Common seas, common shores: Development of e-Navigation Strategy

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Abstract

Advantages of the latest technical development in the field of automation, electronics, telecommunications, informatics, telematics, geomatics and global position fixing techniques, achievement in data storing, processing, analysing, transferring and visualisation should be taken into account and applied to maritime technology. In this paper, the author discusses a strategic vision of the development of the e-navigation concept using these new technologies and the main tasks of the maritime community for the near future in this new field. The author believes it is now the appropriate time to develop a broad strategic vision for incorporating the use of new technologies in a structured way and ensuring that their use is compliant with the various electronic navigational and communication technologies and services that are already available (Weintrit 2006).

E-navigation is 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. E-navigation would help reduce navigational accidents, errors and failures by developing standards for an accuracy and cost effectiveness (NAV 53/13 2007).

E-navigation is, at the moment, a catchall phrase for a concept to bring existing and new technologies together to improve the safety of navigation, commercial efficiency and security. The challenge for the industry will be to produce a unified strategy for this integration and then (and only then) to develop specific systems to meet the needs. This is no small feat. Chart data and systems need to be brought to an agreed standard; position fixing systems need to be of high integrity; communication systems need to be established that meet the needs of e-navigation with agreed technology, protocols and payment plans. This all needs to be achieved with an acceptable cost/benefit balance.

Implementing technology is like a three-legged stool: if any one leg is inadequate, the whole system fails. Here, one leg is the technology itself; another is the procedure for how to use the technology (gained through testing and experience) and the final one is training, both in the operation of the

technology itself but most importantly in the use of the technology with agreed procedures to make good decisions. The development of well-balanced and highly qualified seafarers is possible. It should be one of most important objectives for IAMU members.

Keywords: *Navigation, Marine Transport, Safety at Sea, Communications, Telematics, Geomatics, Integration System, International Standardisation, E-Navigation,*

1 Introduction

The common objective shared by all the International Maritime Organization (IMO) is a commitment to deliver safe, secure and efficient shipping on clean oceans. The IMO has an opportunity to develop and map out a clear strategic vision for one common integration and utilization of all the navigational technological tools at our disposal to secure a greater level of safety and incident prevention which will, at the same time, deliver substantial operating efficiencies with resulting commercial benefits, while also continuing to respect the freedom of navigation rights (Mitropulos 2007).

It has been decided to add a new item on e-navigation to the work program of the IMO Sub-Committee on Safety of Navigation (NAV) and also to that on Radio-communications and Search and Rescue (COMSAR). The aim should be to develop a strategic vision for the utilization of existing and new navigational tools, in particular electronic and radio-communication tools, in a holistic and systematic manner.

E-navigation would help reduce navigational accidents, errors and failures by developing standards for an accurate and cost effective system that would make a major contribution to the IMO's agenda (Mitropoulos 2007; Weintrit & Wawruch 2006).

2 Definition and scope of the concept of e-navigation

E-navigation is the IMO-led concept based on the harmonization of marine navigation systems and supporting shore services driven by user needs. E-navigation is currently defined as (NAV 54/13 2008):

> "E-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine 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".

This central question of "exactly what is e-navigation?" has been the subject of prolonged IMO and IALA working groups' debates (IALA 2007a, 2007b). It was decided to treat e-navigation not as a physical installation, nor as the service provided, but as a strategic framework for developing existing and future technological infrastructure onboard and ashore. As such, the term e-navigation currently incorporates systems and services, but as an e-navigation user requirement is developed, it is envisaged that the term will also include an increased focus on more tangible elements. It should be noted that without e-navigation the multiplicity of systems and equipment would continue to evolve at varying degrees of effectiveness. The development of e-navigation is an opportunity to optimise these developments, and ensure the focus of future developments is on a holistic approach to safe navigation from berth to berth.

It is generally accepted that the IMO concept of "e-navigation" can be thought of as a brand, such as "iPod", without the need for "e" to be specifically defined. The "e" can stand for "enhanced" or "electronic", but this would unnecessarily limit what can be done within e-navigation. It must also be noted that generic electronic marine navigation already exists in many forms and should not be confused with this specific IMO initiative.

