Improving navigational safety

The role of e-navigation

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In *Seaways* (March 2007) The Nautical Institute outlined how a new IMO initiative, e-navigation is being developed to improve the safety of navigation by improved electronic systems.

We now take a look at the causes of collisions and groundings in the past 10 years to try to identify how improved electronic systems may be developed to tackle these causes.

The key goal of e-navigation is the improvement of safety of navigation and collision avoidance. The current definition includes the statement 'to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment'. With this stated objective it is useful to look at where and how recent incidents have taken place.

A recent report by the International Union of Marine Insurance (www.iumi.com) shows a continuing downward trend of percentage of total losses of ships, decreasing from about 0.5 per cent in 1990 to about 0.1 per cent in 2006 as shown in Figure 1 opposite.

The total losses by number of vessels also continued to decline from about 180 in 1994 to 80 in 2006.

These statistics must also be viewed in the context of an expanding world fleet. Since 1998 the world fleet has increased by about 6,000 vessels and, coupled with the reduction in total losses, this indicates a general improvement in navigational safety.

However, when the causes of total losses and serious losses statistics are viewed, it is seen that total losses by grounding and collision have increased by four-five per cent and serious losses by grounding and collision increased by two-three per cent in the years 2002-2006, compared with 1997-2001, as shown in Figures 2 and 3 (opposite).

A startling statistic noted in the investigation into causes of collisions and groundings is the large number of collisions that occurred when the OOW of one or both vessels was completely unaware of the other vessel until the time of the collision. In *Seaways* (August 06), Captain Nick Beer of the UK Marine Accident Investigation Board (MAIB) wrote; *'In 43 per cent of all the collision cases involving merchant vessels that were investigated by the MAIB over a 10 year period, the watchkeeper was either completely unaware of the other vessel until the time of the collision or only became aware of the other vessel when it was too late to take effective avoiding action.'*

This is almost entirely due to very poor watchkeeping, where lookouts are either not present or ineffective, and the OOW is asleep, fatigued, absent, distracted or totally disengaged with the tasks of keeping a safe navigation watch.

■ Despite advances in bridge resource management training, it seems that the majority of watchkeeping officers make critical decisions for navigation and collision avoidance in isolation, due to a general reduction in manning.

The IMO human element vision principles and goals (Resolution A.947(23)) contains the principle: *'In the process of developing regulations, it should be recognised that adequate safeguards must be in place to ensure that a "single person error" will not cause an accident through the application of these regulations.'*

And IMO MSC Circular 878 states: *'A single person error must not lead to an accident. The situation must be such that errors can be corrected or their effect minimised. Corrections can be carried out by equipment, individuals or others. This involves ensuring that the proposed solution does not rely solely on the performance of a single individual.'*

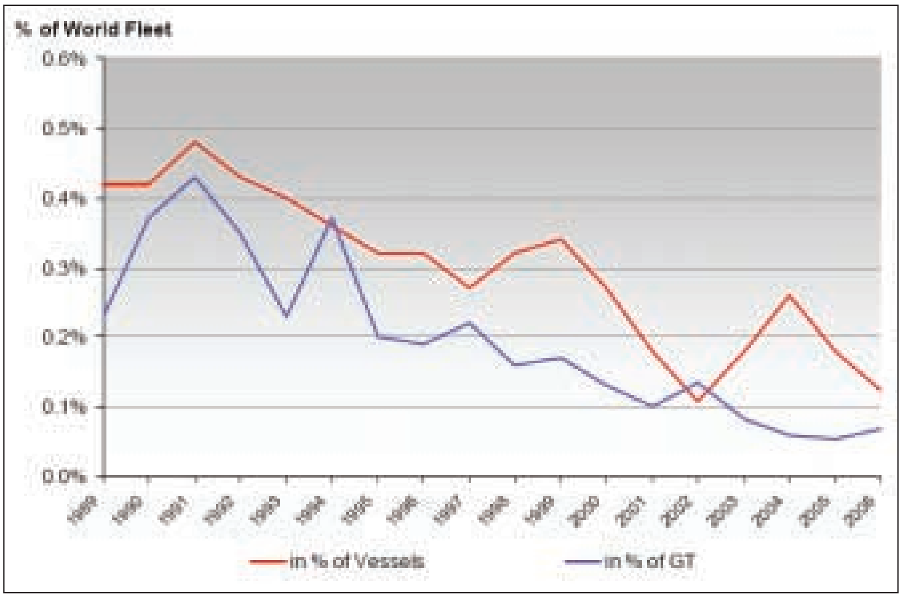
In human reliability analysis terms, the presence of someone checking the decision-making process improves reliability by a factor of 10. If e-navigation could assist in improving this aspect, both by well-designed onboard systems and closer cooperation with vessel traffic management (VTM) systems, risk of collisions and grounding and their inherent liabilities could be dramatically reduced.

