**Navguide: Chapter 4 - e-Navigation**

**4.1 Introduction**

e-Navigation is a broad strategic vision led by IMO for the harmonisation of marine navigation systems and supporting shore services, underpinned by user needs. The concept involves the utilization and integration of all available navigational tools to secure a greater level of safety and accident prevention. Implementation of e-Navigation will, at the same time, deliver substantial operating efficiencies with resulting commercial benefits.

e-Navigation will incorporate the use of new technologies in a structured way and ensure that their use is compliant with the various electronic navigational and communication technologies and services that are already available.

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.

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 instruments and systems, risk of collisions and grounding and their inherent liabilities could be dramatically reduced.

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.

In 2006, seven IMO Member States made a joint submission to the Maritime Safety Committee to “develop a strategic vision for the utilization of existing and new navigational tools, in particular electronic tools, in a holistic and systematic manner.”

IMO, supported by other international organisations such as IALA and IHO and the maritime industry, has made substantial progress in translating the concept of e-navigation to an operational reality. It is expected that by 2014, IMO will approve a strategic implementation plan.

**4.2 Definition**

The definition of e-Navigation adopted by IMO is: “*e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard 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.*

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| **WHAT DOES THE “E” IN E-NAVIGATION STAND FOR?**  It is generally accepted that the IMO concept of “e-Navigation” can be thought of as a brand, without the need for “e” to be specifically defined. The concept of e-Navigation was proposed by IMO Member States in 2006 as a process for the harmonisation, collection, integration, exchange and presentation of maritime information. As such, the “e” could have stood for “enhanced” or “electronic”, but this would unnecessarily limit what can be done within e-Navigation. It must be noted that generic electronic marine navigation already exists in many forms and should not be confused with this specific IMO initiative. |

**4.3 Vision**

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

**Onboard**

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.

**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.

**Communications**

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

commands and include options for GPS and communication modules.

**4.4 Strategy and Implementation**

In 2008, IMO approved the development of an e-Navigation Strategy Implementation Plan. This includes the development of a technical architecture, gap analysis, cost benefit analysis and the creation of a detailed implementation plan. A structured and phased approach is required to capture evolving user needs, making use of the existing agreed methodology. The Strategy Implementation Plan includes priorities for deliverables, a schedule for implementation and provision for the continual assessment of user needs. Implementation will be a phased, iterative process. The architecture for e-navigation will encompass hardware, data, information, communications technology and software. It will be based on a modular and scalable concept and will cater for continued development and enhancements.

The deployment of new technologies is to be based on a systematic assessment of how the technology can best meet defined and evolving user needs within the e-navigation concept. Development of usability standards and further development of the IMO Human Element Analyzing Process (HEAP) will also be undertaken.

Implementation of e-Navigation will commence once IMO approves a Strategy Implementation Plan (expected to be in 2014), which is expected to include:

* Identification of responsibilities to appropriate organizations/parties;
* Transition arrangements;
* A phased implementation schedule along with possible roadmaps;
* Priorities for deliverables, resource management and a schedule for implementation and the continual assessment of user needs;
* Proposals for a systematic assessment of how new technology can best meet defined and evolving user needs;
* A plan for the development of any technology and institutional arrangements necessary to fulfill the requirements of e-navigation in the longer term;
* Proposals on public relations and promotion of the e-navigation concept to key stakeholder groups;
* Identification of potential sources of funding for development and implementation, particularly for developing regions and countries and of actions to secure that funding.

**High Level User Needs**

The IALA 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 described 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 ship borne 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.

**4.5 IALA’s Role**

IALA’s e-Navigation Committee has contributed substantially to the formulation of the IMO Strategy for the implementation of e-Navigation and to the Strategy Implementation Plan. The working groups of the e-NAV Committee are developing shore user requirements, information systems and data structures, a World Wide Radio Navigation Plan, a Radio Communications Plan, enhanced AIS, VHF Data Exchange and a shore-side architecture, together with a documentation structure to encompass the whole of e-Navigation.

**4.5.1 Maritime Service Portfolios**

A Maritime Service Portfolios (MSP) defines and describes the set of operational and technical services and their level of service provided by a stakeholder in a given sea area, waterway, or port, as appropriate. MSPs should be developed to achieve harmonization, modernization, integration and simplification on board and ashore, taking into account the use of the IHO’s S-100 standard.

The objective of the MSP concept is to align global maritime service with the need for information and communication services in a defined operational areA. To achieve such, the first step should be to identify the need for information services and communication infrastructure in the different areas. A set of services will require a certain communication infrastructure capacity, varying from area to area.

It has been agreed that the MSP areas are divided into:

* Harbour operations;
* Operations in coastal and confined or restricted waters;
* Transocean voyages;
* Offshore operations;
* Operations in Arctic, Antarctic and remote areas.

**4.5.2 IMO Adopted Overarching Architecture**

IMO has defined and adopted the overarching architecture as given in Figure 18 NAV57, WP.6, as adopted by MSC90, May 2012, refers. It is composed of a number of elements, which are introduced in a step-by-step fashion as shown below.

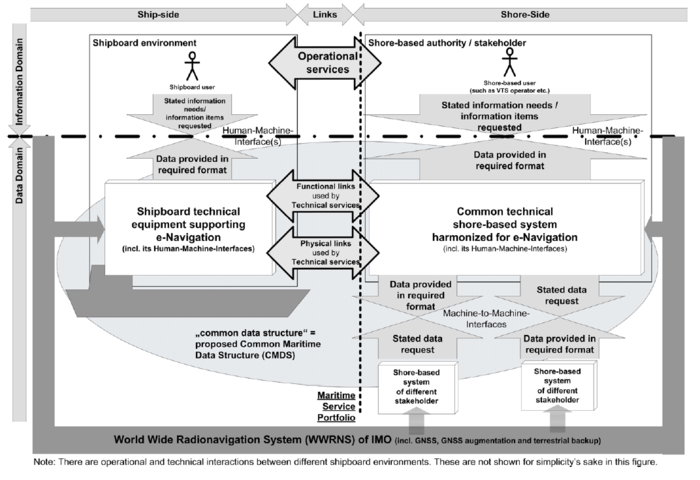
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Figure 18 - IMO Adopted Overarching Architecture

**4.5.3 User’s Perspective in Architectural Terms**

One way of understanding the concept of e-Navigation is to look at it from a user’s perspective. As visualized in Figure 19, the architecture can be divided into three parts; ship side, shore side and the interaction between ship and shore. This represents the overarching architecture from a users’ perspective.

The ship side represents the users on-board a ship, whilst the shore side typically represents users from communities like Vessel Traffic Services (VTS), Allied Services and even users from communities within the logistics domain.

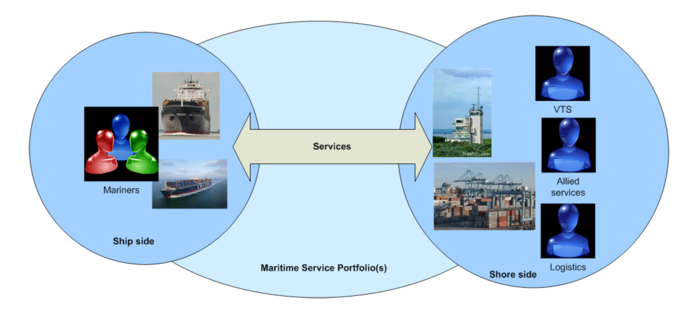
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Figure 19 - e-Navigation Users' Perspective at a Given Moment and Given Place

To enable both sides to communicate and to exchange information, e-Navigation uses the general term “service”. From a user’s perspective, the important services will be the “operational services”. However, there also needs to be “technical services” to be able to provide these operational services (Figure 20). Altogether, these services are referred to as the Maritime Service Portfolio (MSP).

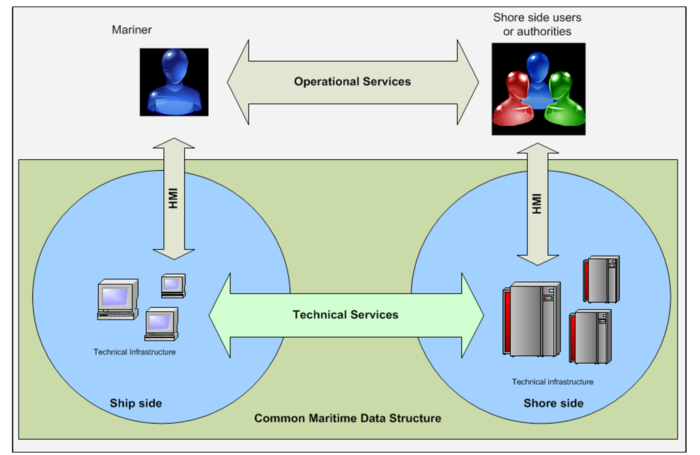
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_4-5-3_Figure20_The_eNavigation_Services_Concept.png)

Figure 20 - The e-Navigation Services Concept

A MSP defines and describes the whole set of operational and technical services and the level of these services, as provided by a stakeholder in a given sea area, on a waterway, or in a port, as appropriate. The MSP concept was conceived to achieve harmonisation, simplification, and tighter interaction of services and systems on board and ashore. It will be further developed based upon the IMO concept of a “Common Maritime Data Structure” (CMDS).

NOTE: Suggestion that current Section 4.5.1 is moved to now follow here.

**4.5.4 The Common Maritime Data Structure**

The purpose of the IMO defined Common Maritime Data Structure (CMDS, see Figure 21) is to harmonise data exchange in the maritime domain by providing a common, authoritative reference. The CMDS is an abstract representation of entities within the maritime domain. It should be accessible by any stakeholder or implementer and should be the reference for the development of maritime services, applications and databases.

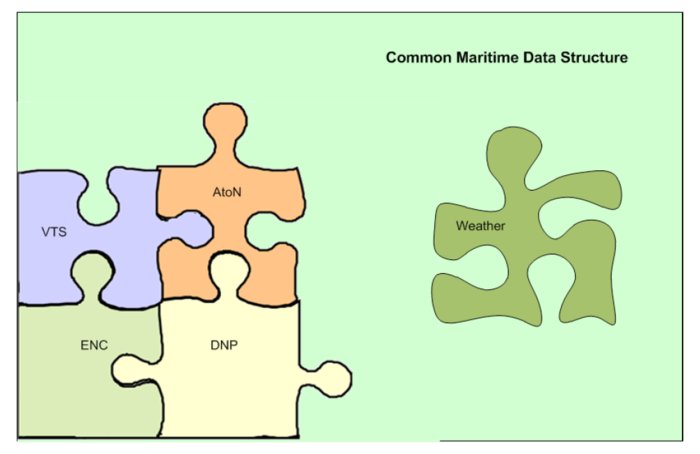
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Figure 21 - The Harmonised Common Maritime Data Structure

Considering the extent of the maritime domain, with all of its stakeholders, the responsibility for the CMDS is subdivided into smaller units, each of which is governed by a recognised authority. However, these authorities cooperate to harmonise the CMDS as a whole (e.g., to avoid duplication of entries). This is one of the main tasks of the IMO established IMO/IHO Harmonisation Group on Data Modelling (HGDM).

