Collision Avoidance in the e-Navigation Environment

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BIOGRAPHIES
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Steve Leighton is a consultant and Head of the Navigation Team at Helios. His work is primarily focussed on the commercial and technical aspects of navigation systems – an area that he has been working in for the past 12 years. He is currently working in the maritime and aviation domains supporting the implementation of new navigation technology and applications.

ABSTRACT
This paper reports the results of a study carried out by Helios for the General Lighthouse Authorities of the UK & Ireland into developments in collision avoidance systems, how they will influence the future development of marine aids to navigation and how they fit into the concept of e-Navigation. Collision avoidance is considered in the wider sense of preventing groundings and striking fixed obstacles, as well as ships colliding with other ships. A survey of the market was carried out to consider the scope and functionality of collision avoidance equipment, including the automatic identification system (AIS), as well as to consider the way in which available equipment operates in the coastal and harbour waters of the UK and Ireland.

The paper considers existing technology of relevance to collision avoidance, including Class A and B AIS equipment, manufacturer specific aids to collision avoidance (e.g. non standardised techniques and functions that aid detection or resolution of potential collision scenarios).

The implementation of current automated collision avoidance alarming was studied, for example whether alarms are triggered by zones or through greater algorithmic intelligence.

The human-machine interface of present systems was also investigated, whether information is provided only on a Minimum Keyboard and Display (MKD), integrated with an ECDIS, or overlaid on radar data and whether it is standalone or integrated with other ship systems.

The interface to/integration with GNSS to provide positioning and timing data for the AIS collision avoidance function was investigated and comparisons made with collision avoidance techniques from the aviation sector.

The paper provides an overview of the technology used in maritime collision avoidance equipment and its functionality as well as how it is used and which groups use which technologies. The findings are then combined in the context of the developing concept of e-Navigation to identify the ways in which the services and infrastructure of the GLAs may be impacted by future developments in the maritime collision avoidance environment.

1. INTRODUCTION
This study was carried out by Helios for the General Lighthouse Authorities of the UK &
Ireland (GLA) to help them to understand the effect of developing collision avoidance technology on their services and infrastructure in a future e-Navigation environment.

The first objective was to identify the drivers of change in the shipping industry such as changes to vessels’ gross-tonnage, speed, and manoeuvrability; expected increases in trade volume; and potential new traffic-routes. Factors taken into account included: world economic growth and its relation to a growth in world trade; developments in seaborne trade vis-à-vis other transport modes; expansion of the cruise sector; port development in the UK, Ireland and EU generally, leading to changing traffic patterns of intra-regional trade to the UK and Ireland.

The second objective was to consider the functionality of existing technology of relevance to collision avoidance, in particular Class A and B AIS, but also manufacturer specific aids to collision avoidance, current automated collision avoidance alarming and the human-machine interface of present systems.

The final objective was to combine the findings from the first two parts of the report to identify the ways in which the services and infrastructure of the GLAs and similar service providers might be impacted by future developments in the maritime e-Navigation collision avoidance environment.

2. THE ROLE OF SHIPPING

Shipping is not only an expanding global business with significant investment opportunities, but also offers economic and environmental benefits over other transport modes. The governments of European maritime nations have demonstrated a wish to maintain their share of world seaborne trade. According to World Bank figures, they are succeeding in doing so. On the latest recorded figures, the volume of containers transported worldwide has increased by 15.2%, to 90.9 million TEUs. Of these, 60 million TEUs passed through European ports.

Europe is on the frontline of shipping trade; it is involved in trade to and from the continent, in the intra-European movement of goods and in global cross-trades. Some 90% of Europe’s merchandise is transported by sea. In 2004, the size of the registered trading fleet of the European Economic Area was 244.3 million DWT (dead-weight tonnes), 28% of the world’s fleet tonnage, a figure that had increased by more than 50% since the start of 2002.

The cost of transporting goods by sea represents only a small (but marginally increasing) proportion of the value of goods imported to the developed economies such as Europe. This reflects the low overall cost of shipping by sea container due to the economies of scale that are available. Freight costs incurred in the imports of developed market economy countries continue to be lower than those incurred in the imports of developing countries. The difference is mainly attributable to global trade structures, regional infrastructure facilities, logistics systems, and the more influential distribution strategies of shippers of developed market economy countries.