NI research

The Nautical Institute has investigated the causes of collisions and groundings over the past 10 years, in which human error was the primary cause. This was conducted from data obtained from the UK MAIB, Australian Safety Transport Bureau, Swedish Accident Investigation Board, Transport Accident Investigation Commission (NZ), Transport Safety Board of Canada, US Coast Guard Marine Board Reports, National Transportation Safety Board (US), Marine Accident Inquiry Agency (Japan), Isle of Man Ship Registry, Irish Marine Casualty Investigation Board (IMCIB), and Accident Investigation Board of Finland. Data was also obtained from The Nautical Institute publications *Strandings and their Causes* and *Collisions and their Causes,* as well as from the Institute's MARS database.

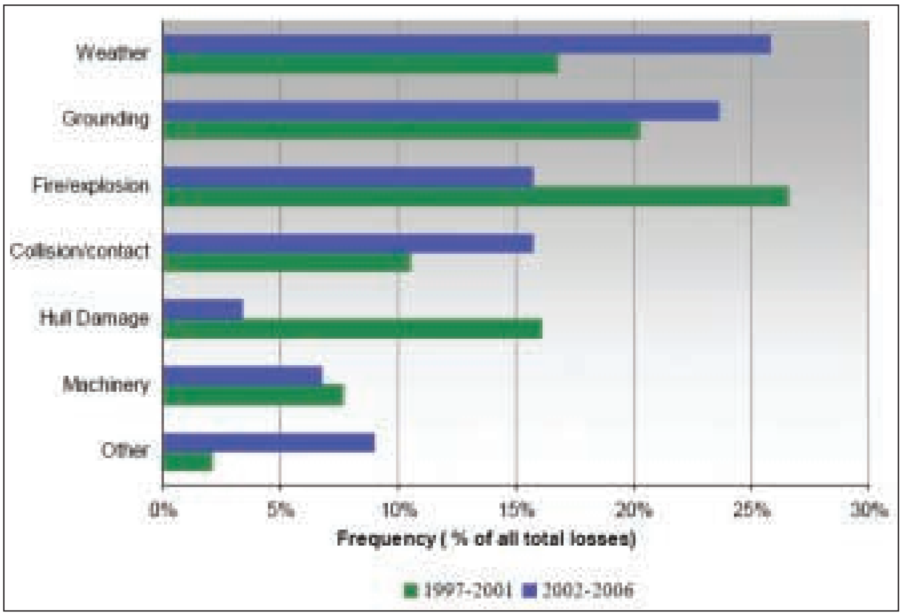
Collisions and groundings due to mechanical and structural failures were not taken into account, nor were incidents where vessels dragged anchor, collided with quays and jetties or were under control of tugs. These constituted about 40 per cent of all incidents of collision and grounding, leaving 60 per cent of incidents accounted for by direct human error.

