more often than the GPS going "off"!). Do we go about revising the multiplication tables of "23"....just in case the calculator goes bonkers?

For all those people so suspicious of all the modern gizmos on the bridge, have they had a look into the cockpits of the very aircraft that fly them to their ports of joining/sign off? The normal transatlantic Boeing carries two people in the cockpit, the autopilot functions with inputs from the anemometer plus the INS and automatically alters course. Perhaps they should go and give a lecture to each of these pilots every time they join/sign off.

The fact remains, no technology is fool proof....but that doesn't mean we should live in the Stone Age! To shrug off modern technology is as stupid as to over-rely on it. I recently used the ECDIS during a Radar and Navigation simulator course and wondered why such a fantastic tool is not used on ships. It would ease the burden from the watch keeper tremendously. There is no good reason why a watch keeper would doze off on the bridge if he had a supply of coffee and wasn't overworked and had a reasonable sense of responsibility. A tired watchkeeper would end up sleeping STANDING, even in the midst of the English Channel traffic, with no modern gizmos.

I'd love to know what other navigators think of this and what their reasons are. Perhaps we could have a healthy debate by which we'd all learn.

Compass errors are one of my "things" and at the beginning of every voyage I have a difficult few weeks reviving the simple and correct routines for confirming and recording the performance of the Standard and Gyro compasses. The Standard compass in particular is the only machine we have at sea which is almost 100% reliable and I do wish this was recognised. I now understand that someone has devised a frightening new technique for obtaining errors and it works like this:

1. A buoy is seen on the radar.
2. The position of the buoy is taken off the chart by dividers and entered in the GPS and saved as a waypoint.
3. The course to go to this waypoint is then obtained off the GPS and considered as the True bearing.
4. This is compared with the radar bearing of the same target.
5. The difference is the compass error. Job Done!!

Admiral Lang's last MAIB Summary had, as a theme, machines are only as good as the men in control. I feel we are reaching the stage where technology is getting beyond the capacity of the present generation. I used to be proud of what I did, now I just look forward to the safety of retirement.

Readers Comment

I was appalled to read about the 'new' method of obtaining a compass error in MARS 200221 (May 2002). Are Seamanship and Navigation not taught these days? Has no-one told the exponents of this method that the position of a buoy is always in doubt and, even if it is correct, the position given is that of the anchor, clump or weight which holds the buoy. Has no-one explained the movement of anchored or tethered objects? The position of the buoy on the chart is never the true position, it depends on the length of chain, depth of water etc

As a marine consultant and surveyor I visit merchant ships from time to time and as a former shipmaster I take an interest in the way in which shipping is conducted nowadays.

Within the last year or two I have had the opportunity to study the passage plans prepared aboard ocean going ships with Japanese, Singapore, Greek and Danish managers. Whilst the layouts of the passage plans have been different, they have all provided much the same information. Courses, waypoints, charts and navigational publications are listed, from pilot to pilot. Details of tides and currents may be given.

What has concerned me is that the remarks columns in the passage plans, when provided, have always been left blank despite the fact that, on at least two of those ships, important information was known to the ship. One shipmaster told me that, on approaching a Scandinavian port, the pilot boat had urged him to "Come closer" and he had replied "No, I don't have the chart, you come out to me", but, as I saw, the passage plan made no reference to that potential problem. The passage plan for another ship, bound for St Petersburg in the depths of winter, made no reference to the certainty of meeting ice and no reference to the obtaining of ice reports despite the fact that, as the master told me, the superintendent had reminded him in the previous port that he would be meeting ice.

In both cases the ship's master was aware of the potential problem but had failed to recognise the importance of recording it in the passage plan. If either of their ships had been damaged, they would have had difficulty in persuading the Authorities that they and their officers had been fully prepared for possible emergencies.

An additional matter for consideration is that none of the four vessels had passage plans for pilotage waters, despite the fact that the ICS Bridge Procedures Guide specifies that "The passage plan should cover ocean, coastal and pilotage waters."

This incident happened a few years ago during a "holiday" as a crewmember of a 50m-schooner in the Baltic Sea and came to my mind when reading the MARS 98015 about the BRM course in Stockholm and the "vital point" of the training: "not to become preoccupied with a single problem".

We were bound for Copenhagen and arrived there under power in the middle of the night. Maybe because of our late arrival the Master of the vessel decided not to follow the main fairway but to take a "short cut" through a network of small harbour channels to reach our indicated berth. Most of the passengers were already asleep. The duty crew were on the forecastle and along each side acting as lookouts because the channel was very narrow and very dark and full of small and unlit buoys (this was their normal state).

During our passage through the channel the atmosphere on board became very intense and anxious because it was difficult to avoid these unlit buoys and all the crew were looking ahead, trying to see the next buoy. The lookouts on the forecastle were always the first to see the shadows of the buoys and they called the warning which was passed from one to the other back to the poop. It seemed to take ages to pass through this channel with. It was absolutely dark and calm and nothing else was heard apart from the call of the lookout, right up to the moment when the whistle of a large vessel interrupted the silence with 5 blasts. I remember looking up and being startled at what I saw. Our vessel was just approaching the main fairway and there was one of these huge Baltic Sea ferries, lit like a Christmas tree, right on our starboard side and we were running directly in front of the giant bow. The next second I heard the three short blasts of our vessel, the schooner shook and jolted and then started - slowly, very slowly - to move astern. The large mass of the ferry passed our bowsprit very close. I still think about the circumstances which led to this incident and I am still not able to understand how it could be possible for the whole ship's crew (at least 10 to 15 people) not to see something like a large, well lit Baltic Sea ferry. The only explanation is that we all were so preoccupied with the small buoys that we forgot to look for much bigger problems.

A partially loaded tanker grounded in poor visibility on the American coast. A Master/Pilot exchange, including appraisal of the prevailing and probable weather conditions forecast for the transit was conducted in accordance with Company Passage Planning procedures prior to getting underway. Fog had prevailed at the berth during the morning but had cleared by the time the vessel left the berth and two of the tugs confirmed that the weather was clear during their transit of the channel to attend the vessel. At approximately 30 minutes into the channel transit, the vessel ran into fog with visibility down to between one and two cables. Lookouts were posted at the bow and the 'bridge-team' increased. The pilot recalled the tugs and requested that they stand by the vessel, with one tug being instructed to lead the vessel in the channel. During transit the pilot used both visual and radar observations for position fixing, while the bow lookouts reported the sighting of channel buoys as the vessel passed, with a 'bridge-team' member logging the time, ship's head, and speed from GPS in the Bell Book.

A large alteration of course was required to pass between an island and the mainland. Inexplicably the pilot failed to execute the 'wheel-over', leaving the vessel heading directly for the land ahead. The pilot, upon realising the perilous situation developing, took belated corrective action but failed to prevent the vessel touching bottom in the vicinity of the headland. On touching bottom, the vessel, due to bank effect, veered across the channel and grounded near the NE end of the island.

The vessel was re-floated with the assistance of the escort tugs, which were now made fast, and anchored in a nearby anchorage. The Coast Guard was notified immediately of the grounding and the sounding of all empty tanks and void spaces including verification of cargo tank ullages commenced. No personnel injuries were sustained as a result of the grounding. Sounding and ullaging confirmed that no pollution had resulted. As a further precaution, a diving team was organised to survey the vessel's underwater hull and rudder area for damage.

Conclusions

The root cause of the incident was due to poor visibility compounded by excessive speed for the prevailing conditions and the pilot's ineffective use of the radar equipment to monitor the vessel's position during transit. The bell book entries indicate that, on encountering fog, the pilot (without protest or intervention from the Master) did not reduce speed commensurate with prevailing conditions. Therefore, on failing to alter course at the planned 'wheel-over' position, combined with inappropriate speed for the prevailing conditions, the pilot was left with little room for manoeuvre or time for critical decision making, and the grounding of the vessel became to some extent inevitable.

A contributory factor was the distraction of the 'bridge-team' in the vicinity of a critical 'wheel-over' position due to the pilot's decision to subsequently make the tugs fast, compounded by the Master's reluctance to take the 'con' from the Pilot even though being aware of the precarious situation developing. In this instance, the Master chose

only to question the pilot's intentions, not having the confidence to override the pilot's judgement, experience and local knowledge.