E-navigation is a broad, long-term, concept, involving many stakeholders and having the potential to impact the entire maritime community. Among those likely to be affected are mariners, vessels, marine pilots, equipment manufactures, vessel traffic services, coast guards, Coastal States, Port States and Flag States, hydrographic offices, ship owners, ship operators and ship charterers. Furthermore, the development of e-navigation will have a significant impact on all faces of training and modification of operating procedures (NAV 53/13, 2007).

3 The case for e-navigation

The rising trend in marine accidents, both in terms of numbers and costs, is mainly associated with collisions and groundings. There are numerous examples of collisions and groundings that might have been avoided had there been a suitable input to the navigation decision-making process.

Research indicates that around 60% of collisions and groundings are caused by direct human error. 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 (NAV 54/13 2008).

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) instruments and systems, the risk of collisions and groundings and their inherent liabilities could be dramatically reduced. However, although e-navigation may be able to

improve the situations described above, there is also a need to recognize the role of the practice of good seamanship, the provision of suitable training, and the use of procedures.

4 Vision of e-navigation

A vision of e-navigation is embedded in the following general expectations for onboard, ashore and communications elements (NAV 54/14 2008):

- **Onboard**
  Navigation systems that benefit from the integration of own-ship sensors, supporting information, a standard user interface, and a comprehensive system for managing guard zones and alerts. Core elements of such a system will include, actively engaging the mariner in the process of navigation to carry out his/her duties in a most efficient manner, while preventing distraction and overburdening;
- **Ashore**
  The management of vessel traffic and related services from ashore is enhanced through better provision, coordination, and exchange of comprehensive data in formats that will be more easily understood and utilized by shore-based operators in support of vessel safety and efficiency; and
- **Communications**
  An infrastructure providing authorized seamless information transfer onboard ship, between ships, between ship and shore, and between shore authorities and other parties with many related benefits (Graff 2007; Korcz 2007).

There is a clear and compelling need to equip shipboard users and those ashore responsible for the safety of shipping with modern, proven tools that are optimized for good decision making in order to make maritime navigation and communications more reliable and user friendly. The overall goal is to improve the safety of navigation and to reduce errors. However, if current technological advances continue without proper coordination there is a risk that the future development of marine navigation systems will be hampered through a lack of standardization onboard and ashore, incompatibility between vessels and an increased and unnecessary level of complexity.

5 The core objectives of the e-navigation concept

The core objectives of an e-navigation concept using electronic data capture, communication, processing and presentation should (NAV 53/13 2007):

- Facilitate safe and secure navigation of vessels with regard to hydrographic, meteorological and navigational information and risks;
- Facilitate vessel traffic observation and management from shore/coastal facilities where appropriate;
- Facilitate communications, including data exchange among ship to ship, ship to shore, shore to ship, shore to shore and other users;
- Provide opportunities for improving the efficiency of transport and logistics;
- Support the effective operation of contingency response (e.g. distress assistance), and search and rescue services;
- Demonstrate defined levels of accuracy, integrity and continuity appropriate to a safety-critical system;
- Integrate and present information onboard and ashore through a human interface which maximizes navigational safety benefits and minimizes risks of confusion or misinterpretation on the part of the user;
- Integrate and present information onboard and ashore to manage the workload of the users, while also motivating and engaging the user and supporting decision-making;
- Incorporate training and familiarization requirements for the users throughout the development and implementation process;
- Facilitate global coverage, consistent standards and arrangements, and mutual compatibility and interoperability of equipment, systems, symbology and operational procedures, so as to avoid potential conflicts between users;
- Be scalable, to facilitate use by all potential maritime users.

