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Development of an e-navigation strategy implementation plan

Overview of the Maritime Cloud concept

Submitted by Denmark, France and the Republic of Korea

SUMMARY

Executive summary:	This document introduces the concept of the Maritime Cloud in support of the seamless transfer of information across all available communication systems. The Maritime Cloud has been proposed in the e-navigation Correspondence Group as the realization of the communication infrastructure for e-navigation defined by the IMO e-navigation strategy as "*A communication infrastructure providing authorized seamless information transfer on board ships, between ships, between ship and shore and between shore authorities and other parties with many related benefits*." (MSC 85/26/Add.1). The Maritime Cloud consists of standards, infrastructure components and service reference implementations ('blue prints') of standardized information services. This document describes benefits to stakeholders, core components, applicability to the prioritized e-navigation solutions, considerations related to governance, impact on legal and operational issues, benefits compared with existing alternatives, administrative burdens, cost and options for implementation.
Strategic direction:	1.1, 5.2
High-level action:	5.2.6
Planned output:	5.2.6.1
Action to be taken:	Paragraph 19
Related documents:	MSC 85/26 and Add.1, NAV 59/6, NAV 59/WP.8, NAV 59/20, NCSR 1/9 (*report of the Correspondence Group on e-navigation*)

Background

1 The Maritime Cloud concept has been proposed by the e-navigation Correspondence Group as the realization of the communication infrastructure for e-navigation, which the IMO strategy for e-navigation defines as: "*A communication*

infrastructure providing authorized seamless information transfer on board ships, between ships, between ship and shore and between shore authorities and other parties with many related benefits." (MSC 85/26/Add.1).

2 The e-navigation Working Group of the IMO Sub-Committee on Safety of Navigation noted in its report to the 59th session of the Sub-Committee (NAV 59/WP.8) that the Maritime Cloud could complement Single Window concepts; however, it was recognized that certain issues should be further investigated. This document aims to elaborate on those issues.

Definition

3 The Maritime Cloud is defined as: "*A communication framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorized maritime stakeholders across available communication systems."*

Brief introduction

4 The Maritime Cloud is a dynamic concept derived from a user-driven process based on experience gained from several e-navigation testbed projects. It is a scalable enabler of seamless information exchange between a variety of available systems and across different physical communication links in the Maritime Domain, as explained graphically in the Annex of this document. With reference to the report of the Correspondence Group on e-navigation to the first session of the NCSR Sub-Committee (NCSR 1/9), the Maritime Cloud is to be considered as part of Task T15 on the proposed e-navigation Strategy Implementation Plan and, more specifically, as a communication infrastructure supporting the five prioritized solutions for e-navigation, as well as other non-prioritized potential solutions to be developed in the future.

4 The Maritime Cloud *is not* to be confused with a 'storage cloud' containing all information about every ship, nor does it refer to 'cloud computing[1]'. Rather, it acts as an open gateway between different authorized stakeholders who participate in the dynamic exchange of information, enabling guaranteed data integrity, confidentiality and authenticity.

5 Specifically, the Maritime Cloud consists of:

- Standards,
- Infrastructure components,
- Service reference implementations ('blue prints') of standardized information services.

6 Based on an appropriate governance regime (to be agreed), the Maritime Cloud is an effective enabler of efficient exchange of information between qualified maritime stakeholders via interoperable information services. It supports the utilization of highly automated interfaces to different secure communication options, enabling better communications related to berth to berth navigation and related services for safety and security at sea and protection of the marine environment, in support of an efficient and Sustainable Maritime Transportation System.

7 The implementation of the Maritime Cloud is envisaged as an evolutionary process based on a gradual transition towards a service-oriented information exchange infrastructure. The adoption of the Maritime Cloud will be flexible, fostering increased levels of collaboration

[1] Cloud Computing: Computing that involves a large number of computers continuously connected through a communication network such as the Internet, or the ability to run a program or application on many connected computers at the same time.

within business domains and enabling supporting systems to interoperate based on open standards.