The safety of the vessel is the Master's primary consideration and responsibility. Therefore it is appropriate to emphasise the critical nature of the Master/Pilot relationship, and the Master's obligation to monitor the pilot's performance and execution of the vessel's passage plan at ALL times. The Master/Pilot relationship also includes the full participation of all members of the 'bridge-team' in the monitoring and execution of the voyage from berth to berth.

I have continually exhorted Bridge Teams to practice their sextant skills when deep sea, and to take visual positions as a primary means of navigation when coasting, rather than rely on electronic aids alone. These exhortations are backed up by the Master's Standing Orders almost without exception but on many vessels there appeared to be some reluctance to actually take visual positions. Having read various trade publications, I'm slowly concluding that this is an industry wide problem. The problem may be down to reasons as simple as the fact that the azimuth mirrors on some ships are of poor quality, are difficult to read at night and give the observed bearing in a reversed compass rose, and/or the height of the repeater is too high for many of our navigators to be able to read the bearing without climbing on a box of some description (boxes and platforms are in place on some ships but not on all). It may be down to training too; do sea schools stress the importance of visual bearings to the young navigation cadets of today? Do Masters frequently and verbally stress their requirements?

There appears to be an inability for today's navigator to be able to deal with taking three visual bearings and a radar range, plotting the position on the chart while maintaining an overview of the traffic situation and, if necessary in port approaches, keeping the Master informed too; this is not specific to one nationality, it's across the board, but it may explain why the navigator is reluctant to leave the security and continuity of the radar display.

Today's navigators seem to be reluctant to go outside into the marine environment when they can simply plot a GPS position, or obtain a position from the radar, or simply put an "x" on top of the Nautoplot light. Also, they certainly do not move themselves from the centre of the wheelhouse to the bridge wing and back to the chart table at anything like the speed we ancient mariners used to do when we were lads. Nor do they look out of the window to compute the movements of other ships with their eyes and brain nearly as much as their predecessors did. They would rather rely on the information gleaned from the ARPA display, no matter the quality of that information. On the other hand, though, do we want the navigators to walk onto the bridge wing, sometimes a decent distance from the centre of the action, to observe three bearings from a moving platform? Is the basic equipment they are using of a suitable standard? Our SMS states that "traditional methods should be used to cross check electronic information," but it's fair to say that a GPS position is often more accurate than the cocked hat obtained from two or three gyro bearings, rarely with error applied, and a radar range or two.

We also use the radar-based parallel indexing technique and have been using it for so long in our Company, since at least the mid-70s when one of my esteemed predecessors was teaching it, that this technique must surely qualify as a traditional method! However, the important fact must not be forgotten: we must back up one method of fixing the ship with another independent method. GPS Positions backed up with radar-derived positions would comply with requirements. With the advent of electronic charts, user-friendly track control steering modes, ECDIS etc., we expect our officers to be more aware of electronic aids than ever before in the past, such that a Master who has been retired for ten years may well struggle to run a bridge successfully until he has had a period of adjustment and training, should he/she return to sea for whatever reason.

Electronic aids have improved so much over the last decade or so that, with a continuation of this progress, eventually the emphasis will change from visual positions being our primary navigation method with electronic aids backing them up to the visuals backing up the electronics. Whether we are prepared to accept this paradigm shift is a moot point but the reluctance to use visuals is prevalent through the ranks from Chief Officer down to cadet. When we consider that GPS is locked into so much of our bridge equipment, from radars to echo sounders, and hardly any one these days can use a sextant to good effect, perhaps we need to consider a progressive change of training emphasis. What are young persons being taught at sea schools? Is the emphasis on traditional or modern navigation techniques? As we slowly evolve to navigation by paperless chart, we, the Company, may need to rethink our stance on this subject.

Inappropriate Reliance on GPS

Report No. 200245

We were approaching a small port at night, using the newly supplied and corrected British Admiralty chart (published 1847, latest edition 1927) for the passage through the reefs and rocky islets into the lagoon. The intention was to approach the entrance of the buoyed channel where a pilot would board. The 2/O had plotted the position of the buoys and channel limits into the basic radar mapping programme, linked to the GPS. I was aware that he rather resented my insistence on fixing the ship's position primarily using visual lighthouse bearings and radar distances. That was until he saw that the radar map graphics placed the channel clearly across the nearest rocky patch, even when account was taken of the half mile correction to WGS datum.

ANNEX C - NOTES FROM NAUTICAL INSTITUTE PRESENTATIONS

BRISTOL – 17 April 2002

You could reduce a lot of visual aids if you could eliminate background lighting on approaches. 40% of lights are wasted

Enhanced lights may be a solution. Enhanced but fewer lights?

The Sea Empress report mentioned leading lights

Lighthouse Authorities have a responsibility to keep the coastline safe for all classes of mariners; There is a cost analysis against the risk, eg to keep a tanker safe versus a yachtsman.

Backscatter is a particular problem when making a port entrance. There is a lot of reliance on GPS etc, but when you are doing your own pilotage you do not rely on the electronic aids because you are in a traffic situation and looking out of the window.

The majority of shipmasters use waypoints on approaches. We are currently talking to local planners to reduce background lights.

The more visual aids - the happier the yachtsman.

The worldwide marine leisure industry is huge, from giant power boats down to small yachts. It is the small yachtsman who uses the lights. If navigational lights were reduced, it would be a problem for the small craft sailor.

Approaching the Needles, you cannot rely on GPS or DGPS. You must use parallel indexing.

Pilots should not be moving between the window and radar. They need 'bridge special awareness'. They rely on approach on 'whether it looks/feels right. They move on transits.

Portable Pilotage aids are like a video game. They don't encourage a pilot to look or think ahead.

Most yachtsmen use passage planning; still take bearings and use all sources of information to help them navigate.

Deep sea – electronic systems make life much easier, but these systems may not be there (war etc) but from A to B they are the best method. In pilotage waters we should not encourage people not to look out of the window. They must be aware of the lateral movement, wind and tide, dangers to shipping & other traffic. Electronic aids should be standardised. Leading lights and buoys etc are especially useful to yachtsmen where the channel may be changing. Are the days of the lighthouse over?

It is good to have lights (lighthouses) as they give reassurance.

There are very few occasions when yachtsmen use only GPS to navigate. 50% of yachtsmen do not have GPS. Yachtsmen who do not have adequate information to navigate, ultimately provide a risk to commercial shipping.

Visual aids are needed and will continue to be so; visual aids at night must be efficient despite background lights; visual aids during the day must be a subject for risk assessment; usage of GPS is still in its infancy – systems will improve – we should look to develop GPS to utilise it better; look to the aviation industry and see how they combine visual and electronic information; it is not essential to have 3 lighthouses in view at any time, but it is vital to use at least 3 sources of navigational information.

ANTWERP– 13 May 2002

We (the Belgian Lighthouse Authority) don't intend to change our policy on general buoyage and visual aids to navigation moreover we tend more to increase...the Belgian government plans to install windmills (in the water) around certain areas and we need to beacon up these areas and it makes our job even more complicated because we need to have security that small ships without G.P.S. or with failing G.P.S. cannot enter these zones...we are actively investing in new buoys...we have about 131 buoys and...the number will increase.

To demonstrate how important buoys are, in a fairway very close to the beaches there were no red buoys, only green buoys, while the fairway was bordered by the beaches. Now, because they expect to have more ships sailing without pilots they have added a big number of red buoys which means that the fairway is now about between 50 and 100 metres narrower than it was before...the same happened in 1997 on the upper part of the river between the Antwerp Locks and the new lock of the canal to Brussels. There also have been several buoys added because they expected that barge owners, skippers of barges and captains of ships sailing without a pilot would have more benefit from these visual aids.

Since the last 25 years, the number of beacons has been reduced and the number of buoys has increased. The Dutch tried to reduce the number of buoys and in fact they were not very successful, and we also see now that in the secondary fairways they are also adding again buoys.

Aeroplanes normally rely on electronic navigation

The airlines have been designed to be navigated electronically and their systems do tend to have second and third failure modes, so that if one goes, another system is always checking it so you get cross check within the systems. This is something which most merchant ships haven't been designed for - some of the more modern ones have and when you get into things like dynamic positioning, obviously you have your second and third failure modes, but in a vessel that only has a G.P.S. or a D.G.P.S. if that one system fails that's it. So if you get a fly by wire then you have to design the system to be flown by wire.

