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# Status of the work on e-navigation conception and plan of its implementation at the beginning of 2014

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**ABSTRACT**
During last session of the Sub-Committee on Safety of Navigation of the International Maritime Organisation (IMO) in September 2013, Secretary General of this organisation informed that shipping industry is waiting for some practical recommendations regarding e-navigation and principle of its introducing and asked for ending the discussion on e-navigation conception and its strategy implementation plan. Paper presents history and state of works on this subject conducted by two IMO Sub-Committees on Safety of Navigation (NAV) and Radio-communication and Search and Rescue (COMSAR) at the beginning of 2014 and remarks regarding possibility of realisation of the shipping industry expectations in near future.

**KEYWORDS: e-navigation**

## 1. Introduction

During last session of the Sub-Committee on Safety of Navigation of the International Maritime Organisation (IMO) in September 2013, Secretary General of this organisation informed that shipping industry is waiting for some practical recommendations regarding e-navigation and principle of its introducing and asked for ending the discussion on e-navigation conception and its strategy implementation plan. Corresponding to the request of the Secretary, correspondence group on e-navigation prepared a report ending stage of development objectives for the e-navigation and presenting a plan for its implementation [1].

Paper presents history of e-navigation and state of works on its development conducted by two IMO Sub-Committees on Safety of Navigation (NAV) and Radio-communication and Search and Rescue (COMSAR) at the beginning of 2014 and author's remarks regarding possibility of realisation of these shipping industry expectations in near future.

## 2. E-Navigation history

The first proposal on development of an e-navigation concept was submitted to the Maritime Safety Committee (MSC) of the International Maritime Organisation (IMO) by Japan, Marshall Island, the Netherlands, Norway, Singapore, the United Kingdom and the United States after an initiative from the United Kingdom in May 2006 in document signed MSC 81/23/10. The co-sponsors of this document proposed to add a new item named "e-navigation" to the work programme of the Sub-Committee on Safety of Navigation (NAV) and on Radio-communications and Search and Rescue (COMSAR). The main task of this item should be the development of strategic vision for the utilization of existing and new navigational and radio communication tools, in particular electronic tools, in a holistic and systematic manner in order to reduce number of 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". Co-sponsors of this document considered that there is a clear need to equip ships'

crew and persons responsible for the safety of shipping ashore with modern tools to make marine navigation and communication more reliable and safety. In addition, to reduce navigational errors and failures, these tools shall deliver benefits in areas such as search and rescue, pollution incident response, security and the protection of critical marine resources, such as fishing grounds. They can also offer operational benefits by enabling the capture of advance information on cargo arrival and increased throughput capacity in congested ports, fairways, and waterways, or in poor visibility conditions. However, if such technological advancement remains uncoordinated, there is a risk that the future development of the global shipping industry will be hampered through lack of standardization on board and ashore, incompatibility between vessels, and an increased and unnecessary level of complexity. As the key structural components of e-navigation policy were defined [1], [2]:

1. Accurate, comprehensive and up-to-date electronic navigational charts (ENC) covering the entire geographical area of a vessel's operation.
2. Accurate and reliable electronic positioning signals, with "fail--safe" performance, probably provided through multiple redundancy, e.g. on board receivers of different satellite and terrestrial radio navigational systems or inertial navigation devices.
3. Provision of information on vessel route, course, manoeuvring parameters and other status items (hydrographic data, ship identification data, passenger details, cargo type, security status, etc.), in electronic format.
4. Transmission of positional and navigational information: ship--to-shore, shore-to-ship (e.g. by vessel traffic services (VTS), coastguard centres, hydrographic offices) and ship-to-ship.
5. Accurate, clear, integrated, user friendly display of the above mentioned information on board and ashore (e.g. using integrated bridge system (IBS) or integrated navigation system (INS).
6. Information prioritization and alert capability in risk situations (collision, grounding, etc.), both on board and ashore.
7. Reliable transmission of distress alerts and maritime safety information (MSI) with reduction of current GMDSS requirements by utilizing newly emerged communication technologies.

