

Developing e-Navigation, the early stages

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ABSTRACT

The official proposal to develop e-Navigation was submitted by seven member nations to the Maritime Safety Committee of IMO in December 2005 as a strategic vision for the utilization of existing and new navigational tools, in particular electronic ones, in a holistic and systematic manner. This concept has been generally approved and the implementation stage of e-Navigation is now beginning, the first practical step towards it being the Marine Electronic Highway (MEH) project in SE Asia which is about to start.

Considering the wide range of options and benefits that could be integrated into e-Navigation, its primary navigational value is in joining the ship's navigators and VTS operators to create a unified team to achieve safer navigation through shared information. There are several issues however, that need to be addressed for e-Navigation to succeed as a service to the users. Some of them, e.g. the ENC coverage or virtual Aids to Navigation, have direct implications for the hydrographic authorities.

In addition, different stakeholders have different understanding of this forthcoming service. Most authorities consider e-Navigation as not involving commercial interests. The commercial users expect more from the new service which they will have to use; they see it as likely to have the capacity to carry additional information. Such a system, adding maritime commercial interests to e-Navigation, is e-Maritime. The concept of e-Maritime is being addressed by the MarNIS project of the European Commission and a commercial project to be announced shortly.

E-Maritime includes e-Navigation and promotes the use of all maritime data and information, and the distribution thereof through ICT, to facilitate maritime transport and provide value added services to improve the operational efficiency of shipping as well as improving safety and security of navigation. This paper discusses the developmental issues of e-Navigation and its wider applications within e-Maritime.

1. History of the concept

According to Norwegian Coastal Directorate [1], about 50% of all serious ship accidents (collisions, contacts and groundings) are related to navigation in some way. Electronic means of navigation have advantages that could increase the safety of navigation. Hence, at the 81st session of the Maritime Safety Committee (MSC81) of the IMO in December 2005, Japan, Marshall Islands, the Netherlands, Norway, Singapore, the United Kingdom and the United States submitted together the following proposal:

It is proposed to add a new item on E-Navigation to the work programme of the Sub-Committee on Safety of Navigation (NAV) and also to that on Radiocommunications 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 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 of safe, secure and efficient shipping on clean oceans.

IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) has been charged by IMO with developing the e-Navigation standards. It defined e-Navigation at the strategy meeting in February 2006 IALA and reviewed it during the recent meeting of the IALA e-Navigation Committee (e-NAV2, 19-23 March, 2007 in Southampton). It reads now:

“E-Navigation is the harmonised collection, integration, exchange and presentation 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”

Seven key components of a safe and comprehensive e-navigation policy defined by IMO have been seen as the basis of developing e-Navigation, they are applicable both onboard and ashore:

1. Electronic charts and weather information
2. Electronic positioning signals
3. Electronic information on vessel route, course, manoeuvring etc.
4. Transmission of positional and navigational information
5. Display of information
6. Information reporting, prioritisation and alert capability
7. Transmission of distress alerts and maritime safety information

These points have to be considered in an integrated fashion and the interaction between them noted.

While conceived to find means to improve the safety and security aspects, e-Navigation has a potential to increase efficiency of ship operations, which is the main consideration for ship-owners, operators and their service providers.

1.1. EC e-Navigation MarNIS Task Force (Oslo, 18.09.2006)

European Commission started working on e-Navigation in parallel with IALA. It tasked the MarNIS (Maritime Navigation Information Services) project with developing e-Navigation.

The MarNIS Task Force meeting extended the concept of e-Navigation to e-Maritime.

It saw the general needs of e-Navigation as:

- to minimise navigational errors, incidents and accidents;
- to protect people, the marine environment and resources;
- to improve security;
- to reduce costs for shipping and coastal states; and
- to deliver benefits for the commercial shipping industry

The last two points extend e-Navigation into a system which the Task Force named e-Maritime.