6 What existing issues and trends in the maritime industry led to the call for e-navigation?

Existing issues and trends in the maritime industry are the following (Basker 2005; Patraiko 2007b; Weintrit et al. 2007b):

- There is an increasing demand by coastal states to seek more information from vessels transiting waters under their jurisdiction and adjacent waters and beyond, to manage the risks they pose and to have a positive means of communicating with them;
- There is an increasing tendency by port and coastal states to implement more rules/requirements for vessels arriving in and/or transiting waters within their jurisdiction;
- There is an increasing tendency among coastal states for regional co-operation;
- The volume of information exchanged among ships and shore organizations is increasing;
- Environmental concerns and future regulatory requirements are expected to continue to acquire ever-higher importance;

- Security concerns continue to have an impact on maritime and other modes of transport;
- Diversification of port services (e.g. pilotage, linesmen, tugs, etc.) will increase, therefore co-operation of allied services will become increasingly important;
- Competency of maritime personnel will continue to vary and skills will fade for those infrequently used skills;
- The use of new technology may necessitate changed training requirements and operational procedures;
- The use of formalised and increasingly precise systems to manage traffic at sea and in ports will grow;
- Although additional Global Navigational Satellite Systems (GNSS) service (e.g. Galileo) will become available and robustness will increase, such space-based systems will also be vulnerable to jamming and unintentional interference;
- Ship design and technology will continue to evolve;
- There will be increasing demands for rapid and predictable transportation and cargo handling schedules;
- The attractiveness of inland waterways as a means of transportation will increase;
- The competition for the use of navigable waters (high seas, costal and inland) will continue to increase (e.g. High Speed Craft, larger and faster commercial ships, recreational vessels, offshore structures, and renewable energy systems).

7 S-Mode concept of the nautical institute

The Nautical Institute endorses the concept of e-navigation and the need to bring together a disparate collection of electronic systems, together with traditional skills, to improve the safety and efficiency of shipping. Although the ultimate goal of shipping is to move cargo from point A to B in order to support the world economy and the needs of society, the shipboard component of e-navigation is critical to the success of the whole system. Following years of research and consultation with mariners, The Nautical Institute has proposed that an S-Mode may be able to play a pivotal role within the concept of e-navigation for improving the safety of navigation (Patraiko 2007a).

The concept of S-Mode builds on the concept of a 'default setting' by being a 'default mode'. This mode is made possible by the increasing use of Multi-Function Displays (MFD) where radar, charts, electronic position systems etc are inputs that can be arranged or re-arranged in any form on a display.

S-Mode would require all navigation displays, regardless of manufacture, to have a clearly identified button, that when pressed brings the display into a standard format with a standard menu/control system, standard interface (i.e.

keyboard/joystick etc.) and basic features. For example there may have to be tactical display, for near-time decisions (collision, and hazard avoidance) and another display for planning. At the press of a button the tactical display might revert to a 12-mile range radar view with targets showing relative vectors and perhaps hazardous depth contours (from vector chart data, such as used on a chart radar). This view would be standardised and familiar to all pilots and mariners, and then could be manipulated through a standard menu system for a limited, although adequate, functionality. The advantage to this would be that:

- Training for S-Mode could be standardised throughout the world;
- Any mariner or pilot would be comfortable reverting to S-Mode and be competent in using the system's layout and functionality, regardless of manufacturer;
- Masters or companies could impose S-Mode use only by crews until such time that they have proven they are competent to use further functionality that may have been provided by individual manufactures.
- S-mode could also be used at times when the bridge team is made up of multiple persons who need to share a common display for decision making.

With the performance of S-Mode secured and strictly governed by the IMO, manufacturers would be able to develop further functionality that they could market it to shipowners as a 'value added feature'. If, in time, these innovative features proved to be popular and effective, they could then be brought into 'S-Mode' in a controlled way by the IMO.

At a basic level, some ships might opt to only have S-Mode functionality installed, but there may be other vessels, which by the nature of their trade or quality of their training, can take advantage of new and innovative features that would be developed by the industry. This is a fledgling idea and the Nautical Institute is currently working with various organizations and stakeholders to further explore the possibility of developing S-Mode.

