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DEVELOPMENT OF AN E-NAVIGATION STRATEGY

Supporting material

Submitted by the United Kingdom

SUMMARY

Executive summary:	This document provides supporting information material developed by the e-Navigation Correspondence Group during its work to identify user needs and propose an implementation strategy for e-Navigation. It considers the aspirations, general principles, existing components and a potential programme for implementing e-Navigation. The Correspondence Group considers that these and other components will need to be addressed during the implementation stage, once agreement has been reached on the high level strategy. It is also hoped that the additional material will help the Sub-Committee reach agreement on the proposed strategy for e-Navigation as proposed under NAV 54/13
Strategic Direction:	5.2
High-level Action:	5.2.4
Planned Output:	5.2.4.4
Action to be taken:	Paragraph 73
Related documents:	MSC 81/23/10; NAV 53/13, NAV 53/13/1 and NAV 54/13

Introduction

1 This paper provides supplementary information developed by the Group that may be useful to the Sub-Committee in its deliberations on the e-Navigation strategy. It considers the aspirations, general principles, existing components and a potential programme for implementing e-Navigation. The key elements of the strategy itself; terms of reference for the Correspondence Group and the main user requirements for e-Navigation are submitted in the e-Navigation Correspondence Group report under NAV 54/13.

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60 YEARS IN THE SERVICE OF SHIPPING

Aspirations for e-Navigation

2 During its work, the Correspondence Group developed a set of qualitative aspirations for e-Navigation based on input from the stakeholders on how, qualitatively; they envisaged e-Navigation developing over time. The main broad benefits of e-Navigation were identified as:

.1 improved safety, through promotion of absolute standards in safe navigation supported by:

.1 improved decision support enabling the mariner to select relevant unambiguous information pertinent to the prevailing circumstances;

.2 a reduction in human error through provision of automatic indicators, warnings and fail-safe methods;

.3 improved coverage and availability of consistent quality electronic navigation charts (ENCs);

.4 introduction of standardized equipment with an S-Mode option but without restricting the ability of manufacturers to innovate;

.5 enhanced navigation system resilience, leading to improved reliability and integrity; and

.6 better integration of ship and shore-based systems; leading to better utilization of all human resources;

.2 better protection of the environment both by:

.1 improving safety as above, thereby reducing the risk of collisions and groundings and the associated spillages and pollution;

.2 reducing emissions that will be enabled by use of optimum routes and speeds; and

.3 enhancement of ability and capacity in responding and handling of emergencies such as oil spills;

.3 augmented security by enabling silent operation mode for shore based stakeholders for domain surveillance and monitoring;

.4 higher efficiency and reduced costs enabled by:

.1 global standardization and type approval of equipment augmented by a “fast track” change management process (in relation to technical standards for equipment);

.2 standardized reporting requirements, leading to reduced bureaucracy and administrative overhead;

.3 improved bridge efficiency allowing watch keepers to maximize time to keeping a proper lookout and embrace existing good practice, e.g., using more than one method to ascertain the ship's position; and

.4 integration of systems that are already in place, precipitating the efficient and coherent use of new equipment that meets all user requirements;

.5 improved human resource management by enhancing the experience and status of the bridge team.

3 To meet these aspirations, a number of basic requirements must be fulfilled as enablers to the implementation and operation of e-Navigation. In particular:

.1 systems must be user not technology-driven and over-reliance must not be placed on the technology to avoid, for example:

.1 system failures causing delays because the ship is now deemed unseaworthy;

.2 loss of basic good seamanship by crews;

.3 substitution of the human element by technology; and

.4 degradation of best practice crew resource management;

.2 operating procedures must be put in place and kept under review, most notably in relation to the human/machine interface, the training and development of mariners and the roles, responsibilities and accountabilities of ship- and shore-based users;

.3 the role of the mariner must not be diminished. The mariner must continue to play the core role in decision making as the role of the shore-based users increases;

.4 human factors and ergonomics must be core to the system design to ensure optimum integration including the HMI, presentation and scope of information avoiding overload, assurance of integrity and adequate training;

.5 adequate resources must be made available and assured both for e-Navigation itself and the necessary enablers such as training and radio-spectrum;

.6 implementation must be measured and not over-hasty; and

.7 costs must not be excessive.

General principles for e-Navigation

4 In addition to meeting the quantitative user requirements captured by the Group, a number of basic principles were identified with which e-Navigation should be developed. These basic principles are as follows.