E-Navigation (protocol oriented) is to ensure provision of navigational data and information, also from / to Aids to Navigation etc., in a standardised/harmonised way to facilitate common interpretation of said navigational data and information.

E-Maritime (system oriented) is the promotion of the use of all maritime data and information, and the distribution thereof, to facilitate maritime transport and provide value added services to improve the profitability of shipping (Fig. 2).

The aim of e-Maritime is to deliver benefits to the public, transport consumers, public authorities and the maritime community, by means of ICT. To do this it will need to :

- Enhance navigation safety and minimise transport incidents and accidents by taking full advantage of e-navigation;
- Monitor and regulate traffic flows;
- Protect people, the marine environment and resources;
- Improve security;
- Reduce the workload of ships' crews;
- Reduce costs for shipping, ports and coastal states;
- Provide interfaces to other modes of transport and
- Improve the interfaces to other maritime stakeholders

E-Navigation is an integral part of e-Maritime as shown in the first five points above.

EMSA (European Maritime Safety Agency) and the European Commission are currently developing a European-wide maritime information system, Safe Sea Net. Although the functionalities of this system are not yet defined, and will depend on a combination of factors, a Directive establishing a Community vessel traffic monitoring and information system (the VTMIS Directive) was adopted. According to the VTMIS Directive there shall be a competent authority for at least:

- a. Agriculture;
- b. Customs;
- c. Health care and medical care;
- d. Immigration;
- e. Maritime safety;
- f. Police matters;
- g. Prosecution;
- h. the protection and preservation of the marine environment;
- i. Search and rescue;
- j. Security;
- k. Statistic matters;
- l. Veterinarian matters.

(VTMIS Directive's definition of competent authority: the authority made responsible by or under national law for the enforcement of laws, regulations, administrative provisions and international agreements with respect to maritime traffic.)

There is no doubt that other countries are going to follow this regulatory route as well.

EC strategy document on e-Navigation is planned for 2008, to a large extent it will be based on the inputs from the MarNIS EC e-Navigation Task Force.

1.2. Key issues and priorities determined by e-NAV1 (IALA)

The first meeting of the IALA's e-Navigation Committee (e-NAV1) took place the same week (18-22 September, 2006) as the meeting of the MarNIS EC Task Force and arrived at a series of practical conclusions.

Considering the wide range of options and benefits that could become part of e-Navigation, the primary value of e-Navigation is to join the ship's bridge team and VTS team to create a unified navigation team that would achieve safer navigation through shared information. For full implementation of such a system it would need to be mandatory for SOLAS vessels and scaleable to all users.

It was suggested that before the primary benefits and value-added services could be realised, an architecture comprising three fundamental elements should first be in place. These are:

- i) Electronic Navigation Chart (ENC) coverage of all navigational areas,
- ii) a robust electronic position-fixing system (with redundancy), and
- iii) an agreed infrastructure of communications to link ship and shore.

1.2.1. ENCs

A full coverage of ENCs for navigational waters will require considerable effort from the world's hydrographic offices. The current nautical chart (paper, raster and ENC) distribution system may

need to be reviewed to ensure easy and ready global access to ENC's. An IMO mandatory ECDIS carriage requirement should improve the rate of ENC production.

It has further been noted that the existence of proprietary updating software in many ECDIS systems has become a key cost issue when implementing ENC data. It is thought that if, through IMO, an open architecture system could be agreed, this would allow a more competitive environment in the purchase, and maintenance of ECDIS systems thus reducing the overall costs of ENC's and increasing the global rate of acceptance.

The current excessive cost of ENC's must be addressed and so far as possible a cost-neutral migration from paper charts should be achieved.

The static data describing bathymetry and topography are provided through official Electronic Navigational Charts (ENC) produced by the relevant Hydrographic Offices. Dynamic data on weather and meteoceano coditions are available from official meteorological services and from various commercial providers (often repackagers of the oficial predictions).