Ultimately, whether S-Mode is accepted or not, vessels navigation systems need to be designed to work both independently and jointly with shore service to improve the operator's ability to focus on the most critical aspects of safe navigation, limiting distractions and reducing single person errors. The application of technology for this goal will only be a single component, and must be equally supported by the establishment of 'best procedures' for use and effective training for both the operation of such equipment and the procedures.

8 Development of strategic vision for e-navigation

The following issues should be considered when developing a strategic vision for e-navigation (NAV 53/13, 2007):

- Global coverage of electronic navigational charts (ENCs);
- Training, competency and common language skills for all involved in ship operations, both at sea and ashore;

- Safety and environmental concerns relating to migration from physical to virtual aid to navigation;
- Technical improvement of GMDSS equipment;
- Workload and motivation of the watchkeepers; and
- Users' requirements.

In order to structure the task of developing a strategic vision for e-navigation using a holistic and top-down approach it is essential to provide a methodology and logical phases to define the essential elements of e-navigation. In this context, the IMO should develop a strategic vision taking into account the logical phases relating to:

- User identification;
- User requirements;
- User services;
- Identify existing systems;
- System requirements;
- Gap analysis;
- Role of cost benefit analysis; and
- System architecture.

It should be noted that this is not a comprehensive list of logical phases and that some of the work can be undertaken simultaneously.

The strategic plan for the International Maritime Organization for the period 2008-2013 recognizes that technological developments have created new opportunities, but may also have negative consequences. New opportunities therefore exist to further develop various IMO initiatives, from safety and security to environmental protection. Developments in communications and information technology will provide opportunities to develop knowledge management so as to increase transparency and accessibility of information. The challenge for the IMO is to:

- Ensure that the technological developments adopted are conducive to enhancing maritime safety, security and protection of the environment, and take into account the need for their global application;
- Ensure the proper application of information technology within the IMO and to provide enhanced access to that information for the shipping industry and others; and
- Ensure that new equipment for use on board ships is designed and manufactured with the needs, skills and abilities of all users in mind.

9 Potential users of e-navigation and their high level needs

A significant number of potential ship and shore-based users of e-navigation have been identified and are summarized by NAV Sub-Committee of IMO (NAV 54/13 2008). A methodology was used to capture evolving user needs. It

was based on the elements contained within the accepted definition of e-navigation and applied templates to define specific user needs based on the harmonised collection, integration, exchange, presentation, analysis and human element aspects for all users. Using extensive feedback from IMO member states, other maritime organisations, and interested parties, an analysis was conducted resulting in the identification of high-level generic user needs for both ship and shore users. Thus the needs of a typical SOLAS ship and a generic shore authority have been used as the basis for the identification of the high-level user needs reproduced below. More detailed user needs may have to be identified as a part of the implementation plan:

- **Common maritime information / data structure**
  Mariners require information pertaining to the planning and execution of voyages, the assessment of navigation risk and compliance with regulation. This information should be accessible from a single integrated system. Shore users require information pertaining to their maritime domain, including static and dynamic information on vessels and their voyages. This information should be provided in an internationally-agreed common data structure. Such a data structure is essential for the sharing of information amongst shore authorities on a regional and international basis.
- **Automated and standardized reporting functions**
  E-navigation should provide automated and standardized reporting functions for optimal communication of ship and voyage information. This includes safety related information that is transmitted ashore, sent from shore to shipborne users and information pertaining to security and environmental protection to be communicated amongst all users. Reporting requirements should be automated or pre-prepared to the extent possible both in terms of content and communications technology. Information exchange should be harmonized and simplified to reduce reporting requirements. It is recognized that security, legal and commercial issues will have to be considered in addressing communications needs.
- **Effective and robust communications**
  A clear need was expressed for an effective and robust means of communications for ship and shore users. Shore-based users require an effective means of communicating with vessels to facilitate safety, security and environmental protection and to provide operational information. To be effective, communication with and between vessels should make best use of audio/visual aids and standard phrases to minimize linguistic challenges and distractions to operators.
- **Human centred presentation needs**
  Navigation displays should be designed to clearly indicate risk and to optimize support for decision-making. There is a need for an integrated 'alert management system,' as contained in the revised recommendation