IHO developed the IHO GI Registry[[1]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_note-1), based on its S-100 standard, as a tool for data modelling for the specification and production of Electronic Navigational Charts (ENC) and Digital Nautical Publications (DNP). The GI Registry is generic in setup and has been adopted by IMO as the tool to develop the CMDS.

Figure 22 describes the simplified generic structure of the GI Registry. The major features of the registry include registers for:

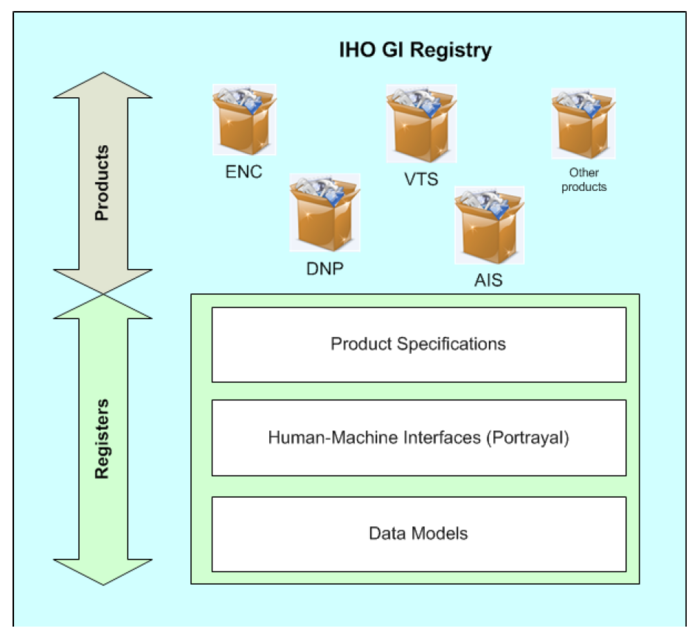
* **Product Specifications** – includes everything needed to fully describe and specify a product such as data exchange protocols and references to HMI and CMDS entities from the GI Registry.
* [](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_4-5-4_Figure22_Simplified_View_of_the_IHO_GI_Registry.png)**Human-Machine Interface (HMI)** – HMI definitions/ specifications can also include references to CMDS entities from the GI Registry. (This register is named Portrayal by IHO).

Figure 22 -Simplified View of the IHO GI Registry

**4.5.5 Shore-based Requirements**

IALA members use shore-based systems (which are composed of products) to provide commonly recognised operational services, for example, in the realms of Aids-to-Navigation and VTS. Many of these shore-based systems have a similar architecture. This architecture has been captured in the Common Shore-based System Architecture (CSSA). In Figure 23, below, the responsibility of the shore-based service provider is within the oval.

Figure 23 also shows a more detailed representation of the technical services already introduced by Figure 20. The common elements of the technical services are:

* Data Collection (e.g., radar, AIS, etc.);
* Data Exchange (ship/shore and shore/ship; e.g., VHF Data Exchange, AIS, etc.);
* Data Processing;
* Gateway (shore/shore; e.g., LRIT Service Centre, inter-VTS services, etc.);
* Human-Machine Interface (HMI).

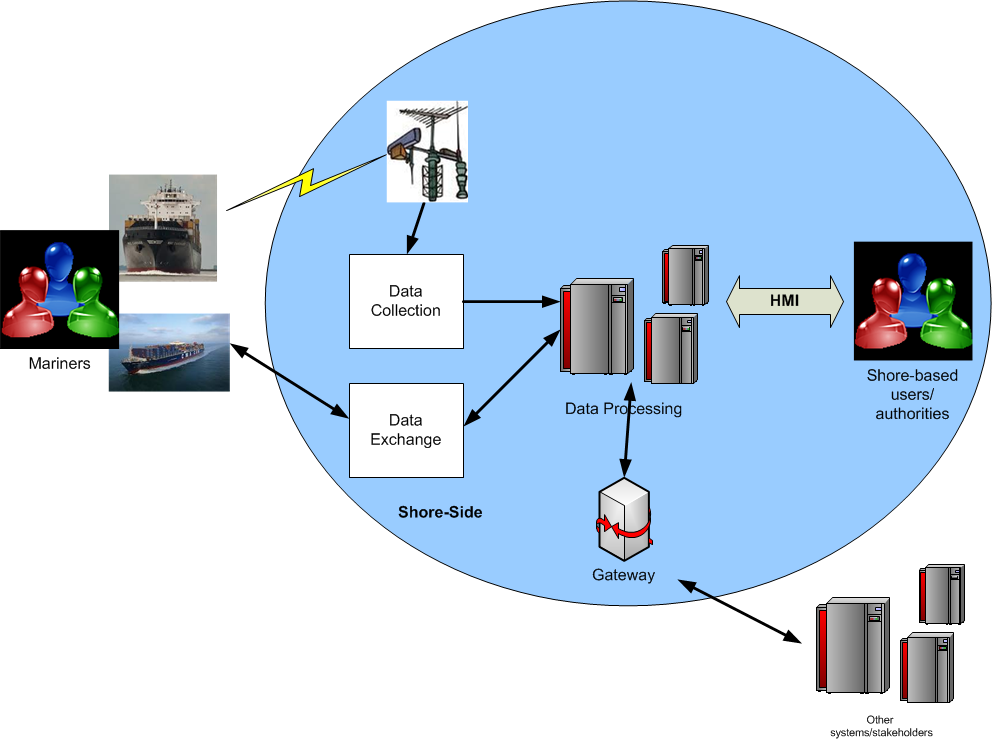
Note that not all technical services require all of these elements. The arrows indicate data flows between these common elements. The data that is exchanged is modelled within the CMDS.

Figure 23 - Simplified View of the Common Shore-based System Architecture (CSSA)

IALA is a Domain Owner within the IHO Registry for the domains of AtoNs, VTS and AIS and is accepted by IHO as a Submitting Organisation.

In addition, e-Navigation will impact the shore-based systems by requiring harmonization. The concept of the CSSA was developed to accommodate the requirements imposed by provision of e-Navigation services.

Existing legacy systems do have varying degrees of compliance to e-Navigation. Most of these systems will require amendment or eventual replacement in order to support e-Navigation services and achieve full e-Navigation compliance.

**4.5.6 Domain Management**

IALA is a domain owner in the IHO GI registry. All product specifications developed by IALA are stored and managed by IALA.

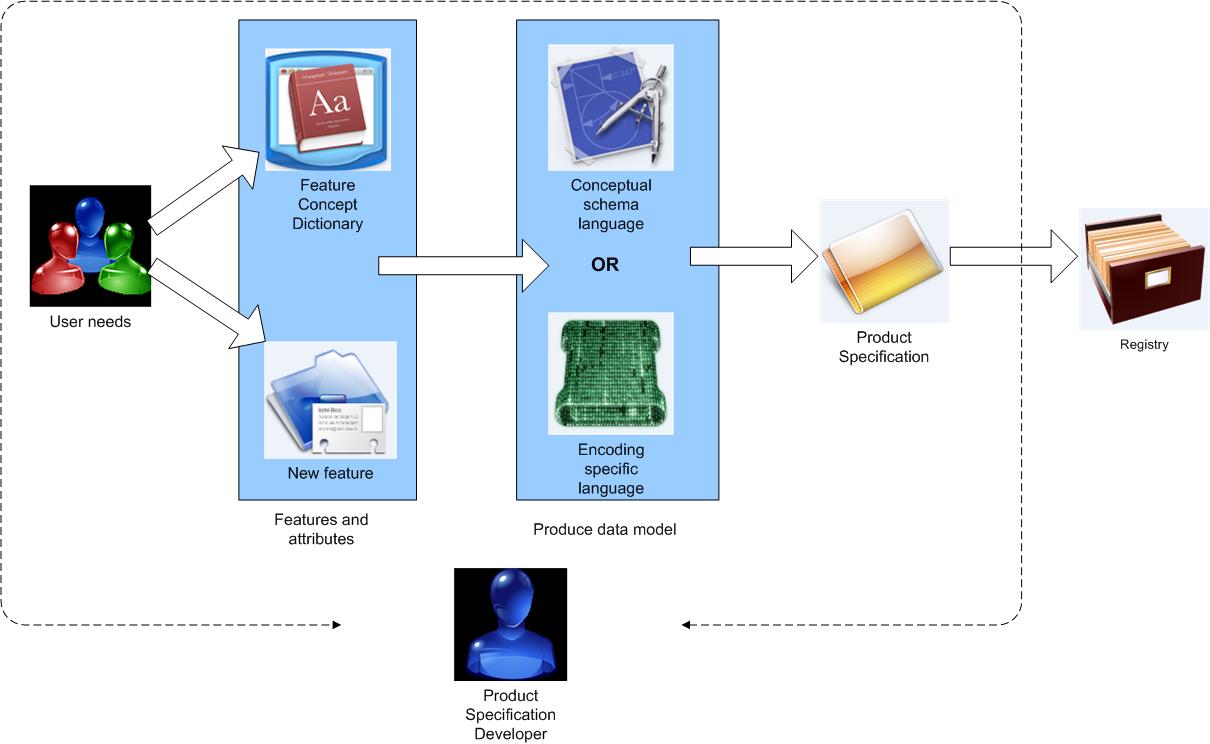
IALA has developed procedures to manage the IALA domain and its role as a Submitting Organisation to the IHO GI Registry. The IALA Domains management and submission process for an IALA S-200 series product specification is described in detail in IALA Guideline 1087. Product specification developers should follow these procedures in order to get the product specification registered in the product specification register.

**4.5.7 Product Specifcations**

The products in the e-navigation context are derived from user needs. These user needs, which are high level and functionally specified have to be transformed to product requirements in order to realise the required functionality. The development of product requirements drives the data model, which in turn generates a product specification and the items to be registered. This is the task of the product specification developer. In Figure 24 the global idea of the route from user need to product specification is shown.

In order to develop a product specification it has to be clear what the product should be. For the provision of e-navigation this product is supposed to be a part of a Maritime Service Portfolio (MSP). The authority responsible for the relevant service creates a description of the desired product and the applicable user needs. Then it is up to the product specification developer to check the registry and investigate if the needed features already exist. In cases where the feature does not exist, a new feature has to be added to the feature concept dictionary (FCD).

