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Background

IC AIS 2-2023 took note of a draft Danish proposal of list of priorities on e-navigation services (document 3-5), welcomed the proposal and provided input as contained in document 3-5 Rev. 1, including renaming the title of the document as "coordinated e-navigation services by 2027 in the Baltic Sea region".

IC AIS 2-2023 invited Contracting Parties to provide input to this revised version to the Secretariat and further invited the Secretariat to conduct an editorial revision of the document recommending submitting the proposal to the next session of the Expert Group on Safety of Navigation for input in relation to topics under their experience.

Finally, IC AIS 2-2023 recommended submitting the proposal to the next session of the Maritime Working Group for consideration and provision of guidance on next steps (Memo of IC AIS 2-2023, para. 3.9-3.12).

IC SAFE NAV 2-2023 considered the proposal, noting that it has been made by EG AIS in relation to the implementation of BSAP action S4 and considered in particular, the topics under the remit of the Expert Group on Safety of Navigation, in connection with particular data sets that should be mentioned due their relevance for navigational safety and route optimization (saving fuel and decreasing GHG emissions). The Session provided the following input (Memo of IC SAFE NAV 2-2023, para. 2.13-2.14):

- the Baltic Sea e-Nav project funded by Interreg Baltic Sea Region will commence in November 2023 and is expected to be able to support this activity;
- the purpose of the draft document on prioritized e-navigation services is still a bit unclear, in particular regarding whether it is supposed to establish new requirements for the Baltic Sea; and
- the Baltic Sea is in the forefront of developing and using new technologies including e-navigation services, and identifying priorities in this regard may be useful also for other regions.

This document contains the proposal for a coordinated e-navigation services by 2027 in the Baltic Sea region including editorial corrections as kindly provided by the Chair of EG AIS and additional input provided by Denmark.

Action requested

The Session is invited to consider the proposal for a coordinated e-navigation services by 2027 in the Baltic Sea region and provide guidance on next steps.

Coordinated e-navigation services by 2027 in the Baltic Sea region

General

Harmonized e-navigation services in the Baltic Sea Region (BSR) will increase the safety of navigation and reduce the risk of fatal maritime accidents. A set of international standards are currently being developed which will make this possible, enabling administrations and authorities in the region to improve maritime traffic assistance. Standards will cover all the different aspects of service provision, including data models, communication links and possible information exchange platforms. For instance, by 2027 it would be possible to have critical safety information sent directly to display on a ship's S-100 enabled ECDIS, either through secure internet provision by use of the SECOM standard [1], or by VDES data transfer through the maritime connectivity platform (MCP) [2]. The latter on the condition that the BSR coastal states have implemented VDES service provision capability by that time.

The common framework for harmonizing the data content and format of e-navigation services is the International Hydrological Organizations (IHO) Universal Hydrographic Data Model, 'S-100', which is based on the geospatial standards developed by the International Organization for Standardization, Technical Committee 211 (ISO/TC211). S-100 has been approved as base line data model for IMO´s e-navigation strategy implementation plan [3]. The 16 Maritime Services, defined by the IMO's Maritime Safety Committee [4] are covered by data models in the S-100 framework. It is to be noted that IMO has earlier also defined a group of Application Specific Messages for AIS and recommended them for broad international use [5]. These messages can deliver limited amounts of safety related information like, for instance, Area notices, Meteorological and Hydrographic data in standard data format.

In addition to S-100 products transmitted via IP connections through mobile networks or satellite communication, e-navigation services can be delivered to ships through VDES system operating in the maritime VHF area. The VDES system consists of four subsystems suitable for the transmission of different types of digital information [6]:

- AIS system, the main purpose of which is to report information related to the position and identification of ships. It can also be used for transmission of AtoN information, including status of AtoN's and virtual AtoN's, but is not intended to be used as a general data transfer system. The data transfer rate is about 9.6 kbps.
- ASM system (new), which in the future is intended to serve as the primary transmission channel for ASM messages in the pre-described format transmitted currently through the AIS system. These include messages defined by IMO [5]. Other information in binary format can also be transmitted. The data transfer rate is about 19.2 kbps.
- VDE-TER system (new), communication channel for free-form data transfer, both between ships and between ships and ground stations. At best, the data transfer rate is about 210.6 kbps.
- VDE-SAT system (new), communication channel for free-form communication between vessels and satellites. At best, the data transfer rate is about 94.7 kbps in the direction of satellites and 47.75 kbps in the direction of ships.