5 **Holistic integration of all existing and emerging tools**: E-Navigation should integrate and utilize all existing tools together with emerging and new technologies to secure a greater level of safety, environmental protection and efficiency for all stakeholders. This holistic approach should not stifle innovation but should provide structure and coordination for technology development to ensure standardization, harmonization, compatibility and reduce complexity and should extend to the coordination of carriage requirements.

6 **Clear Ownership and Control**: Realization of the e-Navigation vision requires a clear, global commitment, articulated through a viable and coherent framework which sets out a migration plan to guide Governments and industry. E-Navigation is a global concept that will be implemented and operated at global, regional and local levels across all user groups. A clear ownership and control (regulatory) structure needs to be put in place to ensure coherence and harmonization, and facilitate seamlessness. This means that the governance of the e-Navigation concept must reside in a single institution that has the technical, operational and legal competences needed to define and enforce the overarching framework with implementation, operation and enforcement taking place at the appropriate level – global, regional, national or local – within that framework. This approach does not mean that the governing organization has to carry out all tasks in-house – it can delegate as appropriate to competent bodies.

7 Being responsible for establishing mandatory standards for enhancing the safety of life at sea, maritime security and protection of the marine environment as well as having a global remit, the IMO is the only organization that is capable of meeting the overall governance requirement.

8 The responsibilities that come with the ownership and control of the concept are:

.1 development and maintenance of the vision;

.2 definition of the services including their scope in terms of users and geography, and the concept of operations;

.3 allocation of responsibilities for the design, implementation, operation and enforcement of e-Navigation, acknowledging the rights, obligations and limitations of Flag States, Coastal States, Port States and the various authorities within those States;

.4 defining the transition to e-Navigation in a step-wise fashion, enabling the realization of early benefits and the re-use of existing and emerging equipment, systems and services;

.5 taking the lead in setting the standards appropriate for e-Navigation covering all the dimensions of the system: shipborne, ashore and communications. These standards should be output-based, i.e., be defined in terms of key performance metrics; they should be functional in nature but must be technology neutral (i.e., should not favour any particular technology solution that is capable of meeting the requirements); the standards should ensure seamless and transparent interoperability of system components (i.e. the interfaces must be defined);

.6 ensuring that the concept accommodates and builds on existing systems and funding programmes, such as the Marine Electronic Highway project in the Malacca and Singapore Straits, and the European Union's projects ATOMOS IV (Advanced Technology to Optimize Maritime Operational Safety – Intelligent Vessel) and MarNIS (Maritime Navigation and Information Services);

.7 facilitating access to funding from international agencies, such as the World Bank, the regional Development Banks as well as international development funding (e.g., United States AID, Europe Aid);

.8 assessing and defining the training requirements associated with e-Navigation and assisting the relevant bodies in developing and delivering the necessary training programmes;

.9 oversight of the implementation of the concept to ensure that contracting States are fulfilling their obligations and ensuring that e-Navigation users within their jurisdiction are also complying with requirements; and

.10 leading the external communications effort necessary to support the case for e-Navigation.

9 **Voyage characteristics**: E-Navigation as a concept must be available continuously to users of all types, afloat and ashore, throughout a voyage including all navigation phases (docking, port navigation, port approach, coastal navigation and ocean navigation). The service must therefore be seamless, automatic and transparent – no action should be required when the vessel transits from one voyage phase to another. The service and associated requirements should also be appropriate for the needs of the various user groups ranging from SOLAS vessels to fishing and leisure craft.

10 Requirements can be differentiated between types of vessel and their operation, e.g., the potentially different watchkeeping requirements of merchant vessels on long passages compared to short-sea shipping, compared to ferries, compared to cruise ships, compared to fishing vessels, compared to leisure vessels and so on. User needs will also vary depending not only on the type of the vessel but also on its location, e.g., in port navigation, coastal navigation and open ocean navigation. For example, some performance requirements are likely to be more stringent for port navigation than for ocean navigation. The whole range of user needs must be considered in the development of system requirements and ultimately the system architecture taking into account different requirements at different geographical locations. As user needs will evolve over time they should be periodically reviewed.

11 The system architecture itself must reflect the requirement to deliver the appropriate level of service when and where it is required acknowledging the variations noted above but also ensuring seamlessness. In particular, it is important that the user is aware, at all times, of the level of service being delivered and that transitions from one service level to another are flagged unambiguously. The system architecture must be based on the needs of the watchkeeper and assess to what degree bridge layouts and operational patterns can be common across the varying user needs.

12 **Phased Implementation**: Various elements of e-Navigation are in operation already, although without the level of integration needed for them to be viewed as e-Navigation. In addition, some elements of the concept may be able to deliver benefits more quickly than others. Therefore, e-Navigation should be planned and implemented using a phased approach both in time and location integrating existing capabilities to address the most critical user needs to deliver early benefits but not creating impediments to longer term developments.

13 The implementation of e-Navigation will be an iterative and ongoing process driven by evolving user needs and the envisaged risk, which will vary in time and location. The phased approach will allow new user needs to be inserted into the programme as and when they occur as well as enabling lessons to be learned on an ongoing basis.

14 The phased approach will also enable ongoing review of progress against the to-be-defined milestones of an overall programme plan. The phases and associated success criteria need to be defined during the detailed planning part of the overall programme.

15 **Attractive to All Stakeholders**: It is critical that e-Navigation must meet the needs and expectations and overcome the concerns of users both afloat and ashore as well as other stakeholders. Here stakeholders are taken to be all those parties that have an interest in the e-Navigation concept, not restricted to the users and providers of services but also including everyone that has an interest or stake, including governments, international organizations, etc. The principal high-level expectations for e-Navigation are that it will deliver improvements in safety, security and protection of the marine environment and these objectives must not become secondary to efficiency or commercial considerations.

16 For e-Navigation to succeed it must not reduce the level of safety provided by navigation systems currently in use while also delivering tangible net benefits to all major stakeholders without imposing unnecessary burdens users afloat and ashore. The focus of the concept should be on delivering a succession of demonstrable benefits that are economically viable. The adoption of e-Navigation will occur quickest if it is on a voluntary, benefit-driven basis using affordable equipment rather than being mandatory.

17 Some of the major problems likely to be experienced in this type of programme are:

.1 the majority of costs are incurred up-front with benefits occurring at a later stage. To counter this issue innovative ways for the infrastructure operators to develop and deliver services should be explored rather than relying on a traditional infrastructure approach where the service provider procures and installs major systems at large capital cost at the front-end of the project and benefits are delivered later downstream;

.2 bespoke equipment is often designed to meet specific local requirements and to operate with proprietary standards. This approach needs to be avoided. E-Navigation systems and equipment should be designed and built to common open standards with no particular technology bias to encourage market pricing and economies of scale; and

.3 the costs and benefits are not distributed fairly between stakeholders with some incurring high costs for limited benefits whereas others incur low costs and reap the majority of the benefits but the participation of all is required for the full benefits to be achieved. Mechanisms should be explored through which these inequalities can be addressed acknowledging that the success of e-Navigation must be assessed on a holistic basis rather than stakeholder-by-stakeholder.

18 To maximize the attractiveness to all stakeholders, both capital and operating costs must be considered. A particular concern is the current cost of satellite broadband Internet services which might be prohibitive for many users. Therefore, one principal user need that must be fed into the system requirements is that of minimizing communications costs.

19 **Pragmatic solution**: The approach to e-Navigation must be pragmatic, making best use of all existing institutions, infrastructure and technologies. The approach must also acknowledge that many stakeholders will have already made significant investments in equipment and systems that are only part-way through their operational life. Therefore, the e-Navigation concept must be flexible enough to incorporate these in the short-term and allow for a transition.

20 Although in the long-term, e-Navigation might alter the role of physical aids to navigation (AtoN) in the overall mix, its principal objective remains to reduce the risk of marine accidents and pollution. It is expected that physical aids to navigation will retain a key role in the marine navigation infrastructure. The criteria applied when defining the mix of AtoNs will continue to depend on the volume of traffic served and the level of risk to be mitigated in line with States obligations under the SOLAS Convention.

21 **Modular and scalable**: E-Navigation should be developed as a modular and scaleable concept based on an international minimum concept of operations. These ideas will allow:

.1 users to implement the appropriate degree of functionality and performance according to their specific needs, ideally on a plug-and-play basis, rather than being limited to fixed sets of functions that may over, or under, deliver;

.2 equipment to be tailored to the physical constraints of vessels, particularly size (e.g., in fitting equipment to the bridge or mounting satellite communications equipment on superstructure); and

.3 solutions should be implemented in a regional basis to meets needs as appropriate but ensuring global standardization, harmonization, compatibility and interoperability.

22 **Application Software and Data**: The e-Navigation concept will rely heavily on application software and electronic data. Increasingly software is used to fulfil safety related functions and it will therefore need to be subject to and certified against the appropriate design, development, maintenance and configuration control standards. In order to achieve certification, the software will need to be developed according to approved standards, which themselves may have to be developed, drawing on the experience of other sectors.

23 It will also be essential that the application software elements are kept up-to-date and that any modifications are managed under an approved configuration control mechanism. Clear, traceable and verifiable means of achieving this will need to be developed as a supporting measure for e-Navigation.

24 The CG notes that the NAV Sub-Committee (NAV 53) has dealt with software maintenance issues concerning ECDIS, which resulted in a Safety of Navigation Circular, and that the COMSAR Sub-Committee (COMSAR 12) has given consideration to the broader issues concerning the maintenance of software and hardware in ship-based computer and other integrated circuit navigation and communication systems. An e-Navigation strategy must address these issues.

25 Mechanisms will also need to be developed to ensure the integrity, updating and authority of the data used within these systems.

26 **Information Security**: Information and its supporting processes, systems and networks are important assets. They need protection in order to ensure service continuity, to minimize risk, and to protect investments. Information security is achieved by implementing a suitable set of controls including policies, processes, procedures, organizational structures and can also include the use of systems comprised of software, firmware and hardware. These controls need to be implemented, monitored, and reviewed to ensure that specific security and business objectives are met. This should be done in conjunction with other business management processes.

27 To ensure information security, systems should be sure to maintain confidentiality, integrity and availability. Confidentiality means the system and its information should only be available to authorized users, and that different users will have different levels of authorization, giving access to different sets of information. Integrity means that the information within a system will only be changed by an authorized user or device, and that unauthorized changes will be detected and corrected. Availability means that the system and the information within are available to the user whenever they are needed.

28 Detailed information security requirements can be derived from a number of sources. The main source will be an organizational risk assessment for the particular stakeholder concerned. The legal, statutory and regulatory regimes, within which the organization operates, and the principles and objectives of the organization itself will be further significant sources. Once detailed requirements have been identified and decisions for the treatment of risks have been made, it is possible to select and implement appropriate security controls, to reduce the risks to acceptable levels. The control regime must then be monitored and audited to ensure it meets its objectives.

Existing components of e-Navigation

29 Clearly e-Navigation should be built on existing navigation and radiocommunication equipment. This equipment needs to be evaluated in order to explain how it could be implemented in the e-Navigation Strategy or how it or the associated standards might need to be amended before it can be integrated. The Group identified the following potential building blocks as the starting point for this evaluation.

30 **Radar**: is a fundamental element of the existing shipboard navigation equipment and should be a cornerstone of an e-Navigation architecture. SOLAS chapter V, regulation 19, requires:

.1 all ships of 300 gross tonnage and upwards to carry a 9GHz radar; and

.2 all ships of 3,000 gross tonnage and upwards to be fitted with a3GHz radar or, where considered appropriate by the Administration, a second 9GHz radar.

31 It also needs to be recognized that within regulation 1.4 Flag States have the ability to determine the extent to which regulation 19 does not apply to certain sizes and types of ships.

32 IMO resolution MSC.192(79):2004, “Revised performance standards for radar equipment” states: “The radar equipment should assist in safe navigation and in avoiding collision by providing an indication, in relation to own ship, of the position of other surface craft, obstructions and hazards, navigation objects and shorelines. For this purpose, radar should provide the integration and display of radar video, target tracking information, positional data derived from own ship’s position (EPFS) and geo-referenced data.”

33 **ECDIS/IBS**: An Electronic Chart Display and Information System (ECDIS) is a computer-based information system designed to replace paper charts on a vessel. Its primary function is to display information from digital charting (from various different formats) and integrate it with positioning data. The navigator can then use it in the same way as a paper chart, plotting a berth-to-berth course into the system, with the added benefit that the vessel's position is automatically determined and always known. In addition, an ECDIS may also display data from radar, sonar, AIS and other on-board instruments.

34 SOLAS currently acknowledges the worth of ECDIS by, subject to Administration approval, taking it as a valid alternative to the nautical charts that all vessels are required to carry. In addition, from July 2008 all new high speed passenger vessels will be required to carry ECDIS (retrofitment of existing craft by 2010). A timetable for the implementation of ECDIS in other vessels will be considered at NAV 54 and it is anticipated that a wider range of SOLAS craft, including both new and existing vessels, would be expected to equip with ECDIS in due course.

35 An integrated bridge system (IBS) is defined as a combination of systems which are interconnected in order to allow centralized access to sensor information or command/control from workstations, with the aim of increasing safe and efficient ship's management by suitably qualified personnel. Performance standards for integrated bridge systems were adopted by IMO in 1996 (resolution MSC.64 (67)).

36 SOLAS chapter V, regulation 19, on carriage requirements for shipborne navigational systems and equipment paragraph 6 states that Integrated bridge systems shall be so arranged that failure of one sub-system is brought to immediate attention of the officer in charge of the navigational watch by audible and visual alarms, and does not cause failure to any other sub-system. In case of failure in one part of an integrated navigational system, it shall be possible to operate each other individual item of equipment or part of the system separately.

37 **Electronic Navigational Charts**: ENCs conformant with IMO requirements and produced to IHO standards will form the backdrop of navigational chart information within ECDIS. At its Conference in 2007 the International Hydrographic Organization (IHO) passed a resolution calling on Member States to come together to achieve adequate coverage, availability, consistency and quality of ENCs by 2010. Significant progress has been made on this issue and the IHO will be reporting to NAV 54 on this subject.

38 **Communications**: Communications will be essential to e-Navigation, in particular for collecting and integrating sources of navigation information and providing the user with the optimum, relevant data on a multi-function display. The modes of communication covered by the concept are:

.1 intra-vessel;

.2 ship-to-ship;

.3 ship-to-shore and shore-to-ship; and

.4 shore-to-shore.

39 The communications media will include both terrestrial and satellite communications.

40 There is increasing pressure on the spectrum from commercial mobile telecommunications applications. Some administrations are promoting spectrum pricing as a method of improving spectrum efficiency. In particular radar designers are being pushed towards technology that will use less bandwidth and reduce spurious emissions. This will eventually free up spectrum and make possible alternative uses of adjoining bands. There is increasing demand for a common communication platform for two-way data communication between ship and shore. There is also a growing requirement for Internet access on ships, at sea as well as in port. Meanwhile commercial providers are looking for markets for their services and this may provide new ways of communicating and presenting navigation information to the user.

41 There are many data communications technologies that are likely to play a role in e-Navigation. In addition to fixed communications, the mobile communications technologies that could d be used include but are not necessarily limited to radio (HF, VHF or UHF), AIS, WiFI and WiMax, satellite communications including Internet Protocol (IP) broadband. Communications can be either be point-to-point or broadcast and could be based on IP but not necessarily on the Internet itself.

42 The selection of the particular technologies used to provide services must be made carefully and will depend on the specific task to be undertaken considering factors such as:

.1 the urgency and currency of the data needed (timeliness);

.2 the volume of data to be transferred;

.3 the bandwidth required;

.4 the location of the users relative to those being communicated with (i.e., the distance over which information is to be transmitted); and

.5 the cost of the communications transaction and of the equipment needed.

43 Ideally the e-Navigation system should be configured to enable the most efficient and cost-effective use of communications technologies on a dynamic self-selecting basis. Such an arrangement would see the user’s equipment self select the appropriate communications bearer from those available considering the above criteria.

44 **Positioning, Navigation and Timing**: The grouping together of the positioning, navigation, and timing functions is a fairly recent, United States originated, idea (see the 2005 Federal Radionavigation Plan). The following is extracted from the United States Space-based PNT Executive Committee:

45 Positioning, navigation and timing (PNT) is a combination of three distinct, constituent capabilities:

.1 positioning, the ability to accurately and precisely determine one's location and orientation two dimensionally (or three dimensionally when required) referenced to a standard geodetic system (such as World Geodetic System 1984, or WGS 84);

.2 navigation, the ability to determine current and desired position (relative or absolute) and apply corrections to course, orientation, and speed to attain a desired position anywhere around the world, from sub-surface to surface and from surface to space; and

.3 timing, the ability to acquire and maintain accurate and precise time from a standard (Coordinated Universal Time, or UTC), anywhere in the world and within user-defined timeliness parameters. Timing includes time transfer.