Traditional European shipping industries face increasing low-cost competition. Shipping is a business that is relatively cheap and easy to enter. This has resulted in European governments’ seeking ways to support their shipping industries, such as fiscal relief in the form of tonnage-based corporate taxation or the waiving of social charges for seafarers.

In broad terms the nature, mix and flow of vessels around the UK and Ireland is unlikely to change substantially, other than through an overall growth in traffic over the next 10 years. However, there are some areas in which variations will occur.

In particular, there may be a shift in the nature of container traffic. Fewer of the large container vessels may operate into UK ports – although clearly they will still transit the Channel. Transhipment is a growing trend, as it is across Europe as a whole.

3. COLLISION AVOIDANCE PROCEDURES

For a vessel at sea, one of the greatest safety issues is the risk of colliding with another object, and it is one of the crew’s highest priorities to ensure that such a risk is minimised. On board all but the smallest ships, the position of watch-keeper is dedicated to this role by maintaining a situational awareness of the environment around the vessel, and advising the rest of the crew accordingly.

Collision avoidance is best performed using a number of different methods together, including radar, the Automatic Identification System (AIS) and visual checking. No single method should be trusted as the sole source of data to avoid collisions. Radar will detect almost all obstacles, but is affected by weather conditions with the potential effect of clutter. AIS is less affected by weather, but cannot detect some vessels and most
obstacles. Used together, these techniques can form a powerful set of tools in aiding collision avoidance. Other devices add other advantages. Sonar is the only device capable of detecting uncharted obstacles underwater. Integrated Bridge Systems and Electronic Chart Display and Information Systems (ECDIS) potentially allow an efficient integration of all available data, and offer an automatic warning of the proximity of charted underwater obstacles such as sandbanks, contingent on appropriate electronic charts being available.

In the short to medium term, at least, the responsibility for maintaining separation from other vessels will remain with the bridge crew and will not become the role of the shore authorities.

Procedures for avoiding collisions at sea are defined in the International Maritime Organisation’s Collision Regulations (COLREGS), the international rules of the road for maritime navigation. They provide various guidelines about how passing, crossing or overtaking manoeuvres should be made, giving details of which ships have right of way depending on the circumstances and the types of ships involved, and what actions these ships should take. It also details the rules on the signals (lights, shapes and sound signals) that a ship should give in any situation. It does not, however, give explicit instructions on how collision with other obstacles should be avoided.

Although not directly addressed in the COLREGS, avoiding collisions with static obstacles such as rocks, wind farms, oil and gas platforms and piers is performed using physical aids to navigation (AtoN) such as buoys, which mark out the areas where vessels should not pass. As with any visual marker, these can be difficult to identify correctly in poor visibility and there may be a risk of the vessel colliding with the AtoN itself. Many AtoNs are fitted with radar reflectors, which make them more visible, or radar beacons, which help with identification. However they provide a limited amount of information and crews still need to exercise extreme caution and vigilance in areas where there is risk of colliding with static obstacles.

4. COLLISION AVOIDANCE TECHNOLOGY

Devices such as radar and AIS are simply further sources of information for the crew, and should not be the sole method of collision avoidance. It is neither wise nor safe to put all trust in a single data-source. Concepts like data fusion embrace this idea and ensure that there is not a single source of data (and no single point of failure).

Data fusion is the concept of combining data from multiple sensors in such a way as to make the resulting information more accurate, more complete, or more dependable than if the information was used separately. In terms of collision avoidance, it means systems like the Integrated Bridge which aims to consolidate all the available information, such as automatic radar plotting aids (ARPA), AIS, radar, electronic charting, and in some cases perform analysis on it to support decision making.

Data fusion provides an efficient way of cross-checking data from various sources (e.g. radar and AIS) to ensure data integrity. It is possible to compare data from separate radar and AIS devices and one approach to data fusion is to overlay the two sources on top of each other, thus making any differences between them more apparent. In a situation where, for example, the incoming AIS data about the position of another vessel is incorrect, having the AIS overlaid onto the radar display would instantly highlight this failure, as the radar return and AIS target would not align. Other, more sophisticated data fusion algorithms actually combine the reports from the different sensors whilst checking the integrity of the solutions automatically.