As most ship owners do, we will only comply with what is internationally agreed upon...if you can prevent the major loss of a vessel by adding a device that costs a few ten thousands of dollars or euros I don't think that a serious ship owner would object to that. Aeroplanes are made to be flown by wire, which has a direct impact on how aeroplanes are built. Maybe we should design ships exactly to be driven or navigated by wire...one of the major problems we have now is trying to combine ancient style built ships with modern navigation techniques - may be not everybody knows perfectly well how to use modern navigation systems. I know from my seafaring days that some of the youngsters were not able to combine the different modes of navigation

Why can't we remote pilot vessels...pilot them from an office. If you put the amount of investment in a vessel that would allow somebody on board to pilot completely blindly the step, financially, is very small than to take off the responsibility of that one individual and put the responsibility in the hands of somebody who has a general view of the navigational or pilotage situation.

The Dutch authority has been multiplying beacons and buoys up to the smallest ones - you have to identify your customer and what is perfectly possible on a merchant ship is probably unacceptable on most leisure vessels.

The Portable Pilot Unit (PPU) - there are many possibilities especially in fairway navigation and when you're talking about deep draught vessels with very restricted manoeuvring possibilities...you will have very precise information about your position but also additional information which is now only available to V.T.S. so each ship will have this information but that goes further down than talking about navigational aids today.

Radar as GPS or DGPS is in fact giving history...when there is bad visibility you do not see the buoys - you only see them on the radar

It is very dangerous to compare air navigation with sea navigation – we don't have the same kind of standardisation or the same place or the same instruments - a pilot is only certified for one plane.

People try to train themselves even in good visibility with a combination of eyeball with the electronic chart monitor so that when you are in restricted visibility you avoid what you see...You cannot expect them to take the same responsibility as an Air Traffic Controller it will never come to that stage.

I teach ages 16 – 21 and I teach the ECDIS and the ARPA course and what I see already in the first exercise, - I put them right into the Dover Strait because they know it pretty well from the other exercises and what happens then is the following thing – I put on the ECDIS, I put on the ARPA - they don't have any sight, there is no panoramic view and I put a lot of targets in it so they have to manually plot the vessels, otherwise they take automatic plotting and everything goes straight on to the ECDIS, so I take manual plotting, they have to choose their own targets. They put them onto the ECDIS and what happens for them it looks like a video game and after 50 minutes I put on some extra vessels or some extra targets and what happens they forget to look at the ARPA, they are only looking at the ECDIS because they see all the targets are on the ECDIS - that is not true of course. I have to say that 90% of them make the same mistake, always a collision, every time so they really think it's a video game, that's why now in our Institute we have chosen to go for panoramic view also so they really see that if there is a buoy out there but it isn't on the ECDIS that doesn't mean there is not a buoy out there.

The fact that the officers are not so common in the practice of using visual aids and the electronic chart system is just basically because of the way everybody's trained...you just can't train electronic charts and ARPA at school without any problem but where are we going to train the use of visual aids? – Only when you are at sea...we have to go back to the system of more sailing time.

We train our guys at sea – it's a boat at sea – and where we practice also the visual aids so in that we learn how to use GPS how to use the buoys in real circumstances at sea when its bad visibility when the circumstances are different so we have the possibility to train them at sea...so, first they get it at school in theory then we go every week at sea for one day - we train them to steer by hand, to have a lookout... they also have to go to sea with a real ship for a few weeks a year....

GPS says we think we should be there but the moment we see a lighthouse we say we are there and GPS is correct.

It is not always possible to use a light because of the shore lights – light pollution.

I have been sailing on coastal vessels for a long time and when I didn't have leading lights I made my lines myself with a house and a tree, with a buoy and a mountain but that's the only way to enter especially if you have cross currents.

The debate is about whether we have a mismatch between the means we have and what we have, what we use and the education we have and the equipment on the ships, and then do we start bashing GPS and Galileo and because its not working? You're better with a three bearing fix...buoys can be off position - it can be very dangerous to rely only on visual aids to navigation, especially when you rely on buoys.

If you use buoys, you need a lot of them to be certain that one is out of position – if you have electronic means of navigation there are also ways of ascertaining that what you get is the right information.

I was trading in a remote part of the world – there is a mismatch between the data from the GPS, the chart data and what's actually there, so no matter what system you use its never going to be the right one – you have to figure it out on the spot because your GPS is no help because it doesn't match with your chart; your chart is not exactly a help because the channel does not lay where the chart says it is and you can't rely solely on the buoys because some of them are missing – so you then refer back to Pilot Books etc. We are increasing the number of buoys because electronic navigation aids are at the moment not as reliable as they should be.

It is possible to fix an AIS transponder to a buoy...AIS doesn't have to be on the buoy – we can ghost it, so the next logical step is why do we need a buoy at all? Why don't we just ghost the AIS position on there...we have two things we have a physical buoy and a ghosting position which means that if that buoy drifts off station and we have two separate, or we have the virtual buoy where it is just the ghosting of the AIS signal.

HOUSTON (HOGANSAC) – 23 May 2002

More into the future visual aids will be used to a lesser extent so they are going to become obsolete.... electronic aids are a tool to add onto visual aids.

Training is the aspect that you have to deal with - continued training of new mariners, taking bearings and using line of sight versus the GPS concept.

I understand in the Pacific where some of the surveys are based on what Cook thought up...if you rely on GPS you go straight across an island.

We are seeing about a 2–3% increase each year in the US of visual aids.

HOUSTON NI – 23 May 2002

The master of a ship finds that only about 50% of usage was made of navigation marks now compared with some time ago, when he was on the bridge; he reckons its probably considerably less when he's not there...on the present voyage he was on the bridge and there was a very conspicuous lighthouse and he turned to the second mate and said 'is that this light on the chart?' The second mate said 'oh yes' and he said 'how do you know that it is the right lighthouse' the second mate responded 'the lighthouse is always there and the GPS puts us here, so therefore it must be the right lighthouse.'

The exit channel there takes you between 2 buoys and he said he himself was not happy until he visually saw the markers on these 2 items. He wanted to see them to make sure he was going through there rather than rely on any electronic navigation aid.

Aircraft get from A to B without the use of visual aids.

What about power failure?

A lot of money is spent on educating navigators but it seems like it doesn't always work...ships do run aground...Are we going to stand more on education or are we going to dumb it down and say the computer is going to run the ship we're going to have electronic waypoints.

I don't think we are anywhere near ready to go to virtual navigation...we need visual, we need correct navigation for our ships to be safe

I'm sure most captains want to navigate properly they want to use a mixture of GPS, they want to use visuals in the right place

It boils down to one basic lesson is look outside the window

I was skipper on a dynamic positioning diving vessel and construction vessel And that was a computer game and this was from the late 70s it became pretty common in the offshore world and you have the DP operator sitting on his desk and moving a little cross to move the ship, working a dive on the seabed or something or you have installed a turret buoy for a FPSO and he's moving around trying to lay pipelines and he forgets to look outside to see his bows hitting the turret buoy he has just installed, and that is a visual aid but people just forget to look outside the window and a similar comment is on the new drill ships that are coming out. They are setting the DP systems inside where you do not even have a view of the outside world so I think a lot it is being dictated by people like us who are sitting in offices and who have forgotten what it feels like to be at sea and look outside...and we are driving designs which are not practical at all.... It is not only the naval architects...a lot of the companies here I see are being dictated in design by engineers or electrical engineers or mechanical engineers who are in charge of projects and who because they've been on some ship sometime back have decided that they know how to design the ship without consulting the guys who are running the ships... and that's in the last 5 years.

You can improve your technology but at the end of the day society is going to expect the master to use prudence and reasonable judgement, in this combination of technical and traditional to achieve the proper result and you are going to be held accountable if you don't. I think that's something that needs to be brought on to younger cadets coming out of the academies and younger mates maybe to keep that in mind always.

Primarily the problems relating to those groundings or those incidents was not primarily because there was an imbalance in what they should of used and what they should not have used ... they were severe operational errors in navigation...traditional versus the new methods that are coming today as far as navigation is concerned there has to be a balance...we cannot write off any of them ... both of them have their importance depending on the situation or what is happening if we are to blindly say that the modern navigator or the young people are purely relying on the technological form of navigation ..