46 Space-based PNT capabilities provide position, velocity, and timing information to an unlimited number of users around the world, allowing every user to operate on the same reference system and timing standard. Such information has become increasingly critical to the security, safety, prosperity, and overall quality of life of citizens in the United States and around the world. As a result, space-based PNT is now widely recognized as an essential element of the global information infrastructure.

47 The criteria to be applied to the sources of PNT used with e-Navigation are:

.1 there is more than one independent input, e.g., e-LORAN, needed and the IMO/IALA comments on the need for a complementary backup to GNSS must be taken into account;

.2 the PNT systems should be based on components of the WWRNS; and

.3 the PNT systems must be compliant with relevant performance standards (e.g., A915).

48 **Situational Awareness**: For a vessel at sea, one of the greatest safety issues is the risk of colliding with another vessel or object, and it is one of the crew's highest priorities to ensure that such a risk is minimized. On board all but the smallest ships, the position of navigation watch-keeper, or Officer of the Watch (OOW), is dedicated to this role by maintaining a situational awareness of the marine environment around the vessel as well as the physical state and operationally capability of the OOW's own vessel (i.e., engineering and stability state), and advising the rest of the crew as required depending on operational circumstances.

49 Lack of situational awareness has been found to be a major or contributory factor in many collision incidents.

50 Judgement and situational awareness are assisted with greater availability of information provided this information is presented properly and does not overwhelm the watch-keeper. Automatic warnings, activated by zone alarms, would indicate if an obstacle had been overlooked, or another vessel is not acting as expected. However, false alarms and information overload need to be avoided.

51 Within the maritime sector there is a growing concern that crews are becoming too reliant on electronic aids to perform collision avoidance, and that technology such as radar, AIS, or ECDIS may actually reduce situational awareness by distracting crews from simply using their own eyes. However a better use of technology may provide a good solution to the problem of high crew workloads and understaffed bridges. If the use of technology on ships increases it will be important to ensure that mariners are properly trained and certified in its safe use, and are aware of any limitations.

52 **Physical Aids to Navigation**: In the e-Navigation environment, physical aids to navigation will still play a key role.

53 Visual marks for navigation can be either natural or man-made objects. They include structures specifically designed as short range aids to navigation, as well as conspicuous features such as headlands, mountain-tops, rocks, trees, church-towers, minarets, monuments, chimneys, etc. Short-range aids to navigation can be fitted with a light if navigation at night is required, or left unlit if daytime navigation is sufficient.

54 It is expected that physical aids to navigation will be retained as part of the overall navigation system mix. e-Navigation is not designed to allow reduction of physical AtoNs in the short term, although based on comprehensive risk analysis it may do so in the longer term, consistent with each State's obligations under the SOLAS convention to provide such aids to navigation as the volume of traffic justifies and the degree of risk requires.

55 **Maritime Information Systems**: SOLAS chapter V, regulation 13, requires Contracting Governments to provide navigational information to mariners. Regulation 13 states: "Contracting Governments undertake to arrange for information relating to aids to navigation to be made available to all concerned. Changes in the transmissions of position-fixing systems which could adversely affect the performance of receivers fitted in ships shall be avoided as far as possible and only be effected after timely and adequate notice has been promulgated."

56 The promulgation of information on navigational safety is coordinated by means of the World-Wide Navigational Warning Service that was established jointly by the IMO and the IHO in 1977.

57 The World-Wide Navigational Warning Service is administered through 21 NAVAREAS[1]. Each NAVAREA has an Area Coordinator who is responsible for collecting information, analysing it, and transmitting NAVAREA Warnings.

58 Lists of aids to navigation are produced by (or for) most national authorities as part of the navigational information made available to mariners in support of SOLAS chapter V, regulation 13.

59 The joint IMO/IHO/WMO Manual on Maritime Safety Information (IMO COMSAR/Circ.15) provides definitions of standard terms to describe particular events that should be used when composing navigational warnings. The terms that are relevant to the condition of aids to navigation are defined in the circular.