Authentication

For provisioning of e-navigation services it is not only enough that the physical infrastructure is in place for the exchange of information, there also needs to be additional systems in place that can facilitate different functions, such as:

- Digital identities – different actors, such as service providers, users, devices, etc., need to have digital identities that can be used to identify themselves and each other.
- Authentication – this is linked with digital identities in that when an actor A is communicating with another actor B, it should be possible for both actors to authenticate the identity of the other actor.
- Integrity – when receiving a message from another actor it should be possible to verify that the message has not been tampered with during transit.

- Service discoverability – when there is more than one instance of a harmonized service, a service consumer needs to be able to figure out which instance to contact and the endpoint it can be contacted on.
- Roaming across communication links – as mentioned above, it is envisioned that S-100 products will be transmitted over different communication links, such as IP and VDES. Therefore, it is important that data can be sent and received in the same way regardless of the underlying communication link.

An example of a system that can provide the above-mentioned functions and be supported by VDE communication link is the Maritime Connectivity Platform (MCP) [2]. The MCP consists of three main components:

- Maritime Identity Registry (MIR) – provides identity management and security functionalities for entities in the maritime domain:
    - Identity management – maritime entities (such as humans, vessels, devices, etc.) can be registered in a MIR with a unique identifier in the form of a Maritime Resource Name (MRN) [7].
    - Public key infrastructure (PKI) – enables registered maritime entities to hold cryptographic public / private key-pairs and issue digital certificates that hold the public key and is bound to the identity of a maritime entity. These digital certificates and public / private key-pairs can be used to generate digital signatures, which can be used to provide authentication and integrity.
    - Web based authentication – the MIR additionally provides web based authentication using the OpenID Connect (OIDC) protocol.
- Maritime Service Registry (MSR) – provides functionality for facilitating service discoverability:
    - Service instance registration – service providers can register information about their service instances in the MSR. Services instances are described using IALA's G-1128 [8], which contains information such as service endpoint, geographical coverage area, references to the service technical design, etc.
    - Service instance querying – service consumers can query the MSR for service instances based on different criteria, such as technical design, geographical coverage area, keywords, etc.
- Maritime Messaging Service (MMS) – provides seamless information exchange over different communication links:
    - Communication link agnostic – the MMS can seamlessly route messages between clients on different communication links e.g., VDE, IP.
    - Subject casting – service consumers are able to subscribe to receiving messages for subjects that they are interested in. Likewise, service providers are able to publish messages to subjects. An example of a subject could be navigational warning in a specific area.
    - Direct messaging – clients can use the MMS to send direct messages to other clients using MRN as the locator.
    - Store and forward – as connectivity at sea can at times be intermittent, the MMS needs to be able to store messages designated to clients that are unreachable and forward them when the clients become reachable again.

Development of the MCP, both specifications and reference implementations, are governed by the MCP Consortium (MCC) which has members from both non-profit organizations, research, government and industry.

All of the components of the MCP are designed and implemented with distribution or decentralization in mind, meaning that several instances of the MCP components can be provided by different service providers, but still be compatible because of the specifications defined by the MCC.

Service harmonization

The future digital fairways can be seen to consist of three components:

- physical infrastructure, including traditional AtoN's, that can be used for the collection and distribution of information,

- digital infrastructure which includes PNT-services (Position, Navigation, Timing-services) and communication networks required for the delivery of the digital services, and
- technical e-navigation services required to implement the Maritime Services using S-100 based product specifications.

The way e-navigation services are provided needs to be coordinated. Decisions also need to be made on which services should be prioritized, globally but also in the BSR.

The equipment of the vessel may need to be updated or its configuration modified to enable the reception, processing and portrayal of the information received via the emerging e-navigation services. The technical harmonization of services between different service providers will minimize the required updates onboard and presumably lead to the widest possible use of the services. A benefit of using VDES as a means of e-navigation service provision is that the existing AIS installation onboard the ships (antennae, wires) can be utilized also for VDES data transfer.

However, coordination is needed related to both the format and the delivery method of the services. The delivery method and format are related to each other. When discussing the preferred delivery channel/format combination, the estimated timelines for the availability of standardized onboard equipment and product specifications should be considered.