Data fusion is being adopted in a number of collision avoidance technologies, where it is possible to overlay data in the way described above. Initiatives like e-Navigation, which call for more integration of devices and better sharing of data, will aid in increasing the level of data fusion utilised in collision avoidance.

5. e-Navigation

e-Navigation is defined by the International Maritime Organisation and International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) as “the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment”.

It comprises a number of structural components:

- electronic navigation charts;
- electronic positioning signals, supplemented by appropriate back-up systems;
- information on the vessel route, bearing, manoeuvring parameters and other status items in electronic format;
- transmission of positional and navigational information from ship to shore, shore to ship and ship to ship;
- clear, integrated display of the above information both on the shore and on the ship;
- information prioritisation and alert capability in risk situations on ship and shore.

e-Navigation is the concept of digitising all information relevant to maritime navigation, including information such as navigational status, usually displayed using visual signals, sharing this information between all users, both ashore and at sea, and displaying it in an easily accessible and understandable way. This will have the effect of networking vessels and shore-stations together, resulting in many benefits such as a reduction in navigational errors, better situational awareness, improved security, improved traffic monitoring, and reduced costs to shipping and coastal states.

e-Navigation should not be viewed as an end in itself. Its role should be part of a process that supplements and supports other critical elements of safe navigation, including watch-keeping skills, observance of the COLREGS, good ship-handling and seamanship and all the procedures and training that underpin these competencies. A physical infrastructure of aids to navigation will remain part of the concept, ensuring the possibility of reversion should the e-Navigation system fail.

The importance of the human element will need to be recognised if the implementation of e-Navigation is to be successful. In particular the management and presentation of alarms will need to be considered carefully. It might be technically possible to warn the mariner and the shore-side operator of every potential collision and grounding risk, but too many, uncoordinated alarms could distract and confuse the operator and reduce their ability to perform their task effectively.

6. ROLE OF THE SERVICE PROVIDER
The aids to navigation (AtoN) service provider has a direct role in supporting vessel to vessel collision avoidance, in particular the marking of channels, Traffic Separation Schemes and hazards that could cause a vessel to divert course for emergency reasons. AtoN providers also support vessel to vessel collision avoidance through the provision of differential corrections to GNSS, enhancing the overall accuracy and integrity of a ship’s position solution (and thereby the broadcast AIS location). It is now generally accepted that a single electronic position fixing system will not be adequate and the eLoran service is likely to contribute to the mix of systems. With regards to vessel to obstacle collision avoidance, physical AtoNs and short-range radio AtoNs will maintain their significant role in preventing groundings and collision with submerged obstacles.

In the future e-Navigation bridge environment automated collision avoidance functionality based on integrated sensors, information systems and decision support tools will play a greater role in the bridge officer’s routine as is the case in aviation today. This will mean that in the first instance the provision of electronic collision avoidance information will be much more viable and has the potential to be one of the primary means of collision avoidance. However, this places a significant onus on the provider of information to ensure that it is timely, accurate and of sufficiently high integrity to support automated collision avoidance.

AIS as an AtoN has a clear role to play in enhancing the quality of the services provided. It greatly improves the detection of AtoNs in all weather conditions, can expedite a response to new hazards, can economically mark newly emerging hazards and can mitigate some of the risks facing the existing infrastructure such as potential reduction in the efficacy of racons. As part of the evolving e-Navigation infrastructure AIS as an AtoN will continue to develop, providing a cost effective means of delivering services in the future, enhancing safety levels for suitably equipped vessels.

7. CONCLUSIONS
7.1 Collision avoidance needs to be considered in the wider sense of preventing groundings and striking fixed obstacles, as well as ships colliding with other ships.

7.2 The AtoN service provider has a key role in supporting all aspects of collision avoidance, which will be an important application of e-Navigation.
7.3 The function of e-Navigation in this context will be to support the mariner and shore-side operator in preventing accidents, thereby improving safety and protecting the maritime environment.

7.4 Data fusion and decision support algorithms will enhance the effectiveness of external information sources such as AtoNs.

7.5 Techniques must be developed for managing alarms and presenting warnings so that they achieve their intended purpose and do not result in distraction or confusion of the operator: