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Product Specification Interoperability Analysis

26 May 2016

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Executive Summary:	This paper provides an overview of the issues arising when different S-100 data products are in simultaneous use on the same screen or in the same ECDIS or similar system. The aim is to define the different aspects of interoperation of S-100 based products, and thereby provide a basis for designing a solution to ensure that user interfaces behave in a user-friendly and predictable manner when different products are simultaneously present in the interface. Exemplary usage scenarios for the combined use of data products are also listed, as a means of ensuring that the solution architecture is capable of dealing with a comprehensive range of interoperation problems.
Related Documents:	--
Related Projects:	(1) S-100; (2) S-101; (3) S-102; (3) S-111; (4) S-112; (5) S-122; (6) S-124; (7) S-411; (8) S-412.

1 Introduction

1.1 Background/overview

Mariners and other users will receive different S-100-based data products, each providing one or more information layers, and will often need to view some of the information layers simultaneously on a future ECDIS as well as in other ship and shore-based scenarios. Other data layers such as radar overlays are also expected to be present. The smooth interoperation and harmonized user-friendly graphical presentations of these various products is a need that has been identified by IHO and other organizations. This paper identifies the potential issues arising in interoperation and harmonized portrayal of S-100-based products and other data layers expected to be used in ECDIS and similar systems, using a representative set of S-100-based product specifications. The analysis will be used to design a specification for interoperability and harmonized portrayal for S-100-based data products.

This scope of this analysis is described in the next subsection. General considerations and expectations for to S-100-based data products as they relate to interoperability are described in the next section, followed by a summary of the current state of development of the product specifications selected for inclusion in this analysis and subsequent design of an interoperability solution. Summary and detailed descriptions of the interoperation issues which arise in the selected set of products follow. Ideas to be used in design of the solution are then described, consisting of scenarios intended to ensure the solution addresses a wide set of interoperation problems and pre-defined collections as a means of dividing the problem into more manageable parts.

1.2 Scope

The scope of the present analysis is the identification of the potential issues related to interoperating S-100-based products on ECDIS, ECS, INS, and similar systems using graphical displays. Other products likely to be used in ECDIS and similar systems are taken into account only to the extent they affect interoperability and harmonized portrayal. Formal detailed requirements and the solution architecture will be addressed later.

1.3 Terms

Interoperability catalogue (IOP catalogue)

A machine-readable file or collection of files describing how an ECDIS or other system must combine data products conforming to different product specifications for display purposes.

1.4 Abbreviations

AML	Additional Military Layer
DQWG	IHO Data Quality Working Group
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Charting System
FC	Feature catalogue
INS	Integrated Navigation System
IOP	Interoperability
PC	Portrayal catalogue
PPU	Portable Pilot Unit
PS	S-100-based Product Specification
UKCM	Underkeel clearance Management

1.5 References

[1] Guideline on Software Quality Assurance and Human-Centered Design for E-Navigation, IMO Circular MSC.1/Circ.1512, 13 July 2015.

2 General considerations

2.1 Data preferences

The ENC dataset is the basic information for safe navigation but not always the most detailed or best available information. Information contained in other data products may provide superior details, accuracy, resolution or be more up to date thus potentially offering the end user significant additional benefits and enabling more sophisticated ECIDS functionalities. A few examples of such situations are described below.

Navigational warnings update the status of navigation aids, include transient hazards and other transient situations (not necessarily only weather-related or other natural conditions).

High-definition or high-resolution bathymetry are inherently better depth information than ENC depth range attributes or sounding values. This obviously depends on the recency of information and the quality of survey. Along with dynamic water level information, bathymetry layers give the mariners and their ECDIS systems information that is closer to what both really want to know – i.e., the actual water depth at a specific time in a specific location – instead of a value referenced to a datum and averaged over time, smoothed over a larger or smaller area, or sampled at a point.

Protected area and other overlays can be expected to contain more details than ENCs for the objects they contain – e.g., a protected area in ENCs is encoded as a *RestrictedArea* in ENC and may or may not provide information about the governing regulation and controlling authority, and if it does it will be only as a catch-all Supplementary Information object with a text block which the mariner must read and understand, which is not machine-processable, and which may be no more than a brief summary. The corresponding area in S-122 would have full details about the governing regulation, a link to the controlling authority, and encode the restrictions according to vessel class and cargo type so that it can be processed by ECDIS software modules which handle alerts and indicators.

2.2 Balancing cognitive load with information availability

The general philosophy in designing the interoperability solution will be that the mariner's ECDIS display should be 'as simple as possible, but no simpler'. On the one hand, the bridge officers should be able to 'sail the ship' and not be distracted by having to tinker with the ECDIS settings or peer at fine detail on the primary or auxiliary display, or by detail only marginally relevant to navigation and route monitoring. On the other hand, details in the data should be accessible if needed, by one means or another. The solution to this dilemma obviously cannot be provided solely by the interoperability catalogue and interoperability processing logic (platforms and displays will be the main factors) but the design philosophy is that the interoperability solution should be flexible enough to allow adjusting of the balance in one direction or another. This flexibility allows implementation to use iterative design and usability evaluation and testing techniques to ensure that they are as 'fit for purpose' as possible under different conditions.

This provision for usability evaluation and testing, and the identification of use scenarios to inform the design of the solution, both support the application of IMO guidelines (MSC.1/Circ.1512) that recommend the use of Human-Centered Design (HCD) and usability testing to ensure that future ECDIS systems can "support users in low and high workload environments, such as during challenging navigation and environmental conditions when users are most vulnerable to making mistakes and when error management and recovery is essential."

2.3 Potential effects on product specifications

The desire and the overall vision for the final IOP catalogue design is to address as many considerations listed in this document as possible and to be able to do so in machine readable form. At the same time some interoperability challenges are very complex and go well beyond what is feasible to achieve in line with this overall vision. For this reason, it is understood that solutions to some of the challenges might require changes to S-100 (particularly additions to the portrayal catalogue functionality) and/or product specifications too, including S-101.

3 Product specification survey

Table 1 contains a summary of available materials and assumptions for the listed product specifications. Since several product specifications are still under development, much of the material is at a preliminary stage of development, so the best available substitute will be used. For example, XML feature catalogues are ready for only a few specifications but the current UML model of the application schema may serve as a substitute since it defines the features, attributes, and relationships which would be encoded in the FC.

Table 1. Specifications and catalogues

	Title	Product Specification	DCEG	FC	PC	Type and formats
S-101	Electronic Navigational Chart (ENC) / *Cartes électroniques de navigation*	January 2016 draft S-101PT1-4.1D on S100WG1 documents page (IHO)	S-100 wg March 2016 meeting documents page (S-101PT1-3A). Updates pending.	Basecamp S-100 Testbed, July 23, 2015, XML (0.8.8) ESRI additions version (0.8.9) in converter package	Basecamp June 19, 2015 (Consider also the S-100 alerts model S-100WG01-10.12A.)	Vector ISO 8211
S-102	Bathymetric Surface / *Surface bathymétrique*	Edition 2.0.0 draft (31 JAN 2016), rec'd 22 Feb 2016	In draft PS.	Application schema in draft PS.	Mostly to be done, but see suggestions in clause 9 of the draft PS.	Grid HDF5
S-111	Surface currents / *Courants de surface*	Draft 1.8 on S-100WG1 docs page	Basic skeleton, in draft PS	Application schema in draft PS.	Substantial text and illustrations in the draft PS. To do – find out if this is substantially all there will be in S-111 about portrayal.	Grid HDF5
S-112	Meteorological and Hydrographic Data AIS Application-Specific Message Dynamic Water Level Data Product Specification	Nov. 2014 draft	See FC	Word text in draft PS defines objects and attributes. Application schema (in draft) looks fairly complete but marked "to be developed"	Draft says it's premature to develop it	Vector GML?
S-122	Marine Protected Areas / *Aires marines protégées*	NIPWG1 docs page NIPWG1-08.7 Application schema was updated after NIPWG1 and is available on the NIPWG Wiki models page. (URL follows this table).	On NIPWG2 docs page, but features need to be updated. The most recent application schema is on the NIPWG models page, also a zipped PDF listing features and attributes.	No XML version, but it can be prepared from application schema.	Preliminary work described on NIPWG1 docs page, see NIPWG1-08.3 and NIPWG1-18.1 portrayal of DQ indicators	Vector GML

	Title	Product Specification	DCEG	FC	PC	Type and formats
S-124	Navigational warnings / *Avertissements de navigation*	Under development.	--	No XML version, but it can be prepared from the application schema. Substitute for printable catalog located on IHO S-124 web page	None, but preliminary materials (KRISO, DMA, S-124 wg chair's slides) with likely directions. Also ACCSEAS and Jeppesen MEH docs.	Vector GML? (Will be influenced by communication system requirements.)
S-411	Sea Ice (WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology [JCOMM]) *Glace de mer (Commission technique mixte OMM-COI pour l'océanographie et la météorologie marine [JCOMM])*	Version 1.1, June 2014 URL follows this table.	Just a reference to WMO publication WMO574.pdf in the PS.	S411FC.xml in annexes zip file, linked on the same download page.	Catalogue in annexes zip file. Portrayal is described in PS.	Vector ISO 8211 and GML
S-412	Met-ocean forecasts (JCOMM) *Prévisions météo-océanographiques (JCOMM)*	Draft datelined June 2015, received 25 February 2016.	Draft datelined June 2015, received 25 February 2016.	No XML version, objects and attributes listed in draft, no application schema (just 1 small UML diagram in PS)	XML and SVG. Symbols listed in separate word file. Partial WIP, under review.	Vector ISO 8211?

Links:

S-122 DCEG: http://wp12183585.server-he.de/npubwiki/wiki/index.php/File:DCEG.doc
NIPWG models: http://wp12183585.server-he.de/npubwiki/wiki/index.php/SNPWG2
S-411: http://www.jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=14168

4 Interoperability Matrix

The matrix that follows is a birds-eye view of products from an interoperability perspective. The identified interoperability issues are listed here. The issues are described in more detail elsewhere in this document (section 5.x), indicated by the number in the first column.

Grey cell – see the "dual" cell, e.g., the grey cell in the Duplicate Features row and S-122 column means "see the S101 cell". Numbers in brackets refer to notes located below the matrix.

Indicating interactions between multiple products simultaneously, as compared to interactions between pair of products, is TBD.

Table 2. Data product interoperation issues

Issue[1]	Product	S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level over AIS	S-122 MPA	S-124 Nav Warnings [16]	S-411 Sea Ice	S-412 Weather overlay
5.1.1	Duplicate feature instances	S-122	[15]	[15]		S-101; but see [15] on coastlines		[15]	[15]
5.1.2	Duplicate feature domains	S-102, S-111	S-101	S-101					
5.1.3	Combined geometries	S-122 [4] S-411 [1]	S-411 [2]			S-101	S-101, S-122	S-101, S-102	
5.1.4	Spatial discrepancies	S-122 [5], S-124 [10], S-112 [12]; S-102, S-111	S-101, S-111	S-101 (?) [11] S-102	S-101 [12]	S-101, S-124 [10]	S-101, S-122	S-101 (?) [11]	S-101 (?) [11]
5.2.1	Display significant features	all [7]					[7]		
5.2.2	Avoid obscuring overlay	S-111, S-102, S-112, S-122, S-124 [13]	S-111, S-124 [13]	S-124 [13]	S-124 [13]	S-124 [13]		S-124 [13]	S-124 [13]

[1] Numbers in Column 1 are section numbers in this document.

Issue[1] \ Product		S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level over AIS	S-122 MPA	S-124 Nav Warnings [16]	S-411 Sea Ice	S-412 Weather overlay
Error! Reference source not found.	Color	S-102, S-122, S-124 [13], S-411, S-412	S-111 Color blending? [3] S-124 [13]	S-102, S-124 [13]	S-124 [13]	S-101, S-124 [13], S-411, S-412	S-101, S-102, S-111, S-112, S-122, S-411, S-412	S-101, S-122, S-124 [13]	S-101, S-122, S-124 [13]
5.2.4	Day, night, dusk modes	All	S-101	S-101	S-101	S-101	S-101	S-101	S-101
5.2.5	Impacts on viewing groups	All	All	All	All	All	All	All	All
5.2.6	Impacts on portrayal catalogues	All	All	All	All	All	All	All	All
5.2.7	Portrayal of data quality	all	S-101, S-111, S-122, S-411 [14]	S-101, S-102, S-122, S-411 [14]	S-101	S-101, S-102	S-101 [17]	S-101, S-111	S-101
5.2.8	Display of text	All	All	All	All	All	All	All	All
5.3.1	Skin of the earth feature replacement	S-102	S-101						
5.3.2	Skin of the feature adjustment	S-101/DWLZ [19]							
5.4	Blended concepts or portrayals	S-411, S-102	S-101, S-411					S-101, S-102	

Issue[1] \ Product		S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level over AIS	S-122 MPA	S-124 Nav Warnings [16]	S-411 Sea Ice	S-412 Weather overlay
5.5	Hierarchy of data	S-111, S-122, S-112, S-124, S-411 [6], S-412	All	All	All	All	All	All	All
5.6.1	Combined additive pick report	S-112, S-122, S-124 S-102 [18]	S-102 [18]		S-101	other publications datasets S-124, S-101	S-124		
5.6.2	Prioritized pick report	S-112, S-122, S-102 [18] S-124 (if features are included)	S-101 [18]		S-101	S-101	S-101 (if features are included in S-124)		
5.7	Interacting gridded information		S-111 combined portrayal [3]	S-102					
5.8	Encryption and authentication	described in 5.8							
5.9.1	PS updates other than FC or PC	TBD							
5.9.2	FC or PC updates	S-122 [9], S-124 [9]				S-101, S-124 [9]	S-101, S-122		
5.9.3	New datasets	S-111, S-122, S-124 [10]		S-101		S-101			

Issue[1] \ Product		S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level over AIS	S-122 MPA	S-124 Nav Warnings [16]	S-411 Sea Ice	S-412 Weather overlay
5.10	Dataset loading and unloading	S-102, S-111, S-122, S-411, S-412 S-124 [12]	S-101	S-101		S-101		S-101	S-101
5.11	Computation of data quality measures	S-102, S-111 S-122	S-101			S-101			

Notes:

[1] Depending on ice type and thickness, vessel characteristics, and availability of ice-breaking services, ice accumulations may effectively reduce the water area that is actually navigable in practice for individual vessels. This will affect various operational tasks, such as route planning, monitoring, calculations of safety contours and safe water, etc., in ways that depend on vessel characteristics. Further, though legally defined “navigable waters” do not change, particular waterways may be officially closed. (E.g., St. Lawrence Seaway.)

[2] Depths of not much use for surface vessel, if the sea surface is covered with thick ice...

[3] Whether one colour, pattern, or line style obscures the other or blends with it to produce something different. Are there any other issues with the presence of gridded information from different data products?

[4] S-122 may have more protected areas than the S-101 ENC has restricted areas of type “nature preserve”. (In some cases this might be considered a discrepancy in the ENC.)

[5] The geometry for the same feature in one or the other product may be more recent.

[6] The display priorities of Ice area fills, Ice area symbols, curves, and point features should be checked relative to the priority table in the S-101 PS C2.x.x (Display Priorities). E.g., the default display priority for ice area fills is 1. S-411 provides for different display modes for its 3 area features (navigation-specific or “scientific”) and for calculating priority relative to land areas.

[7] Symbols for own ship, mariner objects, navigational hazards in S-101 should not be displayed less prominently than any non-hazard feature in another dataset. S-101 restricted areas can be obscured only by a restricted area in an overlay (fine-tuned by CATREA and RESTRN values?). If traffic separation or recommended routes display is turned on their displayed boundaries of system must not be less prominent than area or line features in another dataset. S-124

Navigational Warnings promulgate information about navigational hazards. They should not be displayed less prominently than any non-hazard feature in another dataset.

[8] Displaying bathy surface would turn off display of S-101 depth features but not rocks, wrecks, or obstructions.

[9] Some feature and attribute types are used in both, if a feature or attribute type definition changes in one it may not necessarily change in the other either because of a lag in updating product specifications or a decision to maintain the old type definition. Tools and processes for creating navigation warnings may not use the same version as ship ECDIS.

[10] Changes to the geometry of a feature need to be managed, presumably the most recent S-101 or S-122 data is likely to be correct. Navigation warnings may not use the precise location of a feature such as an unlit light, or not have a geometry, or may be a chart correction which has not yet made it through the ENC update process. The water level coordinates broadcast over AIS may not be at exactly the same location as the feature coordinates in the ENC (e.g., the location of the bridge span).

[11] Clipping of surface current coverage features (or coverage features in other data products) for land may not be precise enough. Tentatively, assume that this can be ignored unless it is a large discrepancy and that dataset quality control will determine whether a discrepancy is large and have processes to find and remove such “large” discrepancies.

[12] May not be displayed at all scales. Optionally at user discretion? Dependent on ship location? E.g., displaying a navigation warning for a navaid fault near a harbor may not be relevant to a vessel which is far away.

[13] May depend on the type and importance of a navigational warning, since some nav messages might cover relatively large areas or even a whole NAVAREA. To be determined – whether there is internal information which can be combined with vessel circumstances to determine criticality or relevance to a particular vessel, or whether the real critical level must be left to the assessment of the bridge officers. Navigational warnings carry information which may have a direct bearing on the safety of life at sea.

[14] Portrayals of data quality for products which (might) use quality areas will have to be harmonized. The question if indicating data quality is not always addressed in the listed specifications so this assessment is likely to change.

[15] One comment on the original draft stated that coastline features may be present in multiple S-100-based products with different geometries. However, the specifications under development assume that S-101 will be the base product and accordingly their feature catalogues do not include coastline features. This analysis will assume that coastline features are not included as a matter of course in products other than S-101.

[16] Currently known plans for S-124 (Navigational Warnings) do not include Notices to Mariners.

[17] Navigational warnings will often be based on incomplete or unconfirmed information and mariners will need to take this into account when deciding what reliance to place on the information contained therein.

[18] The matter of how pick reports work with gridded data, and whether any information contributed by gridded data to a pick report should be additive, prioritized, or whether this should be determined by a configuration setting, should all be investigated. At present portrayal catalogues do not cover pick reports so it will be independent of the S-102 portrayal catalogue.

[19] The possibility of the SOE features being dynamically adjusted (geometry and/or attribute values) based on the corresponding features in other data layers. Work is going on by TWLWG for a zone-system to allow dynamic changes to the depth objects of the ENC charts. A product specification and/or feature catalogue even in draft form remain to be located. Pending further information, this will provisionally be treated as a spatial discrepancy of ENCs with a hypothetical ENC-Dynamic Water Level Zones (DWLZ) subset product ("S-101/DWLZ") that somehow describes the dynamic changes to S-101 depth features.

5 Interoperability issues

The points mentioned in this section were extracted from S100WG-10.2A and extended with additional issues. Other issues for interoperability will be added as and when identified. Out-of-scope and postponed issues are listed at the end of this document.

5.1 Data clashes

5.1.1 Duplicate feature instances

Data clashes resulting from the inclusion (modelling) of the same real world features in multiple PS application schemas. This includes instances of the same feature which may have different attribute values in different domains, even though the feature model is identical or nearly identical. Duplication for the purposes of this issue is provisionally defined as:

- equivalent models, e.g., use of the feature concept from the feature concept dictionary and the attribute bindings in the different application schemas, or
- equivalent subsets, e.g., feature concept, attribute bindings, and values of selected attributes are mostly the same but there are minor differences in the different products such as extra attribute bindings.

5.1.2 Duplicate feature domains

This issue refers to duplicate feature groups resulting from the inclusion of the same real world information in multiple PS application schemas. The features are in principle instances of different feature types, but convey the same information. For example, current information in ENC becomes irrelevant if an S-111 is loaded.

The precise definition of a “duplicate feature domain” for this purpose is left flexible at this point of time and will be refined later during work on the IOP catalogue. Duplication for the purposes of this issue is provisionally defined as:

- equivalent information but different models, e.g., S-101 current features (vector features) and S-111 currents coverage feature concepts,

Exactly where the line should be drawn between this issue and the previous one will be determined during the course of the project.

If some specific products (e.g. currents) must be up-dated before S-101, this must be clearly specified in IHO standards.

5.1.3 Combined geometry

Changes to the location or extent of symbols displayed on the screen due to a feature in one dataset effectively augmenting the geometry of a conceptually different feature in another dataset (though the nominal value remains unchanged). E.g., surface or sea-floor ice may effectively change the geometry of safety contours, by reducing the extent of safe water or affecting depths and underkeel clearance in ways that depend on vessel characteristics and icebreaker activity. (This would be like “addition/subtraction” which is different from the blending described in 5.4, since that would create a portrayal that could still simultaneously indicate both.)

5.1.4 Spatial discrepancies

The geometry for the same physical feature, or of features which are supposed to be coincident (e.g., a RESARE in S-101 and MPAARE in S-122) may be different in different data products, or one product may approximate a complex geometry by a simpler geometry, e.g., approximated area by point, or a part of a coastline by place name, coordinates or partial coordinates of two end points on the main land body.

The clipping of bathymetric surface data or surface current data for land may not be precise enough.

5.2 Harmonized portrayal

Harmonization of portrayal between different data products

5.2.1 Display of significant features

Ensure that less significant features in one data product are not displayed more prominently than more significant features in another product.

How to decide which features are more or less significant? The display priority and viewing groups are the only means of categorizing features.

For safety reasons, mariners must be allowed to easily switch to and view any of the actual original safety information at any time.

5.2.2 Avoid obscuring overlay

When the operator turns on some overlays (e.g. weather) then it would turn off much of the display of the underlying ENC so as not to obscure the weather information. Whether this is to be done by the system, by operator action, or by the system with a notification to the operator is not determined at this time. The IOP catalogue design may have to allow for settings controlling this and output indicating which approach was taken.

5.2.3 Portrayal distinguishability

Distinguishing different datasets that are simultaneously present on the display may be achieved by colour, shape (including fill and boundary patterns), or combination of colour and shape. The key point is distinguishability. The last resort would be determining what colours should be set aside for S-101 and not used in other specifications. Further one must include the fact that interoperability may suppress display of some features resulting in some colour becoming available for use in the overlay. Distinguishability may therefore be conditional and prioritization of data and a set of rules for portrayal distinguishability may be needed. It is obviously also affected by viewing mode (i.e., day, dusk, night).

Set-asides and default colours should be defined for use in the individual data products in case of conflict which cannot be resolved by other means.

5.2.4 Day / night / dusk modes

Mutually compatible day, night, and dusk modes for display compatible with lighting conditions. The design phase will address whether this can be modeled independently of portrayal distinguishability or whether the two must be combined in the interoperability catalogue and processing logic.

5.2.5 Impacts on viewing groups

Review categories, viewing groups, display priorities depending on what products are loaded. Viewing groups may have to leave gaps for inserting layers from other products. Combined design of viewing groups? Multiple product catalogues?

5.2.6 Impacts on portrayal catalogues

Radar/ARPA and AIS overlays must integrate appropriately with visible data products, and both radar/AIS and the visible S-100 data product information should be clearly distinguishable. Significant features (in principle, of all on-screen datasets) should be distinguishable in the presence of radar/ARPA and AIS data. The over-radar flag will have to be taken into account. Strategies for achieving this may have to include a method in the IOP catalogue of managing the visibility and display priority of data products especially relative to radar/ARPA or AIS display by means of the over-radar flag, display priorities, display planes, user settings, context parameters, etc. Additional parameters in templates in the portrayal catalogues, context parameters, guidance for use of the over-radar flag in individual specifications other than S-101, etc., may be needed.

Interoperability catalogue and processing will take into account the fact that radar and AIS are in fact distinguished layers:

a) radar echo overlay (managed by over-radar flag in the existing portrayal model for S-101 and S-57/S-52);

b) radar and AIS target symbols;

c) other AIS symbols than targets (i.e. AtoN, SAR, Base Station, symbols based on AIS ASM messages, etc.).

5.2.7 Portrayal of data quality for combinations of information layers

What are the symbols and styles for portraying the overall quality of interoperating data products, and how do they relate to the symbols and styles for the individual data products involved – e.g., give priority to the indicators from one product, define a priority order for data quality, define new symbols and styles specifically for combined displays, or something else?

If a combined quality measure is computed (see 5.11), how should it be portrayed and how should the system indicate that it is a combined measure, and should individual quality measures also be available (e.g., using a separate data quality pick report, or more fields in the usual pick report)?

"Combination" need not mean equal weighting of all layers not does it mean that only a single measure is shown to the end-user. At the extreme, the combination may give 100% weighting to the ENC and 0% to everything else which means only the ENC data quality is reported. Or, a combined measure may be reported along with a means for the user to view the different factors and their weightings.

5.2.8 Display of text

Text labels or annotations for features (e.g., names, light characteristics, etc.) should be placed so as to avoid overwriting text in other data products.

Some products may be text-heavy or picture-heavy e.g., some nautical publications dataset may include passages from publications. Embedded text may not conform to the ENC's 300-character limit. There may be references to support files or Web pages on the Internet. Text or graphic information in loaded products should interfere at little as possible with the route monitoring display, so the IOP catalogue should define means of achieving this even for text-heavy data products.

Interoperability should conform to the following rules for text displays:

- Text displays should not affect night vision.
- Windows containing text, diagrams, etc., which are superimposed on the route monitoring display shall be temporary. Temporary means that the window can be moved or removed from the display.
- It shall be possible to re-locate such windows in a less important part of the display, such as on land, or behind the own ship symbol.
- A mariner's information panel on the same screen as the route monitoring display should be clearly visible but not detract from the chart display.

The question of "display" includes whether an auxiliary screen should be used.

5.3 Treatment of skin of the earth features

5.3.1 Skin-of-the earth replacement

How S-102 data will replace S-101 skin of the earth features.

5.3.2 Skin-of-the earth feature adjusting

This section covers the possibility of the skin of the earth features geometry and/or attribute values being dynamically adjusted based on the corresponding features in other data layers.

(Work is going on by TWLWG for a zone-system to allow dynamic changes to the depth area objects of the ENC charts, but a product specification and feature catalogue are not available at this time even in draft form.)

5.4 Blended feature concepts or blended portrayals

The navigability of waters with ice depends on multiple ice characteristics. For example winds blowing from the west cause fairways to some west coast ports of Finland to get layered ice (wind pushes ice layers on top of each other until there is ice from the sea bottom up to the surface). When an ice-breaker makes a path through some ice remains between the sea bottom and the keel of the ice-breaker. Ice thickness in such a place could be up to 11 m while the ice-breaker draught is around 7-8 meters.

In such cases a simultaneous display of both ice coverage and underlying depth area is required. Other depth area features such as spot soundings, rocks, wrecks, etc., are also still important. The interoperability solution could be for example by using transparency or creating a temporary blended feature or blended portrayal (rule and/or symbol) of specific combinations of features from different products.

Note: Interoperability with ice is not limited to the products included in this analysis (S-101, S-411). The base chart could be S-101; depth areas may be replaced by S-102 bathymetry or by AML; and UKCM could also be applied at the same time; while the area is covered by ice. While AML and UKCM products are not part of the present analysis, the interoperability solution must be designed so that they can be added.

5.5 Hierarchy of data

Determine the hierarchy of data between different S-100 based specifications that are in the development pipeline.

This probably involves setting the display priorities in terms of the S-101 PS table in C.2.2.8.

5.6 Pick reports

How do pick reports work between different products. Would the pick report display both information from the overlay (such as weather) and the S-101 ENC, or just the weather information? Combined pick reports may be additive or prioritized.

5.6.1 Additive pick reports

Combined pick reports containing data from multiple product specifications, without suppressing any information

5.6.2 Prioritized pick reports

Combined pick reports where information in one data product suppresses or overrides data from another product. This might happen when the same feature/attribute binding appears in two datasets.

5.7 Interacting gridded information

How do two different gridded specifications interact with each other e.g. Surface Currents and Bathymetry.

5.8 Encryption and authentication

What is the encryption method (if any) for the interoperability catalogue? Should it be required or optional for it to be digitally signed and if so who signs it? How is it authenticated and does the authentication process depend on authentication of the FC and PC for different data products? Can the process and infrastructure for signing and authenticating S-100-based datasets or catalogues be used for the interoperability catalogue?

If interoperation requires adaptation, overriding, or substitution of the FC or PC for a data product, what means and processes can be defined to maintain the integrity of the resultant FC or PC?

Note: Catalogues, including the interoperability catalogue, differ from datasets in that catalogues are expected to be used with datasets encrypted and signed by different producers. The questions therefore arise, who shall sign such common artifacts, and what the answer implies for the distribution chain and for data management on the end-user system? The issue should in principle be analyzed as part of feature catalogue and portrayal catalogue management in general, and the answers in that context may well carry over to the interoperability catalogue.

5.9 Data supply chain

5.9.1 PS updates

This covers updates to parts other than to FC and PC e.g., metadata. Currently no issues have been identified under this heading, this section is merely a placeholder for potential issues which may be identified in the future.

5.9.2 Management of FC and PC updates

The IOP catalogue should be designed so as to minimize the need for updating when a FC or PC of a product specification which is in the IOP catalogue is updated. Maintenance processes for product specifications must include evaluation of any side-effects on interoperability and if needed a separate process for maintenance of the IOP catalogue.

Updates to application schemas (feature and information types and relationships) will have to provide for the possibility that features appearing in different datasets will have different sets of attributes and required relationships. This is likely to be the case anyway, since different product specifications are allowed to have different application schemas and publications datasets can be expected to add attributes or have more relationships for a feature than S-101. Technically, in spite of the same camel case name or code, they are different features since they are defined in different product specifications. Also, navigational warnings do not contain complete feature records for Aids to Navigation, they may have references at best.

5.9.3 Provision of new datasets

Dataset coverages and maximum and minimum display scales may need to be harmonized.

Feature geometry should be harmonized.

Feature types and attributes may need to be harmonized.

(The question of updates to product specifications is discussed in the previous subsections.)

5.10 Dataset loading and unloading

Maximum and minimum display scales for visible datasets must be harmonized, though they need not be the same. Portrayal of over-scale indicators may need to be controlled and harmonized especially if over-scale indicators are used in data products other than S-101.

5.11 Joint data quality measures

Each dataset displayed may have its own quality metadata. Quality metadata may be in the form of “quality surfaces” as described by DQWG, or as spatial quality associated to individual features. Quality may be bathymetric or non-bathymetric, and a dataset may have either or both types of quality as well as spatial quality measure associated to individual features.

When different products are simultaneously active on the graphical display, what quality measure should be used – for example, a single combined measure, a preferred measure from one data product, a tuple of measures, or something else – and how should it be displayed, both graphically and in text form? What happens when a layer is turned off or on by the user? How should quality for different products be prioritized?

The quality issues will be different depending on the product combination, since some products contain only gridded data which others have related (the same) vector features.

1) Bathymetric data quality: S-101 with S-102.
2) Spatial extents and locations data quality: S-101 with S-122.
3) Non-bathymetric data quality: S-101 with S-122.
4) For S-101 with S-111, S-411, or S-412, computation of joint data quality is not anticipated since there is no conceptual overlap of features with S-101. Interactions of data quality are likely to be only in connection with portrayal issues such as hiding of text and symbols, combining color fills, etc.
5) S-101 and S-112: Bathymetry information is in principle involved in both either directly or indirectly, but the time scales of the data are different (averaged vs. dynamic real-time) so any interoperation issues will concern only portrayal.

6 Product Interoperability Scenarios

Note: While the scenarios generally refer to bridge officers, cargo vessels, and ECDIS, in most cases, the considerations would generally be the same for other actors, vessels, and equipment, e.g., – small craft operators, leisure boaters, pilots, fishing vessels, ferries, pleasure craft, mobile devices, etc. Differences between user types and equipment which may affect the design of the interoperability catalogue are: type of system and platform in use, ranging from an ECDIS to an off-the-shelf mobile device; level of operator training; and allowable reaction times.

6.1 Information overlay

6.1.1 MPA overlay not allowed to replace ENC data

Goal: Given conflicting data in different data products, the ECDIS shows the more accurate data

Actors: Bridge officer; ECDIS

Description: SOLAS commercial cargo vessel approaching the coast, within the territorial waters of a coastal state. The bridge officer has set the ECDIS to display overlays of S-122 (MPA), S-124 (navigational warnings), S-412 (weather) information over S-101 ENC data. The S-122 overlay data is not allowed to replace ENC information and so it just sits on top of ENC data, i.e., objects in both datasets are visible. The display includes *Restricted Area* features in S-101 along with *Marine Protected Area* features in S-122. The geometry of a *RestrictedArea* feature from the S-122 dataset coincides only approximately with the geometry of an S-101 RestrictedArea with *categoryOfRestrictedArea =4* (nature reserve) but the S-122 dataset is more recent (it was updated later than the ENC, perhaps due to different update cycles) and has the correct information. The system must be able to determine which is more likely to be correct, or provide information that allows the bridge officer to know which is accurate.

Questions: (1) Should there be user control over whether to show both or hide one? (2) At what point should the discrepancy be brought to the attention of the bridge officer – during route monitoring, route planning, or dataset loading or update installation? (3) Should the discrepant areas be treated as a fuzzy area for the purpose of alerts? (4) For automatic alerts should the system select the most conservative setting, which in this case would be the outermost boundary? (5) Is the outermost boundary the most conservative setting in all cases, or should the officers be offered the option to choose?

Variation A: The S-101 dataset was updated more recently, but still has the incorrect boundaries. The solution approach to the main case must not mislead the system or user into replacing the correct boundary data with the incorrect information.

Variation B: The geometry is identical but the *RestrictedArea (S-122*) and *RestrictedArea (S-101)* have different values for attribute *restriction* (which is bound to both feature classes in the respective application schemas).

6.1.2 MSI and NW overlay

Goal: View data in an information overlay as well as everything on the ENC

Actors: Bridge officer; ECDIS

Description: All vessels - SOLAS, non-SOLAS and domestic - have obligations based on Global Maritime Distress and Safety System (GMDSS). The GMDSS includes, among other things, Maritime Safety Information (MSI) and Navigational Warnings (NW). The GMDSS define the concept four categories or sea areas (A1, A2, A3 and A4) based on which together with intended operational area the owner of the vessel installs one or more of the currently available methods for MSI and NW: NAVTEX, Inmarsat SafetyNET or HF NBDP. S-124 is planned as an alternative method to receive MSI and NW for vessels which have broadband communication capability.

The role of MSI and NW is not to replace ENC chart or features of ENC chart. MSI and NW also provide fast online real-time information which will not become part of ENC charts (for example hurricanes, typhoons, hard weather, temporary wrecks as result of grounding, collision, etc., temporary military exercises, etc.) or which inform important notices about charted objects (for example buoy in off-position, unlit, etc.). Currently IEC 61174 ECDIS describes how to integrate ENC charts with NAVTEX and SafetyNET. The current solution is just an overlaying graphical presentation based on symbols specified in IEC 62288 Presentation. The future S-124 will provide added value to this integration – by linking features on the ENC to additional information available about the objects. This will allow, for example, for an off-position buoy to be represented by both a symbol at the current real time position and a modified symbol at the charted position to indicate that there is nothing at the charted position.

6.1.3 Sea Ice or Dynamic water level data overlay

Goal: View data in an information overlay as well as everything on the ENC.

Actors: Bridge officer; ECDIS

Description: The ECDIS displays the overlay for S-411 (Sea ice) or S-412 over S-101 ENC data. Both S-411 and S-412 include features symbolized as area fills with colors or patterns. Overlay data just sits on top of ENC data but the user desires that it should not obscure anything on the ENC.

Area fills for ice areas and examples of line and point symbols from S-411 (iceberg limit and ice lead) are depicted below. The area fills should allow the bridge officers to distinguish ENC areas underlying ice (especially for the lower ice coverages) and the line and point symbols should not obscure ENC line or point symbols which may be adjacent or underlying the S-411 feature.

Object Class	Acronym						
Sea Ice	seaice						? ? ? ? ?
Lake Ice	lacice						? ? ? ? ?
Iceberg Area	icebrg						

In addition to the above described style of area fill there is a need to assist navigation in ice covered areas. This is assumed to use transparency for areas instead of opaque fill. In this style, from a navigation point of view the ice should be sub-divided between a) glaciers and b) ice. Glaciers are like land, they are too thick, etc. for even ice breakers. Other ice than glaciers are possible to navigate if one has capability to break the ice.

Obviously ice-breakers have this capability which has been even proven many times by visiting the North Pole. But there are a lot of cargo and passenger vessel capable to break ice. For example in practice all vessels visiting Finnish Ports during winter time have an Ice class and they are capable even without ice-breaker assistance of navigating through ice (depending of ice class some could do just 10 cm, but some can manage more than 100 cm of ice). For such vessels, effectively the navigable waters are equal in winter and summer. If the navigability is changing, then the reason is not ice, but water level from tidal, wind, etc. A route from open water through ice covered areas to final destination, for example a port, is same in both summer and winter time. What is different is that the vessel may need technical ability to break ice or to use assistance by an ice-breaker.

One cannot use ice thickness to determine what the limit of non-navigable areas is. For example if wind blows for a long time from the west then fairways to some west coast ports of Finland will get layered ice (wind pushes ice layers in top of each other until there is ice from the sea bottom up to the surface). In such cases when an ice-breaker drills a path through the result is that some ice remains between the sea bottom and the keel of the ice-breaker. Ice thickness in such a place could be up to 11 m while the ice-breaker draught is around 7-8 meters.

There is a need for simultaneous display of both ice coverage and underlying depth area. In this case, all other depth area features such as spot sounding, rocks, wrecks, etc. are also important to see simultaneously. The technical solution could be for example by using transparency for the areas covered by ice.

The interoperability with ice is not limited to S-101 + ice. Basic chart could be S-101 with depth areas replaced by S-102 bathymetry or by AML; and UKCM could also be applied at the same time; while the area is covered by ice.

6.1.4 Navigation warning pertaining to a navigation aid

Goal: View data in an information overlay as well as everything on the ENC.

Actors: Bridge officer; ECDIS

Description: A shipping administration has issued a navigation warning indicating that a specified light is unlit. The navigation warning identifies the navigation aid by type and coordinates and list of lights number, but does not include the ENC feature identifier. This warning must to be associated to the corresponding navaid feature(s) in the ENC so that a special symbol appears on the display over, near, around, or otherwise visually linked to the navaid feature (or the ENC symbol is appropriately highlighted), and that a pick report indicates to the viewer that there is a navigation warning related to the navaid.

This is related to S-124.

6.2 Bathymetry replaces soundings

Goal: Given an overlay certified as a suitable replacement, replace the corresponding ENC features with features from the overlay.

Actors: Bridge officer; ECDIS

Description: S-102 (Bathymetry surface) gridded data is displayed over an ENC. The S-102 data is certified as allowable replacement for appropriate ENC features. Depth areas, dredged areas and soundings with multi-point geometry are replaced with bathy surface features. Depth contours are re-computed based on S-102. Alerts trigger when the safety contour is crossed. Contours are computed on gridded data using an algorithm to be determined by the S-102 group.