Proposed new work programme item shall comprise a wide range of issues, extending beyond what is already being done at IMO, including [2]:

1. Increasing the production, coverage and interfaces of ENCs; as well as accelerating the distribution and promotion of commercially viable and globally accepted protocols for ENC production and updating.
2. Agreeing standardized controls and common performance standards of bridge e-navigation systems, including the consideration of such issues as what information needs to be captured, how it should be displayed, how it should be laid out and what should be shared with other vessels and shore-based navigation support centres.
3. Agreeing protocols to provide more information to professional and authorized users, whilst preventing unauthorized access to, dissemination of, or intervention in safety or security-critical, real-time data transmissions.
4. Developing a shared understanding of the potential benefits and mechanics of shore support and oversight, leading to the design and implementation of shore-based marine e-navigation support centres covering coastal and, potentially, international waters.
5. Setting out an orderly and safe migration plan for e-navigation which takes into account the future role of existing navigational tools, in different locations and situations.

MSC 81 decided to include in the work programmes of the NAV and COMSAR Sub-Committees a high-priority item on "Development of an e-navigation strategy", with a target completion date of 2008, and assigned the NAV Sub-Committee as coordinator. Sub-Committee on Safety of Navigation on its 52 session considered item, outlining Japan's approach to e-navigation and, to progress the work before next session, established an intersessional correspondence group on e-navigation. Group was later re-established after each session of the Sub-Committee, the last time in 2013. At the beginning, its work was coordinated by the United Kingdom, later by Norway. Representatives of 44 IMO member states including Poland and 24 international organisations and associations participated in the work of the correspondence group in 2013.

Prepared by the correspondence group definition, architecture and strategy of the implementation of e-navigation have been accepted during the consecutive sessions of the Maritime Safety Committee (MSC). MSC accepted inter alia proposals regarding:

1. Key elements for e-navigation defined on the base of user needs.
2. E-navigation architecture.
3. Developing a Common Maritime Data Structure (CMDS).
4. The use of the IHO's S-100 standard as the baseline for creating a framework for data access and services under the scope of the International Convention for the Safety of Life at Sea (SOLAS).
5. Potential e-navigation solutions defined on the base of identified user needs and gap analysis conducted taking into account the Human Element Analysing Process (HEAP).

According to the approved strategy, the key elements for e-navigation include [3]:

6. Architecture.
1. Human element.
2. Conventions and standards.
3. Position fixing.
4. Communication technology an information systems.
5. Electronic navigation charts (ENCs).
6. Equipment standardization.
7. Scalability.

Following tasks were listed as potential e-navigation solutions defined on the base of identified user needs and gap analysis [3]:

- S1 Improved, harmonized and user-friendly bridge 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 communication equipment;
- S5 Information management;
- S6 Improved access to relevant information for search and rescue;

- S7 Improved reliability, resilience and integrity of bridge equipment and navigation information for shore-based users;
- S8 Improved and harmonized shore-based systems and services;
- S9 Improved communication of VTS service portfolio.

Five prioritized solutions numbered as S1, S2, S3, S4 and S9 were selected from the above mentioned list after formal safety assessment (FSA) conducted using two criteria [4]:

- Seamless transfer of data between various equipment on board;
- Seamless transfer of electronic information/data between ship and shore and vice versa and between ship to ship and shore to shore.

As part of the FSA, the following Risk Control Options (RCOs) were identified which provided effective risk reduction in a cost-effective manner [3]:

- RCO 1 Integration of navigation information and equipment including improved software quality assurance;
- RCO 2 Bridge alert management;
- RCO 3 Standardized mode(s) for navigation equipment;
- RCO 4 Automated and standardized ship-shore reporting;
- RCO 5 Improved reliability and resilience of on board PNT systems;
- RCO 6 Improved shore-based services; and
- RCO 7 Bridge and workstation layout standardization.