60 **Human Factors**: Assessment needs to be made of:

.1 the needs of the user and the degree to which bridge layouts and operational patterns can be common across these varying user needs; and

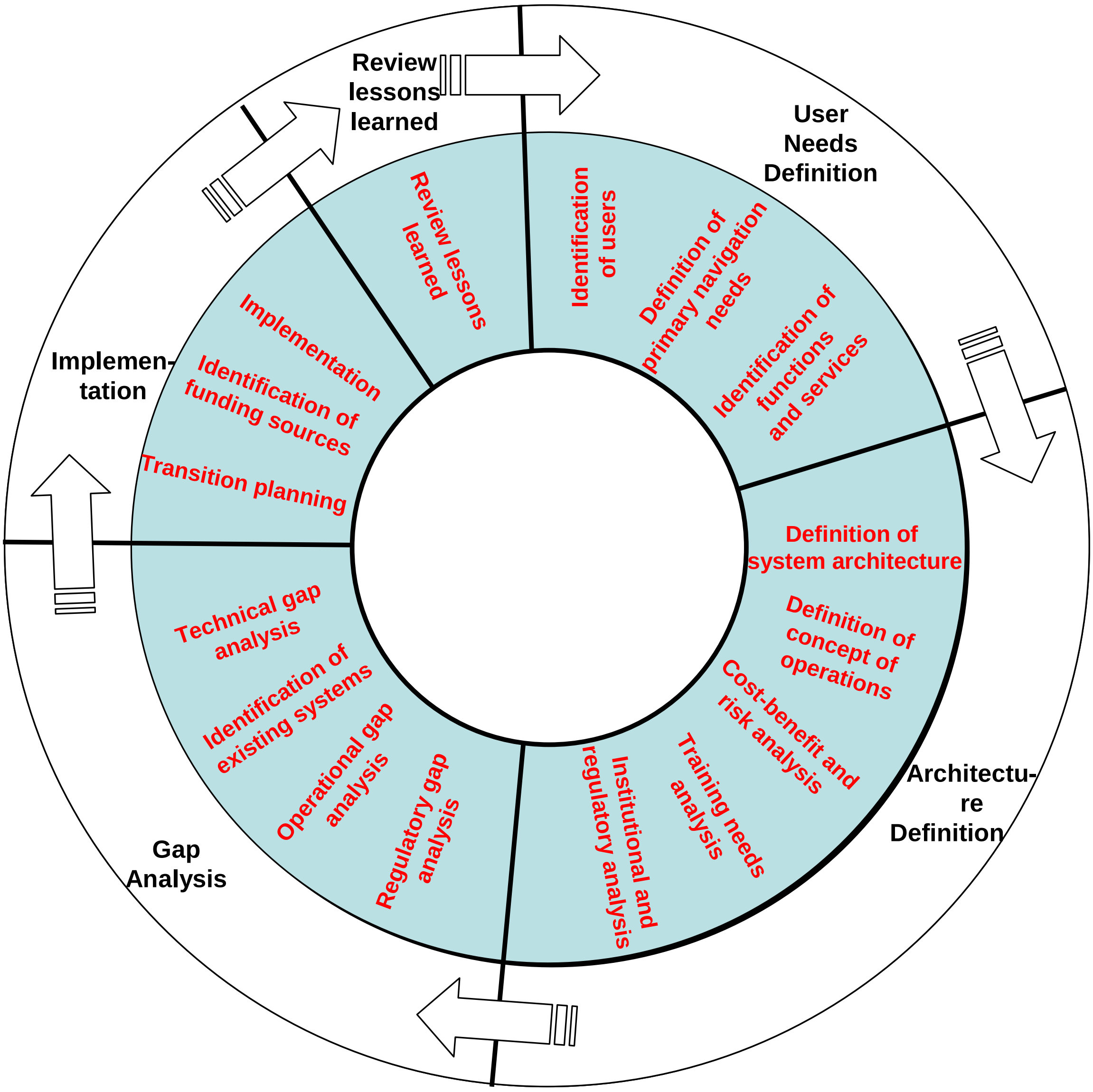
.2 the ongoing need for voice communications, and standardization of language and terminology in the case of VTS and elsewhere in the context of possible revision of Standard Marine Communication Phrases (SMCP).

[1] Arctic NAVAREAs XVII, XVIII, XIX, XX and XXI are approved but not yet operational.

61 Any new or revised integrated arrangements of navigation enabling equipment should take into account the elements of the Human Element Analysing Process (HEAP), and at the same time every effort needs to be made to ensure that such equipment and systems are deliberately optimized to suit the roles and responsibilities of navigation personnel including known generic human strengths and weaknesses.

Potential steps for an e-Navigation implementation programme

62 Implementation of e-Navigation is likely to be an iterative process of continuous development including, but not limited to, the steps shown in the following figure:



63 The logical phases of the e-Navigation strategy should reflect the user-driven approach and start with the formulation of an overall programme with allocation of responsibilities, resource requirements, timelines, critical success factors/performance indicators and review points. To enable the programme to be driven forward IMO should consider establishing an Implementation Group.