6.3 Interleaving of data

Goal: Priority orders in different data products are interleaved so that features of higher priority in the lower layers are not obscured by lower priority features in overlays.

Actors: Bridge officer; ECDIS

Description: S-122 (MPA) data displayed with S-101 data. *RestrictedArea* features from S-122 should be displayed with the same drawing priority as *RestrictedArea* features in the ENC, i.e., drawing priority 5. ENC features of drawing priority 6-8 are drawn on top of S-122 *RestrictedArea* features. Obstruction and Wreck features in S-122 function as location features for fish havens and their priority is conditional (if they also exist in the S-101 ENC dataset the drawing priority in the MPA dataset can be at the same level as restricted areas or superimposed areas in the ENC (2, 3, or 5). *MarineProtectedArea* features in S-122 should conditionally be given priority 5 (the same as restricted areas) since they also indicate restrictions (they have an optional *restriction* attribute).

Note: Providing for such interleaving may require updating the display priorities table in S-101 in some way, e.g., either expanding the list in S-101 product specification to leave gaps between S-101 priorities for priorities of other product specifications, or some method in the IOP catalogue to combine the drawing priorities in the individual portrayal catalogues for different data products.

6.4 Replacement of ENC data with certified MPA overlay

Goal: Certified overlay data replaces the equivalent ENC data

Actors: Bridge officer; ECDIS

Description: Loading data from S-122 (MPA) that is certified to replace the equivalent features of the underlying ENC dataset must result in the removal of the replaced data from the display and its seamless replacement by the certified replacement.

An S-122 MPA dataset contains all the IUCN-listed nature reserves within its coverage and has been tested and certified (in conjunction with other products to be determined) as an acceptable replacement for all nature reserves and similar areas (bird sanctuary, seal sanctuary, ESSA, PSSA, etc.) in overlapping S-101 coverages. The *restriction* attribute conveys only limited information, e.g., there is no information on vessel and cargo types for which the restriction applies. In theory the *restriction* attribute value is the same in both S-101 and S-122 datasets and there is no data clash, however S-122 contains more information since it shows what ships are included and excluded, in information objects associated to the feature. When the S-122 data is loaded, the S-101 *RestrictedArea* features with specified values of *categoryOfRestrictedArea* are removed from the display and the S-122 features displayed in their place with suitably computed drawing priority (the higher of their priorities in S-122 and S-101). Any feature and information associations for the removed *RestrictedArea* features are moved to their replacements.

6.5 Suppression of parts of underlying ENC data

Goal: ENC data is hidden when data intended to suppress ENC data is loaded

Actors: Bridge officer; ECDIS

S-111, S-411 and S-412 will have similar operations where parts of the underlying ENC data may be suppressed while the product is on the screen.

S-111 is coverage data while S-411 and S-412 are vector data so this has 2 variants. The actors are as mentioned above for both.

6.5.1 Suppression of ENC information with coverage data - S-101 and S-111

S-111 (Surface Currents) coverage features suppress any S-101 current features ("Current – non-gravitational", "Tidal stream – flood/ebb"). S-101 *WaterTurbulence* features are retained since they are not covered by S-111.

6.5.2 Suppression of ENC data with vector data - S-101 and S-411 and S-412

Ice area features from S-411 (Sea Ice) suppress any overlapping S-101 *IceArea* features. S-412 (Weather overlay) has *IceEdge* and *LimitOfKnownIce* features – whether they suppress S-411 ice features or vice versa remains to be determined, but may have to be rule-based depending on factors such as which data is more recent.

6.6 Bridge with air gap and wind information

Goal: The navigator can filter out information by user-defined areas, time, and thematic attributes.

Actors: Bridge officer (or barge skipper, or river pilot); ECDIS

Description: Bridge with wind and air gap broadcasting, navigator reviews data 2h before crossing and makes the go/no-go decision. In go scenario, he might have the air gap data till he's 5min away and remove the information but keep the wind information visible for the whole bridge crossing. This scenario implies the ability to show partial information in a very specific area for any length the navigator deems necessary.

S-412 has both wind and water level information (actually all its information) in the same feature type. So "partial information" would mean filtering down to the attribute level, by space, and time

6.7 Passage / route planning

Goal: The system can be configured to display different types of information needed to plan the route for a voyage

Actors: Passage planner (master, navigation officer, mate, or voyage planner in shipping company office); ECDIS

Description: ENC, MPA, navigational warnings, and bathy surface data are used in a back-of-bridge scenario to plan the route for a voyage. The planner may turn on or off different viewing groups or sets of features from different data products so as to provide information about particular aspects of the planning problem without adding clutter by including irrelevant feature types or attributes.

6.8 Route monitoring

Goal: The system can be configured to display different types of information needed to monitor the vessel's route

Actors: Bridge officer; ECDIS

Description: This is the classic "ECDIS" situation. During route monitoring in different circumstances, what are the combinations of information the bridge officers want to see on the ECDIS? All the datasets? Subsets of feature types from some datasets? Sub-cases are defined in the subsections below. (Actors for the sub-cases are mentioned where they may be different from the base case.)

6.8.1 Ocean passage

Products needed on the display are S-101, S-111 (if available for ocean currents), S-124 for NAVAREA warnings, S-411 (if available, for icebergs); S-412 for weather.

6.8.2 Coastal route monitoring

Products needed on the display are S-101, S-102 (depths and safety contour – the latter computed from data), S-111 (currents), S-122 (protected areas), S-124 (warnings about navaids, hazardous conditions, etc. – coastal warnings), S-411 (ice), S-412 (weather)

6.8.3 Navigation in harbour approaches

Products needed are S-101, S-102 (depths and safety contour), S-111 (currents), S-122 (protected areas), S-124 (local warnings), S-411 (ice), S-412 (weather)

6.8.4 Entering or departing harbour

Actors: Bridge officer; pilot; tug operator; ECDIS; PPU

Products needed are S-101 for harbour and berth information, S-112 for water levels, S-102 for bathymetry, S-122 for protected areas in the approach, – all only if sufficiently large scale data (or scale-independent data) is available and only in a relatively small area. Will probably have additional information too, specific to the berth and other inputs e.g., sensors for distance measurements. In fact, berthing might not use an ECDIS at all.

6.8.5 Operations within harbours

Actors: Bridge officer; harbour pilot; tug operator; harbourmaster's office; ECDIS

Products needed are S-101, S-102, S-111, S-112, S-124, other data products specific to the harbour, such as a terminal map.

6.8.6 Operations in narrow channels

Actors: Bridge officer; pilot or river pilot; ECDIS

Products needed are S-101, S-102, S-112, other data products specific to the channel.

