

Paper for Consideration by NCWG

Portrayal Harmonization

Submitted by:	Raphael Malyankar & Eivind Mong on behalf of the S100WG Chair
Executive Summary:	Describes how to go about harmonizing portrayal across products that are in S-98.
Related Documents:	S100TSM7-4.5
Related Projects:	S-98

1) Introduction

In a navigation system where several types of data products and sensor inputs will be used on a common screen there is a need to harmonize the portrayal of the data that is visualized. Harmonization is needed to ensure users are not misled by for example contradicting symbology, text or colours. Harmonization is also needed to ensure the navigation screen is not overloaded with information. IMO has issued several documents providing guidance for how navigation screens should be managed. Guidance documents such as MSC.191(79) '*Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational Displays*' and IMO SN.1/Circ.243/Rev.2, '*Guidelines for the Presentation of Navigational-Related Symbols, Terms and Abbreviations*' have been reviewed for principles that can be used in developing harmonization guidance.

2) References

IMO Resolution MSC.191(79), as amended, Performance standards for the presentation of navigation-related information on shipborne navigational displays

IMO Resolution MSC.232(82), Adoption of the Revised Performance Standards for Electronic Chart Display and Information Systems (ECDIS)

IMO Resolution MSC.466(101), Amendments to the Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational Displays (Resolution Msc.191(79))

IMO SN.1/Circ.243/Rev.2 Guidelines for the Presentation of Navigational-Related Symbols, Terms and Abbreviations

IMO Guidelines for The Standardization of User Interface Design for Navigation Equipment (document designation is still pending from IMO as of 20190917)

IHO S-98 Draft Edition 1.0.0 in progress – Interoperability for S-100 based Navigation Systems

IHO S-4 4.8.0 – Chart Specifications of the IHO

IHO S-52 Edition 6.1(.1), October 2014, With Clarifications up to June 2015 – Specifications for Chart Content and Display Aspects of ECDIS

IHO S-100 4.0.0 – Universal Hydrographic Data Model

3) **Background:**

S-100 based products are developed for a variety of uses. The majority developed to date have some kind of navigational function, and mostly as overlays to ENC. S-100-based Product Specifications generally define only the product itself and its use, not how it will be used in combination with other S-100-based data products or sensor information. It is anticipated that most S-100-based systems, like ECDIS and other ship and shore-based systems, will use several different products simultaneously, each providing one or more information layers. Other data layers such as real-time sensor information from sources like radar and AIS are also expected to be present. The smooth interoperation and harmonized user-friendly graphical presentations of these various products is necessary for safety and efficiency. To achieve this smooth interoperation and harmonized graphical presentation of S-100 data products, rules are needed so that Product Specification developers have a known framework. These rules need to describe how specified products are to be used and displayed simultaneously, and should be defined outside the S-100-based Product Specifications. By defining interoperability rules externally, flexibility is given in the approach and should negate most needs to amend all involved product specifications should any additional product specifications be identified, or any rules need amendment.

IMO has issued recommendations and guidelines on how to present navigation related information. Of particular significance are the two documents noted below.

MSC.191(79), Recommendation on Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational Displays, specify the presentation of navigational information on the bridge of a ship, including the consistent use of navigational terms, abbreviations, colours and symbols, as well as other presentation characteristics. It also addresses the presentation of navigation information related to specific navigational tasks by recognizing the use of user selected presentations in addition to presentations required by the individual performance standards adopted by the Organization.

The IMO SN.1/Circ.243/Rev.2, Guidelines for the Presentation of Navigational-Related Symbols, Terms and Abbreviations, stems from a compelling user need for greater standardization to enhance usability across navigation equipment and systems. Significant variation between systems and equipment produced by different manufacturers has led to inconsistency in the way essential information is presented, understood and used to perform key navigation safety functions. Improved standardization of navigation systems will provide users with more timely access to essential information and functions that support safe navigation.

