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e-Nav, Is It Enough?

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ABSTRACT: In the paper the Author tries to present the background to e-Navigation and its definition, the key elements which in the vision for e-Navigation were covered and the IMO's strength as the co-ordinator of e-Navigation, including strategy implementation plan. The underlying important principles were stated, together with the need to take user needs into account. Recent presentations and comments showed just how ambiguous the term „users" can be in the context of e-Navigation. This led to a more in depth review of the components of the IMO Strategy Implementation Plan. The author tries to answer the question of whether these assumptions, decisions and actions taken were appropriate and sufficient. The author asks the simple question whether the mere adoption and introduction of the concept of e-Navigation in life will be enough to meet all the challenges of the twenty-first century.

1 INTRODUCTION

The shipping industry is constantly moving to digital world. e-Navigation is expected to provide digital information and infrastructure for the benefit of maritime safety, security and protection of the marine environment, reducing the administrative burden and increasing the efficiency of maritime trade and transport [Loginovsky, 2016].

The advantage of the latest technical development in the field of marine engineering, nautical sciences, automation, electronics, telecommunications, computer sciences, telematics, geomatics and global position fixing techniques, achievement in data selection, storing, processing, analysing, transferring and visualisation should be taken into account and applied to the maritime technology. In the paper the author tries to discuss a strategic vision of development e-Navigation concept using those new technologies and the main tasks of the maritime community for the near future in international standardization of maritime education, training, scientific research and technological advances related to development of e-Navigation strategy in order to enhance the cooperation for maritime safety and security and protection of ocean environment.

The author believes it is now 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.

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 maritime education and training, both in the operation of the technology itself but most importantly in using the technology with agreed,

standardized 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 IMO member states and IAMU members [Weintrit, 2016].

2 E-NAVIGATION

2.1 *Development of e-Navigation Concept*

The last decades have seen huge developments in technology within navigation and communication systems. Sophisticated and advanced technology is developing rapidly. Seafarers have never had more technological support systems than today and therefore there is a need to coordinate existing and future systems and more use of harmonized standards. Although ships now carry Global Satellite Navigation Systems (GNSS) and will soon all have reliable Electronic Chart Displays and Information Systems (ECDIS) [Weintrit, 2009], their use on board is not fully integrated and harmonized with other existing systems and those of other ships and ashore. At the same time it has been identified that the human element, including training, competency, language skills, workload and motivation are essential in today's world. Administrative burden, information overload and ergonomics are prominent concerns. A clear need has been identified for the application of good ergonomic principles in a well-structured human machine interface as part of the e-Navigation strategy [Patraiko, 2007], [Weintrit, 2013]. The combination of navigational errors and human failure indicate a potential failure of the larger system in which ships are navigated and controlled. Maritime accidents related to navigation continue to occur despite the development and availability of a number of ship- and shore-based technologies that promise to improve situational awareness and decision-making. These include radio navigation systems, including Global Navigation Satellite Systems (GNSS), Automatic Identification Systems (AIS), Electronic Chart Display and Information Systems (ECDIS), Integrated Bridge Systems (IBS), Integrated Navigation Systems (INS), Long Range Identification and Tracking (LRIT) systems, sophisticated maritime radars, Automatic Radar Plotting Aids (ARPA), Vessel Traffic Services (VTS) and Global Maritime Distress Safety Systems (GMDSS) [Patraiko *et al*, 2010].

The e-Navigation is a major IMO (International Maritime Organization) initiative to harmonise and enhance navigation systems and is expected to have a significant impact on the future of marine navigation. The IMO has mandated that this initiative be led by 'user needs'. It is believed that these technologies can reduce navigational errors and failures, and deliver benefits in areas like search and rescue, pollution incident response, security and the protection of critical marine resources, such as fishing grounds. They may also contribute to efficiencies in the planning and operation of cargo logistics, by providing information about sea, port and forwarder conditions [Patraiko *et al*, 2010].