What is the right balance? It would depend from situation to situation.

MANILA – 6 June 2002

I suggest the visual aids to navigation be maintained because they are very useful especially when you are navigating, piloting in places with strong currents...state or port should keep the minimum number of visual aids to navigation to avoid pollution, to avoid.

A combination of the visual aids and the electronic aids to navigation should be maintained

A tanker was coming from the Bahamas and going down through the Caribbean and entering through the Mona Passage; they were plotting the ship from the GPS...they only fixed the minutes and didn't check the degrees on the GPS...they were one degree of longitude out, so when they changed the course to enter the channel, they went aground – for 32 hours they only checked the minutes and seconds and they were 60 miles out.

A VLCC in Singapore Strait – the 3/0 did not fix the position for about 30 minutes and the vessel went aground... the GPS correctly indicated the vessel was on the bank!

A panamax size bulk carrier fully loaded...very clear day, state of the art equipment, 2 GPS, master on the bridge, second officer and 2 lookouts...echo sounder running, course line properly laid off on the chart, passage plan and relevant sailing direction books out. The master was familiar with the area, but on a vessel of only 5000t; he decided to cut the corner...there is a pinnacle reef that's referred to on the chart and also in the sailing directions...he hit the pinnacle at full sea speed...while every electronic aid was onboard the ship, a simple visual marker on that pinnacle would have alerted their attention.

2 ships touched at anchor...young boy on the bridge...although only 800-1000 metres off the breakwaters, he was using guard range rings set up on the GPS to alert him. It was the sterns of the ships that had touched – if he had got up and walked onto the bridge wing and looked aft he may have been able to see what was happening, but the first he knew of it was when he was thrown off the pilot's chair.

I sail extensively around the Philippine Islands in a boat without engine. In the Philippines specifically, the traditional method is the only way to go because in more than 50% of the country the inaccuracy of the charts, of which there are 175, is quite extraordinary...I have been onboard a vessel where the chart plotter line has actually crossed right through the centre of an island...the triangulation methods used in the early part of the last century even on modern charts are five miles out...a country like the Philippines with 7000 islands needs an awful lot more of the traditional methods because 90% of the people will never see a GPS system. One group of islands surrounded by a reef is as much as 15 miles out from the charted position..

I have a document from the Philippines Coastguard telling me that at any one time in the Philippines more than 50% of the navigation buoys are not in operation or have been blown away by the last typhoon.

Ocean passage should be with electronics – GPS- but when it comes to landfall and when entering shallow waters and dense traffic areas, we should start using our traditional pilotage and close water techniques and visual aids.

The most common denominator with accidents is neither visual aids nor electronic aids to navigation, but human error

With some of the young cadets and training them in some techniques, if the ARPA was saying that something was going to pass at 0.16 they believed that was what it was going to be and with blind faith they believed what a digital display says. There should be more on understanding the limitations of the aids that you are using.

The problem with tradition is that not all traditions are good - sometimes we have to mix everything and education should always be a continuing process

CYPRUS – 11 June 2002

With the ships with the modern bridges they also are given uninterrupted power supplies...so the danger of power failure has been taken well into account.

You have the ECDIS overlay and the radar picture together and therefore by drawing your synthetic radar map you now have 2 independent systems to confirm your position.

...all of them are taken in by the new electronic sea chart not so much from the position fixing part and the accuracy etc but the situational awareness... the master can now remain in one place with all the information at his fingertips and not lose the situational control.

We have to convince the young navigators that they have to learn also to use landmarks, the buoys, the paper charts... they refuse even to go into the chartroom and they like to play with their 'trains'.

Computers can be disturbed by other computers or virus...our effort must be very strong to convince the young people that they have also to learn traditional navigation.

DP systems which are basically computer programs allow a vessel with more than 8 propellers to sit in one position with a man at the end of a cable on the sea bed – nobody would allow that to happen if there was any doubt that that computer would continue to function almost in any situation; it allows you to put a man on the bottom, to dive and to stay there on DP – those systems are tried and tested...they are what we are seeing now, coming along with ECDIS

...commercial satellites can be hacked into

In the Gulf, I had 7 ships and GPS/DGPS were off on every single one of them – they totally removed the service from everyone.

When I was at sea between 1960 and 1969, I sailed with masters who locked the radar up and only allowed it to be used when they were personally on the bridge so they could make sure the second mate or the third mate didn't break it. That's exactly what were having now...we're moving on...I wanted to get my hands on that radar but the master wanted me to take visual fixes all the time... What we've now got is much better systems and young keen officers coming through wanting to see what the systems can do...we've got to teach them the old fashioned systems as well...we've got to teach them how to use an ARPA...we will eventually end up with something similar to fly by wire.

When we are in a river it is much easier to look at a cardinal mark and have a reaction or take a position with a church outside or something like this than to go inside the chartroom reading some numbers... up to three decimals - and how many minutes do you need to process the numbers etc

On the coast we used everything – we had DGPS, we had electronic charts we had ARPA and we had our eyes – we used everything in equal balance...I couldn't tell you what I relied upon more or what I didn't...it was a case of professionalism and training ...I think the progress is excellent and we should not try and block it ...we shouldn't be blind to it, but where we are failing must be in the training because if the young generation doesn't recognise the value of the old things that we have, that have always worked and always will work, then there's something wrong with the training.

I am an ex Jumbo Captain, commercial ocean yachtmaster, and yachtmaster instructor. We come from very similar industries, just a different medium...this meeting could have been 20 years ago in aviation...I was one of the first pilots to get involved in blind landing systems...you offer a pilot now in fog with a blind landing system not working, he will not take the aeroplane. I've actually landed a jumbo at London Airport in 100 metres visibility and the first thing I saw was when the nose-wheel touched the ground - a couple of white lights. Nothing on the visual side in aviation has been removed because of electronics, but electronics are here to stay

ANNEX D - WRITTEN SUBMISSIONS FROM MARINERS

LEISURE YACHTSMAN (PHILIPPINES)

TRADITIONAL & TECHNOLOGICAL AIDS TO NAVIGATION

Creating a Balance between Visual & Virtual Aids

The pendulum of choices swings very much towards 'traditional' aids with the 'A1 eyeball' as the primary source of safe navigation in Philippine Waters. Although GPS is ideal 5 miles offshore, the leisure cruiser is mostly operating in confined waters in an archipelagic state. There are over 7000 islands in these waters.

Charts in Philippine Waters are often inaccurate due to old surveys sometimes using simple triangulation methods. Of the 175 charts produced by the Philippine Charting Agency (NAMRIA) only 37 are recognised by the International Charting Agency. In addition to this, it is a simple fact that after charts get printed coral keeps growing.

However, it is the existence of several physical hazards which must be taken into account. Because of them, navigators on leisure craft can never isolate themselves from constant lookout. To rely solely on GPS and radar and chart plotters is a mistake for several reasons. At night the navigator is moving blindly in areas where these hazards exist, because not even traditional methods will help in locating them.

Fish Attraction Rafts (FARs) & Bamboo Poles

Devices are used in Philippine waters to attract valuable pelagic species, including tuna. Close to shore - outside shipping lanes - in waters frequented by leisure craft, these are usually bamboo poles strapped together lying flat on the sea. Often, in certain areas, upright bamboo poles encased in concrete poured into old paint cans are frequently encountered. In other areas these FARs are made of steel or metal cylinders and can be over 10 metres long. The largest ones can be anchored in over 2000 fathoms, and have been spotted 60 miles offshore. None of them have lights attached or have radar reflectors. During daylight hours some may be seen because they have been painted with bright orange paint, and others have a palm frond sticking upright. These devices are a major hazard for leisure cruisers even in daylight hours, but especially at night.

Fish Pens & Traps

These devices are often found miles from shore and are made up entirely of bamboo. They are in shallower waters, and can take up quite large areas, with bamboo sheds placed on platforms as part of the structures covering many square metres. In some areas these pens have leading lines of poles pushing fish down a V-shaped corridor into a trap. These pole lines can stretch for over 100 metres. These devices are a hazard to navigation, particularly at night, since they are home made and not set up with lights and reflectors.