In order to harmonize and standardize, shore based services rendered for ships under different situations and/or locations were grouped and described as Maritime Service Portfolios (MSPs). NAV Sub-Committee noted the following preliminary list of (MSPs) in 2013 [5]:

- (MSP 1) VTS information service (IS);
- (MSP 2) VTS navigation assistance service (NAS);
- (MSP 3) VTS traffic organization service (TOS);
- (MSP 4) Local port service (LPS);
- (MSP 5) Maritime safety information (MSI) service;
- (MSP 6) Pilotage service;
- (MSP 7) Tugs service;
- (MSP 8) Vessel shore reporting;
- (MSP 9) Telemedical maritime assistance service (TMAS);
- (MSP 10) Maritime assistance service (MAS);
- (MSP 11) Nautical chart service;
- (MSP 12) Nautical publications service;
- (MSP 13) Ice navigation service;
- (MSP 14) Meteorological information service;
- (MSP 15) Real-time hydrographic and environmental information services; and
- (MSP 16) Search and rescue (SAR) service.

It was also agreed that MSPs should consider operations in the following areas [5]:

- Port areas and approaches;
- Coastal waters and confined or restricted areas;
- Open sea and ocean areas;
- Areas with offshore and/or infrastructure developments
- Polar areas; and
- Other remote areas.

In 2013 IMO changed the number and structure of the MSC sub-committees and combined Subcommittees on Safety of Navigation (NAV) and Radio-Communication and Search and Rescue (COMSAR) in one Subcommittee on Navigation, Communication and Search and Rescue (NCSR). As a result of this decision correspondence group on e-navigation established by the NAV Subcommittee completed the work and its report submitted to the first session of the NCSR Subcommittee in 2014 should be considered as a final document.

Results of the work of the correspondence group and views of the Polish representatives on the conception and scope of e-navigation determined at various stages of the work of the group are presented in the publications listed in the bibliography [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16] and [17].

# 3. Current state of development of e-navigation system

Intersessional correspondence group on e-navigation confirmed in its report submitted to the first session of the NCSR Sub-Committee in 2014 all solutions regarding e-navigation, inter alia its architecture, development and implementation accepted by Maritime Safety Committee (MSC) earlier and described in chapter 2. Corresponding to the request of the IMO Secretary General group suggested that five prioritized solutions (S1, S2, S3, S4 and S9) shall be implemented in time period 2015-2019. Proposed time schedule of their implementation and detailed description of required regulatory framework and technical requirements are presented in the annex to this report [1].

Fig. 1 presents e-navigation architecture accepted at this stage of work [1]. Norway - coordinator of the correspondence group prepared additionally:

1. Text of four guidelines requested by the Sub-Committee on Safety of Navigation [18]:
   - Guideline on human centred design (HCD) for navigational equipment and systems;
   - Guideline on Usability Testing, Evaluation and Assessment (U-TEA) of e-navigation systems;
   - Guideline for software quality assurance (SQA) in e-navigation;
   - Guideline for the harmonization of test-bed reporting.
2. List of standards that could be evaluated for e-navigation [19].

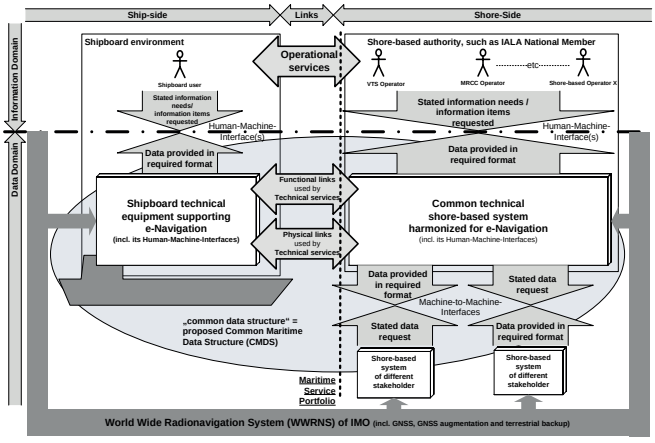


**Fig. 1. E-navigation architecture accepted at this stage of work [1]**

HCD guideline cites ISO standards series 9241 and presents basic information on how to apply the principles of HCD for the effective design of new and modified e-navigation systems. The aim is to ensure that for each stakeholder, users' and tasks requirements are considered in the design process to the greatest possible extent. The requirements are goal-based. Fundamental is collection of user feedback through systematic and formalized usability testing, evaluation and analysis (U-TEA).

Poor usability of the navigational and communication equipment and systems reduces performance and may threaten safety of navigation. Therefore, accepted common methods and techniques for testing, evaluation and assessment of e-navigation systems usability are needed. Guideline for the Usability Testing, Evaluation and Assessment (U-TEA) provides information on this subject and replays Guideline on usability evaluation of navigational equipment suggested by the NAV Sub-Committee.