8 The following sections of this information document describes the Maritime Cloud in terms of benefits to stakeholders, core components, its applicability to the prioritized e-navigation solutions, considerations on governance, implications to legal and operational issues, benefits compared with existing alternatives, administrative burdens, cost and options for implementation.

Stakeholders and benefits

9 In order to achieve seamless communication, a compelling need for a supporting infrastructure was identified in the original IMO e-navigation strategy (MSC 85/26/Add.1). Stakeholders to the Maritime Cloud are ships, ship owners and operators, charterers, agents, ports, VTS, MSI providers, HOs, Met offices, MRCCs, Flag States, Coastal States, Port States, AtoN providers, other relevant maritime authorities, and potentially many others, that require interaction with maritime stakeholders.

10 The benefits of the Maritime Cloud include:

- Ability to reuse existing communication systems, while communicating seamlessly across different digital systems, and further facilitating transition to new technologies and systems.
- Availability of prioritized messaging queuing systems for addressing mobile actors.
- Automatic Quality Assurance of communication links and information delivery through request for automated acknowledgements, when using the Maritime Messaging Service.
- Verification of authenticity of origin and content of information as an additional service (not generally required).
- Enabling automated access from one ship borne single window to multiple National Single Windows for reporting, further enabling a reduction in the administrative burden and cognitive load on mariners.
- Enabling the development of a unified communication terminal able to switch automatically between a multitude of different channels to identify and address a specific actor, thereby reducing the complexity in choosing the right communication system depending on purpose of use.
- Facilitation of the future definition of new and improved information services, based on an open architecture allowing alternatives for distribution of information storage or service points.
- A framework enabling secure ship to ship, ship to shore data exchange, as well as shore to shore data exchange between MRCCs, VTS, ports, agents, National Single Window systems for reporting, etc.
- Further facilitate logistics chain integration with other modes of transport, promoting an efficient and Sustainable Maritime Transportation System.

- Secured private and public communication links supported by the Maritime Cloud, taking into account issues of Cyber-Security.

How will the Maritime Cloud support e-navigation?

11 Existing as well as new communication links may serve to provide information exchange using the Maritime Cloud. Provision of mandatory information services, such as the MSI service under the Global Maritime Distress and Safety System (GMDSS), is currently provided using the NAVTEX and SafetyNet communication services. However, the TELEX based NAVTEX and SafetyNet technologies do not allow the distribution of S-100 structured data, which can be presented on geographically oriented display systems. Mandatory reporting for the purpose of interaction with VTS may utilize VHF voice communication and AIS. Application Specific Messages via AIS or a future VHF Data Exchange System (VDES) could support such functions, and these communication services should remain cost free for ships.

12 Non-safety related communication such as FAL reporting is currently conducted using commercially available systems such as internet satellite connections, allowing the distribution of e-mail. These communication links are non-mandatory, and many options exist. Their bandwidth, availability and cost can be selected based on the specific business need of the ship owner concerned.

13 The Maritime Cloud is capable of delivering a Geocast MSI Service, using Application Specific Messages via no-cost datalinks such as AIS, backed up by already available commercial datalinks. Such a system will be capable of achieving a quick introduction of an MSI service providing machine readable and geographically representable MSI, while providing automatic quality assurance of information delivery, where two-way datalinks are available.

14 The existing AIS system has a limited capacity, which already in some areas does not allow the introduction of additional data services. In order to protect the original purpose and function of the AIS, efforts are underway in IALA and ITU to enable the introduction of VDES. The VDES will be an option that allows the same Application Specific Messages (ASM) that can be used on AIS to be transferred as a new generation of ASM on different channels, thus protecting the capacity and original purpose of the existing AIS, while also allowing a VHF Data Exchange with 10-30 times higher data capacity than the AIS, for ship-ship and ship-shore two-way communications. The VDES system is foreseen to possibly also contain a satellite two-way communication link, and thus this service may have global applicability. This service will be suitable for delivering free of charge mandatory information services based on machine readable data formats near VTS centers, ports, possibly in coastal regions if infrastructure is established – and potentially globally including the polar areas, provided that a business case for establishing a satellite service can be agreed.

