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| IALA G1155 Maritime Service Description |

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MS-2 – Aids To Navigation Service

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No table of contents entries found.

List of Tables

***No table of figures entries found.***

List of Figures

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MS-2 – Aids to Navigation Maritime Service

IALA G-1155 Maritime Service Description

# Introduction

The maritime domain is facing a number for challenges, mainly due to the increasing demand, that may increase the risk of an accident or loss of life. These challenges require technological solutions and e-Navigation, as a concept, is one such solution. The International Maritime Organization (IMO) in 2010, adopted a strategy for the development and implementation of this concept (MSC.85/26/Add.1 Annexes 20 [1] and 21 [2]), which eventually resulted in the adoption of the MSC.1/Circ.1595 Strategy Implementation Plan (SIP) [3]. In that document e‐Navigation is defined as:

“…the harmonized collection, integration, exchange, presentation and analysis of maritime information on-board and ashore by electronic means to enhance berth-to-berth navigation and related services, for safety and security at sea and protection of the marine environment.”

The IMO SIP outlines 5 key solutions as the basis for accomplishing the e-Navigation vision:

* S1: improved, harmonized and user-friendly bridge design.
* S2: means for standardized and automated reporting.
* S3: improved reliability, resilience and integrity of bridge equipment and navigation information.
* S4: integration and presentation of available information in graphical displays received via communication equipment.
* S5: improved communication of VTS Service Portfolio (not limited to VTS stations).

As part of the improved provision of services to vessels through e-Navigation, Maritime Services (MSs) have been identified as the means of providing electronic information in a harmonized way, which is part of solution S5.

Under MSC.1/Circ.1610 [4], as amended [5] per IALA input, the IMO provides a set of descriptions of the identified MSs, to ensure that their future implementation is done internationally in a standardized and harmonized format. The MS-2 ¬– Aids to Navigation Service was introduced, with the aim of promulgating the latest information on AtoN and augment charted AtoN information on an appropriate shipborne navigation display prior to updates to the nautical chart. IALA as the organisation responsible for the harmonization and standardisation of the provision of Aids to Navigation (AtoNs), is the most well-positioned international body to provide a more detailed description of the context of the MS-2 – Aids to Navigation Service and offer guidance the high-level considerations of how it should be implemented. To do so, the IALA G-1155 [6] guideline template is utilised, as this was specifically defined to support the IALA members on the specification process of MS.

## Purpose of this Guideline

The purpose of this document is to provide a holistic overview of the MS-2 – Aids to Navigation Service and its building blocks in a technology-independent way. The aim is to outline the e-Navigation context of the service, establish the captured user needs which justify a business case for it, and finally support the service architects in creating a description on the involved technical services at a high level of abstraction, by providing the key aspects of the service at the logical level:

* Context and goal of the service.
* Relations to other services.
* User needs, information needs, high level functional and non‐functional requirements.
* Requirements traceability matrix.
* Business architecture with a Business Process Model (BPM).

## Context of the Maritime Service

As specified in [5], the MS-2 – Aids to Navigation Service describes the provision of AtoN deployed to enhance the safety of navigation. AIS Application Specific Messages (AIS-ASM) are not included in the description of the MS.

IALA defines an AtoN as any device, system or service, external to vessels, designed and operated to enhance the safe and efficient navigation of individual vessels and/or vessel traffic. The IMO definition of the MS-2 – Aids to Navigation Service includes any Positioning, Navigation and Timing (PNT) services, while Vessel Traffic Services (VTS) are considered separately in [5]. In the question of PNT, the physical AtoN infrastructure is seen as an integral part, as it cannot be spoofed or jammed. In addition, AtoN structures can be utilised to measure the integrity of PNT information. As such, PNT will be considered in this document as well.

### AtoN Information Flow

This maritime service specification document describes the high-level flow of AtoN information between a service provider and the end-users of such a service. In most cases, the service provider is an AtoN Authority, while the end-users include both shoreside authorities/organisations and mariners, which may (or may not) need to display the data onto a type-approved Electronic Chart Display and Information System (ECDIS) or any other Electronic Chart System (ECS) in general. These relationships are illustrated in the information flow diagram of Figure 1. Please note that this diagram is just the representation of a typical envisioned environment, and other variations may also be established.



1. Figure 1: AtoN Information Flow

The diagram is divided into two main sections, illustrating how navigation data is distributed and utilized.

* The Shore-Side
* The Ship-Side

At the core, the AtoN Authority serves as the primary provider of AtoN information. This may be collected directly and/or indirectly, from all AtoN deployed and monitored in the AtoN authority’s area of responsibility. The AtoN Authority is in most cases in close collaboration (in several member states even joint) with the responsible Coastal Authority and the Hydrographic Office (HO) Authority. These three entities are required to continuously share AtoN information. This inter-authority data exchange is expected to take place using the IALA S-201 data product specification. The AtoN information is then disseminated to other key stakeholders such as Search and Rescue (SAR) Authorities, Regional Electronic Navigational Chart Coordination Centre (RENCs), and in some cases even maritime data Value Added Resellers (VARs). The primary data format used for all these interactions is expected to be in line with the IHO S-100 framework. The conformance requirement enhances the data quality and supports the interoperability of the communication mechanisms.

On the commercial and technical side, the AtoN information extends to Value-Added Resellers (VARS), as well as the Distributors and Original Equipment Manufacturers (OEMs), which are responsible for the distribution of navigational data and AtoN information to the end-users using equipment covered by SOLAS. This step includes the communication over the “last-mile”, as this is defined by the IEC 63173-2 (SECOM) [6]. standard. The design and implementation however of the “last-mile” solutions, is considered to be vendor-specific and outside the scope of this document.

Public Portal services could potentially act as another vital distribution point. They can be paid of free of charge services, which may offer access to the AtoN information through IHO S-125 data product specification. S-201 is not suggested for this operation as an unnecessarily large description with potential safety issues. The S 201 format is designed for different aspects of maritime navigation, and although it is technically supported by Electronic Chart Display and Information Systems (ECDIS), this is not currently the accepted standard method of distribution. Navigational Warning (NW) and other MSI-related information may also be shared using the NW IHO S-124 data product. The information flow through a coastal authority or a public portal, may further support the AtoN information dissemination to end-users without equipment covered by SOLAS, more specifically users of third-party Electronic Chart Systems (ECS). This flow can also complement the availability of AtoN information towards the OEMs if and when required.

On the ship-side, the processed and distributed AtoN information is intended to reach all end-users, including SOLAS vessels, non-SOLAS vessels. This ensures that all classes of maritime traffic, from large commercial ships to smaller recreational or non-SOLAS vessels, can reliably access the same navigational information, even if it has been packaged differently, or is distributed with a different update frequency. The harmonized data flow enhances maritime safety by ensuring that critical AtoNs, such as buoys, beacons, and lighthouses, are accurately represented in digital navigation systems. The MS-2 service also aspires to establish a standardized and trustworthy feedback loop for AtoN status reports. This would allow mariners to report AtoN outages and deviations from the advertised standards. Communication security and identity management become paramount in that use case, to ensure the reliability and integrity of the reported outages.

### Types Of Information

As per the non-exhaustive list found in [5], user needs may include the most up-to-date presentation of information on:

* New hazards (fixed or dynamic)
* Temporary channels or routes
* Temporary areas to be avoided (e.g. restricted areas, military exercises)
* Survey, dredging, fishing, special marine events)
* Changed hydrography, such as shifting banks
* Temporary replacement of a charted aid that is off station or removed
* Dynamic areas (e.g. reduced visibility, presence of protected species)
* Polar navigation, provided there is sufficient means of radio communication broadcast and charting
* Ice conditions and navigation
* Incident response (e.g. environmental, search and rescue)
* Port-specific applications (e.g. passage planning, amended pilot boarding location)
* Measures for the protection of the marine environment
* Security
* PNT information on position in real time (timing is a critical component in the provision of some AtoN services, and the need to synchronize and reference radionavigation signals to Universal Coordinated Time (UTC) will increase as look to use more diverse systems and solutions)
* PNT integrity (recognizing the vulnerability of radionavigation systems to interference (e.g. GNSS jamming); the use of multiple dissimilar positioning and timing systems is required to achieve resilience in support of safe navigation and the optimal working of AtoN)

This document also makes special mention to the following types:

* New construction areas (e.g. offshore wind farms)

### Associated Technical Services

Once again, as per [5], the MS-2 – Aids to Navigation Service make use of the IHO S-100 framework relevant data product specifications (S-125, S-124, S-201 and S-240) and is comprised of a set of associated technical services, as shown in the following table:

1. MS-2 Associated Technical Services.

| Name | ID (MRN) | Description | Standardization Body |
| --- | --- | --- | --- |
| Provision of AtoN Information Service to End Users | urn:mrn:iala:techsvc:ss:arm:atoninfo | Using the data model from the S-125 product specification | IALA (IHO) |
| Enhanced AtoN Information for AtoN Authorities | urn:mrn:iala:techsvc:ss:arm: enhancedatoninfo | Using the data model from the S-201 product specification | IALA |
| Navigational Warnings Service | urn:mrn:iho:techsvc:ss:nwinfo | Using the data model from the S-124 product specification | IHO |
| PNT Information | urn:mrn:iala:techsvc:ss:arm:pntinfo | Using the data model from the S-240 product specification | IALA |

## Objectives Of The Service

This section provides information about the objective(s) of the MS-2 – Aids to Navigation Service. These are not operational but rather conceptual. Therefore, they cannot be described directly into Specific, Measurable, Achievable, Realistic, and Timely (SMART) terms. A specific but high-level approach is followed, resulting in the following entries:

* **OBJ1**: Provision of AtoN information service to all end-users.
* **OBJ2**: Provision of AtoN information to other authorities.
* **OBJ3**: Describe physical, virtual and synthetic AtoN.
* **OBJ4**: Deliver the current status and changes of AtoN information.
* **OBJ5**: Supplement charts and nautical publications with accurate “high-quality” AtoN information.
* **OBJ6**: Support the adoption of MASS, supplying up-to-date machine readable AtoN information.

The **OBJ#** identifiers, provided for each of the stated objectives, should be used to reference the objective for each of the technical service requirement specifications.

## Intented Users Of The Service

Following the operational context and the AtoN information exchange diagram of Figure 1, the following non-exhaustive user list is defined for the MS-2 – Aids to Navigation Service:

* Other AtoN authorities
* Coastal Authorities
* Hydrographic Offices
* Regional Electronic Navigational Chart Coordination Centers (RENCs)
* Value-Added Resellers (VARs) and Distributors
* Search & Rescue Services
* VTS Providers
* Other Electronic Chart System providers
* Automated systems for navigation of vessels in coastal and/or open waters.
* Mariners with or without SOLAS equipment navigating in coastal or open waters

# User Needs

This section presents in Table 2 the per objective information needs, which are to be fulfilled by the MS-2 – Aids to Navigation Service. It should be stressed that all users identified in the previous section are included in this context, not just the mariner end-users.

1. The MS-2 User-Needs

| Objective | User Needs |
| --- | --- |
| OBJ1 - Provision of AtoN Information to End Users | Most up-to-date AtoN information |
| Information on expected AtoN changes |
| User-specific warnings on the area of operation |
| Users should be able to select the relevant data segments, for larger area of operations |
| Presentation should be clear and concise |
| Reporting facility to correct discrepancies |
| Ability to trust the data integrity |
| OBJ2 - Provision of AtoN Information to Authorities | Administrative data (metadata for governance) |
| Most up-to-date AtoN information critical for the information flow integrity |
| Ability to trust the data integrity |
| Standardization and common reference framework (e.g. S-100) |
| OBJ3 - Describe Physical, Virtual, and Synthetic AtoN | Clarification of AtoNs types (physical, virtual, synthetic) |
| Compatible descriptions for AtoN types |
| Common framework for managing maintenance |
| OBJ4 - Deliver Current Status and Changes of AtoN Information | Most up-to-date AtoN information critical for delivering status and updates |
| Real-time monitoring information (e.g. telemetry, NW) |
| AtoN service report mechanisms |
| Feedback and validation of AtoN discrepancies (S-100 data products can be utilized) |
| OBJ5 - Supplement Charts and Nautical Publications with Accurate “High-Quality” AtoN Information | Data accuracy and validation information |
| Metadata for verifying data source and accuracy |
| Simplified view of AtoN information, equivalent to a list of AtoN (List of Lights) |
| Simplified views should include AtoN Status |
| Integration support for charting systems |
| Include information that is not urgent enough to be sent as a NW, equivalent to a Preliminary/Temporary Notice to Mariners |
| OBJ6 - Support the Adoption of MASS, Supplying Up-to-Date Machine-Readable AtoN Information | Information in machine-readable formats (JSON/XML) |
| AtoN information endpoint specifications provided |
| Discovery information for the AtoN information endpoints |

# Features

This section describes the main features of the MS-2 – Aids to Navigation Service. These should not be mistaken for the data model features defined in the S-100 framework; in the current context, ‘features’ refers specifically to the service’s functions and capabilities. A list of the main features identified, including their associated descriptions, is presented in Table 3.

Table 3 references several user roles, i.e. seafarers, AtoN authorities, VARs etc. Based on the data exchange interactions depicted in Figure 1, the identified roles can act as a Service Consumer or a Service Provider. In the present context, these are defined as:

* ***Service Consumer***: Refers to any intermediate or end user (as per Figure 1) who ultimately receives AtoN information. The service consumer is the party that benefits from the provided information, which helps them fulfil their statutory or business duties, or navigate safely and efficiently.
* ***Service Provider***: Any entity responsible for packaging, distributing, and presenting AtoN information to the intermediate or end-users (service consumers). This could be a government agency, such as an AtoN Authority or a Hydrographic Office. Alternatively, it might be a private company offering navigation services, like a marine data provider or an ECDIS manufacturer.

1. MS-2 Feature Descriptions.

| Feature Identifier | Feature Description | Objective(s) |
| --- | --- | --- |
| F001 | As a: Seafarer, | OBJ1, OBJ5 |
| I want to: Retrieve AtoN information on specific areas using filtering criteria (e.g., area name, geometry, or dataset identifier), |
| so that: I can access relevant navigation information for my operational needs and minimise the communication resource requirements. |
| F002 | As a: Seafarer, | OBJ1, OBJ4, OBJ5 |
| I want to: Subscribe to updates for specific AtoN information, |
| so that: I can automatically receive changes without repeated manual requests, minimising the required effort and delays. |
| F003 | As a: Seafarer, | OBJ1, OBJ4, OBJ5 |
| I want to: Terminate a subscription to the latest AtoN information when it is no longer needed, |
| so that: I can stop receiving unnecessary updates. |
| F004 | As a: Seafarer, | OBJ1, OBJ4, OBJ5 |
| I want to: Schedule a subscription to the latest AtoN information at any point in the future, |
| so that: I can automatically receive updates on change, but only when I need them to minimise use resource usage and costs. |
| F005 | As a: Seafarer, | OBJ1, OBJ4, OBJ5, OBJ6 |
| I want to: Receive information from multiple authorities using the same equipment (including software), |
| so that: I can safely navigate through multiple areas or responsibility. |
| F006 | As a: Seafarer, | OBJ1, OBJ5 |
| I want to: Confirm the integrity and validity of the received AtoN information even without always-on internet connectivity, |
| so that: I can make decisions based on data I can trust. |
| F007 | As a: Seafarer, | OBJ4, OBJ5 |
| I want to: I want to be able to report discrepancies on AtoN in a standardised way, |
| so that: they can be addressed earlier. |
| F008 | As a: Seafarer, | OBJ1, OBJ3 |
| I want to: View the AtoN information clearly, with the appropriate details and geographic context, |
| so that: I can navigate safely, regardless of whether I am on-board a ship with SOLAS equipment or not. |
| F009 | As a: AtoN Information VAR/ECS Provider, | OBJ1, OBJ2 |
| I want to: I want to be able review and verify the AtoN information I receive, |
| so that: I can guarantee that information to my own users. |
| F010 | As a: AtoN Information VAR/ECS Provider, | OBJ1, OBJ2, OBJ5 |
| I want to: Make my services available only to authorised users, |
| so that: I can protect control who has access to my resources. |
| F011 | As a: AtoN Authority, | OBJ1, OBJ4 |
| I want to: Receive acknowledgments for important updates sent to certain consumers, |
| so that: I can confirm successful delivery and ensure the system reliability. |
| F012 | As a: AtoN Authority, | OBJ1, OBJ4 |
| I want to: Upload updated AtoN datasets to subscribed consumers, |
| so that: They always have the latest navigation information. |
| F013 | As a: AtoN Authority, | OBJ4 |
| I want to: Automate my AtoN servicing information ingest, |
| so that: I can realise operational efficiencies and minimise costs. |
| F014 | As a: AtoN Authority, | OBJ1, OBJ5, OBJ6 |
| I want to: Make my services discoverable by any interested party, |
| so that: all my end users can easily have access to these. |
| F015 | As a: AtoN Authority, | OBJ1, OBJ2 |
| I want to: Keep track of the changes made in my AtoN information, |
| so that: I can review what was sent to my users for auditing. |
| F016 | As a: AtoN Authority, | OBJ4, OBJ5 |
| I want to: access information on the status of AtoN from the consumers, |
| so that: I can check it and then send the MSI consequently. |
| F017 | As a: AtoN Authority, | OBJ4, OBJ5 |
| I want to: validate the user-reported information on the status of AtoN from the consumers, |
| so that: I can ensure the correctness of the information sent as MSI. |
| F018 | As a: AtoN Authority, | OBJ1, OBJ2, OBJ5 |
| I want to: be able to reduce the precision of the publicly reported AtoN locations, |
| so that: small craft users, non-covered by SOLAS, will not accidentally hit them. |

# Guiding Principles

## Architectural Parameters

This section describes the architectural parameters for the MS-2 Aids to Navigation Service. These refer to the key design choices and considerations that shape the overall structure and behaviour of a system. These parameters can influence how well the system performs its intended functions, interacts with other systems, and responds to various inputs.

Each architectural parameter is described in its section below, with the rational for each being clearly stated.

### Focus on the Provision of AtoN Information

The Aton Authorities of the IALA member states, as the organizations responsible for the maintenance and operation of the marine Aids to Navigation in their respective geographical areas, are primarily concerned with fulfilling their day-to-day responsibilities. The aspiration for the MS-2 – Aids to Navigation Service is to support them in that regard. The service should therefore only provide the relevant AtoN information and report discrepancies as soon as possible. Additional information and functionality should be avoided, for the benefit of simplicity and reliability. The service itself may be regarded as an AtoN, and therefore the AtoN categorization and availability objectives, as per IALA O-130 [7], could potentially apply to it.

### Use of the IHO S-100 Framework

AtoN, NW (MSI-related) and any other related maritime information, must be provided using methods that conform to the S-100 framework. This is a key principle for achieving the IMO e Navigation goal of ***“the harmonized collection, integration, exchange, presentation and analysis of maritime information on-board and ashore by electronic means”*** [3]. The exchanged data can be packaged in multiple ways, but under the S-100 framework there are two main recognised container types:

* Exchange of “pure” S-100 Datasets
* Exchange of S-100 100 Exchange Sets

S-100 datasets are in most cases XML-based files, that contain no additional metadata. This simpler representation of AtoN information, can in some cases might be the preferred way for transferring the data, especially if these are not intended for portrayal on ECDIS devices. A related use case could be the digital equivalent of the current List of Lights carriage requirement.

However, for cases where the data is intended (directly or indirectly) for consumption by ECDIS, or other equipment covered by SOLAS, additional information such as the data product feature catalogue and relevant metadata (including security details) is necessary. In S-100, these data structures are organised into a collection of files, known as Exchange Sets. This would be the method of choice for transferring the AtoN information in the Figure 1 data flow, which passes through the HO and the RENCs.

### Use of Established Data Products

AtoN and NW (MSI-related) information must be provided using the existing relevant S-100 product specifications, if present. More specifically, for the associated technical services list, identified in Section 1.2 the respective IHO data products based on the S-100 framework are:

* S-124
* S-125
* S-201
* S-240

This way the information will be more widely understood, while the services will reuse existing data product specifications. For cases where an existing data product specification is not available (e.g. in the case of AtoN Status Reports from mariners), new data standardized product specifications should be proposed and developed.

### Secure by Design

“Secure by Design” is an approach to system development that prioritizes security as a fundamental aspect of the design process, rather than treating it as an afterthought or an add-on feature. This means that security considerations are integrated into every stage of the development lifecycle, from initial concept and design to implementation, testing, and deployment.

This approach is mandatory to be incorporated into the new development of all the MS-2 – Aids to Navigation Service subsystems. Service providers should be able to secure their AtoN information flows, ensuring that only authorised users utilise the system resources, and that this is achieved in a controlled manner. In addition, authentication and authorisation techniques can be used to support potential auditing and even billing capabilities. Finally, all end-users should also be able to independently verify the integrity and accuracy of the information they have received.

### Leverage Automation

One of the key advantages of the MS-2 – Aids to Navigation Service should be its focus on automating tasks, which currently might be performed manually and are quite laborious or prone to errors. By automating these tasks, the MS-2 service can achieve higher data quality and reduce the data processing times. Automation techniques may include examples of Application Programming Interfaces (API), machine readable formats for the data, as well as advanced algorithmic and machine-learning techniques.

Of particular interest to the AtoN Authorities of the IALA member states, is the automation of the communication between them and the HOs. Automatic updates on the status of the AtoN operations, as well as automatic confirmations of successful receipt of those updates by the HO, should be considered as the top priorities during the first phases of the MS-2 deployment.

### Data Driven

The operation of the MS-2 – Aids to Navigation service should be data driven, meaning that the information flow processes should follow the AtoN status changes. This would ensure that critical information, such as AtoN outages, as well as the NW (MSI-related) generation procedures put in place, are promulgated as soon as available.

It is however well understood that this might not always be feasible - at least not during the first phases of the system deployment (due to practical reasons, resource constraints etc.). It is therefore expected that at least initially, only the high priority AtoN discrepancies/changes and NW (MSI-related) information, would follow the data driven approach, while the rest of the AtoN information data flows of Figure 1, would be produced and promulgated at regular intervals (e.g. once a day or a week).

## Functional and Non-Functional Requirements

1. Functional Requirements for the MS-2 AtoN Information Service.

| Requirement Type | Requirement ID | Requirement Name | Requirement Text | Feature Identifier |
| --- | --- | --- | --- | --- |
| **Functional** | MS2-FR001 | Provision of dataset(s) | The service provides S-100 compliant dataset(s) with all current and valid AtoN Information assigned to that dataset(s). | F001, F005 |
| **Functional** | MS2-FR002 | Request for dataset(s) | The end users can receive on demand S-100 compliant dataset(s). Service providers will respond with current data relevant to the request but will not subdivide datasets to less than that defined by the authoritative source of the data. | F001, F005 |
| **Functional** | MS2-FR003 | Filter AtoN Information | The end-users can filter the AtoN information based on a point, line, polygon geometry, AtoN type, AtoN status etc. | F001, F008 |
| **Functional** | MS2-FR004 | Retrieve AtoN Status Updates | The end-users are able to request and filter out only the AtoN which have associated status changes. | F001, F008 |
| **Functional** | MS2-FR005 | Subscribe to dataset(s) | The end users can subscribe to receive S-100 compliant dataset(s) and their respective updates. Subscription requests should be able to include the start and stop time of the subscription. | F002, F004, F005 |
| **Functional** | MS2-FR006 | Status of Subscription | The service provides a subscription status notification. This could indicate termination of subscription from the service provider side. | F002, F003 |
| **Functional** | MS2-FR007 | Data Update Status | The service must be able to provide the users with the status of their respective subscritions and whether the current dataset is the latest one, along with other relevant information. | F002, F006 |
| **Functional** | MS2-FR008 | Cancellation of Subscription | The service provides a facility to cancel the subscription. | F004 |
| **Functional** | MS2-FR009 | Data Validation Certificate | The service can provide on demand the security certificate that was used to secure the data transmission. | F006, F009 |
| **Functional** | MS2-FR010 | Discrepancy Reporting | Provides a secure but open interface for reporting discrepancies. These reports should be authorized, and anonymous reporting should not be allowed. | F007, F016, F017 |
| **Functional** | MS2-FR011 | Discrepancy Flagging | Multiple AtoN service discrepancies are flagged to system administrators as soon as they are reported, so that they can be actioned. | F007, F016, F017 |
| **Functional** | MS2-FR012 | Information Filtering | The end users can filter the relevant AtoN information by name or based on a point, line, polygon geometry, or receive the complete service content. | F008 |
| **Functional** | MS2-FR013 | Delivery Acknowledgement Request | The service is able to request a data delivery acknowledgement for any end-user. The requested acknowledgement should support multiple levels (receiving, reading etc.) | F011 |
| **Functional** | MS2-FR014 | Delivery Acknowledgement Confirmation | The service provides a common but secure facility for all end-users to acknowledge the successful updates of AtoN information if requested. | F011 |
| **Functional** | MS2-FR015 | Subscription Updates | The service is able to identify and contact the subscribed end-users to push updates on the requested dataset(s). | F012 |
| **Functional** | MS2-FR016 | Input Automation | The service updates the advertised datasets, based on the AtoN status updates received. | F013 |
| **Functional** | MS2-FR017 | End-User Precision Tailoring | The service is able to supply AtoN information with certain details (e.g. precision of decimal points) tailored to the correspondig end-user. | F010, F018 |
| **Functional** | MS2-FR018 | Change Log | The service allows data producers to track the record of changes to the advertised dataset(s) for any time interval required. | F015 |
| **Functional** | MS2-FR019 | Change Log State | The service allows data producers to view the full state of the AtoN Information as provided to consumers at any past point in time. | F015 |

1. Non-Functional Requirements for the MS-2 AtoN Information Service.

| Requirement Type | Requirement ID | Requirement Name | Requirement Text | Feature Identifier |
| --- | --- | --- | --- | --- |
| **Non-functional** | MS2-NFR001 | Authorization | Service consumers are authorized by the provider for reception of data by the service. This may be public authorization (everyone has access), or limited authorization associated with a transactional service | F010, F016, F017 |
| **Non-functional** | MS2-NFR002 | Authenticity | Service consumers can verify independently the authenticity of the AtoN information transmitted to them. | F006, F009 |
| **Non-functional** | MS2-NFR003 | Integrity | It is clear to both service provider and consumer whether changes have been made to the AtoN information after this was created. | F006, F009 |
| **Non-functional** | MS2-NFR004 | Availability | The service is consistently available in its ability to deliver AtoN Information to its consumers. (i.e. Service should have a high availability) | F001, F002, F004, F005, F011, F013 |
| **Non-functional** | MS2-NFR005 | Responsiveness | The service provides a response to a service consumer’s request without delay, and the data provided should be (near) real time. | F001, F002, F011, F016 |
| **Non-functional** | MS2-NFR006 | Performance | The service can handle multiple requests simultaneously (e.g. 1000/sec). | F001, F010, F012 |
| **Non-functional** | MS2-NFR007 | Portability | The service makes the data available in portable machine-readable formats (e.g. XML/JSON) | F014 |
| **Non-functional** | MS2-NFR008 | Compression | The service is able transmit the data in compressed format, with the compression method (e.g., gzip) clearly indicated. | F001. F005, F008 |
| **Non-functional** | MS2-NFR009 | Accessibility | The AtoN information is accessible as much as possible and modern APIs should be supported for machine-to-machine communication. | F005, F010, F013, F014 |
| **Non-functional** | MS2-NFR010 | Compatibility | The service is compatible with as many end-user devices as possible and conforms to the latest relevant maritime standards (e.g. IEC 63173-2 (SECOM), S-100 (S-124, S-125, S-201, S-240)) | F005, F010, F013, F014 |

# Business Process Model

Figure 2 on the left depicts the general business process for the update of AtoN information on ENC’s as it is in the current situation. The AtoN information service aims to automate the collection AtoN updates and delivery to the service consumer this is depicted on the right side of the figure.



1. Figure 2: Business Process Model for AtoN Information in ENCs



1. Figure 3: The S-100 Operational Context in terms of the AtoN Information distribution

# Definitions

The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA dictionary) and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

Authentication

(from Greek: αὐθεντικός *authentikos*, “real, genuine”, from αὐθέντης *authentes*, “author”) is the act of proving an assertion, such as the identity of a computer system user [8].

Maritime Safety Information

Navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages.

Navigational Warning

A broadcast message containing urgent information relevant to safe navigation.

Navaid

An instrument, device or nautical publication carried on board a vessel for the purpose of assisting navigation.

NAVAREA

A geographical sea area, as shown in the appendix (IMO A.706(17) established for the purpose of co-ordinating the transmission of radio navigational warnings. Where appropriate, the term NAVAREA followed by an identifying roman numeral may be used as a short title. The delimitation of such areas is not related to and shall not prejudice the delimitation of any boundaries between States.

NAVTEX

Single frequency time-shared broadcast system with automated reception and message rejection/selection facilities. Use of NAVTEX is regulated by the IMO NAVTEX Manual (IMO publication 951).

Service

The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.

Service Data Model

Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model.

Service Interface

The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service.

Service Operation

Functions or procedures which enable programmatic communication with a service via a service interface.

Service Physical Data Model

Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data S-212 to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model. In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.)

# Abbreviations

1. List of Abbreviations

| Term | Definition |
| --- | --- |
| AtoN | Aids to Navigation |
| AIS | Automated Identification System |
| API | Application Programming Interface |
| ASM | Application Specific |
| ECDIS | Electronic Chart Display and Information System |
| ECS | Electronic Chart System |
| ENC | Electronic Navigational Chart |
| GNSS | Global Navigation Satellite System |
| HO | Hydrographic Office |
| IMO | International Maritime Organization |
| JSON | JavaScript Object Notation |
| MASS | Maritime Autonomous Surface Ships |
| MRN | Maritime Resource Name |
| MS | Maritime Service |
| MSI | Maritime Safety Information |
| NW | Navigational Warning |
| OEM | Original Equipment Manufacturer |
| PNT | Positioning, Navigation and Timing |
| RENC | Regional ENC Coordination Centre |
| SMART | Specific, Measurable, Achievable, Realistic, and Timely |
| SOLAS | Safety of Life at Sea Convention (IMO) |
| UTC | Coordinated Universal Time |
| VAR | Value Added Reseller |
| VTS | Vessel Traffic Services |
| XML | Extensible Markup Language |

# References

[1] International Maritime Organization (IMO), “Strategy for the development and implementation of e-navigation,” Resolution IMO-MSC.85/26/Add.1, Annex 20, 2010.

[2] International Maritime Organization (IMO), “Framework for the implementation process for the e-navigation strategy,” Resolution IMO-MSC.85/26/Add.1, Annex 21, 2010.

[3] International Maritime Organization (IMO), “E-navigation strategy implementation plan - update 1,” Circular IMO-MSC.1/Circ.1595, 2018.

[4] International Maritime Organization (IMO), “Initial descriptions of maritime services in the context of e-navigation,” Circular IMO-MSC.1/Circ.1610, 2019.

[5] International Maritime Organization (IMO), “Descriptions of maritime services in the context of e-navigation,” Circular IMO-MSC.1/Circ.1610/Rev.1, 2024.

[6] International Electrotechnical Commission (IEC), “Maritime navigation and radiocommunication equipment and systems - data interfaces - part 2: Secure communication between ship and shore (SECOM),” Guideline 63173-2. Available: <https://webstore.iec.ch/en/publication/64543>

[7] International Organization for Marine Aids to Navigation (IALA), “Categorisation and availability objectives for short range aids to navigation,” Recommendation 1155. Available: <https://www.iala.int/product/r0130/>

[8] “Authentication,” *Wikipedia*. Feb. 13, 2024. Available: <https://en.wikipedia.org/w/index.php?title=Authentication&oldid=1206921340>

# Annex A. IMO User Needs And Priorities

For reference, this annex provides three discrete tables with the user needs and priorities that have been identified in the IMO in MSC.1/Circ.1595, Annex 3 [3]. The tables focus specifically on Shipboard, Shore-based and Search and Rescue (SAR) users respectively. Only the entries that are deemed relevant to the MS-2 Aids to Navigation Service specification have been included.

User need

Justification

Relation to IMO strateg

Priority in terms of work required

Issues to consider

Human Machine & Interface Issues

User-selectable presentation of information received via communication equipment

Seafarers expressed a desire to have the possibility to present user-selectable information received via communication equipment on the navigational displays (e.g. ship in distress, wind speed/ direction, AtoN status, restricted areas). They further requested the possibility to filter some transmitted data for presentation according to user-set parameters (e.g. only information from user-selected sea areas).

* Effective communication - Human-centred presentation needs - Human-machine interface - Analysis
* Research should be conducted regarding the type of information, equipment and systems involved and how to present and/or filter such information.
* Availability of information in real-time with possible presentation on the shipborne navigational displays. Information overload needs to be prevented, therefore, presentation of information should be user-selectable to filter required information. Task-oriented presentation based on INS-tasks (resolution MSC.252(83)).

User need

Justification

Relation to IMO strateg

Priority in terms of work required

Issues to consider

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* Effective communication- Human-centred presentation needs- Human-machine interface- Analysis
* Research should be conducted regarding the type of information, equipment and systems involved and how to present and/or filter such information.
* Availability of information in real-time with possible presentation on the shipborne navigational displays. Information overload needs to be prevented, therefore, presentation of information should be user-selectable to filter required information. Task-oriented presentation based on INS-tasks (resolution MSC.252(83)).
* Maritime Safety Information (MSI) Seafarers expressed a desire to sort and display MSI, such as NAVTEX, SafetyNET, more effectively.
* On most ships, NAVTEX information is displayed on a separate screen or printed on a scroll of paper. The Latitude and Longitude of the MSI must then be compared to that of the ship by the watchkeeper to identify whether the information is relevant and poses a risk. For example, notifications of new and dangerous wreck carriers are not prioritized over drifting buoys, possibly hundreds of miles away from the ship’s intended route. This is a very time-consuming and distracting task, and susceptible to human error. Seafarers considered that presenting such safety information on the ship’s navigation display would be far more effective and a clear benefit of e-Navigation.
  + Effective communication- Human-centred presentation needs- Human-machine interface- Analysis
  + Work with relevant stakeholders to address technical requirements for presenting MSI on shipborne navigation displays. Take note of Methodology for developing e-Navigation user needs using a task-based approach (NAV 55/11/4).
  + Possible re-formatting of NAVTEX data and continuing with transmitting data on same frequencies. Transition from old to new format. Task-oriented presentation based on INS-tasks (resolution MSC.252(83)).
  + Indication of Reliability
  + Seafarers have expressed a concern that on systems such as ECDIS, the ship’s position is always indicated as an absolute, leaving seafarers to rely on their understanding of technically complex systems to assess the accuracy of such indicated positions. Seafarers have expressed a desire for systems to automatically assess the accuracy and integrity of hydrographic data, position fixing data, radar, and other ship sensors to return a graphical indication of assessment.
    - Human-centred presentation needs- Human-machine interface- Data and system integrity- Analysis
    - Investigate effective ways to indicate levels of reliability using graphical representation. Take note of:- Resolution MSC.252(83) (INS)- Other industry standards.
    - Consideration of using, e.g. ellipses of uncertainty to indicate expected accuracy. Consideration of using, e.g. colour or shading changes to indicate integrity of information.
    - Operational Issues
    - Improved Reliability Before seafarers are confident in e-Navigation systems, they must prove far more reliable than many of the present systems.
    - Seafarers today often struggle with electronic equipment that fails or malfunctions in some respect. This may relate to poor performance from radar; electronic chart software faults; incorrect AIS data, GMDSS alerts or loss of position fixing systems. Even a 99% reliability rating would result in a problem for 1 voyage in every 100. This has resulted in many seafarers distrusting electronic systems, and now having grave doubts about relying on e-Navigation. It must be recognized that there is little competence for fixing such systems on board, and obtaining the services of a qualified technician in some ports can be difficult.
      * Effective and robust communications- Data and system integrity
      * It will be necessary to carry out an assessment to quantify reliability parameters. To include specific assessment of reliability of electronic position fixing systems.
      * Design specification for current equipment. Type approval process. Competence of installation and repair technicians. Better control and visibility of software and hardware updates.
      * Reduction of administrative burden and increase use of electronic documentation
      * Seafarers expressed the need to reduce the amount of administrative work on board. They also expressed a desire to replace paper information and documentation by electronic means for easy location of information.
        + Human-centred presentation needs- Data and system integrity
        + Investigate the best way to harmonize and present maritime documentation in an electronic format to improve efficiency and reduce administrative burden.
        + Electronic documents should support: easy localization of information (e.g. with the help of a search function); automatic updates (e.g. of Notices to Mariners); possible integration of information from multiple sources; the integration of information in other systems on the bridge (e.g. ECDIS) electronic documents should be printable or be additionally provided as paper version; the need for traceability and ability to audit.
        + Automated Updating of Baseline Data and DocumentsSeafarers expressed a desire for documents such as charts and voyage planning publications to be automatically updated, with minimal shipboard intervention.
        + Seafarers are required to use a plethora of publications associated with voyage planning and monitoring. These include, but are not limited to: charts, lights list, lists of radio signals, sailing directions, port guides, etc. Currently, most of these are kept on board in paper format and require a considerable amount of time to keep constantly updated. Seafarers believe that e-Navigation can be of benefit if it ensures that all these sources of information are automatically maintained up to date, and all of this information is accessible from a centralized location. Seafarers have also expressed a desire for this information to be easy to access, sort and make sense of. This may be achieved by standard formats or smart systems. Seafarers are very concerned that e-Navigation may lead to more information being made available to them, leading to further overburdening. It is essential that the provision of information via e-Navigation should be managed and presented effectively.

Common maritime information/data structure- Effective and robust communications- Human-centred presentation needs- Analysis

Investigate and harmonize means for automated updating of baseline data and documents, including consideration of legal aspects communication costs.

Consideration should be given to a proper electronic format for the data rather than digital copies of existing paper publications. This would allow the presentation of relevant data in a succinct manner. The need for traceability and ability to audit.

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 ships to facilitate safety, security and environmental protection and to provide operational information. To be effective, communication with and between ships should make best use of audio/visual aids and standard phrases to minimize linguistic challenges and distractions to operators. Research has indicated that a high percentage of seafarers regard language incompatibility and non-standard phrases as a major problem. They also highlighted equipment failure and busy communication channels a concern that needed to be addressed.

Automated and standardized reporting functions- Effective and robust communications- Common marine/data structure- Data and system integrity- Human-centred presentation needs

Research into how voice and digital communication can be made more effective. Plan for greater use of IMO SMCP (resolution A.918(22)). Identify reliability standards for communication technology. Identify communication capacity issues to ensure adequate bandwidth for essential communication needs.

Route exchange. Use of AIS application specific messages. Use of Wireless technology (Wi-Fi and Wi-MAX).

User need

Justification

Relation to IMO strateg

Priority in terms of work required

Issues to consider

Human Machine & Interface Issues

Collection of information

Complete marine domain awareness is essential for the early identification of risks and effective response. The collection of information is necessary to build an enhanced domain awareness, to support safety, security, environment protection and efficiency. This allows for faster and more informed decisions. There are rules that require coastal States to maintain domain awareness. There is currently a gap between the information collected and information required. A change in the type of service offered by a VTS (i.e. Information Service, Navigational Assistance Service or a Traffic Organization Service) may change the functional requirements of the domain awareness system.

* Common maritime information/data structure- Automated and standardized reporting functions- Effective and robust communications- Data and system integrity- Analysis
* Identify the data that will be required. Identify the data sources that will be required. Identify the key data providers, the standards that apply, the types of data they provide and any limitations. Identify the relationship between key data providers and users. Identify relevant legislation. Identify harmonization needs for standards, formats and protocols. Develop a system to allow the global exchange of ship and other maritime reporting data.
* Such information may include both static and dynamic information including hydrographic, environmental, vessel data, AtoN information and known hazards. Take into account AIS and GMDSS standards.Take into account the functionality of existing web-based systems.Take into account the development of Service Level Agreements with data providers.Take into account existing ship reporting systems.There are a multitude of communication methods that should be considered. Consideration will need to be given to legal and liability issues, specifically with regard to the handling of data. Take into account the lessons learnt from development of ECDIS.
* Management of information
* Shore authorities need tools for managing increased levels of information pertaining to the maritime domain awareness. A harmonized and holistic approach to information management will enable shore authorities to manage resources more efficiently. The harmonized and enhanced presentation of domain awareness will improve situational awareness for allied and other support services. Enhanced information management is required for improving logistics management and in support of safety, security and environment protection. Currently, there are major challenges to managing and sharing a diverse range of information from dissimilar systems. Current systems suffer without a harmonized approach to quality and structure.
  + Common maritime information/data structure- Automated and standardized reporting functions- Effective and robust communications- Human-centred presentation needs- Data and system integrity- Analysis
  + Identify the sources and ownership of information to be managed. Identify communication methods/variety of communication methods. Identify quality parameters for different types of information, including accuracy, reliability, latency, etc. Identify specific requirements for alerting for the loss of integrity or system failure. Identify the legal issues pertaining to capturing, storing and sharing data. Seek to harmonize policies for the security and use of data.
  + A gap analysis should be used to identify the capability of present information management systems to deal with an increasing amount of information in a timely manner. Take into account best practice for information management and examples from other industries, such as aviation. Take into account the benefits of open architecture systems.
  + Provision of information to ships
  + Shore authorities have an obligation to provide maritime information to ships. There is a need to improve the delivery and presentation of such information to enhance onboard decision-making. Effective and harmonized communication should allow for the provision of such information in an operationally effective manner.
    - Common maritime information/ data structure- Automated and standardized reporting functions- Effective and robust communications- Human-centred presentation needs- Data and system integrity- Analysis
    - Identify the information necessary to be provided to vessels, taking into account the responsibility assigned to the shore-based provider. Identify the means of communicating the information to vessels.
    - Consider the efficient provision of relevant information pertaining to logistics and commercial activities. Consider how to provide information to the seafarers efficiently and effectively. This pertains to traffic information, MSI, security-related information, updates to nautical publications, met-ocean information, etc. Take into account the need for scalability. Consider a facility for shore authorities to assess the real time status of shore systems and to disseminate this information as appropriate. Take into account the use of AIS binary messages.
    - Quality assurance
    - The shore authority needs to have confidence that the navigation systems being used on board are operating correctly. Shore authorities need to be confident that the information which they receive from and send to the ship is correct. Shore authorities have a need to be capable of establishing effective communication with bridge teams and other shore users.
      * Common maritime information/ data structure- Automated and standardized reporting functions- Effective and robust communications- Data and system integrity- Analysis
      * It will be necessary to carry out an assessment to quantify reliability parameters, taking into account existing IEC standards/IMO Performance Standards for onboard equipment. Investigate the technical and procedural capabilities for monitoring quality. Consider how information can have a quality rating.
      * Consider how shore authorities are assured of the navigation system status on board ships in real time. And for system faults ashore to be brought to the attention of seafarers as appropriate. Consider the effectiveness of communications in terms of technology and language. Consider legal and liability issues.
      * Shore-to-shore information exchange
      * Shore authorities need an enhanced ability to share maritime information amongst authorized shore users to ensure consistency and reduce the reporting burden by ship personnel. More effective shore-to-shore information exchange will aid safety, security, the identification of risk, environmental protection and improve logistics management.
        + Common maritime information/ data structure- Automated and standardized reporting functions- Effective and robust communications- Human-centred presentation need- Data and system integrity- Analysis
        + Identify and/or develop necessary protocols, formats and data structures. Investigate methods for global data sharing. Identify relevant legal and regulatory implications.
        + Consider the need for data security and ownership issues. Consider work done in other relevant industries. Consider the use of standard data exchange protocols.
        + Effective and robust communications
        + A clear need was expressed for there to be an effective and robust means of communication for ship and shore users. Shore-based users require an effective means of communicating with ships to facilitate safety, security and environmental protection and to provide operational information. To be effective, communication with and between ships should make best use of audio/visual aids and standard phrases to minimize linguistic challenges and distractions to operators. Research has indicated that a high percentage of seafarers regard language incompatibility and non-standard phrases as a major problem. They also highlighted equipment failure and busy communication channels as concerns that needed to be addressed.

Automated and standardized reporting functions- Effective and robust communications

Research into how voice and digital communication can be made more effective. Plan for greater use of IMO SMCP (resolution A.918(22)). Identify reliability standards for communication technology. Identify communication capacity issues to ensure adequate bandwidth for essential communication needs.

User need

Justification

Relation to IMO strateg

Priority in terms of work required

Issues to consider

Human Machine & Interface Issues

SAR should have access to relevant information contained within the e-Navigation domain

SAR need a full range of information pertaining to ships and their domain to support the saving of lives.

* Common data structure- Automated reporting- Robust communications data integrity
* \*Effective Communication and information sharing
* SAR must be able to use the e-Navigation infrastructure to communicate and share information effectively with all parties involved in an incident.
  + Common data structure- Automated reporting- Robust communications data integrity