Bancas

Local fishing boats (bancas) with bamboo outriggers on either side are to be found in large numbers in Philippine Waters. At night hundreds of bancas often fish in the dark, and only have a torch (flashlight) on board. Only if a cruiser is coming close will a fisherman turn on his torch and wave it to attract attention.

Lights and Buoys

The Philippine Coast Guard still circulate a document stating that at any one time in Philippine Waters up to 50% of all main buoys and lights may not be operational. Typhoons play their part, as well as a lack of funding and lack of resources to service or maintain or repair these aids to navigation.

Comment

Virtual navigation is more relevant further out to sea in all jurisdictions. Visual navigation is the main event when in tropical waters and in countries like the Philippines where modern technology is too accurate for many current charting, situations, and technology gives no help at all in locating FARs and other unmarked, non-radar reflective devices as well as hundreds of unlit fishing boats.

MASTER MARINER, INSTRUCTOR (PHILIPPINES)

VISUAL NAVIGATIONAL AIDS

Do we still need them? Or we have come to an end of an era?

Visual navigational aids have been with shipping since seaborne trade started in the world for the first time. Navigators have always depended on visual aids to navigate the seas since Phoenician days. Shore lights in the form of fires and then later lighthouses have been in use and abuse historically for a long time. The famous novel “Jamaica Inn” tells us about the abuse of light signals to run ships aground, by shifting the lights, so as to plunder them later.

Over a period of time the pattern has changed and become more sophisticated in the form well built light houses at critical points, with modern technology allowing fog signals, weather forecasts and help in SAR functions. The dedicated people who man the light houses or light vessels have given tremendous service to the marine community, be it an ocean liner, VLCC, small fishing boat, coastal ferry or pleasure craft. The buoyage systems have guided shipping through port approaches, pilot pick up points, lane separation schemes and deep channels for safer transits. As the ships have become bigger in size requiring deeper waters the importance of deep-water channel markings cannot be over-emphasized. In addition, danger marks, wrecks and hazards to navigation have been made known to shipping by the use of buoys.

Light vessels still have their uses today. They may be automated in many of their functions but their use for safer shipping cannot be denied. They serve as pilot vessels in some ports, and at the same mark a critical point in safe navigation.

No electronic device can fully replace visual navigational aids in shipping, even though the cost of maintenance of these visual aids is continuously on the rise. Most of the light-emitting systems have been automated with advance designs using longer life, reliable batteries and electronic devices. Still, basic maintenance is necessary, and these costs cannot be eliminated.

Those countries with large archipelagoes depend mainly on coastal ferry services. For these ferries visual aids are the lifeline for safe navigation. Countries like Canada, Philippines and Sweden for example, each have large ferry network to serve people living on the islands. More affluent countries having large fleets of pleasure craft solely dependent on visual navigational aids all the time. The visual aids are, at any time, much more reliable than electronic aids and are relatively easy to use for an amateur navigator. This is also true for coastal fishing communities who have limited resources to afford electronic aids and many are not trained as navigators.

If we are looking for safer ships and cleaner seas, then visual navigational aids should stay. The cost of keeping these is negligible compared to the enormous cost of accidents caused by ships due to lack of aids in terms of life, resources and clean ups after pollution, and this is applicable to all sectors of shipping.

The industry and administrations should join hands and improve visual aids through joint contributions in realistic terms to improve the safety of shipping.

**RETIRED SHIPMASTER & PART TIME LECTURER IN NAVIGATION &
RADAR (UK)**

THE VALUE OF VISUAL AIDS TO NAVIGATION

Two examples of navigating a ship in restricted visibility:

In the early 1950's as Third Mate on a steam ship of 4042 NRT carrying a general cargo, I had on occasions to navigate the English Channel in thick fog. This was achieved without any electronic navigational aids apart from an echo sounder. As you well know, these passages require great skill and seamanship. They are nerve-wracking and potentially hazardous to life and to the environment.

In the 1990's as Master on VLCCs and LPG carriers, I had on occasions to navigate the Singapore Straits in blinding rain at night. This was achieved with all the available electronic navigational aids apart from ECDIS/EINS systems. Again these passages require great skill and seamanship. They are nerve-wracking and potentially *very* hazardous to life and to the environment.

Conclusion

The only difference I can see between those forty odd years is one of the scale of any potential disaster. Both scenarios were fraught with difficulties to such an extent that on occasions the only safe thing to do was to stop and anchor the ship until the visibility had improved. With the benefit of visual references both the above passages are straightforward and can be achieved without danger or loss of time. Time is money. I cannot see, at any time in the foreseeable future, a situation where electronic aids can safely take the place of traditional visual methods of navigation.

Electronics are, after all, aids not substitutes.

MASTER MARINER (BRISTOL)

VISUAL VERSUS ELECTRONIC NAVIGATION

My gut feeling as a Master Mariner with some 26 years service at sea is yes we need the visual as well as the electronic system.

In my experience, if you took an electronic position whilst near the coast, you automatically double-checked that position against a visual aid. Should the visibility be poor you double-checked the position against a radar fix. One was taught over the years never to rely upon one of anything such as a bearing or distance or sextant angle or whatever.

Even with the electronic fixing system Standing Orders for the Quality System also directed that at least one sight a day had to be taken when deep sea, weather permitting.

With GPS, Omega, Loran and Decca, the readings or positions were always logged in case there was ever a deviation noted from the intended direction. This was always a safety check.

Over the last few years a comet followed by a dust storm passed close to earth and there was some consternation as to whether any of the communication satellites floating around the earth would be damaged. I believe efforts were made to lessen approach angles on satellites to the comet and dust storm to minimise possible damage. Had any satellites been hit I am sure the consequences would have been serious. I did see the consequences of a particle of dust hitting steel at the speed of a comet in space and it was spectacular.

If for whatever reason the satellite GPS system was to go down for a length of time there could be severe consequences for both shipping and aviation as well other GPS customers that are ever increasing.

Too many electronic aids are fed information from the GPS and should there be break in the feeding of this information, who knows when this will be noticed by those on board relying solely on this form of positioning!

In good weather I always used the visual aids when navigating in close waters. When at anchor I used visual aids for transits by day and night. The electronic positioning system was only ever a backup.

Lets hope the Navigation Schools keep teaching the "Old stuff" as well as the new.

PRINCIPAL, MARITIME TRAINING SCHOOL (CYPRUS)

FINDING OUR WAY

"A ship can only be in one position at any one time. The purpose of navigation is to determine this position as accurately as possible".

This quote from an eminent navigational tome reminds me of the basic task facing the navigator on the bridge of a ship. It always has been and always will be the task of navigators; how it is done, to what accuracy and with what reliability I believe is the issue today.

Yesterday

Clearly it was seldom convenient and sometimes impossible to continuously fix the ship's position as accurately as required. Consequently it became necessary to update the last known accurate position. In order to do this it was necessary to know or to estimate as accurately as possible, all the factors which influenced the ships progress. These factors included course steered, speed, time interval since the last accurate position, effect of current or tidal stream and the effect of wind. Although a ship could only be in one position at any one time, it was normal practice for a ship under way to be assigned several positions depending on the method used either to fix or estimate that position.

Observed Position, Dead Reckoning, Estimated Position, Chosen Position, Most Probable Position.

All these were well known to navigators aboard ships, although I confess that the last two were rarely if ever used except perhaps when crossing the Atlantic, on passage to the Caribbean having seen nothing of the sun or stars for days.

Excuse the pun, but what is the true position?

Today

Unencrypted Differential Global Positioning Systems are gradually being introduced worldwide. However mariners are warned against over reliance on the accuracy of DGPS systems when using some large and medium scale charts particularly when closing the coast or approaching off-lying dangers, in particular wrecks.

Whereas GPS produces a quoted accuracy in the order of 100 metres, DGPS can potentially fix a vessel's position to within a few metres. The problem we face today is that the navigation systems we use (and take for granted) are considerably more accurate than those used to compile the original chart.

To use modern chart terminology - lets zoom in on tomorrow:

The problems of local horizontal data, unique to particular areas and their complex relationship with WGS84 datum and the available transformations and datum shifts when applied to DGPS will all have been resolved.

