ANNEX 20

STRATEGY FOR THE DEVELOPMENT AND IMPLEMENTATION OF E-NAVIGATION

1 DEFINITION AND SCOPE

1.1 E-navigation is 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.

1.2 E-navigation is intended to meet present and future user needs through harmonization of marine navigation systems and supporting shore services.

2 THE NEED FOR E-NAVIGATION

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

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

.1 ensure that the technological developments adopted are conducive to enhancing maritime safety, security and protection of the environment, and take into account the need for their global application;

.2 ensure the proper application of information technology within the Organization and to provide enhanced access to that information for the shipping industry and others; and

.3 ensure that new equipment for use on board ships is designed and manufactured with the needs, skills and abilities of all users in mind.

* Resolution A.989(25).

3 THE CASE FOR E-NAVIGATION

3.1 Rising trends of marine accidents both in terms of numbers and costs are mainly associated with collisions and groundings. There are numerous examples of collisions and groundings that might have been avoided had there been suitable input to the navigation decision-making process.

3.2 Research indicates that around 60% of collisions and groundings are caused by direct human error. Despite advances in bridge resource management training, it seems that the majority of watchkeeping officers make critical decisions for navigation and collision avoidance in isolation, due to a general reduction in manning.

3.3 In human reliability analysis terms, the presence of someone checking the decision-making process improves reliability by a factor of 10. If e-navigation could assist in improving this aspect, both by well-designed onboard systems and closer cooperation with vessel traffic management (VTM) instruments and systems, risk of collisions and grounding and their inherent liabilities could be dramatically reduced.

3.4 However, although e-navigation may be able to improve the situations described above, there is also a need to recognize the role of the practice of good seamanship, the provision of suitable training and the use of procedures.

4 VISION OF E-NAVIGATION

4.1 A vision of e-navigation is embedded in the following general expectations for the onboard, ashore and communications elements:

.1 **On board**

Navigation systems that benefit from the integration of own ship sensors, supporting information, a standard user interface, and a comprehensive system for managing guard zones and alerts. Core elements of such a system will include, actively engaging the mariner in the process of navigation to carry out his/her duties in a most efficient manner, while preventing distraction and overburdening;

.2 **Ashore**

The management of vessel traffic and related services from ashore enhanced through better provision, coordination, and exchange of comprehensive data in formats that will be more easily understood and utilized by shore-based operators in support of vessel safety and efficiency; and

.3 **Communications**

An infrastructure providing authorized seamless information transfer on board ship, between ships, between ship and shore and between shore authorities and other parties with many related benefits.

5 CORE OBJECTIVES OF E-NAVIGATION

5.1 The core objectives of the e-navigation concept are to:

.1 facilitate safe and secure navigation of vessels having regard to hydrographic, meteorological and navigational information and risks;

.2 facilitate vessel traffic observation and management from shore/coastal facilities, where appropriate;

.3 facilitate communications, including data exchange, among ship to ship, ship to shore, shore to ship, shore to shore and other users;

.4 provide opportunities for improving the efficiency of transport and logistics;

.5 support the effective operation of contingency response, and search and rescue services;

.6 demonstrate defined levels of accuracy, integrity and continuity appropriate to a safety-critical system;

.7 integrate and present information on board and ashore through a human-machine interface which maximizes navigational safety benefits and minimizes any risks of confusion or misinterpretation on the part of the user;

.8 integrate and present information onboard and ashore to manage the workload of the users, while also motivating and engaging the user and supporting decision-making;

.9 incorporate training and familiarization requirements for the users throughout the development and implementation process;

.10 facilitate global coverage, consistent standards and arrangements, and mutual compatibility and interoperability of equipment, systems, symbology and operational procedures, so as to avoid potential conflicts between users; and

.11 support scalability, to facilitate use by all potential maritime users.