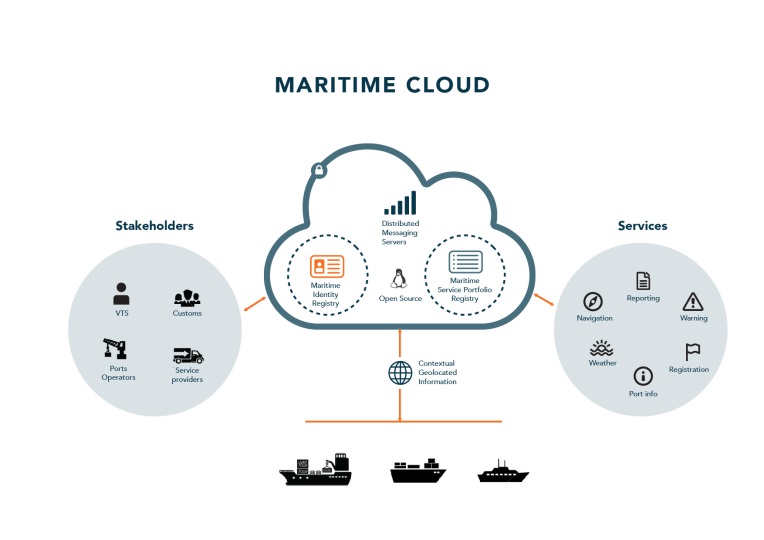
Next a data-model has to be produced, either by means of a conceptual schema language or by means of an encoding specific language. Finally, the previous and other information is captured in a document called a product specification. This document will then be registered, after an approval process, in the product specification register of the GI Registry.



1. Figure 24. Transformation of a User Need into a Product Specification

For the development of a product specification a level of expertise is necessary. This level of expertise is not only necessary on the developer side but also the service provider needs to have some understanding of the process. The right mixture of expertise consists of S-100 experts and understanding of the product requirements and context of the product within the e-navigation scope.

**4.5.8 Maritime Cloud**

The Maritime Cloud is a collection of infrastructure services, standards and governance facilitating secure information exchange in the maritime domain. (Figure 25)

1. Figure 25. Maritime Cloud Components

The Maritime Cloud is architected such that:

* Services can be easily registered, discovered and used.
* Identities can be verified and used to digitally sign communication.
* Messages can be exchanged between components connected to the cloud, these can be either clients operated by humans or services.

Geographic and organizational contexts (e.g., a vessel’s location) are used as key parameters for service discovery, identity verification and message exchange.

The maritime cloud offers a so-called Service Registry. Components connected to the cloud ask the service registry how to access and use a service. Additionally, the Maritime Cloud provides a Maritime Messaging Service (MMS).  You can imagine this component as an automated switchboard. It uses the communication channel available for communication to a service. While the access point (the "telefone") stays the same.

Depending on the request (Name, Type, Location …) the end user is provided with possible service provider and can then choose which service to use.

Nowadays, daily processes include a lot of paper work. Documents need to be signed to prove authenticity. The Maritime Cloud offers means to digitally assure the identity of the communicating partners.

Every message can be exchanged securely using state-of-the art technologies.

The maritime cloud does not include data storage or application hosting. This remains the responsibility of service providers and organizations.

The Maritime Cloud is focused on improving communication and digital interactions based on open standards, while reusing existing components and infrastructure within the current organizations to enable a smooth transition to adoption.

**4.6 Technology for e-Navigation**

Many sub-systems or components will have to be developed, enhanced or provided to realise the full integrated concept of e-Navigation. Crucial among these are Positioning, Navigation and Timing (PNT), communications and information systems. It should be noted that not all of the following technologies or systems will be needed within the e-Navigation concept.

**4.7 IALA Plan**

IALA has developed a World Wide Radio Navigation Plan (WWRNP) aimed at providing the WWRNS to support e-Navigation. One key concept in this plan is the separation of the generation of correction data from the means of transmission, to facilitate broadcasting by a variety of methods. This could lead to the integration of terrestrial systems (DGNSS beacons, e-Loran, AIS) to provide shared data channels and common correction sources, as well as additional ranging signals, contributing to a redundant position-fixing solution, complementary to, but independent of GNSS.

Future standards for position-fixing systems should be considered in the context of position-fixing requirements for e-Navigation. This WWRNP could be the basis for a submission to IMO as a contribution to the WWRNS. The plan provides guidance to IALA members regarding potential future developments, which will enable members to identify areas requiring resource allocation and research activity.

**4.8 Electronic Position Fixing Systems**

**4.8.1 Global Navigation Satellite Systems**

Global Navigation Satellite System (GNSS) is a generic term for a satellite system that provides world-wide services for the determination of position, velocity, and time for multi-modal use.

GNSS is based on a constellation of active satellites, which continuously transmit coded signals in one or more frequency bands. These signals can be received by users anywhere on the earth’s surface to determine their position and velocity in real time, based on ranging measurements.

If a GNSS is recognised by the IMO as a component of the World-Wide Radionavigation System (WWRNS) as set out in Resolution A.1046(27), the receivers of that GNSS will satisfy the IMO carriage requirements for position fixing equipment referred to in Chapter V of the SOLAS Convention.

GNSS receivers, in combination with other equipment, are able to provide PNT information such as:

* absolute positioning;
* relative positioning (this can be further processed to derive speed over ground (SOG), course over ground (COG), etc.); and
* timing.

This information may refer to a stationary observer (static positioning) or to a moving observer (kinematic positioning).

Several Global Navigation Satellite Systems (GNSS) have been deployed, fully or partially, or are under development.

GPS, GLONASS and Beidou have been recognized as components of the WWRNS. It is expected that Galileo will be recognised in the near future. Regional GNSS components like QZSS and IRNSS are planned to become operational in the next few years and may be submitted for WWRNS recognition in due course.

GPS, Galileo, Beidou, QZSS and IRNSS operate interoperable services under the framework of the International Telecommunication Union (ITU).

**Global Positioning System**

The Global Positioning System (GPS) is a three-dimensional positioning, three-dimensional velocity and time system that became fully operational in 1995. The system is operated by the United States Air Force on behalf of the United States Government.

The U.S.Government provides two levels of GPS service. The Precise Positioning Service (PPS) provides full system accuracy to designated users. The Standard Positioning Service (SPS) provides accurate positioning to all users.

The GPS has three major segments: space, control, and user. The GPS Space Segment consists of a nominal constellation of 24 satellites in six orbital planes. The satellites operate in circular 20,200 km (10,900 nm) orbits at an inclination angle of 55 degrees and with a 12-hour period.

The GPS SPS is available on a non-discriminatory basis and free of direct user fees to all users with an appropriate receiver. The service satisfies the requirements for general navigation and harbour approach with a horizontal position accuracy of 9 metres (95% probability)[[3]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_note-3)

A modernization program aims to improve the accuracy and availability for all users and involves new ground stations, new satellites, and four additional navigation signals: three new civilian signals known as L2C, L5 and L1C and a new military code called M-Code.

Further information on GPS can be found on the USCG NAVCEN website ([www.navcen.uscg.gov](http://www.navcen.uscg.gov)). The website also has a link to the latest United States Federal Radionavigation Plan that provides a comprehensive account of current and future developments for GPS.

**Global Navigation Satellite System** (GLONASS)

The Global Navigation Satellite System (GLONASS) is a three-dimensional positioning, velocity and time system managed by the Russian Space Agency for the Russian Federation.

It is available on a non-discriminatory basis and free of direct user fees to all users with an appropriate receiver. With a full complement of 24 satellites, the service satisfies the requirements for general navigation and gives a horizontal position accuracy in the region of 12.4m (95%) over any 24-hour interval, given a position dilution of precision (PDOP) of 2.[[4]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation#cite_note-4)

Recent launches have included the improved GLONASS M satellites with a second civil signal. Since 2011, the constellation is being replenished with GLONASS-K satellites that provide a third civil signal on L3.

GLONASS satellites use Frequency Division Multiple Access (FDMA), however new satellites will provide additional signals using code division multiple access (CDMA) to become interoperable with other GNSS.

Further information on GLONASS and future developments can be found on the Russian Space Agency, Information Analytical Centre website ( www.glonass-ianc.rsa.ru ).

**Galileo**

Galileo is the European GNSS designed to be interoperable with other GNSS, managed and operated under civil control.

The Galileo programme is currently in its deployment phase, which is due for completion in 2020. Planned satellite launches will enable early services to be offered as more satellites become available.

The deployment and the exploitation are entirely financed through the budget of the European Union, while two non-EU members, Norway and Switzerland, contribute through international agreements.

Galileo will offer the following services:

* **An Open Service (OS):** With positioning accurate to around 1 meter using up to three different frequencies (E5a, E5b and L1), free of charge to the user and providing positioning and synchronization information intended mainly for high-volume satellite navigation applications;
* **A Public Regulated Service (PRS):** Restricted to European government-authorized users, for sensitive applications which require a high level of service continuity. It will use strong encrypted signals. It may be accessed by non-EU states and international organizations subject to bilateral agreements.
* **A contribution to the Search and Rescue Service (SAR) of the COSPAS-SARSAT system:**Galileo’s worldwide search-and-rescue service will forward distress signals to a rescue coordination center by detecting emergency signals from beacons and relaying messages to them in near real time.
* **A Commercial Service (CS):** Encrypted for authentication purposes and offering very high accuracy to the sub-decimeter level, it will target applications for professional or commercial use owing to improved performance and data with greater added value than that obtained through the open service.

Galileo will use a constellation of 24 satellites to achieve its positioning performance targets, but aims to have a constellation of 30 satellites when fully operational, to include in-orbit. spares.

Further information on Galileo can be found at the following website:[http://ec.europa.eu/growth/sectors/space/galileo/](http://ec.europa.eu/growth/sectors/space/galileo/" \t "_blank)

**BeiDou**

Beidou Navigation Satellite System (BDS) is China’s independently constructed and operated system. It can be compatible with other GNSS in the world. It can provide all-time, all-weather PNT services with high accuracy and high reliability for all kinds of users. As a joint office established by related governmental departments, China Satellite Navigation Office (CSNO） is in charge of management on the construction, application promotion and industrialization of BDS.

BDS consists of three major components: the space constellation, the ground control segment and the user segment. The space constellation consists of 5 GEO satellites and 30 non-GEO satellites. Upon the full system completion, BDS can provide positioning, velocity measurement and timing services to users worldwide. It can also provide wide area differential services with the accuracy better than 1m.

By the end of 2012, BDS consists of 14 operational satellites in orbit, including 5 GEO satellites, 5 IGSO satellites, and 4 MEO satellites, and possesses Full Operational Capability (FOC) for the Asia-Pacific region. It can provide positioning accuracies of better than 10m and velocity measurement with better than 0.2 m/s. Meanwhile, it also has the capability of providing one-way and two-way timing with 50ns and short message communications with 120 Chinese characters per message.