Navigators will emulate their aeronautical counterparts. The so-called voyage plan of today will have become an automatic voyage executive (AVE). A fully integrated system will take the vessel from berth to berth, interrupted only by the navigator making alterations for collision avoidance. Pilots will have become redundant as ports VTS systems become empowered to effectively con a ship direct to its berth. Systems will be duplicated and even triplicated and the concept of 'watch dog' computers will have given us not only reliability but also the verifiability required.

The only difference between today and tomorrow is the willingness of administrations around the world to recognize that the means are already here; all that is required is to find a way, but quickly.

To Conclude

My main concern is for young men and women entering the industry today who have not grown up with 'yesterday' and are becoming increasingly frustrated with the fact that tomorrow is not coming quickly enough.

As a result I fear we may not be far away from the day when an individual who has prematurely encompassed the new technology finds that the industry has not supported him with catastrophic consequences.

Already his world is about SENCs and ECDIS; all the information is held in a database - the ECDIS is able to continually interrogate the information available and thereby warn of any danger that falls within the end user's set parameters. It is because of this ability that Vectored charts and S57 derived displays are sometimes referred to as intelligent. Motivating him to properly correct paper charts that he believes are out dated and 'old fashioned' is becoming increasingly difficult.

Finally - do we really believe that GPS will fall out of the sky - do we really believe that someone will pull the plug - do we really believe that with the technology we have today we don't know where we are?

MASTER MARINER - BERTHING MASTER (HOUSTON)

Visual Aids to Navigation: Comments

Up to the time I read the article in Seaways last October, I had taken for granted that fixed and floating visual aids to navigation would always be there for the use of the navigator- just like the sun, moon and stars. It was inconceivable that a time would come when a ship's captain would have to take his vessel down a channel without any markers to guide him.

Certainly, with present state of the art technology, I cannot imagine how this could be achieved. Nothing is simpler and safer, than to look at a buoy or leading lights, and keep your ship on the correct course, making due allowance for currents. Being able to confirm the position with regular GPS fixes makes the situation safer still.

When I was Chief Mate on a VLCC in 1970, I remember when my company offered to supply me with one of those new state of the art electronic calculators to use for working out the cargo. I was suspicious of this thing, and really preferred to stick with my trusty Facit calculating machine. Little could I imagine that in thirty years time, a tanker's control room would have no mimic diagrams or valves, just two computer screens.

Things change. No doubt, thirty years from now, when ECDIS and integrated navigation systems will be standard equipment on all ships, backed up by several GPS systems, and ARPA, the need to look out the window will be as redundant as my old Facit machine. Hard to imagine, but it's inevitable.

When I was trained as a junior officer in the 1960s, it was drummed into us that every position fix had to be double-checked. Three bearings were better than two, radar ranges should be used to back up visual bearings, and with the advent of Decca and Loran, position fixes should be confirmed, from time to time with visual bearings.

So, the question is this. With real-time position displayed on an electronic chart, and ample system redundancy: is there still a need to take a bearing and distance of a fixed navigation mark to further confirm our position? My response would be - yes.

The sextant and its use in fixing our position using celestial bodies may become redundant, because in ocean waters, far away from land, we can afford to have a navigation system failure. However, close to land, no matter how sophisticated our navigation systems may be, it will always be necessary to confirm our position by eye.

As you pointed out in your presentation, the human eye is the most reliable piece of navigational equipment on the bridge of a ship. But what use will it be if it has nothing to observe?

Technology has progressed at an exponential rate over the last twenty years, and will probably continue to do so. Consequently, it's difficult to predict how we will be navigating a ship twenty years from now. However, after listening to the discussion following your presentation, I believe that fixed and floating aids to navigation will be an integral part of the navigation system during that period.

MASTER MARINER (PHILIPPINES)

I have been a Master Mariner for twenty years, commanded various vessels of different registry and crews.

In the early seventies I did the traditional way of navigation by the eyeball, the sense of smell, celestial navigation by sun, planets, and stars. We had on board the following electronic navigational equipments: radio direction finder (RDF), radar, Omega, Loran, Decca navigator, and the Geographical Positioning System (GPS). With the introduction of the GPS and computers mariners become lazy in doing the traditional ways of navigation especially the younger generations.

Electronic navigation positioning are all dead reckoning (DR) position and this is to be corrected by your fixed position with the traditional ways before you can rely on the electronic equipment. I have observed/plotted through Decca navigator especially in the English Channel, North Sea, Baltic, etc. is more accurate on coastal waters navigation (0-500 nautical miles) ranges compared with the Omega, Loran navigational equipments which is for long range navigation. After sunset or before sunrise the long range navigational system (Omega, Loran, GPS) cannot be relied upon for it has certain errors like the radio wave becomes distorted, diminishing and radio interference, which take effect when nearing the coastal areas.

On high seas if skies are clear, I have to look at celestial bodies daily and nightly for fixed positionings (noon position, etc.) combined with the GPS DR position by comparing the traditional eyeball position and the GPS the fixed latitude of the traditional and the GPS are identical except for the Longitude which is fixed that produce differences. The fixed longitude of the GPS is advance by one (1) nautical mile of the fixes through traditional way.

In my point of view we have to combine the traditional approach, which is eyeball with the electronic navigational equipments. These equipments are only an aid, which you have to rely on visual aspects.

ANNEX E - PRESENTATION TO NAUTICAL INSTITUTE BRANCHES

THE USE OF VISUAL AIDS TO NAVIGATION

A Nautical Institute Presentation by

Commodore David Squire CBE FNI

My paper titled *The Use Of Visual Aids To Navigation*, appeared in the October 2001 edition of *Seaways*. The paper provides a general review of past, current and likely future policies and practices concerning the establishment and use of visual aids to navigation in coastal waters and port approaches.

In it, I have made a number of observations, some of which are expanded on in this presentation, in the hope that it will generate debate and provide the Nautical Institute with some feedback on what are the real trends in coastal and harbour navigation today, so that they can offer an informed view, to the appropriate authorities, on how these trends may influence the future siting and characteristics of fixed and floating visual aids to navigation.

But first, what are visual aids to navigation? I have defined them as *visual devices, external to a vessel, which are provided to help mariners determine their position and course, to warn them of dangers or obstructions or to advise them of the location of the best or preferred route.* They can, of course, be fixed or floating.

It is not the purpose of this project to advocate the removal of aids to navigation. What we are trying to do is determine current, and possibly future, navigational practices and get a better understanding of the full value of aids to navigation today and in the foreseeable future.

So, while the title of this presentation is the *Use of Visual Aids to Navigation*, its real purpose is for us to discuss *modern navigational practices*, to look at the *traditional versus the technological* and to debate the question *what is the right balance?*

There is no doubt that the development of, and the reliance on, visual aids to navigation have changed with the advance of technology, which has raised questions as to their future role and disposition. But it is, of course the duty of lighthouse authorities and national administrations to determine the right mix of these aids, to satisfy the needs of the mariner, through meaningful risk assessment. But, the Nautical Institute believes that any such assessment must include consultation with a wide cross-section of mariners to establish the way in which they use visual aids in this era of increasing electronic technology.

This is part of that consultation process. During the course of this presentation I will be quoting extensively from various documents and reports of incidents, to provide some real examples of good and bad navigational techniques that are being practiced today.

There is, of course, a STCW requirement for navigators to prove their ability to determine the ship's position both by the use of celestial bodies, and by that of landmarks and aids to navigation, including lighthouses, beacons and buoys, but in practice these means of determining the ship's position have perhaps become, to some anyway, secondary to the use of satellite, radio and radar navigation techniques. This has been brought about by the continuing development of Global Navigation Satellite Systems, such as the United States' Global Positioning System (GPS) and the Russian Federation's Global Navigation Satellite System (GLONAS), as well as the more accurate differential systems such as DGPS, together with shipborne navigation aids including Integrated Bridge Systems designed to automate the collection, processing and display of the ship's navigation and other sensor data and the increasing use of electronic navigation charts and the Electronic Chart Display and Information System (ECDIS) such that it is now possible to provide real-time displays of a vessel's position, as well as anti-grounding and anti-collision warnings when interfaced with the radar. Perhaps, for the future, we have to determine also the possible impact of Automatic Identification Systems (AIS).