The ENC coverage is improving and expected to cover the main shipping routes in the near future. Raster electronic charts (RCS) are used for the areas not covered by the ENC's. While provision of the ENC's and raster charts, as well as of their updates, is the prerogative of the Hydrographic Offices and need not to be discussed here, the data transmission channels developed for e-Navigation will be used for transmission of the chart data.

Transmission and display of meteoceano data (weather, currents, etc.) was not clearly described in the submission to MSC 81. These types of data are certainly important to navigation, and the way they are presented and communicated to users will most likely change in the future towards a more electronic format. It is expected the HGMIO (IHO-IEC Harmonization Group on Marine Information Objects) will be actively involved in developing these aspects of e-Navigation.

1.2.2. Position Fixing

Key elements required for e-Navigation position fixing are:

- appropriate accuracy, availability, continuity, and integrity (as per IMO Res A.915(22)).
- adequate redundancy
- compatibility between systems
- appropriate datums (vertical and horizontal)

Current GNSS have a common weakness in that they are all subject to accidental or intentional interference. Consideration should be given to a back-up independent non-GNSS Electronic Position Fixing System and sensors as a potential component of e-Navigation. e-Navigation systems should enable the electronic capture of radar ranges, radar and visual bearings, etc. for position fixing.

It is advisable that mariners should maintain skills through regular training so they are always capable of using alternative position fixing methods.

1.2.3. Communications

The following is a list of key communication aspects required for e-Navigation, relating to both technical issues and content:

- autonomous acquisition and mode switching (i.e., minimal or no mariner involvement needed)
- common messaging formats
- sufficiently robust (e.g., signal strength, resistance to interference)
- adequate security (e.g., encryption)
- sufficient bandwidth (data capacity)
- growth potential
- automated report generation
- global coverage (could be achieved with more than one technology)

The following communications issues will require resolution to achieve the above:

1. It seems likely that a satellite broadband link will be required to achieve the above requirements, and consideration must be given to how this will be achieved.
2. The question of cost and who pays for the provision of a satellite broadband link must be resolved early in development of e-Navigation.

1.2.4. Human Element

Human element issues need to be addressed when developing an e-Navigation strategy:

- Man/machine interface (i.e., balance between standardisation and allowing for innovation and development).
- Modes of information display/portrayal
- Appropriate communication of situation awareness
- Equipment should be designed to engage both the bridge team and VTS operator, maintaining high levels of attention and motivation without causing distraction.

1.3. e-NAV2 (IALA) meeting 19-23 March, 2007

The meeting reinforced the earlier findings and provided a descriptive model (created by N. Lemon of AMSA, see Fig.1)