15 A new technology called NAVDAT has already been approved at ITU, which will be tested in the coming years, to demonstrate the ability to introduce a modernized version broadcast system in the same frequency band as NAVTEX. The same physical infrastructure can be reused to deliver higher bandwidth broadcast of an MSI Information Service using S-100 structured data.

16 Coastal mobile broadband communication links (3G or 4G) could further provide high-rate data transfer between ship and shore. A prerequisite for combining most of these options is, however, an underlying communication infrastructure, unless each shore based actor is required to have its own radio network. The Maritime Cloud Geocasting service will allow for the gradual introduction of future systems such as NAVDAT or VDES, for the provision of mandatory services intended to be cost free for the users, while utilizing commercially available internet services as a backup and thus providing additional resilience.

The Maritime Cloud and the specific e-navigation solutions

17 Different e-navigation solutions would benefit from the Maritime Cloud as follows:

17.1 S1: Improved, harmonized and user-friendly bridge design

The Maritime Cloud supports provision of harmonized information services to mariners, enabling integration of navigation and communication systems, allowing ship designers the introduction of more user friendly bridge designs. Through methods like '*the Almanac*' (NAV59/6, Annex 2, page 7), easy checking of updated contact details of ships nearby, ports, pilot contact points, VTS, MRCCs etc., will enable user-friendly communication and automatic discovery of information services and automated transfer of data/information.

17.2 S2: Means for standardized and automated reporting – FAL reporting (MSP 8)

17.2.1 Today information flows are at a point midway between signed and authorized paper documents, still often painfully filled in by hand, and the computerized handling of information. Most documents produced by computers are still sent manually to the other involved party (and often re-entered manually into another computer). Excessive manual procedures which carry the risk of taking the attention of navigators away from their primary task of safe navigation should be avoided. The world of Internet, e-mail or electronic exchange of information where data is sent from computer to computer with minimal human intervention is rapidly developing.

17.2.2 The timely arrival of information is a vital component in international transport. As described in IMO FAL.5/Circ.40, the electronic transfer of structured data through EDI, and in general electronic business, has none of the disadvantages of paper documents and brings substantial benefits and savings to the companies which implement it. Accuracy (data are received directly from computer files and are not re-entered manually), speed and savings (on the cost of copying, filing, distributing and capturing data) are some of the obvious advantages.

17.2.3 The e-navigation solution S2 is specifically targeted towards enabling automated electronic exchange of such information, based on the recommendations of the IMO's Facilitation Committee as well as local and regional harmonization of electronic reporting systems. IMO FAL.5/Circ.40 describes in detail how formats for facilitation of electronic business are available, and provides recommendations on standards and recommended practices for implementation.

17.2.4 The Maritime Cloud aims to provide mechanisms that enable the automated and secure seamless integration of business systems. Via the Maritime Identity Registry (NAV 59/6, Annex 2, page 4), methods will be provided that support authentication, integrity and confidentiality of reportable information in the communication process. The Maritime Service Portfolio Registry will facilitate the determination of whether a particular port or national system for FAL reporting supports automated transfer of FAL standardized EDI data formats, other formats, or whether information must be entered into an existing single window system, sent via e-mail in a specific local data format, or ultimately printed, signed and delivered via alternate means. In the case of FAL reporting, the most likely physical communication links between ship and shore will be commercially available internet connections. The choice of communication link will be a business decision based on the business needs of the ship.

17.2.5 Existing single window systems for reporting do not have to be abandoned. Instead, an evolving process of automating integration gateways as alternatives to manually entry of data in a web form will be facilitated.

17.2.6 Where and how the reportable information is stored and maintained will be a business decision of the individual operators. A captain may maintain all reportable information on board his ship and push it through to the relevant authority or single window system at the required time – or the shipping company may choose to trust a service provider/agent with the task of maintaining and storing most of the information, only requiring limited synchronization of information from the ship at regular intervals, in order to facilitate the relevant reporting on time.