2.2 *Definition of the e-Navigation*

The e-Navigation is a current international initiative that is intended to facilitate the transition of maritime navigation into the digital era, is a vision for the integration of existing and new navigational tools, in a holistic and systematic manner that will enable the transmission, manipulation and display of navigational information in electronic format [Weintrit, 2015]. The IMO has defined e-Navigation as "the harmonized collection, integration, exchange, presentation and analysis of marine information on board 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" [IMO, 2008], [IMO, 2014]. The e-Navigation would help reduce navigational accidents, errors and failures by developing standards for an accurate and cost effective shipping. e-Navigation is intended to meet present and future user needs through harmonisation of marine navigation systems and supporting shore services.

The IMO further describes the compelling need for e-Navigation as a clear and compelling need to equip the master of a vessel and those ashore responsible for the safety of shipping with modern, proven tools to make maritime navigation and communications more reliable and user friendly and thereby reducing 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 standardisation onboard and ashore, incompatibility between vessels and an increased and unnecessary level of complexity.

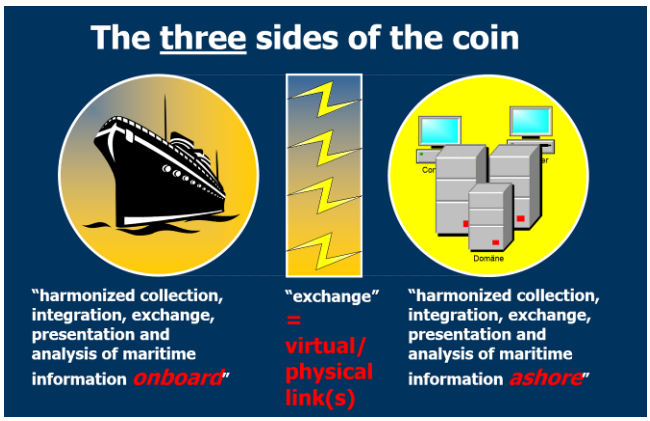

Figure 1. Three main faces of e-Navigation concept

2.3 *Electronic Navigation versus e-Navigation*

The strength of the IMO's e-Navigation initiative is that it should lead to greater harmonization of navigation information and communication on an international basis. This will be essential for safety at sea and international trade. The weakness, however, is the time it will take to obtain agreement by all nations and stakeholders, particularly in a time of such rapid technology advancement. Electronic navigation is with us for decades and is epitomized now by ECDIS with GNSS. Electronic navigation are forms of navigation that ships can use, which rely on

technology powered by electricity. Methods of electronic navigation include:
- Satellite navigation, satellite navigation systems,
- Radio navigation, the application of radio frequencies to determining a position,
- Radar navigation, the use of radar to determine position relative to known objects.

We recognize that this is widely relied upon, or even over-relied upon. The training requirements for ECDIS came into force in January 2012 as per the Manila amendment to STCW [IMO, 2010], and the first phase of ECDIS carriage requirements commenced in July 2012. The phased carriage requirement of Electronic Chart Display and Information System (ECDIS) is underway and is scheduled to be completed by 2018. ECDIS is a complex system and will be one of the most essential tools for supporting mariners in their efforts to ensure the safety of navigation and protection of the marine environment'. The ability to harness the power of ECDIS and to avoid catastrophe due to incompetence is largely down to training and familiarisation.

Electronic Navigation ≠ e-Navigation

e-Navigation is a concept to support and improve decision-making through maritime information management and it aims to [Patraiko, 2007], [IMO, 2008]:
- facilitate the safe and secure navigation of vessels by improved traffic management, and through the promotion of better standards for safe navigation;
- improve the protection of the marine and coastal environment from pollution;
- enable higher efficiency and reduced costs in transport and logistics;
- improve contingency response, and search and rescue services;
- enhance management and usability of information onboard and ashore to support effective decision making, and to optimize the level of administrative workload for the mariner.

2.4 *Two Aspects of e-Navigation*

There are two aspects of the title question "e-Nav, is it enough?": narrow and wide. In the narrow aspect we can really say that abbreviation e-Nav is enough, when we are talking about e-Navigation:

e-Nav = e-Navigation

In wide aspect the problem is much more complicated.