It is expected that when fully operational, the BeiDou constellation will consist of approximately 40 satellites and will be capable of providing global coverage.

For further details on BDS, including the number of satellites currently in orbit, please refer to the CSNO website [1].

[1] Further information on BDS can be found on the CSNO website (http://en.beidou.gov.cn/index.html)

**Quasi-Zenith Satellite System**

Japan is developing a Quasi-Zenith Satellite System (QZSS). QZSS is based on 3 satellites in highly elliptical, inclined orbits, and one Geo-stationary Satellite. The final constellation is expected to consist of 7 satellites, with each transmitting 6 signals in the L-band: 3 in L1, one in E6(L6), one in L2 and one in L5.

Full implementation will also provide augmentation services to GPS and QZSS.

The signal in E6(L6) aims to support a commercial service with high data rate (2 kbps).

www.QZSS.go.jp

**Indian Regional Navigational Satellite System**

The Indian Regional Navigational Satellite System (IRNSS) will be an independent navigation system covering the Indian region through a space segment of 3 GEO satellites and 4 IGSO satellites. The inclination of the orbital plane of the IGSO satellites is low, so that all the satellites can be seen simultaneously over India.

Three IRNSS services are anticipated:

* Open Service using signals in the L5 and S bands;
* Precise Positioning Service using signals in the L5 and S bands;
* Restricted Access Service using signals in the L5 band only.

The Open and Precise services target dual frequency users but it is also intended to compute and broadcast ionosphere-corrections to support single frequency users. Owing to the limited coverage of the IRNSS network of reference stations the satellites will, apart from the navigation payload, also include a dedicated C-band uplink/down-link ranging payload to support precise satellite orbit determination.

**4.8.2 Differential Global Navigational Satellite System[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=18" \o "Edit section: 4.8.2 Differential Global Navigational Satellite System)]**

The aim of GNSS augmentation services such as Differential Global Navigational Satellite System (DGNSS) is the improvement of GNSS based positioning within a given area. In this context various methods can be applied to increase the accuracy of GNSS based positioning and to verify the integrity of applied components (systems, services) and provided data. An essential basis for DGNSS service provision are own GNSS measurements gathered in real time at single reference stations or a network of them.

DGNSS service provides correction terms of ranging errors per satellite in view. This principle is applied by IALA Beacon DGNSS providing range and range rate corrections derived at reference station site from differences between surveyed and known distances to satellites in view. Satellite Based Augmentation Systems (SBAS) provides area correction parameter, whose application enables the determination of range and range correction for users in large-scale regions such as Europe. In this case a network of ranging and integrity monitoring stations (RIMS) is used to measure and model the spatial varying error behaviour.

Accuracies in the centimetre level can be achieved by DGNSS services employing the application of real time kinematic techniques (RTK) for positioning. The gain of accuracy is achieved by the common processing of range and phase measurements collected at reference station and user site to apply single and double difference methods during position determination.

In safety-critical application DGNSS services should be enriched with integrity functions realising the monitoring of data and system integrity in real time. The monitoring can be realised by plausibility and consistency tests as well as methods estimating error behaviour and budgets. Integrity data as results of the integrity monitoring informs the user about the current usability of applied components and provided output data.

The DGNSS service provision is realized by radio signals carrying augmentation, correction, and integrity data. Users operating in service areas and equipped with appropriate receivers can use these augmentation data to:

* enhance accuracy of GNSS based positioning;
* notify faulty satellites or GNSS failure;
* detect satellite signals with increased propagation errors;
* exclude disturbed signals from positioning;
* be informed about the usability of services or other information.

Currently, DGNSS services are provided for operational satellite navigation systems such as GPS and GLONASS. In principle, similar DGNSS services are planned or can be provided for developing GNSS such as GALILEO, BeiDou and QZSS.

Each DGNSS service can be separated into a part generating and a part distributing the augmentation data. The generation of DGNSS augmentation data requires own GNSS measurements gathered at a single reference station or a network of them. Different DGNSS messages and services may use different generation methods and means of dissemination. At present certain communication channels used for the provision of DGNSS augmentation data are assigned to specific DGNSS services. For example, the provision of DGNSS augmentation data is realized by terrestrial radio transmitters (IALA Beacon Transmitter, AIS) or via satellite transponders (SBAS).

**IALA Beacon DGNSS**

The aim of IALA Beacon DGNSS is the provision of non-encrypted differential corrections as well as integrity information to maritime users to improve accuracy and integrity of GNSS based determination of position, velocity and time data (PVT). The method of differential positioning was developed in the nineties, is internationally accepted and supported in most coastal waters, especially in areas of high traffic density. The differential corrections are determined at known positions of reference stations or a network of them. For this purpose the difference between expected and measured ranges is used to derive actual range and range rate corrections.

Additionally, integrity monitoring functionalities are implemented to assess the usability of GNSS signals and provided DGNSS service.

The radio link used for the provision of DGNSS correction and integrity data is internationally defined at ITU (Recommendation ITU-R M.823-3). At present the DGNSS signal transmission is realized in the maritime radionavigation band (283.5 to 325 kHz)[[7]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_note-7). At user site type-approved DGNSS radio beacon receivers meeting IEC 61108-4 test and performance standards are necessary to enable the ship-side use of DGNSS services for an improved PVT data determination.

The recapitalisation of DGNSS infrastructure is an ongoing process. Of the options available, some service providers have opted to replace existing hardware with similar dedicated Reference Stations and Integrity Monitors (RSIM); some have invested in software RSIM; while others have adopted a network of reference stations to create virtual RSIMs. Other solutions, such as integration with SBAS may evolve within the enhancement of the maritime PNT system.

The full list of about 400 maritime radiobeacon based DGNSS stations (as notified to IALA by authorities) can be accessed via the IALA website (www.iala-aism.org).

Refer to IALA publications:

* Recommendation R-121
* Guideline 1112

**AIS for DGNSS Transmissions**

Automatic Identification System (AIS) is a ship to ship and ship to shore data broadcast system, operating in the VHF maritime band, and is described in more detail in section 4.19.

AIS has the capability of providing DGNSS corrections to onboard equipment using standardized transmissions (Message No 17) as described in IALA Recommendation A-124.

**Maritime Phase-Based GBAS (MGBAS)**

In the last decades the development of phase-based techniques was driven by surveying to achieve position accuracies with GNSS in the centimetre level. In IALA R-135 the RTK technique was mentioned as an approach to meet maritime requirements on high-precision positioning in port areas and for automatic docking. Several manufacturers of maritime GNSS/DGNSS equipment provide solutions supporting RTK based positioning.

It is noted that RTK is a short-range system and that there is a need to introduce monitoring and assessment of the integrity of RTK services and RTK based positioning in the context of safety-critical applications.

**RTK Over AIS**

In survey applications the RTK correction information is usually distributed to users via VHF/UHF radio modems or via commercial broadband internet. However when used in hydrographical measurements further away from the shoreline these communication options might not be available all the time. The communication options in these areas would be via satellite or via AIS (the latter is also available only inside coastal VHF coverage usually less than 70km from shoreline).

RTK over AIS is in operational use for selected user groups in some countries and it has been reported to function without major problems and deliver the required positioning accuracy. When using RTK over AIS, it should be noted that it puts a high demand on the channel loading. Other limitations of this technique are that only one mobile user can be served by one AIS base-station at a time, reduced understanding of accuracy due to rapid atmospheric fluctuations and that it may not be applicable in areas of high channel loading. The channel loading problem may be addressed in the future by using the additional channels allocated for VDES.

**4.8.3 Satellite Based Augmentation Systems[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=19" \o "Edit section: 4.8.3 Satellite Based Augmentation Systems)]**

Satellite Based Augmentation Systems (SBAS) support wide-area or regional augmentation through the use of additional satellite-broadcast messages. The basic scheme is to use a set of monitoring stations (at very well-known position) to receive GNSS signals that will be processed in order to obtain some estimations of these errors that are also applicable to the users (i.e. ionospheric errors, satellite position/clock errors, etc.). Once these estimations have been computed, they are transmitted to the users by means of a GEO satellite.

**Wide Area Augmentation System**

The Wide Area Augmentation System (WAAS) has been implemented by the US FAA to support the use of GPS for general and commercial aviation over continental United States. It was recently extended to cover parts of Mexico and Canada. At present, the WAAS architecture includes 38 reference stations, 3 master stations, 4 up-link stations, 2 geostationary satellite links and 2 operational control centres. Further information on WAAS can be found on the USCG Navigation Centre website (www.navcen.uscg.gov).

**European Geo-stationary Navigation Overlay Service**

The European Geostationary Navigation Overlay Service (EGNOS) is the European satellite-based augmentation system that provides safety critical navigation services to aviation, maritime and land-based users over most of Europe. EGNOS augments the GPS L1 Coarse/ Acquisition (C/A) civilian signal by providing corrections and integrity information.

EGNOS provides three services:

* **Open Service (OS)**, freely available to any user. The main objective of the EGNOS OS is to improve the achievable positioning accuracy by correcting several error sources affecting the GPS signals. (https://egnos-user-support.essp-sas.eu/new\_egnos\_ops/sites/default/files/library/official\_docs/egnos\_os\_sdd\_v2\_2.pdf)
* **Safety of Life (SoL) Service,** provides the most stringent level of signal-in-space performance developed primarily to support aviation. Its use in the maritime sector is being explored with a view to supporting maritime SoL users in the future.

(https://egnos-user-support.essp-sas.eu/new\_egnos\_ops/sites/default/files/library/official\_docs/egnos\_sol\_sdd\_in\_force.pdf).

* **EGNOS Data Access Service (EDAS)** is the EGNOS terrestrial data service which offers ground-based access to EGNOS data in real time and also in a historical FTP archive to authorised users (e.g. added-value application providers) (https://egnos-user-support.essp-sas.eu/new\_egnos\_ops/sites/default/files/library/official\_docs/egnos\_edas\_sdd\_v2\_1.pdf).

The EGNOS Space Segment comprises 3 geostationary (GEO) satellites. The EGNOS Ground Segment comprises a network of Ranging Integrity Monitoring Stations (RIMS), two Mission Control Centres (MCC), six Navigation Land Earth Stations (NLES), and the EGNOS Wide Area Network (EWAN) which provides the communication network for all the components of the ground segment.

Further information on EGNOS can be found via website ( <http://www.egnos-portal.eu/> and <https://egnos-user-support.essp-sas.eu/>)

**Multi-Satellite Augmentation System**

In Japan, the Multi-Satellite Augmentation System (MSAS) is an SBAS similar to EGNOS and WAAS. MSAS has been commissioned for aviation use, with two GEO-links using the L1 band via dedicated satellites shared with communications and meteorological missions. The system has been operational since 2007 and there are plans to add additional services on L5 in the future[[8]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_note-8). **GPS-Aided Geo Augmented Navigation System**

India is developing a GPS-Aided Geo Augmented Navigation system (GAGAN), which is an SBAS similar to WAAS and EGNOS. GAGAN includes 8 reference stations, 1 mission control centre, 1 up-link station and 1 Geo link through the L1/L5 transponder on the INMARSAT 4-F1 satellite. At the time of writing, further information on GAGAN may be found via the website (www.isro.org).

**System for Differential Corrections and Monitoring**

Russia is developing an augmentation to provide corrections for GLONASS and GPS called the System for Differential Corrections and Monitoring (SDCM). This system consists of 3 geostationary satellites, assigned PRN codes 125,140 and 141.

**4.8.4 Receiver Autonomous Integrity Monitoring[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=20" \o "Edit section: 4.8.4 Receiver Autonomous Integrity Monitoring)]**

Receiver Autonomous Integrity Monitoring (RAIM) is a technology developed to assess the integrity of GNSS signals and therefore the integrity of GNSS based positioning. This kind of integrity monitoring is autonomously realized within the user’s receiver with special importance for safety critical applications, such as aviation and maritime.

Range measurements are required from at least 4 GNSS satellites to enable the determination of position, velocity and time data. However the application of RAIM in a navigation receiver requires redundancy in the range measurements.

Safety-critical RAIM algorithm might use only “Fault Detection” (FD) or “Fault Detection and Exclusion” (FDE), which enables the continuation of operation in the presence of a single GNSS satellite and signal failures. To detect a faulty satellite, at least five range measurements are required, whereas to isolate and exclude a faulty satellite, at least six range measurements are required. While RAIM can detect many failure modes, it cannot detect some failures affecting multiple satellites.

The upcoming availability of various GNSS will increase the usable number of navigation signals for RAIM based positioning. New and modernized GNSS supports the provision of GNSS signals in 2 or more frequency bands and improves therefore the capability of GNSS based ranging.

Future advancement in RAIM algorithms should improve the availability and continuity of RAIM based positioning. Such enhanced RAIM techniques – so called Advanced RAIM (ARAIM) – may become available to maritime users (www.navipediA.net/index.php/araim).

**4.8.5 Terrestrial Systems[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=21" \o "Edit section: 4.8.5 Terrestrial Systems)]**

**Loran-C**

Loran–C is a hyperbolic radionavigation system which was developed during the late 1950’s to meet U.S. Department of Defense requirements. The Russian Federation operates a similar radionavigation system called CHAYKA. There are currently about a number of Loran–C and CHAYKA chains operating around the world. The principal coverage areas include Saudi Arabia, China Sea, Korea, North West Pacific and the Russian Federation. Loran–C chains comprise between three to five stations that have a spacing of 600 to 1000 nautical miles. The signal format is a structured sequence of specially designed radio pulses on a carrier wave frequency centred on 100kHz. One of the stations is designated as the ‘master’ and transmits groups of 9 pulses. The other stations are called ‘secondaries’ and these transmit groups of 8 pulses.

The spacing between groups of ‘master’ pulses from a single chain is a characteristic unique to that chain and is referred to as the Group Repetition Interval (GRI).

The 100kHz carrier wave frequency favours the propagation of a stable ground wave over long distances. Careful signal design allows Loran receivers to determine positions using the ground wave and reject the delayed sky wave that would potentially distort the received signal.

The transmissions from each chain are monitored and controlled continuously. System abnormality indicators are built into the signal format and can be identified by the receiver providing inherent integrity warnings.

**eLoran**

Enhanced Loran (eLoran) is a terrestrial navigation system developed from Loran-C. It is a Positioning, Velocity, and Timing (PVT) service for use by land, sea and air navigation as well as other applications reliant on timing data.

eLoran uses a series of radio pulses on a carrier wave frequency centered on 100kHz, provided by terrestrial broadcast sites.

.

eLoran uses an all-in-view method of operation, calculating the distance to all eLoran stations in view. eLoran stations are also synchronised with, but independently of, GNSS time. Synchronising to a common time source allows receivers to employ a mixture of eLoran and GNSS signals. eLoran receivers calculate the distance from each station by firstly assuming that the entire earth’s surface is covered in sea-water. By knowing the speed of the signal over sea-water along with the times of transmission and reception a pseudorange can be calculated. This pseudorange is then adjusted to take into account the propagation delays due to the signal passing over land, these delays are called Additional Secondary Factor delays (ASFs). ASFs are measured by the service provider and are supplied to users as a database built into their receivers. ASFs may change slightly due to weather or seasonal effects, reducing the efficiency of the correction and affecting accuracy. However, this is resolved by installing a differential-Loran reference station nearby, which is able to measure the difference and calculate a correction. The correction information is then passed back to the eLoran station for dissemination to the user over the eLoran data channel.

The inclusion of a data channel as part of the main transmission is one of the inherent features of eLoran and can be used to provide other data services in addition to differential corrections.

eLoran provides positional accuracy in the region of 8 - 20 metres (using differential technics) and time and frequency performance (to stratum-1 level) similar to current GNSSFor more information the reader is encouraged to seek the advise of Radio Technical Commission for Maritime Services Special Committee 127 (SC-127) on eLoran Systems.

**Compatibility Between eLoran and Loran-C**

Legacy receivers are able to use both eLoran and Loran-C signals as eLoran stations form part of the presently organised chains. However, legacy Loran-C receivers will likely not provide the user with the best accuracy performance.

Users should ensure their receivers are able to decode the Loran Data Channel to receive integrity alerts, UTC time and differential-Loran correction data. They should also ensure their receiver is capable of storing and applying up to date ASF data.

**4.8.6 Ranging-mode[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=22" \o "Edit section: 4.8.6 Ranging-mode)]**

Investigations are being conducted on the benefit of expanding the functionality of existing systems; by providing a timing signal from which the user may then calculate their position independently from GNSS and this is known as Ranging-mode (R-mode).

At present the IALA MF beacon system and AIS Services are being considered as candidates for modification to add R-mode functionality. Both systems are globally distributed and are widely used in the maritime field. By providing timing information over their normal MF or VHF transmissions, a shipboard receiver may then calculate a distance (range) to the transmitter. By calculating the range to several stations, the user is able to calculate the ship’s position. Coverage, geometry and interference questions would need to be investigated.

The provision of R-Mode services would require the availability of an accurate non-GNSS timing source at the transmitter. High stability clocks could be an expensive option and it is more likely that time would be sourced from a low frequency radio time clock or eLoran.

**4.9 Radar Aids to Navigation[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=23" \o "Edit section: 4.9 Radar Aids to Navigation)]**

Radar aids to navigation are devices that provide returns to a ship’s radar that help to locate and/or identify a navigation mark.

The IMO carriage requirements contained in (Chapter V, Regulation 19) of the SOLAS Convention 1974 (as amended), states all ships of:

* 300 gross tonnage and upwards to carry a 9 GHz radar;
* 3,000 gross tonnage and upwards to be fitted with a 3 GHz radar or, where considered appropriate by the Administration, a second 9 GHz radar.

Some administrations may impose other carriage requirements.

IMO Resolution MSC.192(79) Adoption of the Revised Performance Standards for Radar Equipment 06 December 2004 states that 9 GHz radars should be capable of detecting radar beacons and should be capable of detecting SARTs and radar target enhancers. By omission, 3GHz radars are not required to detect radar beacons and SARTS. With the removal of the 3GHz radar racon detection requirement, ship-owners are free to use higher performing radars, often referred to as New Technology (NT) radars.

9 GHz radars are also extensively carried by vessels not covered by SOLAS or local regulation. Because of this high rate of carriage, radar aids to navigation in the 9 GHz band are especially useful.

**4.9.1 Radar Reflectors[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=24" \o "Edit section: 4.9.1 Radar Reflectors)]**

A radar reflector is a passive device designed to return the incident radar pulses of electromagnetic energy back towards the source and thereby enhance the response on the radar display. By design, a radar reflector attempts to minimise the absorption and random scattering effects.

A radar reflector is generally installed as a supplementary device at sites that would also be marked with a light. The main objectives of its use are to enhance:

* target detection at long ranges (for example, for landfall navigation);
* target detection in areas of sea or rain clutter; and
* radar conspicuity of aids to navigation to reduce the risk of collision damage.

The performance of a radar reflector can be defined in terms of its effective radar cross section (RCS). This is a value determined by comparing the strength of radar signals returned by the radar reflector with the equivalent return from a radar reflective sphere of 1m2 reflecting area.

The range at which a radar reflector target can be detected is dependent on the heights of the radar antenna and the reflector and the output power of the radar. There are analogies to the geographical range of visual marks. The radar performance of corner cluster reflectors may vary considerably from one make to another.

Use of small radar reflectors can also be subject to multipath fading effects. Please see IALA Guideline No.1010 on Racon Range Performance for a discussion on multipath fading.

Most radar reflectors are designed for use by 9 GHz radars. The reflectors are also usable with 3 GHz radars; however, the effective radar cross section is about an order of magnitude less.

**4.9.2 Radar Target Enhancers[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=25" \o "Edit section: 4.9.2 Radar Target Enhancers)]**

A Radar Target Enhancer (RTE) is a device that amplifies and returns the pulse from a ship’s radar to give an enhanced image on the radar screen. The returned signal from an RTE is not coded. The RTE was designed primarily for buoys and small vessels that might normally carry a passive radar reflector. RTE testing has shown RTEs to have provided an effective radar cross section (RCS) of about 100 m2, compared with an RCS of 20 to 30 m2 for passive radar reflectors typically fitted to buoys.

To date, commercially available RTEs only operate in the 9 GHz band.

RTE use is subject to multipath fading effects. Please refer to IALA Guideline No.1010 on Racon Range Performance for a discussion on multipath fading.

**4.9.3 Radar Beacon[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=26" \o "Edit section: 4.9.3 Radar Beacon)]**

Radar beacons (racons) are receiver/transmitter devices operating in the maritime radar frequency bands (9 and 3 GHz) that enhance the detection and identification of certain radar targets. Please note that IMO MSC.192(79) removed the requirement for 3GHz radar to detect racons.

A racon responds to the presence of a ship’s radar by sending a characteristic pulse train. The response appears as a coded mark (or “paint”) on the ship’s radar display (refer Figure 24) that highlights the range and bearing of the racon. The display paint can be fixed to a specified length or can be dependent on the radar range setting and uses a Morse character for identification.

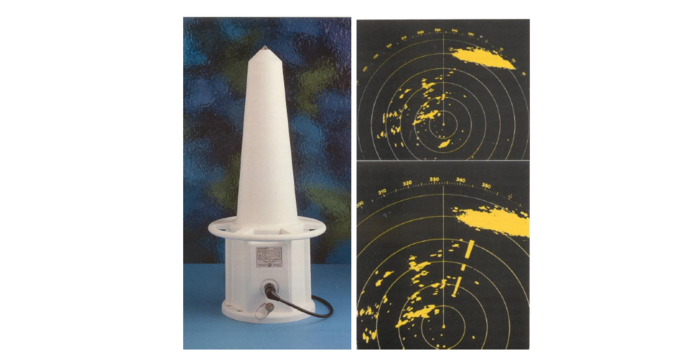
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_4-9-3_Figure24_A_Racon_and_Radar_Display_with_and_without_Racon_Character.png)

Figure 24 - A Racon (left) and a Radar Display (right) with and without the Racon character  
**Applications**

A racon is generally considered to be a supplementary aid to navigation installed at sites that would also be marked with a light. The number of vessels capable of making use of a racon is effectively unlimited.

A racon can be used for:

* ranging and identification of positions in ice conditions or on inconspicuous coastlines;
* identification of aids to navigation, both seaborne and land based;
* landfall identification;
* indicating centre and turning point in precautionary areas or Traffic Separation Scheme (TSS)
* marking hazards;
* indicating navigable spans under bridges;
* identifying leading lines.

**4.9.4 Frequency-Agile Racon[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=27" \o "Edit section: 4.9.4 Frequency-Agile Racon)]**

A frequency-agile racon responds on the frequency on which it is interrogated and the response can be re-painted on each radar sweep. The purpose of frequency agility is to provide a signal to the radar that is within the receiver bandwidth of the radar. However, to avoid masking other features on the radar screen, the racon response is usually switched on and off on a preset cycle.

**Signal Characteristics**

Racons operate in the 9 GHz band with horizontal polarisation, and/or in the 3 GHz band with horizontal and optionally vertical polarisation.

|  |  |  |  |
| --- | --- | --- | --- |
| **Preferred Terminology** | **Alternatives** | | |
| 9 GHZ | 9300 9500 MHZ | X-BAND | 3 CM |
| 3 GHZ | 2900 3100 MHZ | S-BAND | 10 CM |

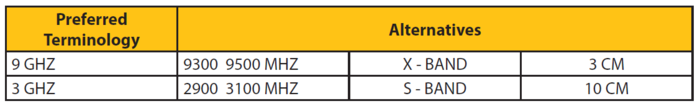
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_2014_table18.PNG)

Table 18 - Preferred Terminology for the Description of Racon Operating Frequencies

**4.9.5 Racon Performance Criteria[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=28" \o "Edit section: 4.9.5 Racon Performance Criteria)]**

The availability of a racon is the principal measure of performance determined by IALA. In the absence of any specific considerations, IALA recommends that the availability of a racon should be at least 99.8%.

|  |
| --- |
| Refer to IALA publications:   * Guideline 1010 on Racon Range Performance; * Recommendation R-101 on Maritime Radar Beacons (Racons); * Recommendation O-113 for the Marking of Fixed Bridges Over Navigable Waters. |

**4.9.6 Racon Technical Considerations[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=29" \o "Edit section: 4.9.6 Racon Technical Considerations)]**

There are a number of technical considerations in the use of racons to assist the navigation of a ship:

* The angular accuracy of the bearing between the ship and racon depends entirely on the interrogating radar, while the accuracy of the range measurement depends on both the radar and racon;
* When racons are used in leading line applications, an alignment accuracy of about 0.3 degrees can be expected;
* When the ship is very close to the racon, side-lobes from the radar antenna can trigger the racon. The resulting multiple responses on the radar display may be a distraction and can mask other targets. Side-lobe suppression techniques are standard features of frequency agile racons.

**4.9.7 Use with New Technology Radars[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=30" \o "Edit section: 4.9.7 Use with New Technology Radars)]**

All currently available and installed racons are designed for use with high power pulse radars. In comparison, NT radars use low power transmissions with long pulses. Due to the low received peak signal strength and long pulse at the racon, current racons may not detect NT radars and may not transmit a response usable by NT radars. Studies have shown that pulsed NT radars are able to reliably trigger racons at shorter ranges than would have been achieved with a conventional magnetron pulsed radar. Note that FMCW radars (also grouped into the family of New Technology radars) are a special case which require individual analysis and measurement. The IMO regulations regarding X band radars and racons remain unchanged and although detection and triggering range might be reduced, it is the responsibility of manufacturers of X band NT radars to retain racon functionality.

Despite changes to the IMO regulations relating to S band racons, existing racons with 3 GHz capability will continue to be useful to 3GHz pulse radars of both Magnetron and pulsed New Technology variants although advanced clutter reduction techniques optimised in the knowledge that display of Racon signals is no longer a functional requirement in this frequency band, may attenuate or even remove the Racon pulse train from the radar video and display. There may be a need to replace all high power pulse radars, thereby impacting all racons with 3 GHz pulse capability.

**4.9.8 Radar Referenced Positioning[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=31" \o "Edit section: 4.9.8 Radar Referenced Positioning)]**

Algorithms may be developed to allow the radar display to be overlaid upon the electronic chart using detectable recognised navigational features (racons, passive radar beacons or land edge patterns etc.). This technique, although unlikely to challenge the accuracy of a GNSS based position fix, might be adopted as part of a PNT integrity assessment and/or as a back-up in the event of GNSS service or equipment failure or corruption.

**4.9.9 Non-radio Positioning (Inertial)[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=32" \o "Edit section: 4.9.9 Non-radio Positioning (Inertial))]**

Many studies have been carried out on the integration of GNSS with Inertial Measurement Units (IMU) for marine navigation. There exist various grades of IMU, from the very expensive navigation grade, through tactical grade, to low cost units based on the Micro Electro Mechanics System (MEMS). The IMU grade characterizes the achievable performance of data provision covering velocities and orientations. A small IMU grade is associated with higher drift rates. Depending on the different drift rates an IMU can provide contingency for various lengths of GNSS outages.

In combination with a GNSS compass an IMU can provide accurate and stable heading data even for longer GNSS outages. None of the currently available inertial systems is capable of maintaining all levels of navigation accuracy during a lengthy outage of GNSS. For ocean areas, both navigation and tactical-grade IMUs will give protection for appreciable outages over 15 minutes and navigation grade IMUs approximately 1 hour. For the coastal areas the required accuracy of 10 meter could be obtained for 3.5 minutes with a navigation-grade IMU and 1.5 minutes with a tactical grade IMU.

**4.9.10 Non-radio positioning (ePelorus)[[edit](http://www.iala-aism.org/wiki/ialawiki/index.php?title=Navguide:_Chapter_4_-_e-Navigation&action=edit&section=33" \o "Edit section: 4.9.10 Non-radio positioning (ePelorus))]**

An electronic pelorus (ePelorus) is a device for taking bearings of visual marks and converting them to an electronic format for input to an electronic chart system. Such a device would enable the integration of visual AtoNs with e-Navigation. The concept was promoted in a paper by the Nautical Institute in about 2008, as a backup system for navigation.

The feasibility of constructing a low-cost ePelorus from off-the-shelf components is being investigated, to demonstrate its effectiveness as a backup and to evaluate the potential for integrating visual AtoNs with e-Navigation.

**4.10 Communications**

**4.10.1 Maritime Radio Communications Plan**

IALA has prepared a Maritime Radio Communications Plan (MRCP) for the communications required to support e-Navigation. The MRCP is intended to meet the key strategy element of identifying communications technology and information systems to meet user needs. This may involve the enhancement of existing systems or the development of new systems. The IALA work starts by identifying existing and future systems, then drawing on the user requirements already identified to assess the information flows and the data channels needed.

**4.11 Long Range Identification and Tracking**

**4.11.1 Introduction**

Competent authorities with responsibility for aids to navigation, port security and other shoreside activities are often faced with the requirement to maintain surveillance of maritime approaches to their ports and port facilities for safety, security, and environmental protection.

These authorities are pursuing vessel tracking technologies to assist in the detection, classification, identification, and tracking of vessels. Among these technologies, Long Range Identification and Tracking (LRIT) has been implemented internationally for tracking ships globally.

**4.11.2 Concept**

Long range identification and tracking (LRIT) is a cooperative surveillance capability. In the simplified LRIT concept (Figure 25), a ship carries radio communications equipment that reports identification, position and time to authorities tracking that ship. However, the final implementation of LRIT is more complicated as explained below.

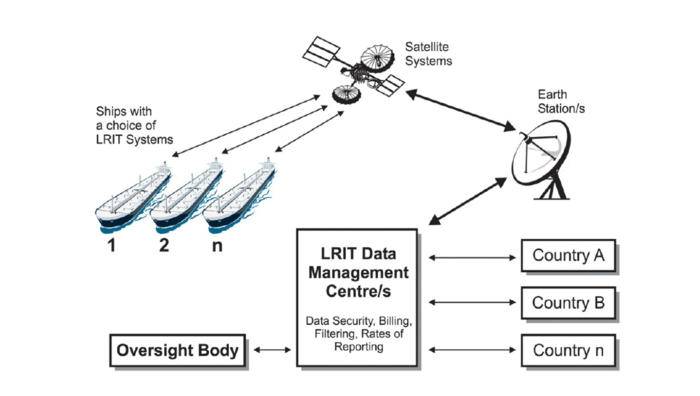
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_4-11-2_Figure25_Simplified_LRIT_Concept_(INMARSAT).png)

Figure 25 - Simplified LRIT Concept (INMARSAT)

**4.11.3 Performance Standards and Functional Requirements**

The approved performance standards and functional requirements for long-range identification and tracking lay out the LRIT system architecture (Figure 26) and describe how the long-range identification and tracking system works.

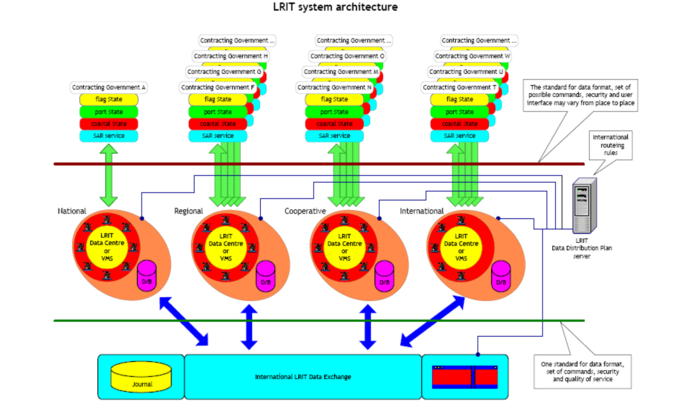
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_4-11-3_Figure26_LRIT_System_Architecture.png)

Figure 26 - LRIT System Architecture

In this architecture, the Administration determines whether its ships will report to a national, regional/cooperative, or the international LRIT data centre. Each of these types of centres may use multiple communications service providers. The architecture is also designed to accommodate multiple application service providers. Building on the basic concept noted above, a ship carries radio communications equipment that reports identification, position and time to the national, regional/cooperative, or international LRIT data centre tracking that ship. The Administration of the ship can access the LRIT information directly from the data centre. Other Contracting Governments that are entitled to that information (i.e., port and coastal states) can request the information through their data centre and thence through the international LRIT Data Exchange. The LRIT information is routed to the requesting data centre through the data exchange.

**4.12 Automatic Identification System**

Automatic Identification System (AIS) is a ship and shore-based data broadcast and interrogation technology, operating in the VHF maritime band, that makes it possible to monitor and track ships from suitably equipped ships, and shore stations.

AIS’ characteristics and capability make it a powerful tool for enhancing situational awareness, thereby contributing to the safety of navigation and efficiency of shipping traffic management. Shipboard AIS enables the provision of fast, automatic and accurate information regarding risk of collision allowing the Closest Point of Approach (CPA) & Time to Closest Point of Approach (TCPA) to be calculated from the positional information transmitted by target vessels. AIS increases the possibility of detecting other ships, even if they are behind a bend in a channel or river or behind an island in an archipelago. AIS also solves the problem inherent with radars, by detecting smaller craft, fitted with AIS, in sea and rain clutter.

An AIS unit is a VHF radio transceiver capable of exchanging information such as station identity, position, course over ground, speed, length, ship type and cargo information etc., with other ships and suitable receivers ashore within VHF range. Figure 27 gives an overview of the system.

Once set up correctly, information from an operational shipboard AIS unit is transmitted continuously and automatically, without any intervention by the ship’s staff. AIS transmissions consist of bursts of digital data ‘packets’ from individual stations, according to a pre-determined time sequence. Therefore, AIS is an important supplement to existing systems, including radar. In general, data received via AIS will enhance the information available to the Officer of the Watch and the Vessel Traffic Service Operator (VTSO).

The International Maritime Organization (IMO) has established carriage requirements for merchant ships. The International Telecommunication Union (ITU) has defined the technical characteristics and ratified the global frequencies. In addition, the International Electrotechnical Commission (IEC) has developed methods for testing AIS for global interoperability.

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| This section aims to provide a broad overview of AIS. The reference list at the end of this section assists the reader seeking amplifying information on various aspects of AIS. |

**4.12.1 Purpose & Function**

The purpose of AIS is to positively identify vessels, provide additional information in order to assist in collision avoidance and assist in vessel tracking. It also aims to simplify and promote the exchange of information automatically, thereby reducing the need for doing so verbally (e.g.mandatory ship reporting by radiotelephony).

AIS satisfies the following functional requirements, as laid down by IMO:

* in a ship-to-ship mode for collision avoidance;
* as a means for littoral States to obtain information about a ship and its cargo;
* as a VTS tool, i.e. ship-to-shore (traffic management).

AIS automatically exchanges shipboard information (provided by shipboard sensors), between vessels and between a vessel and a shore station(s).

**4.12.1 System Characteristics**

**Frequencies and Capacity**

AIS operates on four VHF FM radio frequencies AIS1 (channel 87B – 161.975 MHz), AIS2 (channel 88B– 162.025 MHz) and Channels 75 and 76 in the maritime mobile band. Transmissions consist of bursts of ‘data packets’ from individual stations, according to an automatically determined time-ordered sequence. Stations organize themselves on the common frequencies (AIS 1 and AIS 2) based on the knowledge of their own transmissions and that of other stations. This method of operation is known as Self Organizing Time Division Multiple Access (SOTDMA). The time slots for AIS transmissions are all precisely aligned to Coordinated Universal Time (UTC), provided for by a Global Navigation Satellite System (GNSS) receiver. This avoids the possibility of two stations transmitting at the same time, in the same slot. There are 2250 time slots available on each frequency per minute, making the total number of slots equal to 4500. Channel 75 and 76 are used for Long Range satellite detection of AIS.

In this architecture, the Administration determines whether its ships will report to a national, regional/cooperative, or the international LRIT data centre. Each of these types of centres may use multiple communications service providers. The architecture is also designed to accommodate multiple application service providers. Building on the basic concept noted above, a ship carries radio communications equipment that reports identification, position and time to the national, regional/cooperative, or international LRIT data centre tracking that ship. The Administration of the ship can access the LRIT information directly from the data centre.

Other Contracting Governments that are entitled to that information (i.e., port and coastal states) can request the information through their data centre and thence through the international LRIT Data Exchange. The LRIT information is routed to the requesting data centre through the data exchange.

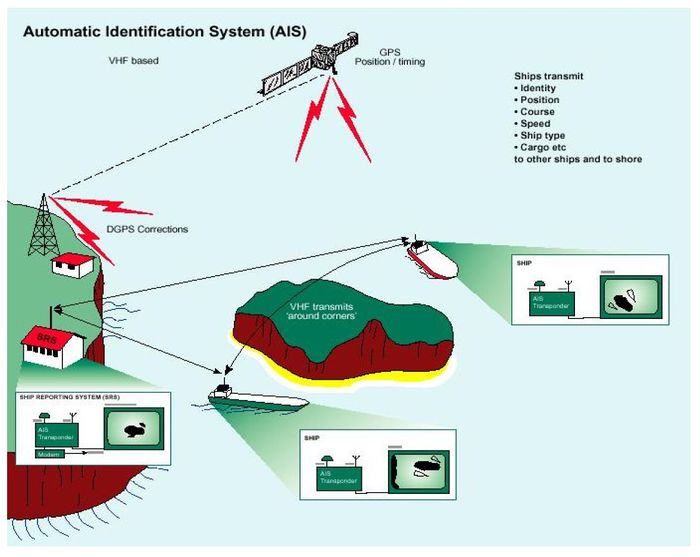
[](http://www.iala-aism.org/wiki/ialawiki/index.php/File:Navguide_2014_Figure_27.jpg)

Figure 27 - Overview of the AIS System

**4.12.2 Shipboard AIS**

A shipboard AIS unit transmits its own data to other vessels and to AIS equipped stations continuously and autonomously. It also receives AIS data of other stations (ship and shore) and can display this data textually and graphically, as required.

Each AIS station consists of a VHF transmitter, two VHF SOTDMA receivers, a VHF DSC receiver, a GNSS receiver (to provide timing for slot synchronisation), and a marine electronic communications link to shipboard display and sensor systems.

Positional information can be derived from the internal GNSS or an external electronic position fixing system. The display panel with the unit is often the only means of showing received AIS daaA. Together with a keypad, this basic configuration is known as a Minimum Keyboard and Display (MKD).

The display part of a MKD, as a minimum, consists of three lines of data, each showing bearing, range and identity of the target. In practice, most MKDs display more lines of data and may also have a simple graphical display, showing the relative location of targets, rather like the Plan Position Indicator of a radar.

Ideally, AIS information should to be displayed graphically on a radar, ECDIS or on its own dedicated display.

**Available Information**

The AIS information transmitted by a ship station includes four different data sets:

* **Fixed or static information** is entered into the AIS unit on installation and need only be changed if the ship changes its name, call sign etc. This information is broadcast every six minutes or on request by a shore authority;
* **Voyage related information** (destination, ETA etc) is manually entered and updated during the voyage. This information is also broadcast every six minutes. In order that correct AIS information is broadcast to other vessels and shore authorities, mariners are reminded to enter current voyage related data such as draught, type of hazardous cargo, destination and ETA properly at the beginning of each voyage and whenever changes occur;
* **Dynamic information** is automatically updated from the ship sensors connected to the AIS. This includes COG, SOG, position (with accuracy and integrity flag), time and navigation status (e.g., underway);
* Broadcast or addressed **short safety related and application specific messages**, as required.

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| Refer to IALA publications:   * Guideline 1028 on the Universal Automatic Identification (AIS) – Volume 1, Part 1 – Operational Issues; * Guideline 1029 on the Universal Automatic Identification System (AIS) – Volume 1, Part 2 – Technical Issues; * Guideline 1082 on an Overview of AIS. |

**4.12.3 Shore-based AIS**

SOLAS Chapter V, Regulation 19, 2.4 refers to the carriage requirements for AIS. The regulation states that AIS shall provide and receive information from appropriately equipped shore stations. The provision of shore based AIS will be necessary to attain the full benefit of the 1974 SOLAS Convention (as amended).

As AIS can be seen as a tool related to Vessel Traffic Services (VTS), Competent Authorities should consider implementing AIS into existing VTS Centres. Information on the use of AIS in VTS operations is contained in Sections 1015-1027 of the IALA VTS Manual.

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| Refer to IALA publications:   * Recommendation A-123 on the Provision of Shore Based Automatic Identification Systems; * Recommendation A-124 on the Automatic Identification System (AIS) Shore Station and Networking Aspects relating to the AIS Service. |

**4.12.4 Meteorological & Hydrological Information**

IMO is responsible for the AIS Binary Broadcast Messages (AIS Message 8) and a message structure has been defined for meteorological and hydrological information. A number of countries operate tide gauges and current meters to assist the prediction of tidal heights and streams or for the broadcast of real-time information to shipping. The latter is generally used to overcome the sometimes considerable differences between actual tide heights and predicted values due to meteorological and mean sea level fluctuations. Providing real-time information of this type, for example dynamic under-keel clearance, wave heights or sea state can be seen as applications of e-Navigation, requiring integration between shore-side and ship-borne systems.

**4.12.5 AIS Aids to Navigation**

A special type of AIS station fitted to an aid to navigation provides positive identification of the aid without the need for a special ship-borne display. In addition, AIS as an AtoN can provide information and data that will:

* complement or replace an existing aid to navigation, providing identity, state of ‘health’ and other information such as real time tidal height and local weather to surrounding ships or back to a shore authority;
* provide the position of floating aids (mainly buoys) by transmitting an accurate position (corrected by DGNSS) to monitor if they are on station;
* provide real-time information for performance monitoring, with the connecting data link serving to remotely control changes in AtoN parameters or switching on back-up equipment;
* provide local hydrological (hydrographical) and meteorological information;
* possibly replace radar beacons (racons) in the future, providing longer range detection and identification in all weather conditions;
* gather shipping traffic data on AIS fitted ships for future aid to navigation planning purposes.

For practical or economic reasons it may not be appropriate to fit an AIS to an AtoN.

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| Refer to IALA publications:   * Recommendation A-126 on the Use of the Automatic Identification System (AIS) in Marine Aids to Navigation; * Recommendation O-143 on Virtual Aids to Navigation; * Guideline 1050 on the Management and Monitoring of AIS Information; * Guideline 1081 on Virtual Aids to Navigation. |

**4.12.6 Carriage Requirements**

There are two ‘types’ of AIS units for ship stations. These are termed Class A and Class B units.