The research also indicated that most incidents take place outside VTS areas,



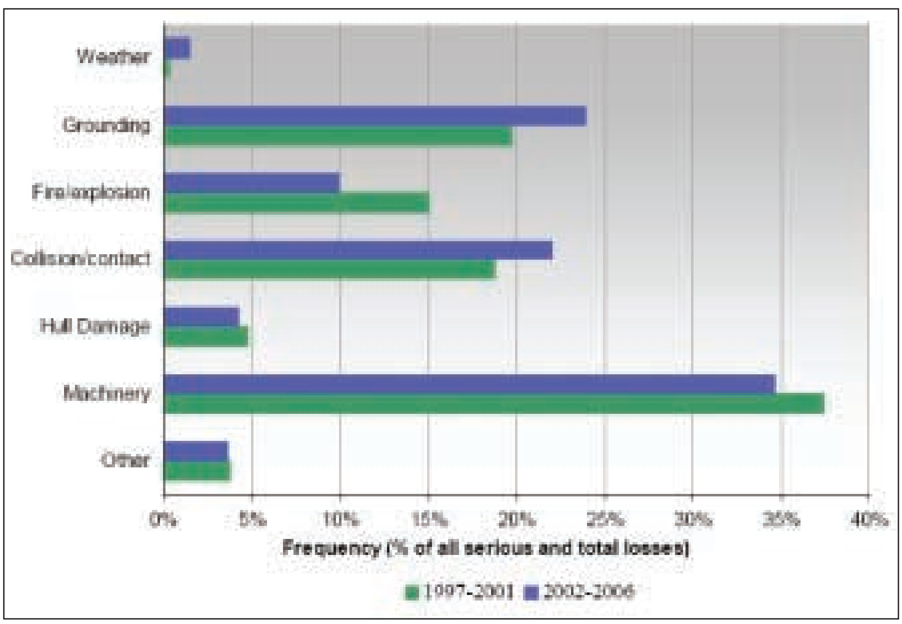
LMIU

▲ Figure 1: Total losses 1989 – 2006 as percentage of world fleet - vessels >500gt



Source: LMIU, losses as reported in *Lloyd's List*

▲ Figure 2: total losses 1997-2006 by cause (all vessel types – vessels>500gt)



Source: LMIU

▲ Figure 3: Serious losses 1997-2006 by cause (all vessel types – vessels>500gt)

indicating that VTS works effectively, considering that most close quarter situations take place in VTS areas.

For both collisions and groundings, there are no internationally agreed attributions for causes and many of the investigated incidents were attributed to multiple causes. Therefore, for the purpose of this research, each attribution was recorded. For instance, it is accurate to say that 23 per cent of incidents were attributed to 'poor or no lookout' and that 13 per cent were attributed to 'unaware of other vessel' but it would not be accurate to group these as 36 per cent, as the summation may contain the same incident in each category.

Collisions

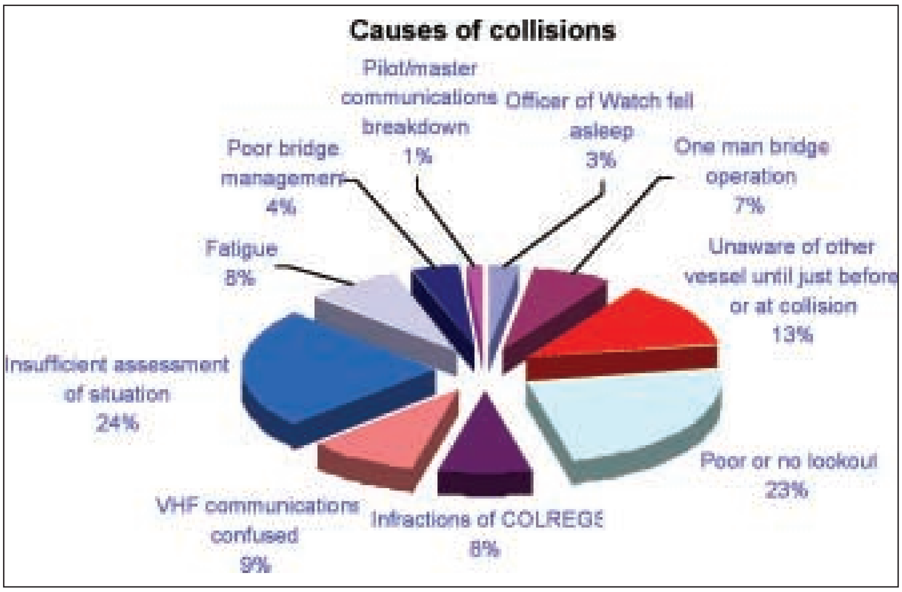
Of the collisions investigated, 24 per cent were due to insufficient assessment of the situation, 23 per cent to poor lookout and, significantly, in 13 per cent of the collisions they were completely unaware of the other vessel until (or just before) they collided. Other causes were due to confusion of VHF communications, infractions of the Colregs, fatigue and OOW falling asleep, poor bridge management and pilot/master communications breakdown.