Prioritized services

Below some services are listed, which on the one hand are considered important for navigational safety, and on the other hand are at the necessary stage of technological maturity and in terms of international standardization process:

Maritime Safety Information (MSI)

Each coastal state is required to publish information on navigational hazards and marine weather warnings and forecasts in their waters. The following IHO (International Hydrographic Organization) S-100 Product Specifications could be used to deliver the information, with the understanding that they do not replace mandatory IMO regulations:

- Nautical warnings can be delivered to ships using the S-124 (Navigational Warnings).
- Amendments regarding to aids to navigation provision can be provided using the S-125 (Marine Aids to Navigation, AtoN).
- Weather warnings (e.g., gale or storm warnings) can be provided using S-412 (Weather and Wave Hazards).

The organizations providing data to ships can vary between countries in the Baltic Sea Region. Especially, content in S-124 and S-125 (see AtoN information service) data product specifications should be coordinated both at a national and regional level, in order to minimize data duplication. It is important to especially follow the process of S-125 standardisation as well as the related data model development.

In addition to services based on IHO S-100, Maritime Safety Information may be provided to ships using Application Specific Messages (ASM).

- Nautical and weather warnings can be delivered using ASM FI=22 Area notice (broadcast) or ASM FI=23 Area notice (addressed).
- Weather forecasts can be delivered using ASM FI=26 Environmental.

The services based on IHO S-100 and Application Specific Messages carrying MSI could be delivered to vessels through different physical channels as described in Table 1.

Table 1. Relation between the delivery channel and format of MSI information.

Delivery channel	Format of the information
Broadband internet connection (e.g., mobile network, satellite connection)	S-100 services based on IHO: • S-124 - Navigational Warnings • S-412 - Wave and Weather Hazards
VDES / VDE TER (VDE terrestrial)	S-100 services based on IHO: • S-124 - Navigational Warnings • S-412 - Wave and Weather Hazards
VDES / VDE SAT (VDE satellite)	S-100 services based on IHO: • S-124 - Navigational Warnings • S-412 - Wave and Weather Hazards
VDES / ASM	Application Specific Messages (ASM): • ASM FI=22 Area notice (broadcast) • ASM FI=23 Area notice (addressed) • ASM FI=26 Environmental
VDES / AIS	Application Specific Messages (ASM) Safety Related text Messages (SRM) Message 21: Aids-to-navigation report (including information in the “AtoN status” field)

AtoN Information

Information on Aids to Navigation, including planned or temporary changes in the status of AtoN's can be provided to ships using S-125 (Marine Aids to Navigation, AtoN).

Table 2. Relation between the delivery channel and format of AtoN information.

Delivery channel	Format of the information
Broadband internet connection (e.g., mobile network, satellite connection)	S-100 services based on IHO: • S-125 (Marine Aids to Navigation, AtoN)
VDES / VDE TER	S-100 services based on IHO • S-125 (Marine Aids to Navigation, AtoN)
VDES / VDE SAT	S-100 services based on IHO • S-125 (Marine Aids to Navigation, AtoN)
VDES / ASM	Application Specific Messages (ASM): • ASM FI=22 Area notice (broadcast) • ASM FI=23 Area notice (addressed)
VDES / AIS	Message 21: Aids-to-navigation report

Ice navigation

Information on ice movements and thickness is vital information for safe shipping in winter months. Recommended routes through ice can also be provided to assist vessels.

The IHO S-411 Sea Ice Information product specification is a vector product specification that is primarily intended for encoding the extent and nature of sea ice for navigational purposes. Sea ice information may be considered supplementary additional information that complements the S-101 ENC. The recommended routes through ice can be delivered to ships using IHO S-421 Route Plan - product specifications. In addition to service based on IHO S-100, Ice Navigation information may be provided using ASM.

- Ice boundaries and recommended routes through ice can be delivered using ASM FI=22 Area notice (broadcast) or ASM FI=23 Area notice (addressed)
- Recommended routes through ice can be delivered also using ASM FI=27 Route information (broadcast) or ASM FI=28 Route information (addressed).

Table 2. Relation between the delivery channel and format of information supporting ice navigation.