**Class A** ship-borne mobile units must comply with ITU-R M.1371, and are required to be carried on board those vessels to which Regulation 19 of SOLAS Chapter V applies and meet the IMO performance standard. All these ships were to have AIS fitted by 31 December 2004.

**Class B** ship-borne mobile equipment, while also complying with ITU-R M.1371, is designed for vessels such as pleasure craft and fishing vessels. These units provide less functionality than Class A units, and do not necessarily meet all the IMO performance requirements. They are designed to operate co-operatively with Class A units.

Administrations can require the carriage of Class B units as part of their domestic requirements.

**4.12.7 Cautions When Using AIS**

The Officer of the Watch (OOW) should always be aware that other ships, in particular pleasure craft, fishing vessels, warships and some shore stations including VTS centres, may not be fitted with AIS.

The OOW should always be aware that AIS fitted on other ships as a mandatory carriage requirement, might, under certain circumstances, be switched off, particularly where international agreements, rules or standards provide for the protection of navigational information. AIS can also provide incorrect information if the input data is wrong.

Navigators should be aware of the limitations of AIS. In particular, government agencies and owners should ensure that watch-keeping officers are trained in the use of AIS[[9]](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation#cite_note-9). Because of these limitations navigators are advised that AIS should not be used as the primary means of collision avoidance.

**4.12.8 Strategic Applications**

From a number of maritime perspectives (such as VTS and regulatory compliance), the availability of comprehensive ship information, offers a mechanism for:

* better monitoring of compliance with national and international regulations for mandatory routeing and reporting systems, Particularly Sensitive Sea Areas, discharging of oil, garbage disposal etc;
* maritime logistics applications such as fleet management, cargo tracking and port facilities (movement of pilot boats, tugs etc);
* better control, co-ordination and response in the event of marine incidents, such as SAR and pollution;
* shore -based navigational assistance;
* shipping information gathered from AIS can be channelled into a central repository of a local, national or regional network serving maritime administrations, port authorities, shipping agents, freight handlers, customs, immigration, etc..

Further information on AIS can be found within IMO, IALA, ITU and IEC documentation.

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| Refer to IALA publications:   * Guideline 1026 on AIS as a VTS Tool; * Guideline 1028 - Volume 1, Part I – Operational Issues; * Guideline 1029 - Volume 1 Part II – Technical Issues, Edition 1.1; and * Technical Clarifications on ITU Recommendation ITU-R M.1371-1 Edition 1.5. |

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| Refer to IMO publications:   * Recommendation on Performance Standards for an Universal Shipborne Automatic Identification System (AIS) (MSC 74(69) Annex 3); * Guidelines for the onboard operational use of shipborne Automatic Identification Systems (AIS) (Resolution A.917 (22), as amended by Resolution A.956 (23)); * Performance Standards for the presentation of navigation-related information on shipborne navigational displays (Resolution MSC.191(79); * SN/Circ.227 Guidelines for the installation of a shipborne Automatic Identification System (amended by SN/Circ 245); * SN/Circ.236 Guidance on the application of AIS Binary Messages; * SN/Circ.243 Guidelines for the presentation of navigation-related symbols, terms and abbreviations * SN/Circ.244 Guidance on the use of UN/LOCODE in the destination field of AIS messages. |

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| Refer to ITU Publications:   * ITU-R M.1371-1 Recommendation on the Technical Characteristics for a Ship-borne Universal Automatic Identification System (AIS) Using Time Division Multiple Access in the Maritime Mobile Band; * Radio Regulations, Appendix S18, Table of Transmitting Frequencies in the VHF Maritime Mobile Band; * ITU-R M.823-2 Recommendation on the technical characteristics of differential transmissions for global navigation satellite systems from maritime radio beacons in the frequency band 283.5-315 kHz in region 1 and 285-325 kHz in regions 2 and 3. |

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| Refer to IEC Standards:   * 61993 Part 2: Class A Ship-borne equipment of the Automatic Identification System (AIS) - Operational and Performance requirements, methods of testing and required test results; * 61108-1 (2nd edition): navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS); * 61162-1 (2nd edition) Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners; * 62320-1: Maritime Navigation and Radiocommunication equipment and systems – Automatic Identification System. AIS base stations - Minimum operational and performance requirements - methods of test and required test results; * 62320-2 Maritime Navigation and Radiocommunication equipment and systems – Automatic Identification System. AIS aids to navigation - Minimum operational and performance requirements - methods of test and required test result; * 62287-2 (Part A and B) Class B AIS (Part A – CSTDMA; Part B – SOTDMA); * 61097-14 (pending) Global Maritime Distress and Safety System (GMDSS). AIS search and rescue transmitter (AIS-SART) – Operational and performance requirements: methods of testing and required test results. |

**4.12.9 Electronic Chart Display and Information System**

Although Electronic Chart Display and Information System (ECDIS), as ship borne equipment, is not an “aid to navigation” as defined by IALA, it deserves to be mentioned because it brings major changes to the manner in which vessels are navigated. ECDIS uses digital vector data in a way that replaces the traditional paper charts with a more versatile electronic product that can draw on a variety of positioning and data inputs, such as GNSS, DGNSS, AIS, radar, echo sounder, compass, an electronic chart, navigational publications, the chart amendments and tidal and meteorological information.

**Performance Standards**

The performance standards for ECDIS have been defined by the International Maritime Organization (IMO), in conjunction with the International Hydrographic Organization (IHO). IMO Resolution A.817(19) as amended by Resolution MSC.64(67) and by Resolution MSC.86(70) enables maritime administrations to accept ECDIS as a legal alternative to navigation using paper charts and to meet the chart carriage requirements of SOLAS Chapter V/19.

**Performance Elements**

There are two key performance elements to ECDIS:

* An approved processing system (or ‘box’) that has been certified as meeting the IEC 61174 and other relevant performance testing specifications;
* Electronic Navigational Charts (ENCs) that have been issued by or on the authority of a government, hydrographic office or other relevant authority and meet the standards set down in the 3rd Edition of the IHO Publication 57 (S-57) and other related IHO standards governing electronic charts;
* Raster Navigation Charts (RNC) that are effectively electronic copies of paper charts and have been issued by or on the authority of a government, hydrographic office or other relevant authority, may be used in an ECDIS to meet carriage requirements, but only in those cases where no ENC has been published covering the area in question.

While an ECDIS ‘box’ may be capable of reading other forms of electronic charts, it ceases to be a compliant system without the official ENC. Electronic charts that will not satisfy the SOLAS carriage requirements include:

* All electronic charts that are not issued under the authority of a national authority;
* All charts that do not conform to the relevant IHO standards for electronic charts;
* Additional information on ECDIS is available on the IMO and IHO websites.

**4.13 Maritime Information**

The timely provision and display of maritime information will be an essential component of e-Navigation. Generically called Marine Information Overlays (MIOs), this includes both static and dynamic information capable of being used ashore (e.g., at a VTS Centre) and onboard ships at sea.

Static information could pertain to marine protected areas, sea ice coverage, emergency management/response areas, and seafloor bathymetry. Dynamic operational information would be broadcast via AIS binary messages as time-critical information regarding ship/voyage data, marine traffic signals, area notices, dangerous cargo, environmental, meteorological, hydrographic, and status of AtoN. In particular, mariners require this type information pertaining to the planning and execution of voyages, the assessment of navigation risk and compliance with regulation. The provision and use of MIOs will depend on the current situation and task-at-hand.

At the 54th session of the IMO Safety of Navigation Subcommittee (July 2008) it was recommended that there be Common Maritime Information/Data Structure that would 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. Ideally, 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.

At present, there is no specific guidance or standards related to the presentation/display of MIOs on shore-based equipment or systems. However, there are a number of general and equipment-specific international standards that have been adopted by IMO, IHO, and IEC that contain “guidance” related to the presentation/display of various types of shipborne navigation-related information. This is something that will need to be part of e-Navigation development and implementation.

**4.14 AtoN Attribute Information**

The exchange of information about AtoN between any parties in a digital environment will require an internationally agreed standard so that information can be automatically compiled for sending and automatically understood by systems that receive it.

Such a standard will enable harmonisation of the management of information about AtoN, and in particular information that is relevant to mariners: “situation normal” data (position, colour, shapes, light etc) and also “situation abnormal” (lost top mark, light on reduced range, unlit etc). In GIS terms this sort of information can be described as attribute data (information particular to a GIS object, such as an AtoN) and metadata (data about the attribute data).

**4.15 e-Navigation Testbeds**

The term testbed is used across many disciplines to describe a platform that is used for research, development or testing. Such a platform is can be protected from a live (or production) environment. However, in the maritime domain, it is often necessary to conduct live tests with appropriate safety precautions in place.

In order for e-navigation solutions to have global application, IALA will facilitate the collation and sharing the outcomes of testbeds. In recent years, some of the more prominent testbeds that have been set up for e-navigation applications include:

* EfficienSea (Baltic Sea);
* ACCSEAS (North Sea);
* Mona Lisa (Baltic Sea);
* The Marine Electronic Highway (MEH) (in the Straits of Malacca and Singapore).

The implementation of e-Navigation will be phased and iterative.

Therefore, it is important that outcomes or lessons learnt from test-bed projects be considered in the context of the main elements of the IMO Strategy Implementation Plan (i.e. user needs, architecture, gap analysis and solutions that are the subject of cost-benefit and risk analyses). IALA has taken on the role of coordinating the requirements and results of e-Navigation Test Beds.

1. A registry is simply a bookkeeping device where definitions/ specifications are kept in organised locations known as registers. the registry eases the tasks of development of new things, by providing a centralised source for finding definitions/ specifications
2. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-2) Refer to in particular MSC85/26, Annex 20, paragraphs 9.9.1., 9.1.5, and 9.9.3.
3. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-3) GPS Performance Stanards, 2008.
4. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-4) United Nations Office for Outer Space Affairs, “Current and Planned Global and Regional Navigation Satellite Systems and Satellitebased Augmentations Systems”, 201
5. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-5) At the time of writing, further information on Galileo may be found on the internet [http://ec.europA.eu/enterprise/policies/satnav/](http://ec.europa.eu/enterprise/policies/satnav/) galileo/index\_en.htm
6. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-6) At the time of writing, further information on BeiDou may be found on the internet hhttp://www.en.beidou.gov.cn/csnclist.html
7. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-7) A 1kW transmitter will generally allow position fixing to better than 10 metres over a radius of about 200 nautical miles.
8. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-8) United Nation Office of Outer Space Affairs
9. [Jump up ↑](http://www.iala-aism.org/wiki/ialawiki/index.php/Navguide:_Chapter_4_-_e-Navigation" \l "cite_ref-9) Section 12 of the IALA Guideline 1028 on AIS Volume 1 Part 1 – Operational Issues.