3 THE IMO E-NAVIGATION STRATEGY

It should be noted that the term e-Navigation is often used in a generic sense by equipment and service providers. This claim should be seen as an aspiration, rather than an indication of compliance.

The work conducted by the IMO during the last years lead to the identification of specific user needs and potential e-Navigation solutions.

The e-Navigation Strategy Implementation Plan (SIP), which was approved in 2014 [IMO, 2014], contains a list of tasks required to be conducted in order to address 5 prioritized e-Navigation solutions, namely [Weintrit, 2013]:
- improved, harmonized and user-friendly bridge design;
- means for standardized and automated reporting;
- improved reliability, resilience and integrity of bridge equipment and navigation information;
- integration and presentation of available information in graphical displays received via communication equipment; and
- improved Communication of VTS Service Portfolio (not limited to VTS stations).

It is expected that these tasks, when completed during the period 2015–2020, should provide the industry with harmonized information in order to start designing products and services to meet the e-Navigation solutions. The ultimate goal of e-Navigation is to integrate ship borne and land based technology on a so far unseen level. The e-Navigation is meant to integrate existing and new electronic navigational tools (ship and shore based) into one comprehensive system that will contribute to enhanced navigational safety and security while reducing the workload of the mariner (navigator) [Bibik *et al*, 2010]. The bridge between those two domains will be broadband communication technology which is about to arrive in regular commercial shipping within the next years to come. The constituting element of this integration, however, is a common maritime data model. The existing concept of the Geospatial Information Registry can be adapted to the enhanced scope of a future Marine Information Registry covering additional maritime domains by expansion, amendment and moderate rearrangement. Though the basic philosophy of the IHO S-100 Registry prevails, virtual barriers for maritime stakeholders to associate with the Registry concept must be lowered by all means. This includes options to adopt existing register-ike structures including identifier systems and stewardship for selected areas and elements of additional maritime domains in contrast to the possibly daunting overall third party ownership for a wide scientific field by potential contributors. Besides the recognized international organizations like, IMO, IHO, IEC and IALA who are currently discussing the further steps in e-Navigation, a grass root movement may take place with several stakeholders involved populating the Marine Information Registry. Such a grass root movement would truly demonstrate that e-Navigation has been understood and accepted. To allow for the orderly development of that stage of e-Navigation in accordance with the IMO defined goals and aspirations of e-Navigation, it would be required to activate the appropriate IMO instruments already in place to define the fundamental principles and structure of the Marine Information Registry, to assign roles and responsibilities amongst international organizations and stakeholders, and thereby facilitate the seventh pillar of e-Navigation, its "cement", namely the Common Maritime Data Structure (CDMS) [Weintrit, 2011].

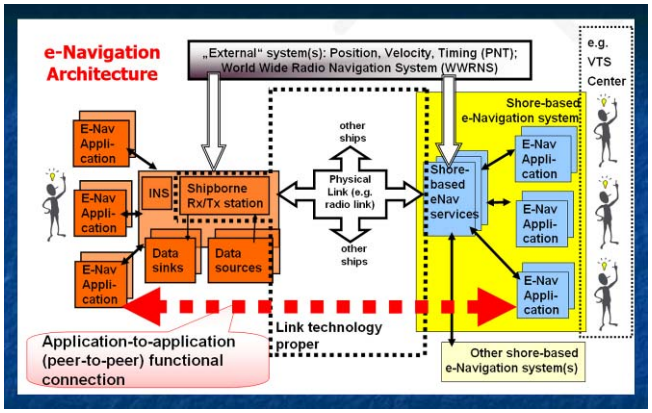

Figure 2. Conceptual e-Navigation Architecture [IMO, 2014]

For ships' navigating officers, masters and pilots to make the very best decisions concerning the safe navigation of a vessel, they need quality tools, good procedures and training that addresses how to use such tools within the context of making good decisions. Users need to be competent and confident when using information from navigation equipment such as ECDIS, Radar, ARPA, AIS, and electronic position fixing systems GNSS, in order to use them as effective tools.

4 E-NAVIGATION – AN UNIVERSAL, COMPREHENSIVE TOOL, PANACEA FOR ALL PUEPOSES

4.1 *Wrong Approach*

Unfortunately e-Navigation is not the "magic word", picklock which can open all doors and solve each navigational problem.