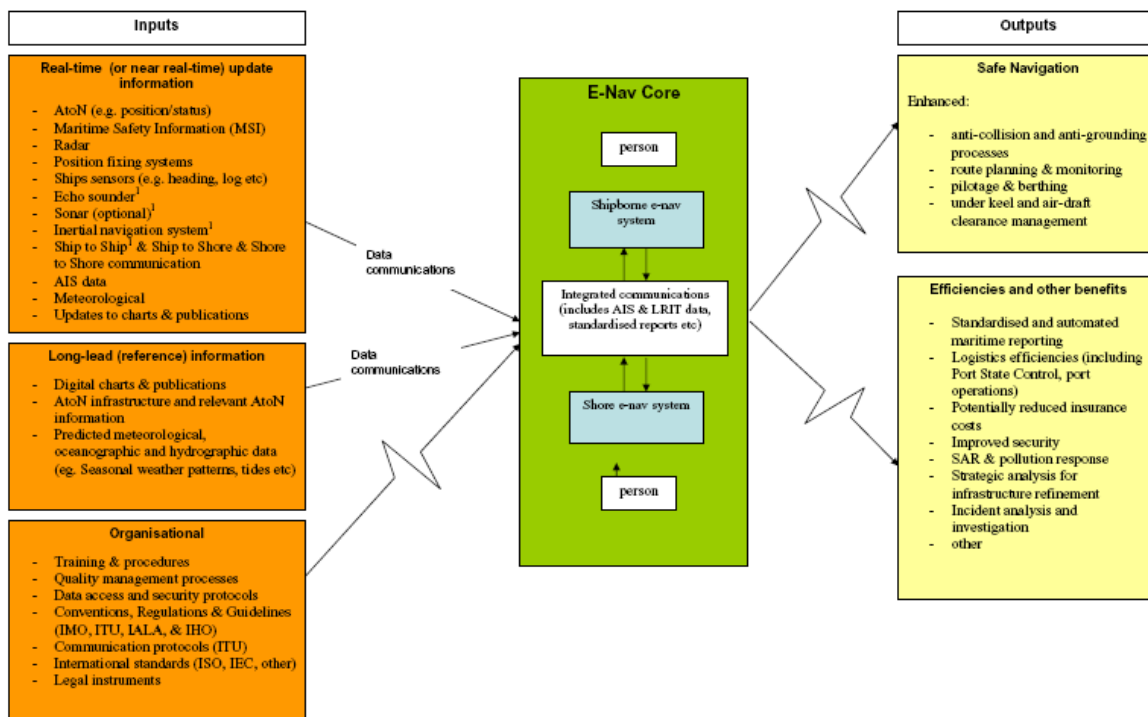
The following have been seen as the key goals of e-NAV:

- improve the safety of marine navigation for all vessels and protection of the environment
- improve the efficiency of marine navigation and vessel traffic services,
- provide opportunities for improving the efficiency of transport and logistics,
- improve the monitoring of and communication with sea-borne transport therefore enabling competent authorities to provide enhanced security and other allied services,

- support SAR services and incident management, and
- provide improved tools to facilitate optimum support and to engage mariners and shore based users whilst maintaining high levels of attention without causing distraction or undue burden.

These goals of e-navigation will be achieved by making best use of elements such as:

- harmonized and standardized data and information exchange,
- interoperable communication technologies and associated protocols and system architecture in compliance with ITU regulations,
- information analysis and management, presentation and control systems developed in compliance with IMO regulations,
- bridge displays and interfaces with the ability to present information in a standardised format,
- high integrity positioning and timing information, and
- relevant data, such as hydrographic and meteorological information.



1. Ship specific

Fig. 1. A Descriptive Model for E-Navigation [2]

The meeting suggested high-level user requirements, derived from the e-NAV goals and elements, which are applicable to ship and shore to varying degrees:

- mariners, in particular, require the integration and harmonisation of existing navigation, navigation support and communication systems (Note: this is seen as being broader and more holistic in nature than Integrated Bridge Systems or Integrated Navigation Systems),
- mariners require a capability to plan passages, with appropriate and relevant background information (e.g. nautical chart data, metrological information, established routing measures etc.)
- mariners and shore operators require clear and effective prioritisation of relevant and appropriate information,
- mariners and shore operators require a standardised graphical presentation of information and standardised equipment interface tools and controls,
- mariners and shore operators require an ability to simply and quickly invoke a standard mode of system presentation and operation,
- whilst high integrity positioning and timing information are needed for safe navigation, mariners require to be able to conduct safe navigation using own ship sensors (e.g. echo sounder information, radar information and gyro information),
- shore operators and mariners require a capability to facilitate assessment of vessel traffic and tools to assist decision making for monitoring and collision avoidance,
- Mariners require a capability for the automatic provision of all necessary reports to competent shore authorities, and
- Mariners and shore operators require that all alerts, alarms and warnings, including Maritime Safety Information, are harmonized, standardized and based on sound ergonomic and Human Element principles.