As shown in the case studies below, the number of incidents caused by insufficient assessment of the situation, poor lookout and the OOW being completely unaware of the other vessel should give cause for concern.

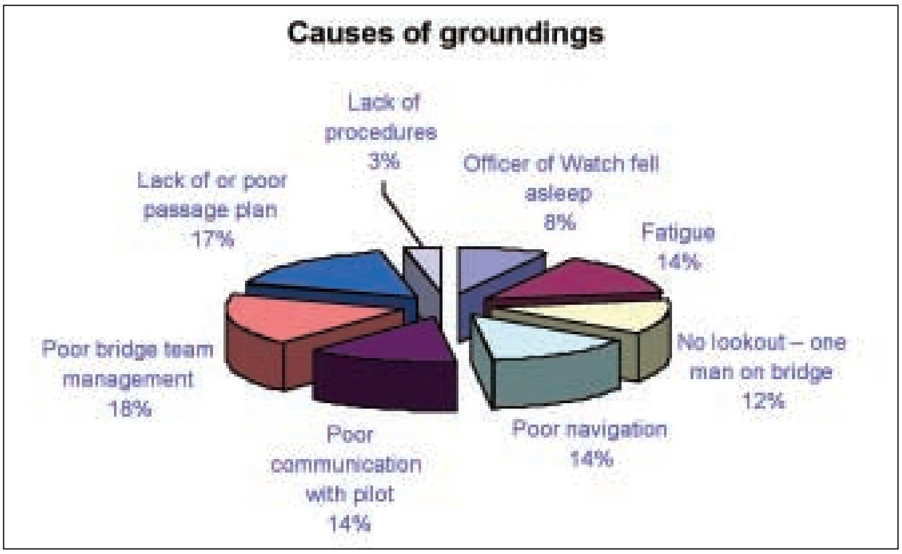
In the report of the collision between the bulk carrier *Kinsale* and the cargo vessel *Eastfern* on the morning of 25 September 2000, the MAIB noted: *Contributory causes of the accident were that, until shortly before the collision,* Kinsale*'s chief officer was unaware of the approach of his ship to* Eastfern *and* Eastfern*'s bridge team was unaware of the approach of the* Kinsale. *The visibility at the time of the accident was good although it was during the hours of darkness.*

Similarly, in the report of the collision between the cargo ship *Ash* and the tanker *Dutch Aquamarine* on the afternoon of 9 October 2001, MAIB concluded: *The OOW of the* Dutch Aquamarine*, which was the overtaking vessel, did not see the* Ash *until just before the collision.* Again the collision occurred in good visibility.

Another example is the collision, in good visibility and sea conditions on the morning of 5 January 2004, between the bulk carrier *Bunga Orkid Tiga* and the fishing vessel *Stella VII*. According to the Australian Transport Safety Board (ATSB): *'Neither*



▲ Figure 4 – Attributed causes of collisions Source: NI



▲ Figure 5 Attributed causes of groundings Source: NI

vessel was maintaining an effective visual lookout. That the OOW of the Bunga Orkid Tiga *did not properly assess the risk of collision, making a series of small alterations of course, became distracted and did not maintain radar watch.'*

In the collision between the container ship *Bunga Teratai 4* and the fishing vessel *Mako* on the morning of 4 July 2003, in good visibility, the Transport Accident Investigation Commission (NZ) identified a number of safety issues including: *'The skipper of the* Mako *did not observe either visually or by radar the* Bunga Teratai 4 *before the collision; the standard of bridge resource management on the* Bunga Teratai 4 *was poor; and there was insufficient positive action to avoid collision on the part of the OOW of the* Bunga Teratai 4.'