Figure 3. e-Navigation is not a magic word which can open all doors and solve each navigational problem

To paraphrase the ancient maxim "All roads lead to Rome" we can say today that in marine shipping "All roads lead to e-Navigation".

Figure 4. To paraphrase the ancient maxim "All roads lead to Rome" we can say today that "All roads lead to e-Navigation"

Frankly speaking, today all navigation and communication systems are considered as elements of the e-Navigation without any deeper reflection. Finally, once again we receive another top secret "black box" with hidden details.

Figure 5. Today, all navigation, communication and data exchange systems are considered as elements of another completely covered "black box", commonly referred to as e-Navigation

We are talking about communication, navigation and data exchange systems, which according to the e-Navigation definition collect, integrate, exchange, present and analyse marine information on board and ashore by electronic means, but as can we see everything goes in the end to an universal, common chute.

Figure 6. Little funny, unambiguous image depicting the current situation in which communication, navigation and data exchange systems collect, integrate, exchange, present and analyse marine information on board and ashore by electronic means, but in the end everything goes to common dump, commonly referred to as e-Navigation

So it looks like, maybe a little interesting in the beginning, but we are all invited to a common e-Navigation platform. It must eventually work.

Figure 7. All stockholders with navigation and communication backgrounds are invited to a common e-Navigation platform

5 INTERNATIONAL INITIATIVES

5.1 *IMO Initiatives*

The IMO as a specialized agency of the United Nations, which primary purpose is to develop and maintain a comprehensive regulatory framework for shipping and its remit includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping and as the leading international body for maritime professionals will continue to use the resources of its members states to promote the effective application of the e-Navigation concept, of course including innovative methods of education and training.

5.2 *Organizational changes in the IMO and IALA*

The IALA approved the road map for changing the status of IALA from that of a non-governmental organization (NGO) to that of an international intergovernmental organization (IGO). This is a major step in the evolution of that association.

IALA stands ready to carry out the role that will best assist in the improvement and harmonization of aids to navigation worldwide. In the view of the IALA, this will be best achieved if IALA has a strong, international legal framework that ensures transparency and good governance, that positions IALA to work in close collaboration with governments and other intergovernmental organizations, and that fosters the work of IALA as the peak international technical body in the field of aids to navigation.

IALA's aim is to foster the safe, economic and efficient movements of vessels, through improvement and harmonization of aids to navigation worldwide and other appropriate means, for the benefit of the maritime community and the protection of the environment.

IALA will be the international organization that can assist governments in its area of expertise – marine aids to navigation – to [IALA, 2013]:

- acquire, evaluate and disseminate marine technology knowledge and facilitate access to that knowledge,
- develop marine technology and infrastructure to facilitate the transfer of marine technology,
- develop human resources through training and education,
- promote international co-operation at all levels.

The IMO has recently amalgamated its Safety of Navigation (NAV) and Search and Rescue (SAR) sub-committees into Navigation, Communication and Search and Rescue (NCSR) sub-committee (due to better manage of the e-Navigation strategy) and at its recent Symposium on the Future of Ship Safety recognized the benefits of moving to a goal based safety regime in which technical expertise is provided by a range of international organizations.

Both these changes and the continued development of e-Navigation provide the opportunity for IMO and IALA, with the support of its National Members, to make important and lasting contributions to the safe, economic and efficient movement of vessels.

5.3 *The EU e-Maritime Initiative*

Maritime transport is a major economical contributor in the EU as well as a necessary component for the facilitation of international and interregional trade on which the European economy is strongly dependent. The EU e-Maritime initiative [Pipitsoulis, 2009], is

seen as a cornerstone for the achievement of the strategic goals of the EU Maritime Transport Strategy 2018 and related policies, recognising the critical role of ICT for productivity and innovation, and anticipating a new era of e-Business solutions, based on integrated ICT systems and tools.