6 BENEFITS OF E-NAVIGATION

6.1 The main broad benefits of e-navigation are expected to be:

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

.1 improved decision support enabling the mariner and competent authorities ashore 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 Navigational 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 navigation safety as above, thereby reducing the risk of collisions and groundings and the associated spillages and pollution;

.2 reducing emissions by using 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 automated and standardized reporting procedures, leading to reduced administrative overheads;

.3 improved bridge efficiency allowing watchkeepers 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.

* S-Mode is the proposed functionality for shipborne navigation displays using a standard, default presentation, menu system and interface.

7 BASIC REQUIREMENTS FOR THE IMPLEMENTATION AND OPERATION OF E-NAVIGATION

7.1 To attain these benefits, a number of basic requirements should be fulfilled as enablers to the implementation and operation of e-navigation. In particular:

.1 implementation of e-navigation should be based on user needs not technology-driven and over-reliance should not be placed on 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 inappropriate substitution of the human element by technology; and

.4 degradation of bridge resource management and best practices by the crew;

.2 operating procedures should 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 mariner should continue to play the core role in decision making even as the supporting role of the shore-based users increases;

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

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

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

.7 costs should not be excessive.

8 POTENTIAL USERS OF E-NAVIGATION AND THEIR HIGH-LEVEL NEEDS

8.1 A significant number of potential ship and shore-based users of e-navigation have been identified and are summarized at annex 2.

8.2 A methodology was used to capture evolving user needs. It was based on the elements contained within the accepted definition of e-navigation and applied templates to define specific user needs based on the harmonized collection, integration, exchange, presentation, analysis and human element aspects for all users. Following extensive feedback from Member States, other maritime organizations, and interested parties, an analysis was conducted resulting in the

identification of high-level generic user needs for both ship and shore users. Thus the needs of a typical SOLAS ship and a generic shore authority have been used as the basis for the identification of the high-level user needs reproduced below. A more detailed user needs may have to be identified as a part of the implementation plan.

.1 **Common maritime information/data structure**

Mariners require information pertaining to the planning and execution of voyages, the assessment of navigation risk and compliance with regulation. This information should be accessible from a single integrated system. Shore users require information pertaining to their maritime domain, including static and dynamic information on vessels and their voyages. This information should be provided in an internationally agreed common data structure. Such a data structure is essential for the sharing of information amongst shore authorities on a regional and international basis.

.2 **Automated and standardized reporting functions**

E-navigation should provide automated and standardized reporting functions for optimal communication of ship and voyage information. This includes safety-related information that is transmitted ashore, sent from shore to shipborne users and information pertaining to security and environmental protection to be communicated amongst all users. Reporting requirements should be automated or pre-prepared to the extent possible both in terms of content and communications technology. Information exchange should be harmonized and simplified to reduce reporting requirements. It is recognized that security, legal and commercial issues will have to be considered in addressing communications needs.

.3 **Effective and robust communications**

A clear need was expressed for there to be an effective and robust means of communications for ship and shore users. Shore-based users require an effective means of communicating with vessels to facilitate safety, security and environmental protection and to provide operational information. To be effective, communication with and between vessels should make best use of audio/visual aids and standard phrases to minimize linguistic challenges and distractions to operators.

.4 **Human centred presentation needs**

Navigation displays should be designed to clearly indicate risk and to optimize support for decision making. There is a need for an integrated “alert management system” as contained in the revised recommendation on performance standards for Integrated Navigation Systems (INS) (resolution MSC.252(83)). Consideration should be given to the use of decision support systems that offer suggested responses to certain alerts, and the integration of navigation alerts on board ships within a whole ship alert management system. Users require uniform and consistent presentations and operation functionality to enhance the effectiveness of internationally standardized training, certification and familiarization. The concept of S-Mode has been widely supported as an application on board ship

during the work of the Correspondence Group. Shore users require displays that are fully flexible supporting both a Common Operating Picture (COP) and a User Defined Operating Picture (UDOP) with layered and/or tabulated displays. All displays should be designed to limit the possibility of confusion and misinterpretation when sharing safety-related information. E-navigation systems should be designed to engage and motivate the user while managing workload.