17.3 S3: Improved reliability, resilience and integrity of bridge equipment and navigation information

17.3.1 The Maritime Messaging Service will allow for the introduction of future information services, based on the utilization of several different communication links backing up each other seamlessly. This will provide reliability and resilience in communication. Based on the request for acknowledgements when providing messaging via the Maritime Messaging Service, a basis is provided for automated quality assurance of information delivery. Through the regular updating of the position of mobile actors, Quality Assurance measures may provide qualitative reports related to the coverage areas or the availability of specific communication services, or quantitative reports on the quality performance of individual radio installations.

17.4 S4: Integration and presentation of available information in graphical displays received via communication equipment

17.4.1 One example of an information service which may be improved through definition of S-100 data structures (or Application Specific Messages), integration of communication equipment and graphical displays is the promulgation of MSI. Such development of data structures could soon be extended to include Temporary and Preliminary Notices to Mariners, which it will be possible to provide through the same communication infrastructure.

17.4.2 The 'Geocast' capability of the Maritime Cloud will be particularly useful for providing a quality assured, standardized MSI or weather service, based on S-100 standardized information services. This service can extend the existing coordinated broadcast service, providing quality assured delivery of MSI to all ships inside any given area, or making available to a ship MSI or weather data relevant to an intended voyage.

17.4.3 A Geocast MSI service that is complementary to the current, technology specific coordinated broadcast of MSI provided through the GMDSS or various local provisions can be readily implemented. Such a Geocast MSI service will enable a complementary service based on existing, commercially available datalinks as well as Application Specific Messages. Support for display systems such as an upgraded ECDIS or other display system can evolve over time. This will facilitate a transition from the existing TELEX based NAVTEX and SafetyNet systems under the current GMDSS towards any commercially available datalinks or any new communication systems such as NAVDAT or VDES, which may become available as part of the e-navigation implementation or GMDSS modernization.

17.4.4 Denmark and France are already in the process of implementing solutions for registering Navigational Warnings and T- & P- Notices to Mariners in a 'single window' coordinated broadcast system. Once information is registered in the national 'single window' MSI system, coordinated broadcast of MSI is automated through a multitude of broadcast systems (NAVTEX, SafetyNet, NBDP, voice VHF – or local warnings on teletext or webpages, etc.) as may be relevant. Promulgation via the Maritime Cloud geocasting (NAV 59/6, Annex 2, Figure 3) is currently tested, using the Maritime Messaging Service, in the e-navigation testbed projects in Europe and Asia described in the information paper NCSR1/INF.Y.

17.4.5 Global services such as the World-Wide Navigational Warning Service (WWNWS) as well as local services can be supported by a geocasting service. By retaining one or more broadcast components in this regime, the basic MSI service becomes available to the GMDSS compliant as well as the non-SOLAS segment. The participants in the Maritime Cloud will become part of a regime of quality assured MSI delivery, based on structured data that can be presented on graphical navigation displays.

17.5 S9: Improved Communication of VTS Service Portfolio

17.5.1 The Maritime Service Portfolio (MSP – NAV 59/6, paragraph 37) is a combination of functional and technical service to be provided by a competent authority or recognized maritime service provider.

17.5.2 VTS information service (MSP 1): Existing VTS information services available in a particular VTS area, such as the provision of weather or oceanographic data, traffic, information on special restrictions, etc., may be made automatically available. Advanced standardized services based on the development of S-100 data structures may be implemented and their availability announced via the Maritime Service Portfolio Registry of the Maritime Cloud. This will enable automatic recognition of the access point for such services. The chosen communication system may impose restrictions to the level of detail that can be contained in the VTS information service. Different versions (with different levels of detail) of the same information service may thus be implemented.

17.5.3 Information services may initially be delivered via AIS using Application Specific Messages. These may initially be designed simply to provide a link to a web address for an existing VTS information web portal with more detailed information, accessible through other means of communication such as commercially available internet connectivity. Advanced S-100 based information services can at a later stage be announced using the Almanac (NAV 59/6, Annex 2, page 7), and automatic interaction with such services implemented in relevant systems.