on IMO performance standards for Integrated Navigation Systems (INS), to be given to decision support systems that offer suggested responses to certain alerts, and the integration of navigation alerts onboard ships within a whole ship alert management system. Users require uniform and consistent presentations and operation functionality to enhance the effectiveness of internationally standardized training, certification and familiarization. The concept of S-Mode has been widely supported as an application onboard ships during the work of the IMO experts working group. Shore users require displays that are fully flexible supporting both a Common Operating Picture (COP) and a User Defined Operating Picture (UDOP) with layered and/or tabulated displays. All displays should be designed to limit the possibility of confusion and misinterpretation when sharing safety related information. E-navigation systems should be designed to engage and motivate the user while managing workload.

- **Human-machine interface**
  As electronic systems take on a greater role, facilities need to be developed for the capture and presentation of information from visual observations, as well as user knowledge and experience. The presentation of information for all users should be designed to reduce 'single person errors' and enhance team operations. There is a clear need for the application of ergonomic principles both in the physical layout of equipment and in the use of light, colours, symbology and language.
- **Data and system integrity**
  E-navigation systems should be resilient and take into account issues of data validity, plausibility and integrity for the systems to be robust, reliable and dependable. Requirements for redundancy, particularly in relation to position fixing systems, should be considered.
- **Analysis**
  E-navigation systems should support good decision-making, improve performance and prevent single person error. To do so, shipboard systems should include analysis functions that support the user in complying with regulations, voyage planning, risk assessment, and avoiding collisions and groundings including the calculation of Under Keel Clearance (UKC) and air draughts. Shore-based systems should support environmental impact analysis, forward planning of vessel movements, hazard/risk assessment, reporting indicators and incident prevention. Consideration should also be given to the use of analysis for incident response and recovery, risk assessment and response planning, environment protection measures, incident detection and prevention, risk mitigation, preparedness, resource (e.g., asset) management and communication.

- **Implementation issues**
  Best practices, training and familiarization relating to aspects of e-navigation for all users should be effective and established in advance of technical implementation. The use of simulation to establish training needs and to assess its effectiveness is endorsed. E-navigation should as far as practical be compatible forwards and backwards, and integration with equipment and systems should be made mandatory under international and national carriage requirements and performance standards. The highest level of interoperability between e-navigation and external systems should be sought where practicable.

10 Conclusion

E-navigation is, at the moment, a catchall phrase for a concept of bringing existing and new technologies together to improve safety of navigation, commercial efficiency and security. The challenge for the industry, working through IMO, will be to produce a unified strategy for this integration and then (and only then) to develop specific systems to meet the needs. This is no small feat. Chart data and systems need to be brought to an agreed standard; position fixing systems need to be of high integrity; communication systems need to be established that meet the needs of e-navigation with agreed technology, protocols and payment plans. This all needs to be achieved with an acceptable cost/benefit balance (Weintrit at al. 2007a).

Implementing technology is like a three-legged stool: if any one or more legs is inadequate, the whole system fails. Here, one leg is the technology itself; another is the procedure for how to use the technology (gained through testing and experience) and the final one is training, both in the operation of the technology itself but most importantly in using the technology with agreed procedures to make good decisions. The development of well-balanced and highly qualified seafarers is possible. It should be one of most important objectives for IAMU members.

The concept of e-navigation is a worthwhile and essential goal that we should embrace. However we should be aware that 'electronic navigation,' led by commercial developments, is already with us and flourishing. Systems already exist that have high levels of integration both onboard and via communication links to shore, and this will continue to develop regardless of the work of the IMO. E-navigation, however, gives us a chance to bring this development within a strategic vision (Bibik at al. 2007).

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position fixing systems need to be of high integrity; and communication systems need to be established that meet the needs of e-navigation with agreed technology, protocols and payment plans. This all needs to be achieved with an acceptable cost/benefit balance.

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