1.4. Regulatory activities affecting e-Navigation

There are already several ongoing activities within IMO, International Hydrographic Organisation (IHO), International Electrotechnical Committee (IEC) and other organisations which are highly related to the key components of e-Navigation. Some examples:

- IMO Resolutions A.817(19), MSC.64(67), MSC.86(70), Performance standards for electronic chart display and information systems;
- IMO NAV52, Agenda item 4, Revision of the performance standards for INS and IBS
- IMO NAV52, Agenda item 6, Evaluation of use of ECDIS and ENC development
- IMO NAV52, Agenda item 10, Performance standards for ship borne GALILEO receiver equipment
- IHO S52, Specifications for chart content and display aspects of ECDIS;
- IHO S52 appendix 1, Guidance on updating the electronic navigational chart;
- IHO S52 appendix 2, Colour and symbol specifications for ECDIS;
- IHO S52 appendix 3, Glossary of ECDIS-related terms;
- IHO S57, Transfer standard for digital hydrographic data;

- IEC 60936-4, Radar, Part 4: Ship borne radar -ECDIS back-up (in preparation).
- IEC 61174, Electronic chart display and information system (ECDIS);
- IEC 62288 Displays for the Presentation of Navigation Related Information (ECS standard in preparation)

This is not a complete list and, in addition, more regulations can be expected as e-Navigation moves from conceptual to implementation stage.

Still unsolved are the issues concerning usage of AIS and LRIT telecommunication channels. The infrastructure may be provided by the authorities but AIS capacity may be insufficient for the full e-Navigation data stream. LRIT is still an unknown but it is not foreseen that e-Maritime services will be welcome even if there is sufficient spare capacity, unless the commercial users pay for the infrastructure. IALA is working towards technical solutions but the question of who will be footing the bill even for the official e-Navigation services provided by the authorities remains to be answered.

There are a several different levels at which e-Navigation can and should be considered, e.g.:

- Systems
- Functionalities
- Information (data flow, exchange, harmonising)
- Organisation (including infrastructure)

Some e-Navigation issues need special attention:

- Centres and authorities ashore are not mentioned (it seems that the document of IMO regarding e-navigation is ship-centric and does not take account of the organisation and tasks on shore).
- Education and training

E-Navigation should contain at least AIS, ENC, DGNSS, LRIT from the beginning (see Fig.1), other components to be added as required.

UK proposes e-Navigation centres and so does IALA, this may be a crucial point deciding who provides the physical infrastructure and who supplies the functionalities and service part. Whether any official infrastructure will be made available to e-Maritime (the commercial operators) is unknown, high level negotiation will be required to obtain such access. The MEH project may become an important precedent in this matter.

2. Commercial developments

International trade has been growing at a rate in the order of 5 to 8% in the 2004 and 2005 the majority of which involves the carriage of goods by sea. The world's shipping fleet moves in order of 80% of all international trade. There are in the order of 85,000 significant ships in the world fleet (about 45,000 of them are SOLAS class) and the estimated annual turnover of the shipping industry is more than US\$ 500 billion.

As mentioned earlier, e-Maritime proposes, in addition to addressing safety and security issues,

- to reduce costs for shipping and coastal states; and
- to deliver benefits for the commercial shipping industry

It appears that e-Maritime (e-Navigation plus related information services for shipping, and their stakeholders, see Fig. 2) may represent a significant developmental opportunity for the maritime services providers.