.5 **Human machine interface**

As electronic systems take on a greater role, facilities need to be developed for the capture and presentation of information from visual observations, as well as user knowledge and experience. The presentation of information for all users should be designed to reduce "single person errors" and enhance team operations. There is a clear need for the application of ergonomic principles both in the physical layout of equipment and in the use of light, colours, symbology and language.

.6 **Data and system integrity**

E-navigation systems should be resilient and take into account issues of data validity, plausibility and integrity for the systems to be robust, reliable and dependable. Requirements for redundancy, particularly in relation to position fixing systems, should be considered.

.7 **Analysis**

E-navigation systems should support good decision making, improve performance and prevent single person error. To do so, shipboard systems should include analysis functions that support the user in complying with regulations, voyage planning, risk assessment, and avoiding collisions and groundings including the calculation of Under Keel Clearance (UKC) and air draughts. Shore-based systems should support environmental impact analysis, forward planning of vessel movements, hazard/risk assessment, reporting indicators and incident prevention. Consideration should also be given to the use of analysis for incident response and recovery, risk assessment and response planning, environment protection measures, incident detection and prevention, risk mitigation, preparedness, resource (e.g., asset) management and communication.

.8 **Implementation issues**

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

9 KEY STRATEGY ELEMENTS AND IMPLEMENTATION

KEY STRATEGY ELEMENTS

9.1 The key strategy elements for e-navigation based on user needs include: Architecture, Human Element, Convention and Standards, Position Fixing, Communication Technology and Information Systems, ENCs, Equipment and Standardization and Scalability are detailed below.

.1 **Architecture**

The overall conceptual, functional and technical architecture will need to be developed and maintained, particularly in terms of process description, data structures, information systems, communications technology and regulations.

.2 **Human element**

Training, competency, language skills, workload and motivation are identified as essential. Alert management, information overload and ergonomics are prominent concerns. These aspects of e-navigation will have to be taken into account in accordance with IMO's human element work.

.3 **Conventions and standards**

The provision and development of e-navigation should consider relevant international conventions, regulations and guidelines, national legislation and standards. The development and implementation of e-navigation should build upon the work of IMO*.

.4 **Position fixing**

Position fixing systems will need to be provided that meet user needs in terms of accuracy, integrity, reliability and system redundancy in accordance with the level of risk and volume of traffic.

.5 **Communications technology and information systems**

Communications technology and information systems will have to be identified to meet user needs. This work may involve the enhancement of existing systems or the development of new systems. Any impacts affecting existing systems will need to be identified and addressed, based on technical standards and protocols for data structure, technology, and bandwidth and frequency allocations.

.6 **ENCs**

At NAV 53 IHO reported, "There would be adequate coverage of consistent ENCs by the time any further mandatory carriage requirements were likely to be adopted by IMO". The Sub-Committee was also of the opinion that the availability of ENCs

* Includes but not limited to the requirements prescribed in SOLAS, MARPOL and STCW Conventions.

worldwide was most important and requested IHO and Member Governments to continue their efforts in increasing the coverage. E-navigation will likely benefit from increased functionality of the future IHO S-100 standard.

.7 **Equipment standardization**

This part of the work will follow the development of performance standards and will involve users and manufacturers.

.8 **Scalability**

IMO Member States have a responsibility for the safety of all classes of vessels. This may include the scalability of e-navigation for all potential users. Extension of the concept to non-SOLAS vessels should be seen as an important task, to be addressed, in the first instance through consultation on user requirements.

IMPLEMENTATION

Clear ownership and control

9.2 The governance of the e-navigation concept should 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. 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, IMO is the only organization that is capable of meeting the overall governance requirement. Responsibilities that come with the ownership and control of the concept are specified in annex 1.

Implementation of the e-navigation strategy

9.3 The implementation plan will need to identify responsibilities and appropriate methods of delivery. Implementation of the strategy will also need to take into account promotion of the e-navigation concept to key stakeholder and user groups.