Both MSC.191(79) and SN.1/Circ.243/Rev.2 has recently been revised and an implementation timeline has been established for when the revised versions enter into effect. IMO noted in the NCSR6 Report of the Navigation Working Group that; *SN.1/Circ.243/Rev.2, does not revoke SN.1/Circ.243/Rev.1, however, for the purpose of applying resolutions:*

- .1 MSC.191(79), guidelines in SN.1/Circ.243/Rev.1 continue to apply [until:
 - .1 [1 January 2024] for radar equipment, electronic chart display and information system (ECDIS) and integrated navigation systems (INS) installed on or after [1 January 2024];*
 - and*
 - .2 [1 July 2025] for all other navigational displays on the bridge of a ship installed on or after [1 July 2025]; and. 1 January [2024/2025]]; and**
- .2 MSC.191(79), as amended by resolution MSC.466(101), guidelines in SN.1/Circ.243/Rev.2 will apply as from [1 January 2024*

These timelines have a significant impact on any portrayal harmonization by S-100 based Product Specifications since the implementation dates fall in the estimated range when version 2 or 3 of various Product Specifications can be expected, noting that versions 2 or 3 are anticipated to be the first operational use versions. The implementation date coinciding with S-100 based Product Specification release times will likely see OEMs pushing for harmonized portrayal for S-57 and S-100 based products in accordance with the IMO guidance, and any IHO harmonization should therefore align with the IMO guidance as far as practical. To minimise the effect on OEMs.

4) Portrayal Harmonization Framework;

Portrayal harmonization is needed to lessen the user burden in terms of training, and number of visual variables to remember and consider when using systems capable of portraying S-100 based products. Portrayal harmonization is also needed to give predictability to system implementors. IMO has developed guidance for presentation of navigational information, this guidance should be leveraged for a portrayal harmonization framework.

IMO SN.1/Circ.243/Rev.2 (Guidelines for the Presentation of Navigational-Related Symbols, Terms and Abbreviations) notes in section 15, the principles that was applied when designing the appendices to the guidelines. Not all these principles are directly applicable to harmonization of portrayal between data products as they are mainly applicable for Human Machine Interfaces. However, even the principles that are not directly applicable still provides important guidance that can positively influence portrayal harmonization. Particularly noteworthy principles are;

- consistency in use of symbols and patterns referencing Appendix 2 which provides information on icons, symbols and abbreviations that require standardization. Consistency enables recognition and detectability across the user interfaces of different navigation systems. Humans react positively to patterns and logical groups of items, and use categories to search for individual bits of information. User testing can identify groupings and patterns of information that should be prioritized for consistency. Patterns incorporate the way in which someone uses information and the types of information that are grouped together.
- using location and grouping for consistency provides for recognition. Human perception and search works faster with cues than complete recall, especially when aided by consistency. The user must recognize where information is, or how to perform a process. In performing functions, the user should not need to recall where something is located, or the process for doing something. This is the ability for the user to recognize an event, process or information flow rather than recall the detail of how to get to that point. This is integral to usability.
- prevent errors by ensuring users always see navigational critical information. Prevent errors, emergency exit – Continuous testing during development will identify possible error paths that can be removed. Users should be aware of how to navigate back to the start of a process, and also be aware of where they are in that process. The user should always be able to see navigation critical information even if layers of information are interlaid with the ENC/Radar.

Before rules can be established for portrayal harmonization, a framework must first be defined. This framework should state what is in scope and what is out of scope in order to have a set limit of what is being defined so that issues such as scope creep is limited as much as possible. One important aspect to define is the user system, as there are a great variety of potential users of S-100 based products. Most S-100 based product specifications to date has been developed for ECDIS. ECDIS being a long-established concept is therefore the best user system to limit the framework to, since other users of S-100 based products are likely to know how the ECDIS concept relates to their systems. ENC is an integral part of ECDIS and therefore should be defined as the base layer for the portrayal harmonization framework. Additional layers can be classified as two main types, additional information to that of the ENC or enhanced information to that of the ENC. Additional information would be information that is not contained in the ENC, while enhanced information are layers that contain improved detailed or higher resolution than what is in the ENC.

Portrayal harmonization should next consider if there is a fixed set of layers that must be considered the within the scope of the rules, or if the rules should be more flexible to accommodate additional layers, such as future products or regional specialities.

- Pros of fixed set list of layers is the predictability it gives for implementers since most variables are known and can be accounted for.
- Con of fixed set list of layers is the inflexibility of not being able to add new layers without creating a new version of the rules and the implications that will have on user systems requiring updates also.
- Pros of a flexible list of layers is the rules will be more general and easier to maintain, with less likelihood of having to create a new version of the rules for new layers, another pro is that users can create their own combinations and add layers as per need, such as in regional special circumstances.
- Con of flexible list of layers is that implementors have less predictability of what layers to expect with higher possibility of unexpected layer combinations.

The draft S-98 Interoperability Specification is written like a framework to give a ruleset that applies to a system that can combine an undefined set of layers, rather than establishing a fixed list of product specifications to be use in a system.

The next thing to consider is how the framework should account for multiple layers portrayed simultaneously. Lessons from the Interoperability Workshop that KHOA/KRISO/NOAA held in Daejeon in 2017 found that it is not expected that more than 2-3 layers will be turned on at any given moment. The various S-100 product specifications under development do not factor in portrayal with any other layer than ENC. Additionally, with more layers visualized simultaneously there is an increased likelihood that there will be clutter issues that may obscure significant features and increase any risk of unsafe operation. The framework should therefore limit the number of simultaneous layers to a set of preconfigured combinations in normal operating mode, while permitting more flexibility for users with specialized requirements. Significant features should be considered as those that may not turned off at any moment during route following. In ECDIS and ENC they are considered to be in the display base. In other S-100 based products there may also be significant features and these should be considered in the same spirit as the display base defined in the IMO ECDIS performance standard (Resolution MSC.232(82)).

5) Areas of the navigation screen where harmonizing portrayal across data products is needed;

Product specifications will interact in several areas within a user system. This section proposes some guidance for what are the areas of special concern that product specification developers should review. Moreover, each area of special concern for harmonization of portrayal has specific guidance proposed as a starting point for discussion and further refinement. A number of overarching tenets should be considered for portrayal harmonization guidelines;

- Portrayal harmonization must consider that any parts of a product specification that impact the user interface must be developed in alignment with IMO Guidelines for The Standardization of User Interface Design for Navigation Equipment (document designation is still pending from IMO as of 20190917).
- Even though a great number of different combinations is possible, there is an expectation that mariners will mostly use a limited number of predefined combinations and much less often make their own combinations for very specific tasks or situations. These known combinations should be the basis for harmonization.
- User defined combinations are unpredictable and can only be accounted for by general harmonization rules.

a. Pick reports

Pick reports may be defined in the individual product specification and this may cause issues when using two or more products simultaneously, and the products have conflicting configurations defined for pick reports. Independent definition of pick reports may also increase the burden on the user since pick report styles may differ significantly cause additional strain on the user. This would also require additional training to familiarize users with products that can be safety critical. Harmonized portrayal pick reports should therefore be a goal for any system that will use more than one product. It should be possible for pick reports to visualize to the user the information from all visible underlying products. Data should be organized to facilitate navigation through complex reports in a manner that is logical when considering the layer order visual on the screen. Human Machine Interface (HMI) strategies should be considered to make the task of reviewing the pick report take as little effort as possible for the user. This can be facilitated by harmonized look and behaviour across products when used in the same operational mode. Flexibility should be given to permit some variation between ECDIS operation modes. Pick reports should have a sort order that reflect what products are on the screen.

Where the harmonization of pick reports should be facilitated is unclear as there are some options for harmonization. Three main options are available;

1. Leave the harmonization to OEMs; let product specification developers have the option to define own rules and have OEMs harmonize, using IMO guidance, when products are used in combinations, e.g. ECDIS.
2. Provide some guidance; create a guideline that describes a common structure for pick reports, including when used in combinations of more than one product. Product Specification developers must consider the boundaries of the guideline during Product Specification development. OEMs implement their interpretations of according to guideline.
3. Define machine readable pick report configurations; centrally, (e.g. S-100) define machine readable pick report configurations, and product specification developers work within these set limits. OEMs implement the S-100 defined structure to read and utilize the configurations from the Product Specifications.

b. Content harmonization

Content between products should be harmonized to reduce the risk of conflicting messages between products. As noted by IMO SN.1/Circ.243/Rev.2; significant variation between systems has led to inconsistency in the way essential information is presented, understood and used to perform key navigation safety functions. Standardized and harmonized content of products is part of the solution to reduce the noted risk since the product usually is part of the system.

Where feature concepts are different, but the information content is equivalent and the use is intended for ECDIS, considerations should include the update cycle of the information and priority should be given to the concept that is most likely to be updated most frequently. Other considerations should include any relations that the concept has to other feature concepts, and consequences of breaking these must be considered when choosing which concept to give the priority. In establishing that there is a priority of concepts, the Product Specification developers should consider the use of the two overlapping products. First priority should be given to resolving the overlap, by for example removing the overlap from the least prioritized Product Specification. If this is not possible, the S-98 Interoperability Catalogue should be configured to suppress the least prioritized product.

EXAMPLE: Developers investigate the update cycles of real-time current data products and discover that they are updated more frequently than S-101 **Current – Non-Gravitational** and **Tidal stream – Flood/Ebb** features, and features from the real-time current datasets are therefore preferred replacements for S-101 current features. Note that the question is decided not by comparing dates

encoded in features, but on the basis of real-time data that is available on an ongoing basis vs. historical information gathered at a past date.

Product Specification developers should strive to maintain a data model that is as harmonized with related data models as possible. Due considerations should be taken before developing a concept that is different but functionally equal to similar concepts in other product specifications.

c. Display of significant features

Significant features should have the highest display priority to ensure that less significant features in one data product are not displayed more prominently than more significant features in another product. The Chart Specifications of the IHO (S-4) provides guidance in determining how to manage significant information and should be used as a guideline when work is carried out to define significant features between two or more products. For example, S-4 B-340 describes a landmark as: *A landmark is any natural or artificial object prominent from seaward, at a fixed location on land, which can be used in determining a location or a direction.* Other types of prominent features can be regulatory areas that impact navigation and therefore should not be obscured by less significant regulatory areas. Similarly, features that describe outages to regular aids to navigation are likely more important than the aid that is not functioning normal. It is likely that in some cases, the more significant features are in a different product specification and ensuring that significant features are not obscured must therefore be managed in cooperation between two or more product specification teams.

In some cases, it may be necessary to amend the data model to ensure that significant features are not obscured or made ambiguous by the product interaction in a user system. Product Specification developers should make use of metadata to define which products interactions are anticipated, and work with the responsible parties to ensure highest possible alignment. S-100 metadata has the layer identification attribute in dataset discovery metadata that can capture such information. In some cases, it may be necessary that this cooperation on product alignment continues between producers.

Producers should have production procedures that includes guidelines for how to harmonize features between products, especially products that are considered complementary. Such guidance should also consider situations where the producer may not be the only producer providing navigational significant products.

For example; ENCs are produced by a Hydrographic Office while the Coast Guard produces products that contain information about Marine Radio Signals and Marine Traffic Management. The two organizations should harmonize their production procedures to ensure significant feature harmonization is carried out jointly between the three products.

d. Symbol harmonization

Symbols are used to visually convey information and need to convey the same information despite which product they are used for. As noted in IMO SN.1/Circ.243/Rev.2, “consistency enables recognition and detectability across the user interfaces of different navigation systems. Humans react positively to patterns and logical groups of items, and use categories to search for individual bits of information. User testing can identify groupings and patterns of information that should be prioritized for consistency. Patterns incorporate the way in which someone uses information and the types of information that are grouped together”. Symbols should therefore be harmonized across all products used in the framework (ECDIS) to ensure the risk of contradictory messages are reduced as much as possible.

Symbol harmonization should be a coordinated effort utilizing the guidance within IMO SN.1/Circ.243/Rev.2 and S-4. These two documents should be the first source of finding portrayal of features that need visualization in a navigation system. Within IHO the Nautical Cartography Working Group is tasked with coordinating portrayal. Given IHO’s leadership in defining the portrayal of the chart, all organizations that

produce data products intended for the navigation screen should coordinate their symbol creating with IHO NCWG. Where the existing symbology in S-4 and IMO SN.1/Circ243/Rev.2 is insufficient, NCWG should be consulted when new symbology is created.

New symbology should be tested within the product itself, and also in product combinations to ensure sufficient harmonization and that any risk of ambiguities is sufficiently addressed.

e. Colour harmonization

Colours or combinations of colours usually have specific meanings associated to them on the navigation screen. For example, black usually means a physical object or boundary (e.g. coast line), while magenta usually means a non-physical object or boundary (e.g. restricted area boundary). Another example is that any symbology using red may be an issue for ECDIS operated in night mode as they may become very difficult to see to the red ambient light on the bridge, and therefore the use of red should be avoided as much as possible. It is therefore important to ensure that the use of colour is harmonized between layers to reduce the risk of giving the user ambiguous information. IHO S-4 provides useful guidance to use of colours and these guidelines should be adhered to by all S-100 based product specifications that is intended for navigation systems.

Colour harmonization should be a coordinated effort utilizing the guidance in IMO SN.1/Circ.243/Rev.2 and S-4. Within IHO the Nautical Cartography Working Group is tasked with coordinating portrayal. Given IHO's leadership in defining the portrayal of the chart, all organizations that produce data products intended for the navigation screen should coordinate their colour usage with IHO.

f. Harmonization of operating mode (Day/Night/Dusk modes)

ECDIS is designed with different colour modes to account for ambient light conditions on the bridge of the vessel. These modes support an operating environment that preserves the navigator's light sensitive vision which can be critical in spotting situations that impact safety of navigation, especially at night. It should therefore be required that all S-100 based product specifications that are intended for navigation screens at a minimum support the operating modes of the navigation system where the data product is intended to be used.