Whereas "e-Maritime" stands for internet based interactions between all the different stakeholders in the maritime sector, the EU e-Maritime initiative is aimed at supporting the development of European capabilities, strategies and policies facilitating the adoption of upgraded e-Maritime solutions in support of an efficient and sustainable waterborne transport system fully integrated in the overall European transport system.

The EU e-Maritime aims to promote coherent, transparent, efficient and simplified solutions based on advanced information technologies. This would allow reaching the following three policy objectives [Lynch, 2010]:

- Improving the safety and security of maritime transport services and assets and environmental protection: Port and ship security and safety increasingly require integrated surveillance, monitoring and control systems, incorporating adequate 'intelligence' for proactive, remedial and cross-border operations;
- Increasing the competitiveness of the EU maritime transport and logistics industry: Improved utilisation of advanced ICT will lead to innovation regarding the quality of shipping services and will facilitate reduction of operational costs and increased competitiveness of the sector. At the same time, the performance of the whole EU transport system can be improved by better integrating waterborne transport into efficient door-to-door transport services in Europe and beyond;
- Reinforcing the human factor: EU seafaring and maritime professions experience a serious shortage of qualified people. Young people do not go to the sea as they used to. An important factor is the lack of continuing professional education offered to the mariners in a flexible manner at sea and ashore, as well as difficult reconciliation of family life and working life. The e-Maritime solutions can support competence development (improved long-distance training) and improve welfare for seafarers (access to long-distance health services; connectivity with families; …).

If the main aim of e-Navigation was to enhance the navigation capabilities of a ship without compromising its efficiency, e-Maritime aimed to increase its profitability without compromising its safety. Due to the cooperation of the European partners involved, close coordination had been established between the two initiatives. The EU e-Maritime initiative supported the deployment of e-Navigation services in Europe, while e-Navigation provided a global perspective for the EU initiative. The EU's e-Maritime and IMO's e-Navigation both make use of the same electronic technology, processes and service, and the European Commission wants to make use of those being developed by IMO for e-Navigation wherever possible in the e-Maritime concept development.

In summary the e-Maritime initiative aims at optimizing maritime related processes and reducing the administrative burden. This will be done by identifying existing practices and regulations and by proposing improvements and simplifications deriving from use of electronic systems and information.

5.4 *e-Navigation Specific Training*

The IMO's Strategy Implementation Plan (SIP) describes the further development of e-Navigation and contains a plan for enhancing public awareness of e-Navigation. The SIP focuses on five prioritized solutions, as follows [Weintrit, 2013]:

S1: improved, harmonized and user-friendly design;
S2: means for standardized and automated reporting;
S3: improved reliability, resilience and integrity of bridge equipment and navigation information;
S4: integration and presentation of available information in graphical displays received via communications equipment; and
S9: improved communication of VTS Service Portfolio.

The implementation of all prioritized solutions require specific training referred to the used technical methods and new operational procedures to comply with the key messages for all stakeholders listed in the table "Examples of key messages to promote the benefits of e-Navigation". A detailed description and a table presenting the structure of the SIP are included in [Weintrit, 2013]. Scrutinizing the solutions in detail it becomes clear that the solutions S1 and S4 address the equipment and its use on a ship only, while S2 and S9 address improved communications between ships, ship to shore and shore to ship. Solution S3 addresses both bridge equipment and e.g. shore-ship information as part of the PNT system. Consequently training courses which must developed for the solutions S2 and S9 must include new technical and operational competencies for both users groups, the seafarers and the shore side users. With regard to S9 the STCW requirements and the "IALA Model Course V-103/1 – Vessel Traffic Services Operator Training" must be revised. A possible solution could be an IMO Model Course on "Operational use of VTS Services" [ACCSEAS, 2015].

5.5 *e-Navigation Training Proposals*

The e-Navigation requires new methods of maritime education and training for cadets and deck officers [Barsan & Muntean, 2008], [Loginovsky, 2016].