9.4 In order to capture evolving user needs, it is important that the implementation strategy elements remain under review. A structured approach will be required to capture evolving user needs, making use of the existing agreed methodology, to incorporate any ensuing changes into the strategy and implementation plan.

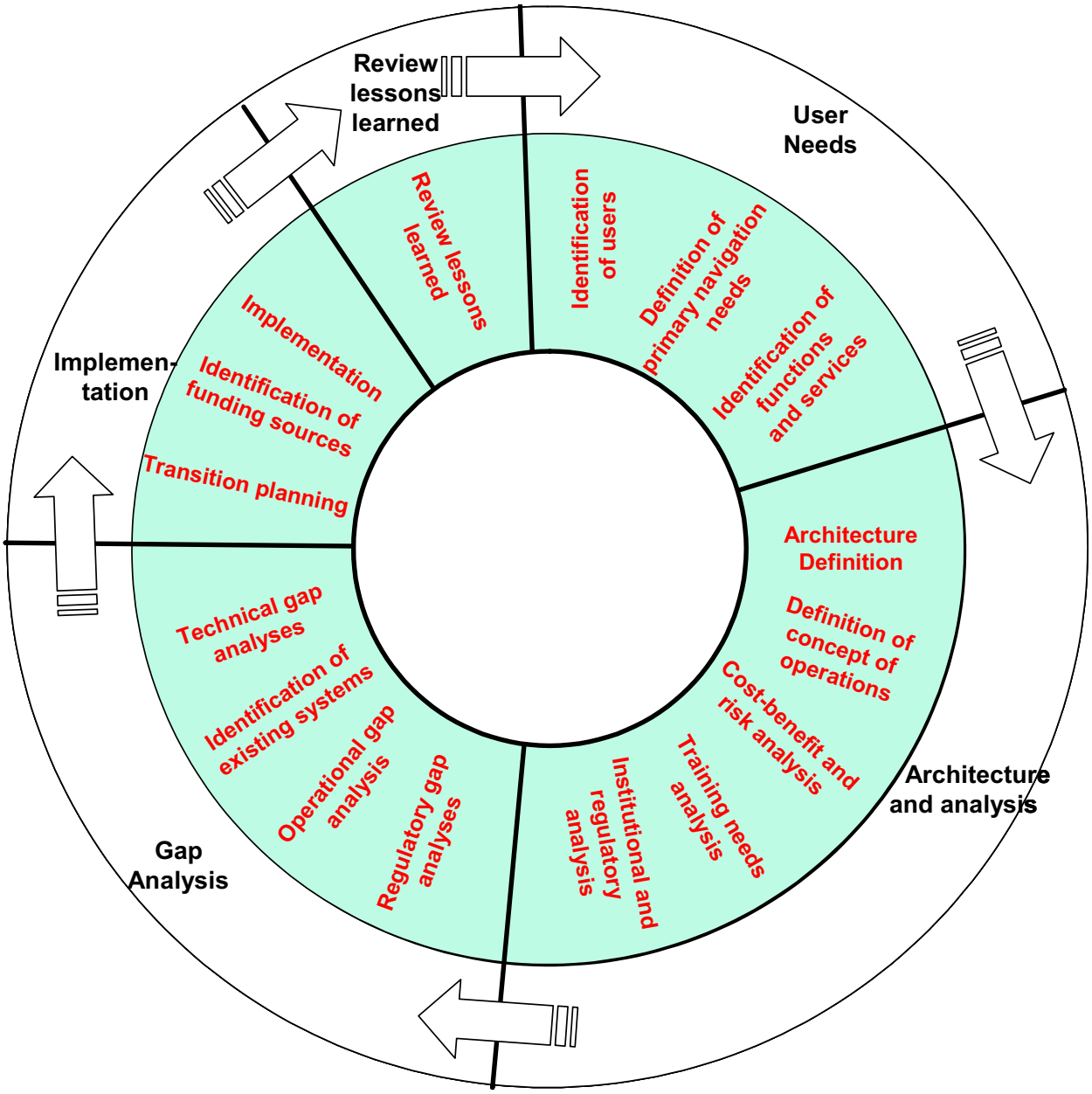
Strategy implementation plan

9.5 A strategy implementation plan should include priorities for deliverables, resource management and a schedule for implementation and the continual assessment of user needs. The identification of commonalities across users making best use of existing capabilities and systems should be considered. In the future, the deployment of new technologies should be based on a systematic assessment of how the technology can best meet defined and evolving user needs within the open structured e-navigation concept. Similarly, proposed changes to tasks and