There is some evidence to suggest that the use of these modern systems may be to the detriment of the principles of good seamanship. For example, one observer suggests that *'whilst GPS is a very useful tool for the mariner, it is superseding the need for*

navigators to monitor their position relative to channels, banks, buoys and other marks.'

Another suggests that 'modern electronic navigation systems have transformed navigation to the point where visual references may not be considered necessary any longer' and that 'as electronic systems develop we could get to the stage where buoys and lighthouses become obsolete and we place total reliance on the electronic systems to get us to a destination.'

It is inevitable that the development of these systems should dictate the way ahead in terms of future navigational practice. But we must bear in mind the limitations of some of these developments, such that the widespread availability of GPS and DGPS receivers, at low cost, is increasingly encouraging mariners of all classes to navigate closer inshore and, in the case of the leisure and fishing sectors, to do so in conditions of darkness and reduced visibility where they would not have previously ventured. Indeed, rather than reducing the number of visual aids to navigation around the coast, one particular authority is having to increase them, and fit lights to over 50 hitherto unlit buoys, to mitigate the risk of any leisure or fishing vessel grounding, or colliding with a buoy at night.

We should also be mindful that:

- there may be ships at sea with defective navigational aids.
- many shipborne navigational aids depend for their operation on reliable power supplies, which could be interrupted at any time.
- administrations that control position-fixing systems, do not accept responsibility for the consequences of inaccurate positions being obtained by means of such systems.
- there is increasing evidence that radar equipment is not always properly adjusted.

- there are dangers in suspending human judgement when interpreting the various presentations of information.

Returning to the point about the accuracy of position fixing systems: as yet, there is no internationally accepted Global Navigation Satellite System and there may still be a question mark over the integrity, availability, control and accuracy of the existing systems for other than general navigation.

Indeed, while in May 2000, it was announced that the US would discontinue the use of Selective Availability (SA) by 2006, such that civilian users of GPS would be able to pinpoint locations up to ten times more accurately than hitherto, the statement of the President of the United States also alluded to a capability to selectively deny GPS signals on a regional basis when national security was threatened. There is a rumour that this was done during the Gulf War in 1990.

Many administrations warn against over-reliance on the quoted accuracy of such systems, particularly when referred to the World Geodetic Reference System of 1984 (WGS84). For example, the UK Hydrographic Office, in a Notice to Mariners, warns against *‘over-reliance on the quoted accuracy of GPS and DGPS referred to WGS84, when using large and medium scale admiralty charts, including charts on which it is stated that WGS84 positions can be plotted directly.’* It advises that *‘when closing the coast or in the vicinity of dangers, which may have been fixed relative to the coastline, vessels should always verify their GPS position in relation to the charted detail by using alternative methods of position fixing.’*

It also warns mariners that, *‘in all cases, prudent positional clearance should be given to any charted feature, which might present a danger to their vessel.’*

A recent supplement to the commercially produced **Red Sea Pilot**, aimed at the leisure market, is even more emphatic in saying that *‘although the most recent editions of charts from all the major Hydrographic Offices are reconciled to WGS84, this cannot compensate for shortcomings in the original 19th century surveys.’* It comes up with the following advice to mariners:

- *Always navigate, even with GPS, with circles of probable error of at least 2 miles, and at night at least 5 miles.*
- *Navigating by GPS alone in the Red Sea and Gulf of Aden is stupid. Do not do it. Make daylight landfalls and use hand-bearing compass and radar, if you have it, to establish WGS84-to-chart error factors.*
- *Treat all waypoints with appropriate caution, ...and never assume that the waters between, close to or at waypoints are free of hazard.*
- *Use GPS for navigating from A to B but not for pilotage when near A or B.*
- *Be cautious about using any GPS position as a destination.*
- *Allow a margin of error and always use other navigational aids, the Mk 1 eyeball, radar, echo sounder and hand-bearing compass as a check.*

I have found a couple of interesting articles, from yachtsmen, on the subject of making a landfall. I realise that the techniques for navigating a yacht may be different from those for say, a very large crude carrier, but the same principles apply. The first one is from a skipper who is giving general advice to his reader, based on his own experience. He says:

‘I usually decide where I will join the entrance channel, picking a buoy some distance from any dangers. Large ships use the fairway buoys, which mark the beginning of the buoyed channel but in smaller vessels you can often safely join the channel nearer shore. Arriving at your chosen buoy can be accomplished by normal navigation techniques or the use of a waypoint in a Loran or GPS. Ideally you will perform both. I had my chosen buoy picked out and its coordinates entered in the GPS so imagine my surprise when we arrived at the chosen position to find not a buoy but a large ship at anchor. It was my error in entering into the GPS a wrong position. In our case we had been plotting our positions on a chart

and so had not been too far from our chosen point but if we had blindly followed the GPS and I had made a larger error it could have been disastrous.’

The second tale from another skipper describes making a landfall at night, and approaching a small harbour. He says:

‘We were bound for a harbor I had never entered before. We had three GPS receivers aboard and all were in agreement down to the hundredth of a mile or so. We also had confirmed our position with a twilight star fix and were plotting lines of position with a hand-bearing compass.

Instead of plotting a waypoint on the GPS and steering toward it, I chose a safe meridian and a danger bearing. Steering toward a waypoint can become confusing, especially as you near the mark and the cross track corrections become more significant. Also, steering around shoals requires plotting several waypoints, increasing the possibility of errors as you follow a dot-to-dot course.

A danger bearing is an old navigational trick that is useful in all types of coastal navigation. Unfortunately, our danger bearing was not as helpful as I had hoped because we could not easily discern any of the harbor approach lights and instead had to use a distant radio mast on top of a mountain south of the harbor.

Everything went according to plan and we actually picked up the harbour lights earlier than expected. Working as a team, we conned our way into the harbor, using the spotlight to illuminate each succeeding marker and keeping a steady eye on the depth sounder.’

In the first case, the skipper was perhaps relying too much on the use of GPS, the result of which could have been disastrous, if he had not been maintaining a plot on the chart. But, in the second, the skipper is exercising a considerable degree of prudence by using a mix of modern and traditional navigational techniques to his best advantage, which perhaps demonstrates that, while satellite navigation may provide the primary means of position fixing, when out of sight of land, the leisure sailor will navigate more by

reference to visual aids to navigation when in sight of land, or when approaching a fairway, or harbour.

Some may argue that this is all very good for the yachtsman, where the navigation suite may comprise a basic fit of compass, log, echo-sounder and handheld satellite navigation system, but that the same rules do not necessarily apply in, for example, the state of the art merchant vessel. And this is where I think we may encounter a diverse range of views.

Let me give some thoughts, looking first at coastal navigation:

It can be argued that, even for close-in coastal navigation, the use of differential GPS as the primary method of position fixing, backed up by radar ranges and bearings, instead of position lines taken from the traditional visual aids, is perfectly acceptable, provided that the maximum margin of error is taken into consideration when establishing the optimum safe passing distance from any hazard.

Indeed, the traditional method of making a landfall by recognising a lighthouse or natural feature of the land may be a past practice, although one would wish to believe that no self-respecting mariner would make a landfall without even a cursory glance at that lighthouse or feature, to confirm that he is where he should be.

And, while the STCW Code requires that fixes be carried out *by more than one method whenever circumstances allow*, it does not stipulate that one of those methods should be by visual means, albeit it requires the officer in charge of the navigational watch to *positively identify all relevant navigation marks*. This could either be visually or by cross reference to a satellite or terrestrial or radar position fix. But, this method may not be acceptable in, say, congested and restricted traffic separation systems, such as the Singapore Strait or Dover Strait, where the size of a vessel and its manoeuvrability may dictate a position accuracy of considerably less, and where visual or radar reference to, and the need to properly identify, fixed or floating aids may be appropriate, to ensure that the correct and safest route is being followed. Nor may it be entirely acceptable in the one-man bridge situation, where the officer of the watch may be so pre-occupied with a busy traffic situation that he could become disorientated,

because he is unable to plot his position on the chart as frequently as may be prudent. The real-time position information provided by ECDIS (if fitted) may, of course, alleviate this but better still would be visual or radar reference to both fixed and floating aids.

What about pilotage?