17.5.4 Navigational Assistance Service and Traffic Organization Service (MSP 2 & MSP 3): Navigational Assistance Services and Traffic Organization Services will require a higher degree of interaction between ship and shore, in some cases a higher degree of quality assurance of information delivery and in some cases assurance of authenticity of the communicating parties. The Identify mechanisms of the Maritime Cloud will support authenticated and potentially secure communication (NAV 59/6, Annex 2, page 7).

17.5.5 Vessel Shore Reporting (MSP 8): It is expected that most of the mandatory reporting information related to VTS reporting lines can be derived from information already available in onboard systems. Creating a local ship borne collection of such information and automation of the mandatory reporting process will reduce the need for extensive use of voice communication for manual and repeated reporting of the same information. The geographical location of reporting lines and the information required at the passage of this line are envisaged to be described as part of the information contained in the Almanac, based on S-100 data structures.

17.5.6 In the short term, mandatory reporting information might be encapsulated into Application Specific Messages, which can be transported via preferably cost-free digital communication systems such as the AIS – or other available communication systems.

Options for implementation of the Maritime Cloud

18 It is generally expected that registering actors to participate in the Maritime Cloud will be a simple process, which may easily be integrated with existing work procedures, such as issuing call signs and MMSIs for ships or shore stations, but including a more advanced

digital certificate where needed (NAV 59/6, annex 2, page 4). Once registered, each actor will be given access to maintain most parts of own contact information and decide whether access to it is public or restricted, such as the ship's e-mail address, a VTS center's VHF working channel, or how to access local port information. The components included in Maritime Cloud Data Centers should be operated based on international standards for cyber security. There are several different options for implementing the data centers that host the core components of the Maritime Cloud, noting that these are not intended to include large scale storage of all information, but only components that facilitate authenticated information exchange and automatic discovery of information services. This document describes three scenarios, and their associated advantages and disadvantages.

18.1 **One international data center:** The simplest scenario would be one single company or organization operating a global data center. Each Flag State will have responsibility for the logical content of their own national part of the registries, and all maritime parties will be able to register through their National Competent Authority, enabling them to interact as authorized parties to the Maritime Cloud.

18.1.1 Advantages: This is a very simple solution with low technical complexity. There will be no complexities associated with maintenance of one coherent core system.

18.1.2 Disadvantages: The responsible operator will have full control of the system, and all stakeholders must agree to trust one single global organization. The data center must apply methods for assuring redundancy in all aspects of its operation and prevent the physical data center from becoming a single point of failure.

18.2 **One international organization – three regional data centers:** In this scenario, one international organization governs three regional data centers divided evenly by time zones, for instance one in the American time zone (UTC – 8 hours), one in the European/African time zone (UTC) and one in the Asian/Pacific time zone (UTC + 8 hours).

18.2.1 These regional data centers should constantly synchronize public data on a peer-to-peer level, enabling functional transfer to another data center, in case the connection to one data center fails.

18.2.2 Each Flag State will have responsibility for the logical content of their own national part of the registries, and all maritime parties will be able to register through their National Competent Authority, enabling them to interact as authorized parties to the Maritime Cloud. Ships and other entities may connect via the nearest data center, or any of the other data centers.

18.2.3 Advantages: This solution is technically relatively simple and provides a high degree of resilience through the distributed network of redundant data centers. The time zone separation will ensure that operational personnel is available during normal working hours with at least one of the major physical data centers at any point in time. This model could provide a path whereby developing countries may achieve exceptionally low entry barriers for participation in the Maritime Cloud.

18.2.4 Disadvantages: None identified.

18.3 **National data centers + an international data exchange:** This scenario fully resembles the LRIT regime. Each Flag State will either have its own data center, or join a regional data center, and each data center will exchange data through the International Data Exchange. Ships will connect through the data center they are registered with.