Finally, a report of the collision between the cargo ships *Marina-S* and *Tinto* on the morning of 25 April 2006 was produced jointly by the Swedish Accident Investigation Bureau and the Danish Division for the Investigation of Maritime Accidents. Their conclusions stated that contributing causes to the collision included: *'On both ships the OOW was alone on the bridge; visibility had deteriorated and at the time of the accident was very poor; the OOW on* Tinto *had neither observed* Marina-S *by radar nor visually and was not aware of the fact that the risk of a close quarter situation and a risk of collision existed; the OOW of* Marina-S *observed* Tinto *on the radar at a distance of 5.5 nm, but took no action to avoid a close quarter situation.'*

■ Figure 4 shows the percentages of the causes of collisions. (Note: some collisions were attributable to more than one cause.)

On the morning of 17 October 2006, in visibility of about four-five miles, the ro-ro ferry *Maersk Dover*, tanker *Apollonia* and container ship *Maersk Vancouver* were involved in a close quarters situation, which fortunately did not result in a collision. The OOW on *Maersk Dover* received a VHF radio call from the deep-sea pilot on the Apollonia, advising him of the developing situation. Until than, the OOW of *Maersk Dover* was unaware of the presence of the *Apollonia*.

The report of the investigation by the MAIB again shows the dangers of single person errors. Their conclusion in the accident report was that this incident occurred: *'as a result of poor watchkeeping practices and the OOW (*Maersk Dover*) becoming distracted by an incoming SAT C message; the OOW choosing to sit on a foot-rest while answering the call was ill-advised as his view of the horizon was obstructed by bridge equipment; sufficient manpower was available on the bridge but the requirement to maintain an effective lookout had been ignored; when the OOW went to investigate the Sat C alarm, the last remaining visual safety barrier was removed. There was no longer a visual lookout or radar watch being maintained on the bridge of the* Maersk Dover.*'*

Groundings

Of the groundings examined, 17 per cent were attributable to poor or no passage plan, and 18 per cent to poor bridge management teams. Of the cases where the visibility was mentioned, some 70 per cent went aground in good visibility. More than one third of the cases were partly attributable to the OOW suffering fatigue or falling asleep.

Falling asleep was the principle cause of the groundings of the cargo vessels *Sofia* on 12 May 1997, *Najaden* on 12 July 1997, *Pamela* on 3 August 1998 and the *Bianca* on 31 March 2003 where, in all cases, the Accident Investigation Bureau of Finland found the cause of grounding was due to OOW falling asleep and that he was alone on watch at the time of the grounding.

It was also the cause of grounding of the *Pentland* on the morning of 7 December 1998, *Coastal Bay* on the morning of July 21 2000, *Jambo* on the morning of 23 June 2003 and *Jackie Moon* on the morning of 1 September 2004, where the MAIB reports came to the conclusion that the OOW was suffering fatigue, fell asleep and was alone on the bridge at the time of the accident.

Case studies indicate that critical decisions made by one man in isolation, either through being alone on the bridge or by not having procedures in place for input from others in the bridge team, can have catastrophic results.

An investigation by the Isle Of Man Marine Administration into the grounding of the *Transmar* on the evening of 29 January 2000 found: *'The OOW was alone on the bridge, there was no detailed passage plan, he failed to monitor the vessel's track and ignored information presented to him that showed the vessel was standing into danger.'*

Transport Safety Board (TSB), Canada in its investigation into the grounding of the tanker *Mokami* on the afternoon of 31 October 2000, stated that: *'No passage plan had been implemented and the information on the chart not closely scrutinized, the bridge resource management was not fully implemented, resulting in each member of the bridge team operating in isolation, leaving the OOW to rely solely on his own performance, leaving no room for error.'*

The Australian Safety Transport Board (ATSB), investigating the grounding of the *Bunga Teratai Satu* on the morning of 2 November 2000, said that different factors contributed to the grounding. Among these: *'The OOW had allowed himself to become distracted, for a period of 15 minutes, from the navigation of the ship, by a telephone conversation, the ship's cross-track GPS alarm was not loud enough to attract attention and that the absence of an appropriate level of bridge resource management on the vessel allowed a basic error by one person to result in a serious accident.'*