6.8.7 Operations in congested waters

Actors: Bridge officer; deep sea pilot; VTS controller; ECDIS; VTS display

Products needed on the display are S-101, S-102, S-112, other data products specific to the waterway if any.

6.8.8 Berthing

Actors: Bridge officer; pilot; terminal operator; tug operator; ECDIS; PPU; or custom application

A large vessel approaching a berth, possibly assisted by tugs and S-101 for harbour and berth information, S-112 for water levels, S-102 for bathymetry – all only if sufficiently large scale data is available and only in a relatively small area. Will probably have additional information too, specific to the berth and other inputs e.g., sensors for distance measurements. In fact, berthing might not use an ECDIS at all, but other specialized equipment that uses only a subset of S-101 information (possibly in a specialized berthing chart) plus water level and depth data plus specialized sensors and may be partially guided from shore.

6.9 Shore-based displays

Goal: Clear surface picture of vessels, tracks, selected geographic features, and related information in a particular area or port.

Actors: VTS controller; harbormaster (including deputy, assistant, or other port official); shore-side display.

Data products may be used in shore-side displays. Additional information such as the radar picture, AIS information, information about navaid status, new or transient obstructions, terminal or berth information, etc., will be overlaid over the picture. A large format screen or multiple screens may be used. Information about navaid status and transient obstructions such as containers overboard, etc., is assumed to be available in the form of as S-124 data.

This kind of application is not within the scope of this project.

7 Data loading and pre-defined product loading combinations

Since different operating scenarios e.g., passage planning, route monitoring, etc., will involve loading different collections of data products, and since they are likely to be more or less the same for the same class of end-user, it may be useful to specify pre-defined collections or "base collections" of products which can be loaded by the user under specific conditions or for specific tasks. An ECDIS would allow the user to select from a list of pre-defined product combinations instead of loading and unloading individual data products. SOLAS V or other external requirements should be taken into consideration.

A pre-defined collection is basically a package that collects a set of data product identifiers, display priorities, context parameters, user settings, portrayal catalogues, etc., into an identifiable collection. Pre-defined collections are intended to break down the interoperability problem into more manageable chunks, define the appropriate design elements for the IOP catalogue, and help identify what changes are needed to product specifications or portrayal catalogue structures to accommodate such scenario-based default and user-customizable product loading rules. (Customization at lower levels, e.g., feature group or individual feature, is out of scope at present.)

The ECDIS is expected to be able to allow the user to set up the ECDIS for a particular task by selecting one of the pre-defined collections.

An initial list of pre-defined collections follows in the table later in this section. The initial collection sets will be encoded in a system configuration file. It is envisaged that the ECDIS will allow end-users to adapt the collections or customize them by changing the load sets, selecting portrayals, changing context parameters and user settings, etc. Customized collections can be saved – thereby allowing operators, masters, and bridge officers to add to the library of pre-defined collections available on the ECDIS. Either initial or customized collections can be reloaded at a later time. Users can also load additional data products, real-time information (e.g., radar, AIS) or unload one or more of the default products after a pre-defined collection is loaded.

The categorization that follows is intended only as a working set for IOP catalogue design purposes and not a prescription for S-100-based ECDIS.

N: not loaded

P: Partially loaded

Y: Loaded

O: Optional (loaded or unloaded at user option)

C: Customized subset of features, e.g. a subset selected by feature type, attribute value, or creation time

Table 3. Pre-defined collections

Collection Purpose \ Product	S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level	S-122 MPA	S-124 Nav Warnings	S-411 Sea Ice	S-412 Weather overlay	Other	Remarks
Voyage and route planning										
Voyage planning	Y	N	N	N	Y	Y	O	C	UKCM – if coverage available	The voyage plan defines the start and end of the voyage and the intended transit time considering the ship's parameters. Ice conditions are important for the time calculation, S-122 and S-124 areas may be bypassed due to their status (active, inactive)
Route planning, ocean or offshore voyage	Y	N	Y	N	Y	Y	O	C	UKCM – if coverage available	also desktop or multi-screen Based on the assumption that a previous check allows the ship to enter the port of destination, S-111 might have effects on the planned route
Route planning, coastal voyage	Y	Y	Y	O	Y	C	C	C	UKCM	also desktop or multi-screen S-111 – as above. S-124m S-411, S-412 – only if relevant to general track.
Route monitoring										Takes weather conditions into account
Route monitoring, ocean	Y	N	O	N	N	C	Y	Y	radar, ARPA, AIS	also multi-screen S-124: only selected areas presented
Route monitoring, coastal	Y	N	Y	N	Y	C	Y	Y	radar, ARPA, AIS	also multi-screen S-124: only selected areas presented

Collection Purpose \ Product	S-101 ENC	S-102 Bathy Surface	S-111 Surface Currents	S-112 Dynamic Water Level	S-122 MPA	S-124 Nav Warnings	S-411 Sea Ice	S-412 Weather overlay	Other	Remarks
Route monitoring, congested waterways (e.g. TSS)	Y	N	Y	N	Y	Y	Y	O	radar, ARPA, AIS	also multi-screen
Route monitoring shallow waterways	Y	Y	Y	Y	C	Y	N	C	radar, ARPA, AIS, UKCM	also multi-screen suppress S-101 depth areas, replace by S-102; S-122 not needed for pier approach; S-412 wind and visibility information is needed
Route monitoring, port approach/departure (Piloting)	Y	Y	Y	Y	C	Y	O	C	radar, ARPA, AIS, UKCM	also PPU S-122 if there are nearby nature reserves
Other operations										
Berthing	Y	Y	N	Y	N	N	N	O	specialized apps	also on mobile or special display
Harbor movement	Y	Y	Y	Y	N	N	N	N	--	also PPU
Transit of bridge	Y	Y	C	C	N	C	O	O	specialized apps	Also mobile or other display. Spatio-temporal and attribute filters applied to S-111, S-112, and S-124 data (see 6.6)

8 Issues not part of this analysis

8.1 Persistent unique identifiers

This specification should also give consideration to the potential need for persistent universal identifiers and how that might work within S-100.

8.2 Issues postponed or out of scope

These will either be addressed later or not at all.

1) Testing procedures, to ensure that data products are, not only tested against their own performance criteria, but also tested against their intended interaction with other data products; [postponed]
2) Recommend which specifications should be reserved for front of bridge use versus back of bridge planning. [not in scope]
3) Maintenance of IOP catalogue: The process and organizational structure for maintenance of the IOP catalogue. Probably set up a project team whenever a FC is revised or extended?
4) User customization or users moving layer priority or select individual features or groups of features.
5) Interoperability for shore-based displays is out of scope of the present analysis.
6) Procedures for certification of datasets or data products and roles in the certification and distribution chain are out of the scope of this analysis.