18.3.1 Advantages: This scenario allows the reuse of the organizational and governance structures developed for the LRIT, with only modifications to the technical services provided through the data centers.

18.3.2 Disadvantages: The technical complexities of many different data centers will be significant. Design will have to be based on a large set of internationally agreed technical standards. As a result, establishment will be time consuming, and development and operation will come at a relatively high cost. As the technologies evolve and require updates, coordination between the many different data centers will require significant resources. Coordinated updates across many different data centers could be a high risk operation.

Implications of the Maritime Cloud

19 The implications of the Maritime Cloud will have to be given careful consideration, as part of Task 15 described in the report of the e-navigation Correspondence Group on a draft Strategy Implementation Plan (NCSR 1/9), taking the following considerations into account:

19.1 **Legislation**: This will be part of Task T16.

19.1.1 Potential needs for amendments to legislation will have to be considered. Such considerations may relate to the infrastructure itself, such as ensuring that information registered by a particular National Competent Authority in the Registries of the Maritime Cloud is under the governance of the national legislation of that country.

19.1.2 Considerations will also have to be given to the implications of specific information services – for instance there may be implications for Radio Regulations and potentially for other instruments, if a service for promulgation of Maritime Safety Information is to be delivered via multiple data links detached from specific radio systems.

19.2 **Organisation and responsibilities**: As part of Task T16, possibilities for governance of the Maritime Cloud based on existing conventions and a selection of implementation option should be considered. Responsibilities relating to the operation of the core components, and for the information contained in the relevant registries should be defined.

19.2.1 From the outset, it is not foreseen that the delivery of information services via the Maritime Cloud infrastructure would involve any change to organization, responsibilities or liability issues in comparison to the provision of similar services today.

19.3 **Performance, procedures and standards**: In developing the Maritime Cloud, the performance required to achieve a scalable system will have to be defined, as well as operational and technical standards, recommendations and guidelines, which will have to be developed as part of Task T15.

19.4 **Shipboard and shore based Infrastructures**: Tasks T7, T9 and T13 in the draft Strategy Implementation Plan for e-navigation could establish relevant shipboard integration, enabling the utilization of the common shore based communication infrastructure delivered by Task T15.

19.5 **Services**: Task T8 in the draft Strategy Implementation Plan will enable the development of single window systems. Task T14 will harmonize the framework for developing data structures, that support the prioritized e-navigation solutions. The communication infrastructure will enable seamless transfer of information related to all of the solutions mentioned, and Task T17 will bring further development of the Maritime Service Portfolios, enabling advanced information services for the future.

19.6 **Cost**: Distribution of cost related to communicating new information services is not envisaged to change, but rather to follow the general principles of the past based on the principles of the GMDSS, where communication related to safety, urgency or distress involved no cost for ships, while use of data links for operational routine communication is chargeable per usage.

19.6.1 It is envisaged that the prioritized e-navigation solutions will be implemented as reference implementations by e-navigation testbed projects. If these projects apply a suitable open source and free software licensing policy (NAV 59/6, Annex 5, page 1 – planning of testbeds), such software can be made freely available for others to implement and integrate into existing systems and procedures. This would further secure low entry barriers for developing countries to participate in e-navigation.

19.6.2 Considering that the geographical awareness of mobile actors in the Maritime Cloud (NAV 59/6, Annex 2, page 6) could in principle be regarded as a realization of the function of an LRIT Data Center, consideration could be given to making use of the LRIT Data Centers by transferring of public spending on LRIT to an implementation based on the Maritime Cloud, with a much wider potential for bringing benefit to the maritime transport sector.

19.6.3 As part of Task T18, testbeds for e-navigation should be requested to provide analysis of cost/benefit estimations of the solutions addressed.

Action requested of the Sub-Committee

19 The Sub-Committee is invited to take note of the information provided in its deliberations on the Strategy Implementation Plan for e-navigation.

ANNEX

How the Maritime Cloud supports e-navigation through seamless integration of different physical communication links

Existing as well as new communication links may serve to provide information exchange using the Maritime Cloud.