In the ATSB investigation into the grounding of the *Crimson Mars* on 1 May 2006, one of the factors contributing to the eventual grounding of the vessel was due to single person error. *'None of the* Crimson Mars *bridge team did anything effective to detect, or recover from, the errors which led to the grounding. They did not adequately monitor the actions of the other members of the team… the master and the pilot did not effectively create an environment that fostered "challenge and response" and consequently this tool was not used. This led to inadequate monitoring of the pilotage passage, and resulted in "single person errors" occurring and not being detected in time to prevent the grounding.'*

Finally, in the investigation into the grounding of the containership *Berit* on the morning of 5 January 2006, the MAIB conclusion on the factors that caused the accident included: *'The OOW might have become complacent and lost sight of his responsibilities as an OOW, he had dismissed the lookout leaving himself alone on the bridge and he was unable to maintain a safe navigational watch as he was reportedly distracted using his mobile telephone for over 40 minutes.'*

■ Figure 5 shows the percentage of the attributed causes of groundings. (Note: some incidents were attributable to more than one cause.)

Japanese investigations

The Japanese Marine Accident Inquiry Agency (MAIA) publishes annual reports on the causes of marine accidents by type. The latest report received is for 2004 and has similar findings to the Institute's investigation, even though three-quarters of the incidents involve fishing vessels and small craft.

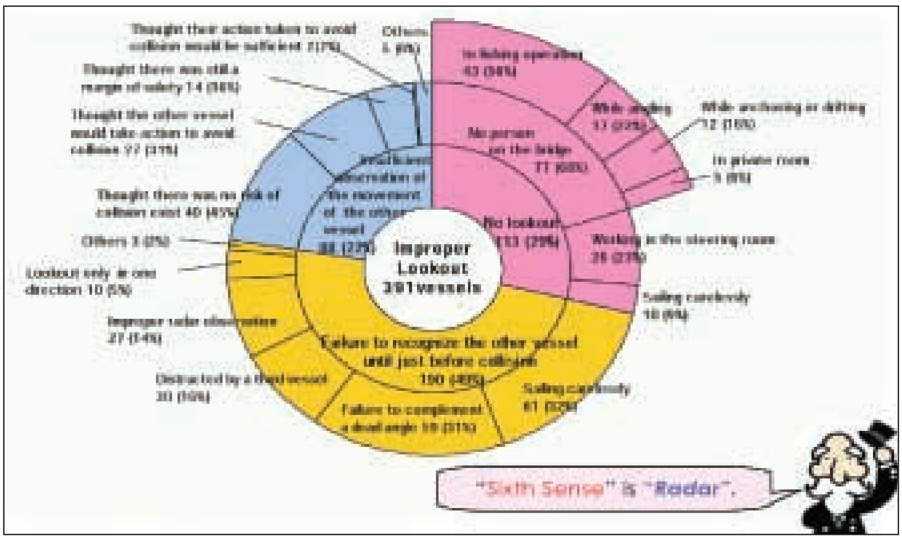
In their investigations into collisions, the MAIA found that improper lookout accounted for about half the cases, of which 49 per cent failed to see the other vessel until just before the collision, 29 per cent had no lookout and 22 per cent made insufficient observations of the other vessel, as shown in Figure 6 below.

In their investigations into groundings, the MAIA found that half the accidents were attributable to two factors – the OOW falling asleep and the vessel's position not being checked. This is shown in Figure 7.