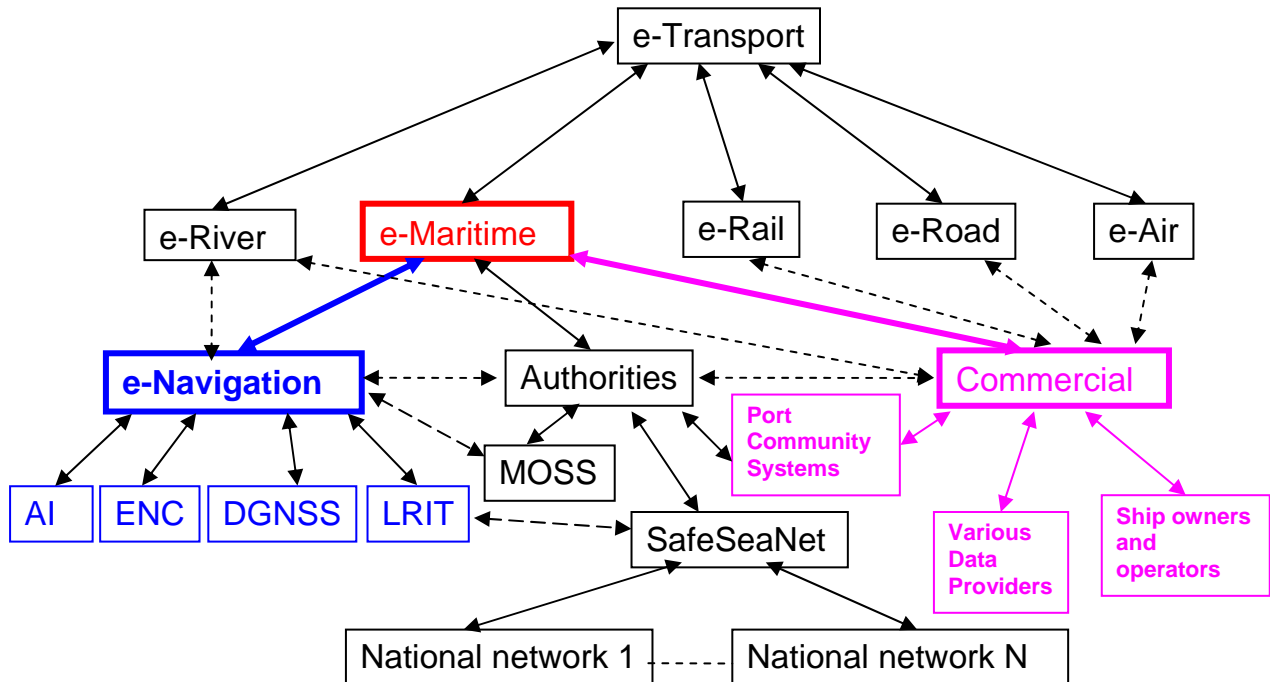


Fig. 2 e-Navigation and e-Maritime data exchange flows

The shipping industry is a reluctant adopter of new technologies. This inertia is a function of regulatory, compliance, training and cultural constraints. However, as containerisation shows, if there is a clear commercial reason for the adoption of technology the shipping industry can be revolutionised by new technologies and ideas.

More importantly the Internet (and effective service delivery systems), the availability of MetOcean forecasts supported by Earth Observations, new methods of tracking ships and changes to the perception of security/safety threats to shipping and posed by shipping, place the shipping industry at a turning point in the adoption of new technology. The drivers for change are moving from being “good practice”, “regulatory pressure” and other intangibles to being services that impact directly the cost of ship operations. Such impacts can now be achieved by reducing fuel consumption and reducing the cost of regulatory compliance.

The primary user requirements are to satisfy the key navigation functions in getting the ship from point A to point B.

E-Navigation needs to address :

- what are the user requirements for each of the activities?
- how would these requirements be met under e-navigation?
- what might the challenges be?

E-Maritime will address the commercial operational aspects leading to higher shipping efficiency and reduced costs.

3. Hydrographic aspects of e-Navigation

The optimum e-navigation concept is one where only ENC's will be used, i.e. where the data required can be selected by the navigator, and extraneous information discarded. E-Navigation should provide seamless details of the chosen passage route.

However, the current limitations on the use of ENC's in e-navigation are firstly that the hydrographic data available for many sea areas are not only old but are also based on out-dated survey methods. Updating this for use in official vector chart datasets is problematical in that a number of coastal states do not have the physical or financial resources to carry out the new surveys required. Until these limitations are resolved, the use of RNC and paper charts will continue.