Within IHO the ENC Standards Maintenance Working Group (ENCWG) is tasked with managing S-52 - Specifications for Chart Content and Display Aspects of ECDIS which specify the portrayal rules for S-57 ENC. These rules will be the basis for S-101 ENC Portrayal. Nautical Cartography Working Group is tasked with coordinating portrayal. Jointly these two working groups can be a good source for advice in work on harmonizing colour usage in different portrayal operating modes.

Given IHO's leadership in defining the portrayal of the chart, all organizations that produce data products intended for the navigation screen should coordinate their colour usage with IHO.

g. Viewing group harmonization

Within the S-100 Portrayal Catalogue Concept there is a portrayal management concept called viewing groups that should be considered for harmonization between products. The viewing group is a concept to control the content of the display. It works as an on/off switch for any drawing instruction assigned to the corresponding viewing group. The concept can be seen as a filter on the list of drawing instructions (ref S-100, 9-11.1.3). S-100 based products that will be portrayed on the same screen should have viewing groups harmonized so that overlaps of information does not cause significant features to be obscured by less significant features.

When developing S-100 Based Product Specifications intended for Navigational Use, the developers should consider tools where viewing group lists are analysed between Product Specifications to find undesired viewing group overlaps. This could be tools like S-100 viewers where test data can be reviewing in logical pre-defined combinations to ensure there are no undesired viewing group overlaps, in addition tools like tables of utilized viewing groups can be made to make easy comparison between the individual Product Specification's usage of viewing groups.

Developers of S-100 Based Product Specifications intended for Navigational Use should consider visual tests in testbeds with widest possible content for comparison as a methodology for discovering undesired viewing group overlaps. The systematic utilization of viewing software comparing test data from logical combinations of products can assist in discovering undesired viewing group overlaps that can be resolved and verified by follow-up tests.

With the expectation of increasing amounts of S-100 Based Product Specifications intended for Navigational Use, and versions thereof as their lifecycle progress, considerations should be made to making the use of the pre-defined combinations of Product Specifications concept more restrictive to limit the possible combinations, and to assign viewing groups to specific pre-defined combinations of Product Specifications]

h. Text

MSC.191(79) as amended require in 5.2.3 that use of text should be presented using simple unambiguous language that is easy to understand. Navigation terms and abbreviations should be presented using the nomenclature defined in the Guidelines and encouraged their use for all shipborne navigational systems and equipment (SN.1/Circ.243, as revised) and Appendix 2 of the IMO Guidelines for The Standardization of User Interface Design for Navigation Equipment. Similarly, S-4 (Section 500 - Text: Language, Numbers, Abbreviations, Names, Styles and Fonts) have defined some common navigation terms and abbreviations that is used in the presentation of navigational information. This textual guidance has been implemented in S-52 and should jointly with the IMO guidance be used as a reference for harmonizing the use of text in S-100 based Product Specifications intended for navigational use.

i. Alarms and Indications

IMO Resolution MSC.232(82) states in 11.3 and 11.4 and their sub paragraphs how and ECDIS should respond to risk of crossing, dangers, prohibited areas or areas with special conditions. In Appendix 4 and Appendix 5 of the same resolution details of which areas ECDIS should detect and provide an alarm or indication for are given. All product specifications which are intended for navigation should specify any feature combinations that match one or more of the areas for which alarm or indication should be given to ensure there is a harmonized implementation of alarms and indications in navigational products.

Within IHO the ENC Standards Maintenance Working Group (ENCWG) is tasked with managing S-52 - Specifications for Chart Content and Display Aspects of ECDIS which specify the portrayal rules for S-57 ENC. This includes guidance for which feature attribute combinations should be considered to match the IMO ECDIS Performance Rules.

Given IHO's leadership in defining the portrayal of the chart, all organizations that produce data products intended for the navigation screen should coordinate their alarm and indication rules with IHO.

6) Recommendations

Consider these guidelines a starting point for portrayal harmonization guidelines for data products intended for navigation systems.

Monitor IMO developments and maintain alignment with IMO portrayal harmonization guidance.

Action Requested of the NCWG

Discuss the proposed guidelines in this document.

Consider if additional areas of portrayal harmonization should be added.