Delivery channel	Format of the information
Broadband internet connection (e.g., mobile network, satellite connection)	S-100 services based on IHO: • S-411 (Sea Ice Information) • S-421 (Route plan)
VDES / VDE TER	S-100 services based on IHO: • S-411 (Sea Ice Information) • S-421 (Route plan)
VDES / VDE SAT	S-100 services based on IHO: • S-411 (Sea Ice Information) • S-421 (Route plan)
VDES / ASM	Application Specific Messages (ASM): • ASM FI=22 Area notice (broadcast) • ASM FI=23 Area notice (addressed) • ASM FI=27 Route Information (broadcast) • ASM FI=28 Route Information (addressed)

Route exchange

Sharing information on intended routes and estimated times of arrival is important in order to be able to optimize the transport efficiency and to reduce the time ships are idle. The product specification developed here is S-421, and has also been adopted by CIRM, the international association for marine electronics companies. Route exchange can be used as part of several other e-navigation services, such as route cross check, flow management, ice navigation, under keel clearance management, chart management, route optimization and search and rescue.

In addition to services based on IHO S-100, limited route information i.e., waypoints, may be exchanged using ASM FI=27 Route information (broadcast) or ASM FI=28 Route information (addressed).

Table 2. Relation between the delivery channel and format of Route information.

Delivery channel	Format of the information
Broadband internet connection (e.g., mobile network, satellite connection)	S-100 services based on IHO: • S-421 (Route plan)
VDES / VDE TER	S-100 services based on IHO • S-421 (Route plan)
VDES / VDE SAT	S-100 services based on IHO • S-421 (Route plan)
VDES / ASM	Application Specific Messages (ASM): • ASM FI=27 Route Information (broadcast) • ASM FI=28 Route Information (addressed)

Other VTS services

Today VTS communication and interaction with ships is almost exclusively undertaken by traditional VHF voice communications, however it is envisioned that in near future much of the information exchange can also be done digitally.

Information provided by the VTS includes information that can originate from external sources, such as the services described above. In addition, VTS provides ships information related to the management of ship traffic, traffic clearances and other factors that may influence ship movements.

The VTS specific digital services are still under development. This development will require coordination in the Baltic Sea Region to ensure that ships are able to use the same services in all the countries in the area.

It is to be noted that the digital services mentioned above can be limited depending on areas where the Vessel Traffic Services are implemented.

Ranging Mode (R-Mode)

Reliable PNT information together with accurate ENC information forms the foundation for electronic navigation where digital e-Navigation services will be used. R-Mode is a terrestrial radionavigation system under development. It aims to provide an independent backup system for GNSS. R-Mode is based on transmissions on MF and marine VHF bands (i.e., DGPS and VDES frequencies).

In the southern part of the Baltic Sea region, there is already an R-Mode test area in operation. The plan is to extend the test area in the coming years to cover also the central parts of the Baltic Sea region. The provision

of R-Mode service requires regional coordination between Baltic Sea countries and further work to reach a cooperative and harmonized regional approach is encouraged.

Other hydrographic S-100services

A few other data sets should be mentioned as they are important for navigational safety and route optimization (saving fuel and decreasing GHG emissions).

S-111 Surface currents

An understanding of surface currents is an important factor in the safety of navigation as currents affect the motion of vessels. A surface current forecast can also be an important tool for the ship owner as more efficient navigation along the current saves fuel and reduces GHG emissions.

S-129 Under Keel Clearance Management

Under Keel Clearance Management (UKCM) is the concept of Initial voyage planning to encode information about a vessel's under keel clearance for use in managing the safe passage through shallow waters. Where a UKCM service is operational a ship planning its voyage can determine the time periods when there are suitable tidal conditions for it to transit an area. A UKCM service provider completes calculations based on a range of possible arrival times to determine a pre-plan, which contains one or more time windows for a specified draught that a ship’s master can choose from.

References

[1] IEC 63173-2 Maritime navigation and radiocommunication equipment and systems - Data interfaces - Part 2: Secure communication between ship and shore (SECOM).

[2] https://maritimeconnectivity.net/

[3] IMO MSC.1/Circ.1595, e-Navigation Strategy Implementation Plan – update 1, 25 May 2018.

[4] IMO MSC.1/CIRC.1610, Initial Descriptions Of Maritime Services In The Context Of E-Navigation, 14 June 2019.

[5] IMO SN.1/Circ.289, Guidance on the Use of AIS Application-Specific Messages.

[6] IALA G1117 VHF Data Exchange System (VDES) Overview.

[7] IALA G1143 Unique Identifiers for Maritime Resources.

[8] IALA G1128 The Specification of e-Navigation Technical Services.