A number of datasets relevant to passage planning and execution are available in paper formats (publications) and increasingly in electronic datasets. They include :

- Sailing directions (Pilots)
- Tidal stream atlases
- Tide tables and various methods of tidal prediction
- Lists of lights
- Lists of radio signals – which includes data on communications, Electronic Position Fixing Systems (EPFS), weather services, Global Maritime Distress and Safety System (GMDSS), pilot services and port operations, Vessel Traffic Services (VTS) and reporting systems and satellite navigation systems.
- Other thematic and miscellaneous paper charts and publications include data on fisheries areas, distance tables, buoyage systems, etc..

The navigator's requirements are to obtain necessary data or advice as accurately, explicitly, rapidly and efficiently as possible. All of the above could be converted to digital datasets and included within the e-navigation system without great difficulty. Some aspects, such as tidal stream and tide table data could be displayed as real-time ENC vectors in electronic chart display and information systems (ECDIS) once the regulations permit it.

The issues of copyright, royalties, etc. with respect to these and to hydrographic data in general need to be addressed and resolved.

4. CONCLUSIONS

In addition to the safety and security aspects, e-Navigation, or to be more precise e-Maritime, has a potential to increase efficiency of ship operations, which is the main consideration for ship-owners, operators and for service providers.

E-Maritime, of which e-Navigation is a part, is a provision system for all maritime data and information, and the distribution thereof, to facilitate maritime transport and provide other value added services to improve the profitability of shipping. The aim of e-Maritime is to deliver benefits to the public, transport consumers, public authorities and the maritime community, by means of ICT

The following trends in overall maritime operations and management are likely to occur:

- Ship design and technology will continue to evolve.
- Commercial pressures will demand ever-more rapid and predictable transportation and cargo handling schedules.
- Heightened international security concerns will have an impact on maritime trade processes.
- Environmental standards are expected to continue to acquire ever-higher stringency and priority.
- Professional competency of marine personnel will vary, notwithstanding the adoption of international standards.
- The volume of information being exchanged among ships and shore organisations will increase.
- The use of formalised and more rigorous systems to manage quality and safety at sea and in ports will increase.
- Advances in technology will necessitate an expanding or changing requirement for trained work forces.
- The environmental attractiveness of inland waterways as methods of transportation for goods and passengers will increase.
- Coastal and inland waterways will be increasingly used for recreational and other purposes, such as offshore renewable energy systems.
- Co-ordination of port services will become increasingly important in the interests of safety as well as commerce where such services may be obtained from different sources (e.g. public/private).
- There is an ever greater reliance on GNSS Positioning, Navigation and Timing (PNT) services for navigation, positioning aids to navigation and Automatic Identification System (AIS) operation.

These overall maritime trends are likely to lead to the following consequences for e-Navigation:

- The effective management of the high-density data transfer between ships and between ships and shore facilities will become an increasing requirement.
- Advances in technology will make possible the detection, identification, and precise tracking of vessels outside existing VTS areas. These will include Long Range Identification and Tracking (LRIT) as well as terrestrial and satellite-based reception of AIS signals.
- Comprehensive and effective risk assessment will increasingly become the basis for the safe management of navigation, including by means of VTS.
- There is likely to be a trend to control shipping by means of “directions”, rather than passing information and advice. However, this has liability implications and demands greater reliability of tracking systems.
- The need to assure and certify the competency of shore-side operators and supervisors in order to reduce any exposure to increased liability is likely to add to the scope and priority of such training.
- In areas of high density or co-existing commercial and recreational traffic, there may be a new need to manage/control recreational and small craft by shore-side authorities to ensure the safety of navigation. Security issues may also demand such controls.

References

[1] Contribution to MarNIS WP1.1, 24.08.2006

[2] eNAV2-06 Input paper (Australia e-NAV workshop), 19.03.2007