In this section the author presents the candidate solutions relating to education, training and using simulators. In the Interreg North Sea Region Programme ACCSEAS were identified in total 14 training proposals, described in the "Baseline Report" [ACCSEAS, 2015]. Some were portrayed in detail including technical specifications and user manuals. At the end of ACCSEAS project the solutions reached a different stage of development. For further work on training and use of simulators in e-Navigation training and demonstration it is reasonable to group them as follows:

1 Maritime Service Portfolios (MSPs),
2 Route Topology Model (RTM),

3 "Maritime Cloud" as an underlying technical framework solution,
4 Innovative Architecture for Ship Positioning:
   – Multi Source Positioning Service,
   – R-Mode at existing MF DGNSS and AIS Services,
5 Maritime Safety Information / Notices to Mariners (MSI/NM) Service,
6 No-Go-Area Service,
7 Tactical Route Suggestion Service (shore-ship),
8 Tactical Exchange of Intended Route (ship-ship and ship-shore),
9 Vessel Operations Coordination Tool (VOCT),
10 Dynamic Predictor (for tug boat operations),
11 Augmented Reality/Head-Up-Displays (HUDs),
12 Automated FAL Reporting,
13 Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF),
14 Real Time Vessel Traffic Pattern Analysis and Warning Functionality for VTS.

The majority of mentioned solutions are thoroughly investigated and ready for developing training arrangements except the last three solutions. They are in principle recognized, but unfortunately yet not ready for developing training arrangements.

In addition, in the author opinion, we should take into account the following extra proposals [Weintrit, 2016]:
1 Virtual Aids to Navigation (Virtual ATON) and AIS ATON (Real, Synthetic and Virtual),
2 Back-up Arrangements for ECDIS,
3 A robust electronic position-fixing system with redundancy,
4 IHO S-100 Universal Hydrographic Data Model (explanation and use).

First of all we should teach our students how to:
– avoid common-mode failures (e.g. GPS/GNSS, e-Loran, inertial systems, integrity checks),
– improve situational awareness (target matching, coherent presentation), and
– prevent information overload (alarm management, essential information only).

6 CONCLUSIONS

Thanks to advances in information technology, free communication between ocean and land is now available and all maritime society carry forward the e-Navigation for maritime accident prevention, transport efficiency, energy conservation and marine environment protection purpose. A large-scale implementation of the e-Navigation features is inevitable in the near future. The impact of electronics and computers on the ships' bridges is well known for at least 30 years. Despite this, there are still a lot of debates regarding the real improvement of safety based on electronics. Because the future means e-Navigation, we have to start to prepare our students to face the challenges raised by an increasing amount of navigation information that must be selected, absorbed, processed and analysed in a proper way, in order to determine the correct actions.

In order to achieve this goal, to traditional methods to teach navigation must be added a new kind of module able to integrate the main information from all kind of navigational sources and sensors. We have to develop the students habitudes to generate their own overall image of the surrounding situation, based on as much information available as possible. We also have to develop new kind of maritime safety culture of our students for a self-learning process when confronted with new types of navigational equipment and a new layout/configuration of the integrated bridge system. They have to obtain a proper onboard training, starting with enough time to familiarize and understand the user manuals of the navigation equipment installed in the INS/IBS.

It is envisioned that e-Navigation will be a 'living' concept that will evolve and adapt over a long time scale to support this objective. During this time information will change, technologies will change, political and commercial objectives will change, and tasks will change, and even our expectations will change. However it is unlikely that the need for safe and efficient seaborne transport will change significantly. It is also certain that the safe and efficient transport will continue to rely on good decisions being made on an increasingly constant and reliable basis. Some decisions may be made with increased dependence on technology, but at some level we will always rely on good human decisions being made and therefore every effort needs to be made to apply an understanding of the Human Element at all stages, of design, development, implementation and operation of e-Navigation. Therefore we need new, modified education and training system dedicated and targeted to e-Navigation and well standardised international procedures for marine navigation.

Although it is not yet fully known in detail how this idea will be realized, the term e-Navigation maybe not distinctly enough, but is clearly visible on the horizon.

Figure 8. Although it is not yet fully known in detail how this idea will be realized, the term e-Navigation maybe not distinctly enough, but clearly visible on the horizon

Ship transport can be said to be the original Intelligent Transport System and developments in this sector should be of interest for ITS research in other modes. This has been realized by the shipping community and the e-Navigation (by IMO) and the e-Maritime (by EU) initiatives testify to this. Both initiatives have identified the information architecture as critical for the future development of the ship

transport area. The development of a maritime ITS architecture needs to consider legacy systems, the international nature of shipping, international legislation and standards as well as highly varying quality of service on available communication channels.