Even the absolute accuracy of differential GPS may be insufficient for pilotage, but this will be dependant on the size and draught constraints of a vessel, relative to the width and depth of the channel. This is where, ideally, visual techniques would come into play and where the conduct of the pilotage will be reliant upon the various methods of position fixing by, for example, the use of position lines obtained through visual observation of fixed aids, natural charted features and conspicuous objects, and radar ranges and parallel indexing, together with visual references to transits (ranges), or leading lines, clearing bearings or headmarks from fixed aids, or from natural conspicuous features such as promontories, chimneys etc; and floating aids albeit not as an infallible means of position fixing. We should be mindful also, that in some river estuaries the navigable channel may be something of a moving feast due to the shift of the sea or river bed.

If a pilot is engaged for this phase of the navigation, he will be employed because of his intimate knowledge of the area, and he will rely heavily upon a variety of visual aids, both fixed and floating, either directly or through the use of radar, to monitor the passage of a vessel, to indicate wheel-over positions and to provide him with a lead towards a berth, dock or lock. But, will the introduction of Vessel Traffic Services, and of Portable Pilotage Aids for pilots, impact on the way in which pilotage is conducted in the future?

We do not live in the ideal world. The techniques that I have mentioned are generally applied by naval vessels, but they are manpower intensive, and it is therefore inevitable that we should adapt to new techniques which are predominated by electronic systems that require only the one operator.

We all recognize the impact of minimum manning on the bridge, even during pilotage. Nonetheless, the navigation still has to be monitored. Maybe visual fixing and the use of radar for parallel indexing (which is not very easy in a very narrow channel) are past practices, but can we be sure that DGPS-based systems combined with ECDIS, for example, are providing us with infallible alternatives?

Direct visual reference to buoys or beacons can readily provide the mariner with an indication of leeway, set and tidal flow, while the use of transit bearings on fixed or floating aids can provide him with an easy indication of whether he is maintaining his charted track or if he is stopped when approaching an anchorage in a tideway.

But, it is open to question whether the shape of a buoy or its topmark is likely to be of any significance in the future, particularly with the advent of electronic charts (and possibly VTS and AIS), and the fact that the vector chart has the facility to change the features of symbols to display them either in a traditional or simplified form.

I am now going to recite some examples of groundings, which I believe have a bearing on this debate. The first concerns a 21,000gt container ship that went aground on the Great Barrier Reef.

The vessel was navigating in good visibility, in waters that were neither confined nor congested and where one simple alteration of course was required by the officer of the watch. This alteration of course had a margin of safety of more than 7 miles before the vessel would run into danger. This with a speed of 20 knots, gave more than 20 minutes for an error to be identified. Fixing was by GPS onto a paper chart.

The vessel ran aground, due to the inattentiveness of the officer of the watch, who allowed himself to become distracted from the navigation of the ship, for a period of about 15 minutes, by a telephone conversation being made by his wife, who was on the ship's bridge wing, such that he did not hear the waypoint arrival alarm on the GPS and therefore did not alter course at the appropriate time. The ship was travelling towards a featureless horizon with no visual cues to mark the reef, which was largely submerged.

Although the real cause of the grounding was through the inattentiveness of the officer of the watch, the report of the investigation suggests that had there been something such as a beacon to mark the reef it may have stimulated the mate from his reverie so that he may have reacted to save the situation.

Next is a fishing vessel in coastal waters, but bound for the fishing grounds. With the skipper and two deckhands in the wheelhouse, two serviceable radars, a GPS and a DGPS receiver, a video plotter albeit capable only of displaying a latitude and longitude grid, an echo sounder, and chart, the vessel was adequately manned and equipped to safely depart from port and maintain a proper lookout.

The vessel's intended track was displayed on the plotter, based upon waypoints inserted at intervals during a previous entry or departure. The chart for the area was available, but not used, and did not show the vessel's departure track. The skipper's primary method of monitoring the position was using the video plotter, but he was not reliant upon it. He was also able to check the vessel's position by radar and visual references.

So far so good. However, the situation altered significantly, when visibility was reduced and the radar pictures degraded with the onset of heavy rain. Apparently unable to obtain radar and visual references, the skipper was now totally reliant on the video plotter for keeping the vessel on track and clear of navigational dangers. He eventually sent the two deckhands out from wheelhouse to keep a lookout from the open deck. One went forward to the bow and saw land close by and directly ahead; very shortly afterwards, the vessel grounded.

The investigation found that the skipper was totally reliant on the video plotter, which in itself was not adequate for the safe navigation of the vessel in confined waters. DGPS and GPS positions were not plotted on the paper chart.

The third sad tale is of a 28ft yacht on passage from Cherbourg to Plymouth (UK). As the yacht headed towards the eastern entrance of Plymouth sound, she grounded on rocks, subsequently broke up and sank, with the loss of her skipper.

The vessel carried adequate navigation equipment including GPS navigator, echo sounder and paper chart. Navigation prior to making a landfall was conducted using the GPS and by plotting the positions on the chart, but for the approach to Plymouth sound, the skipper was navigating by eye. He knew the waters well and visibility was good.

It is not possible to know exactly what plan the skipper had in mind as he headed for Plymouth sound, but seemingly it involved keeping to seaward of a number of yellow firing range buoys, of which there were seven in almost a straight line, three of which were lit.

The skipper clearly anticipated following them until he thought it was safe to alter course to starboard. As they passed close down the line, the skipper and the one member of the crew who was with him in the cockpit realised they had not been counting them. As they passed what they thought was either the third or fourth buoy, course was altered to starboard to round up for the eastern channel. It is possible the skipper thought he had reached the most westerly buoy in the line and had clear water to run up to the eastern channel. For the approach, he used the eastern breakwater sector light as the head mark. It was identified as 'a red light'. He did not take a bearing of it or check his position by any means. He continued to navigate by eye.

Throughout this period the GPS was functioning correctly but was not being used. The echo sounder was switched off. No positions were being plotted on the chart.

Soon afterwards there was what one of the crew described as an 'almighty bang'. Almost immediately the 'something' was identified as a rock. The vessel had grounded.

The investigation report highlighted the importance of using pre-planned clearing lines on known dangers, the use of the echo sounder, identifying buoys correctly and verifying the vessel's position by other means such as GPS, and by using the available navigation aids to advantage.

By way of a summary, I turn to the words of the Chief Inspector of the UK Marine Accident Investigation Branch, which I have taken from one of his recent Safety Digests.

He says:

'We live in the age of the GPS, a very accurate, very reliable and very easy system to use. We use it all the time to fix our position and we all have come to rely on it. The younger generation will have been brought up on it, and will invariably assume that the position given on the read out, or the marker on the automatic chart plotter, will be correct. Everything else must, by definition, be relative to where our own ship is.

But there is one big problem. What happens if, on rare occasions, it isn't working for some reason? Can we spot when it isn't functioning correctly, and can we still navigate safely if it isn't available?

Modern navigational systems that rely much more on electronic charts, integrated radar displays and GPS derived positions provide excellent navigational information. The navigator, however, still needs to know their limitations. He needs to continually check that the information he is using is accurate against some other reference.

Misidentifying navigational marks, especially by day, is a common feature in many groundings.

Being familiar with an area is a great asset, but time spent in preparation is seldom wasted. Other basic techniques such as identifying natural transits, calculating clearing bearings and lines of bearing, and working out minimum depths of water all play a valuable part in ensuring a safe passage when navigating close inshore.

I hope that, through this presentation, I have provided some food for thought. I have discussed some modern navigational practices and looked at the traditional versus the technological. In terms of visual aids to navigation, it seems clear to me that the

traditional method of fixing by lines of position from visual bearings of lighthouses etc is becoming a past practice, and there is little need for visual aids along the coastline for this purpose. We know that mariners of all classes are navigating closer inshore, and that they are placing greater reliance on electronic navigation aids. There is a tendency for some to forget to look out of the window, and there are others who, even though they do not carry electronic charts, are neglecting to plot the vessel's position on the paper chart.

We do not yet know of the full impact that VTS and AIS will have on the navigation of vessels in the future. But what is certain, is that the need for visual aids to navigation is likely to continue, not so much for the purpose of position *fixing* but increasingly so for *visual reference*, particularly at choke points in a busy traffic separation scheme and in all phases of a pilotage.

The question is: What is the right balance?



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