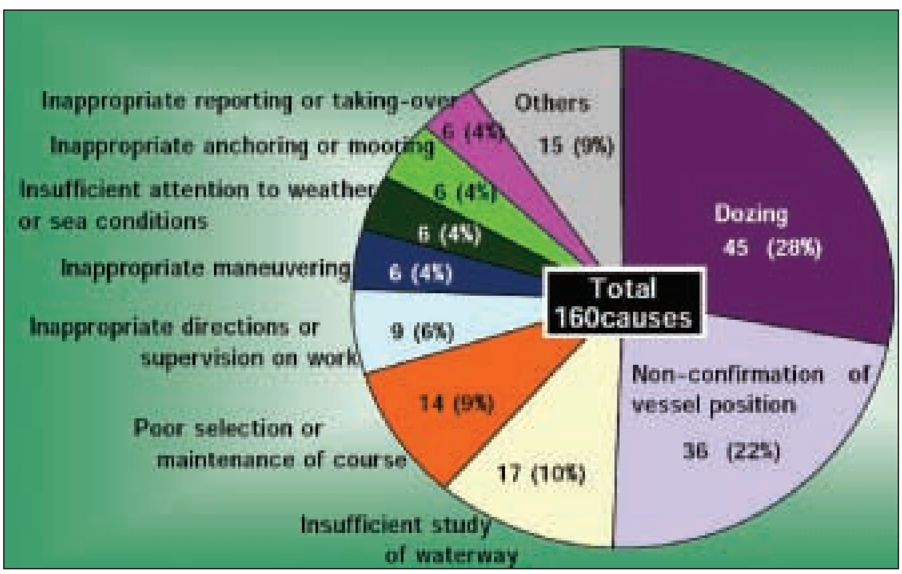
All the examples quoted in this Nautical Institute research, have to be seen in context, as these case studies were drawn from limited databases. Many more accidents and near misses are not reported by the master or the company, nor investigated by the flag state or the results of these investigations published. Many of the near miss reports that are contained in The Nautical Institute MARS database indicate similar findings.

The challenge

Given this understanding of the causes of these recent collisions and groundings, and given the opportunity of developing a



▲ Figure 6: Factors of improper lookout in case of collisions 2004 Source: MAIA Japan



▲ Figure 7: Factors causing groundings 2004 Source: MAIA Japan concept of e-navigation as a strategic vision, the challenge now is to define how the concept of e-navigation can improve navigational safety.

The following are some suggestions that an e-navigation strategy might embrace that would help improve the safety of navigation by addressing the identified causes of incidents and single person error in particular.

- Develop a system that maximises a mariner's ability to make good decisions. This should at least embrace:
  - Solas chapter V, Regulation 15, Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures.
  - MSC/Circular 1091, Issues to be considered when introducing new technology on board ship.
- Develop a system of sensors and zones that alert watchkeepers to impending hazards. This will rely both on technical systems, training and procedures that would result in a dependable system that mariners would feel 'naked' without utilising.
- Develop a system and hierarchy of alerts; such as alarms, warnings, indications etc that would reduce distraction and improve operational response.
- Develop a system that enables ship and shore to work effectively as an extended navigation team to avoid single person errors.
- Develop a system that enables VTM to positively communicate hazards and alarms to vessels.

E-navigation

Efthimios Mitropoulos, Secretary General of IMO, said that e-navigation should not reduce the navigator solely to the role of monitoring the system, but enable him or her to obtain optimum navigational support and information from it to facilitate and ensure appropriate and timely navigational and anti-collision decision-making in accordance with good seamanship. This is a crucial factor if we are not to introduce more 'technology assisted' collisions and groundings. The obligation will always remain with the officer of the watch to comply with the Collision Regulations and 'maintain a proper lookout by…all available means…so as to make a full appraisal of the situation and of the risk of collision' (*Seaways* March 2007).

Solas Regulation V/15 identifies certain issues of an operational nature including: *'When considering the aim of promoting effective and safe bridge resource management, a design consideration should be to minimise the opportunity for a single person error resulting in risk or damage to the vessel.'*

E-navigation aims to achieve safer navigation through the *'harmonised collection, integration, exchange and presentation of maritime information onboard and ashore by electronic means'*. Nautical Institute research indicates that although the general industry trend is that navigation is getting safer, there are still unacceptable situations that lead to near misses and accidents that could be prevented through improved systems, the following of proven procedures, and better education and training.

IMO's Safety of Navigation Committee (Nav 53) will be meeting during this month to discuss the development of a strategic plan for e-navigation. Bringing together technology and the human element to improve safety through the reduction of single person error would be a very worthwhile goal.