64 The first step in the programme is that of definition of user and stakeholder requirements that is the subject of the Correspondence Group and is reported in NAV 54/13. The next step should be the identification of the groups of functions or services needed to meet these primary navigational needs, based on a structured, systematic and traceable methodology that relates the functions to tangible operational benefits. This methodology should also be used to prioritize the elements of e-Navigation that will deliver early benefits without prejudicing longer-term developments. Japan has provided an illustration of this methodology (NAV 53/13/1).

65 Preliminary work has been undertaken on architecture definition and reported in NAV 53/13. Future work should take this into account as well as considering the work being carried out by IALA on shore-side infrastructure. Definition of the integrated e-Navigation system architecture and concept of operations should be based on consolidation of the user needs across the entire range of users, taking account all possible economies of scale. The architecture should include hardware, data, information, communications and software needed to meet the user needs. The system architecture should be modular and based on hardware and software open architectures to allow functions to be included or removed according to the needs of a particular user and to cater for continued development and enhancement.

66 Cost-benefit and risk analysis should be an integral part of the programme. It should be used to inform strategic decisions, but also to support decision-making on where and when certain functions need to be enabled. The analysis should be performed according to accepted principles, addressing financial and economic aspects as well as assessing the impact on safety, security and the environment.

67 Training needs analysis should be performed based on the system architecture and operational concept resulting in a training specification.

68 Institutional and regulatory requirements analysis should be undertaken, based on the system architecture and operational concepts.

69 Preliminary gap analysis has already been performed and reported in NAV 53/13. Future work in gap analysis should build on this previous work and focus on the following elements.

.1 regulatory gap analyses particularly identifying gaps in the present frameworks that need to be filled, e.g., in the provision of services in international waters. Based on this analysis, any institutional reform that is needed should be proposed for implementation;

.2 operational gap analysis to define a reduced concept of operations that could be used based on the integration of existing technology and systems;

.3 identification and description of existing systems that could be integrated into the e-Navigation concept[2] covering functionality, reliability, operational management responsibilities, regulatory status as to specification/standardization, fitment and use, generational status and integration with e-Navigation system requirements; and

[2] See previous section, paragraphs 29-61.

.4 technical gap analyses, comparing the capabilities and properties of existing systems with the architectural requirements to identify any technology or system development that might be needed, based solely on the user needs. This should result in a programme of development work that needs to be done to provide technology solutions to user requirements in their entirety (i.e. the final phase of e-Navigation).

70 Following the gap analysis, a plan will need to be formulated for the development of any technology and institutional arrangements necessary to fulfil the requirements of e-Navigation in the longer term together with a reduced architecture and concept of operations that can be achieved through integration of existing systems.

71 Implementation of e-Navigation itself could comprise a number of component activities as described below:

.1 transition planning, taking into account the phasing needed to deliver early benefits and to make the optimum use of existing systems and services in the short term. The implementation plan should be phased such that the first phase can be achieved by fully integrating and standardizing existing technology and systems (the reduced architecture identified during the gap analysis) and using a reduced concept of operations. Subsequent phases should develop and implement any new technology that is required to deliver the preferred architecture and implement the overall concept of operations;

.2 the implementation plan must allocate responsibilities to the appropriate parties – IMO, other international organizations, States, users and industry – as well as timelines for implementation actions and reviews. A stable and realistic implementation plan will create forward enthusiasm and momentum for e-Navigation across the maritime sector;

.3 identification of potential sources of funding for development and implementation, particularly for developing regions and countries and taking actions to secure that funding; and

.4 implementation itself, in phases, perhaps based on a voluntary equipage of (integrated) existing systems to begin with, but with mandatory equipage and use of a full e-Navigation solution in the longer term.

72 The final phase of the iterative implementation programme should be to review, lessons learned and re-plan the subsequent phases of the programme. It is important to understand that e-Navigation is not a static concept, and that development of logical implementation phases will be ongoing as user requirements evolve and also as technology develops enabling more efficient and effective systems. However, it is critical that this development takes place around a stable set of core systems and functions configured to allow extension over time.

Action requested of the Sub-Committee

73 The Sub-Committee is invited to note the above information and make use of it in its deliberations on e-Navigation.

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