Prior to the full realization of the concept of e-Navigation, we must make sure, whether indeed our ideas, realized projects and test-beds and the development of standards are going exactly the correct direction. Is the concept of e-Nav is really enough for us and it is truly what we expect?

REFERENCES

ACCSEAS, 2015. ACCSEAS: The Interreg IVB North Sea Region Programme: ACCessibility for Shipping, Efficiency, Advantages and Sustainability ACCSEAS Baseline and Priorities Report, Latest version: 3.4a, London, 14 January 2015.

Barsan E. & Muntean C., 2008. e-Navigation Requires New Methods of Training for Deck Officers. Proceedings of the 9th Annual General Assembly of the International Association of Maritime Universities (IAMU): Common Seas, Common Shores: The New Maritime Community. Editors: Donna Nincic and Graham Benton. California Maritime Academy, San Francisco.

Bibik L., Królikowski A., Czaplewski K., Duda D., 2008. Vision of the Decision Support Model on Board of the Vessel with Use of the Shore Based IT Tools. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 2, No. 3, September.

IALA, 2013. IALA – an International Organization. Safely Navigating the Future. International Association of Lighthouses Authorities IALA-AISM, Saint-Germain-en-Laye, France.

IMO, 2008. MSC 85/26/Add.1, Annex 20. Strategy for The Development and Implementation of e-Navigation. Maritime Safety Committee, International Maritime Organization, London, 2008.

IMO, 2010. International Convention on Standards of Training, Certification and Watch-keeping for Seafarers (STCW 2010), International Maritime Organization, London.

IMO, 2014. MSC 94/21, Report of the Maritime Safety Committee on its 94 session, Maritime Safety Committee, International Maritime Organization, London 26 November.

Loginovsky V., 2016. IMO e-Navigation Concept and MET Trends Analysis. Proceedings of the 17th Annual General Assembly International Association of Maritime Universities. Vietnam Maritime University, Haiphong, Vietnam, 26-29 October, pp. 276-281.

Lynch C., 2010. e-Maritime Overview. Sustainable Knowledge Platform for the European Maritime and Logistics Industry (SKEMA) Periodic Study: e-Maritime Task 1 Report, 5th Feb.2010.

Patraiko D., 2007. Introducing the e-Navigation Revolution. Seaways, The International Journal of the Nautical Institute, March.

Patraiko D., Wake P., Weintrit A., 2010. e-Navigation and the Human Element. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 4, No. 1, March.

Pipitsoulis C., 2009. e-Maritime: Concept and Objectives, European Commission, DG Energy and Transport, 26th March.

Weintrit A., 2009. The Electronic Chart Display and Information System (ECDIS). An Operational Handbook. A Balkema Book. CRC Press, Taylor & Francis Group, Boca Raton – London - New York - Leiden, pp. 1101.

Weintrit A., 2011. Development of the IMO e-Navigation Concept – Common Maritime Data Structure. In: Mikulski J. (ed.) TST 2011, Communications in Computer and Information Science, vol. 239. Modern Transport Telematics. Springer, Heidelberg, pp. 151-163.

Weintrit A., 2013. Prioritized Main Potential Solutions for the e-Navigation Concept. TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 7, No. 1, March.

Weintrit A., 2015. Software Quality Assurance in e-Navigation. In: Mikulski J. (ed.) TST 2015, Communications in Computer and Information Science, vol. 531. Tools of Transport Telematics. Springer, Heidelberg, pp. 141-150.

Weintrit A., 2016. International Standardization of Maritime Education, Training, Scientific Research and Technological Advances related to Development of e-Navigation Strategy in Order to Enhance the Cooperation for Maritime Safety and Security and Protection of Ocean Environment. Proceedings of the 17th Annual General Assembly International Association of Maritime Universities. Vietnam Maritime University, Haiphong, Vietnam, 26-29 October, pp. 8-18.