Software quality assurance (SQA) guideline bases on several existing international regulations and standards of the International Organisation for Standardisation (ISO) and International Electrotechnical Commission (IEC) related to software and data quality and applicable to e-navigation systems. The main goal of the guidance is to ensure that software requirements from relevant regulations, applicable standards, and from stakeholders are fulfilled throughout the life cycle of an e-navigation system and the life cycle of any related data used within software. It should be used as a basis for development of e-navigation related software understood as:

- Software as a system;
- Software as a component of an e-navigation system or equipment;
- Software to impact on an e-navigation system or equipment;
- Any other software related to e-navigation.

The guideline is general in nature and is not intended to provide specific quality assurance requirements for individual e-navigation software systems.

Last guidance describes principles of harmonization of e-navigation systems tests and trials and reporting of their results.

E-navigation system will integrate ship's bridge equipment and introduce digital communication between ships and ships and coastal station. Due to that existing IMO, IEC and ISO standards for equipment and systems required by chapters III, IV V and XI of the SOLAS Convention shall be taken into account during its development. Some of them may require be updating and modifying.

Submitted by Norway list of standards that could be evaluated for e-navigation contains numbers and titles of relevant IMO resolutions and circulars and IEC and ISO standards.

Radio communication is a key for e-navigation. Any communication systems used for e-navigation purposes must be able to deliver appropriate MSPs. Existing communication systems may be divided into those [1]:

- Used for distress and safety-related communications such as for the promulgation of maritime safety information (MSI), as is currently mandated by GMDSS, and AIS; and
- Commercially available systems, such as various satellite solutions (e.g., Inmarsat, Iridium and VSAT) as well as terrestrial telephone and data networks, such as GSM /3G/4G.

Future communication systems may include VHF data (VDES) and NAVDAT and be developed for internet based solutions, such as a maritime cloud, facilitating system wide information management solutions. Existing and future communication links could be integrated via a maritime intranet. This infrastructure will primarily be based on IP communications links but will enable the utilization of free links for safety and mandatory reporting where appropriate, enabling a seamless integration and transition between available communications technologies [1].

An interesting proposal to solve the problem of communication in e-navigation is presented in the document submitted to the first session of the NCSR Sub-Committee by the Republic of Korea and will be discussed this year probably [20].

# 4. Conclusion

According to the definition elaborated by the correspondence working group on the basis of definition proposed by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and accepted by IMO, e-navigation means "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". Significant development in technology within navigation and communication systems was observed in last decades. At the same time it has been identified that the human element, administrative burden, information overload and ergonomics questions are prominent concerns. It is expected, that e-navigation will provide digital information and infrastructure for the benefit of maritime safety, security and protection of the environment, reducing the administrative, human and language burdens and increasing the efficiency of maritime trade and transport. Mentioned concerns cause necessity of application of good ergonomic principles in a well-structured human machine interface as part of the e-navigation strategy.

The e-navigation strategy implementation plan (SIP) attached to the report of intersessional correspondence group on e-navigation to the first session of the NCSR Sub-Committee presents a list of tasks and specific timelines for the implementation of prioritized e-navigation solutions during the period 2015-2019. Particular tasks are described in detailed manner. They should, when completed in this time period, provide the industry with the harmonized information, in order to start designing products and services to meet the e-navigation solutions.

Introducing of e-navigation system may change in considerable manner methods of collecting, dissemination and presentation of marine data and information, mainly MSI and technical devices used for this purpose. Ship to shore communication will be simplified due to the establishing single point of contact (one window concept) and introducing digital data transmission instead of voice reports in much wider range of communication. Presentation of digital information on integrated display units will enable utilization of the automatic advisory systems on ships and ashore. This will help to increase the level of safety and security of navigation and protection of the marine environment.

In my opinion, discussed in this paper report of the correspondence group on e-navigation re-established during last, 59 session of the NAV Sub-Committee and submitted to the first session of the NCSR Sub-Committee completed not only the work of this group but, at the same time, the phase of the development of an e-navigation strategy implementation plan.

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