process, such as those resulting from the analysis of maritime accidents, should also incorporate the assessment of user needs. Co-operation with relevant maritime projects should be maintained throughout the implementation process in order to benefit from synergies.

Potential components of an e-navigation implementation process

9.6 Implementation of e-navigation should be a phased iterative process of continuous development including, but not necessarily limited to, the steps shown in the following figure:



9.7 The potential components of an e-navigation implementation plan are given below:

.1 User needs

The first step in the plan is that of identification of users and their requirements. 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;

.2 Architecture and analysis

.1 Definition

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;

.2 Cost-benefit and risk analysis

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;

.3 Training needs analysis

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

.4 Institutional and regulatory requirements analysis

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

.3 Gap analysis

The gap analysis should 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* 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

.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.

Implementation of e-navigation

9.8 The implementation plan should identify 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.

9.9 Implementation plan for e-navigation should 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 identification of potential sources of funding for development and implementation, particularly for developing regions and countries and taking actions to secure that funding; and

.3 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.

Review of lessons learnt

9.10 The final phase of the iterative implementation programme should be to review, lessons learned and re-plan the subsequent phases of the plan. 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.

---

* See annex 1.

ANNEX 1

RESPONSIBILITIES FOR OWNERSHIP AND CONTROL OF THE E-NAVIGATION CONCEPT BY IMO

The responsibilities that come with IMO ownership and control of the concept include:

.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 identification 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 phased approach, 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 performance standards appropriate for e-navigation covering all the dimensions of the system: shipborne, ashore and communications. These standards should be based on user needs and should encourage technology neutrality and interoperability of system components;

.6 ensuring that the concept accommodates and builds on existing maritime systems and funding programmes;

.7 facilitating access to funding from international agencies, such as the World Bank, the regional Development Banks as well as international development funding;

.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 monitor 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 and coordinating the external communications effort necessary to support the case for e-navigation.

ANNEX 2

POTENTIAL E-NAVIGATION USERS

The tables below provide examples of e-navigation users classified into:

shipborne users, and

shore-based users.

Shipborne users
Generic SOLAS ships
Commercial tourism craft
High-speed craft
Mobile VTS assets
Pilot vessels
Coastguard vessels
SAR vessels
Law enforcement vessels (police, customs, border control, immigration, fisheries inspection)
Nautical assistance vessels (tugs, salvage vessels, tenders, fire fighting, etc.)
Counter pollution vessels
Military vessels
Fishing vessels
Leisure craft
Ferries
Dredgers
AtoN service vessels
Ice patrol/breakers
Offshore energy vessels (rigs, supply vessels, lay barges, survey vessels, construction vessels, cable layers, guard ships, production storage vessels)
Hydrographic survey vessels
Oceanographic research vessels

Shore-based users
Ship owners and operators, safety managers
VTM organizations
VTS centres
Pilot organizations
Coastguard organizations
Law enforcement organizations
National administrations
Coastal administrations
Port authorities
Security organizations
Port State control authorities
Incident managers
Counter pollution organizations
Military organizations
Fairway maintenance organizations
AtoN organizations
Meteorological organizations
Hydrographic Offices/Agencies
Ship owners and operators, logistics managers
News organizations
Coastal management authorities
Marine accident investigators
Health and safety organizations
Insurance and financial organizations
National, regional and local governments and administration
Port authorities (strategic)
Ministries
Marine environment managers
Fisheries management
Tourism agencies (logistics)
Energy providers
Ocean research institutes
Training organizations
Equipment and system manufacturers and maintainers

***