The provision of hydrographic services as core element of E-navigation - Status and perspective

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Abstract: *The further improvement of the universal hydrographic data model S-100 forms the basis of the current technical standardisation activities of the International Hydrographic Organisation. S-100 specifies, for hydrographic and related information, the methods and tools for data management, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. Those features form the basis for all aspects of information handling envisioned under the e-navigation concept of the IMO. The submission reports on the latest development of the S-100 framework, the scope of derived data products and describes the purpose and contents of the interoperability specification. Special attention is put on the flag ship project S-101 Next Generation Electronic Navigational Chart (ENC). The related synopsis comes with a time line for the regular provision and use of such data sets. The transfer of the S-100 concept to other scientific domains is demonstrated for meteorological data (sea ice).*

1. Introduction

As defined by the International Maritime Organization (IMO), e-navigation is "the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment". Hydrographic services constitute an important component of the information required for the safe operation of ships. The International Hydrographic Organization, the IHO, is the intergovernmental organization responsible for creating a global environment in which the Hydrographic Offices of its Member States, currently 85 of them, provide collectively adequate, standardized and timely hydrographic services and ensure their widest possible use.

These services include, according to the international Convention for the Safety of Life at Sea (SOLAS), "the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation". The provision of "all nautical information necessary for safe navigation" in digital format is a key-enabler for e-navigation. That objective is partially met with the progressive uptake of Electronic Chart Display and Information Systems (ECDIS) on ship bridges and the provision by Hydrographic Offices of the relevant integrated charting services to ensure that mariners have access to up-to-date seamless digital chart coverage of Electronic Navigational Charts (ENC). The implementation of e-navigation requires extending the concept from chart information to all nautical information. Driven by the constraints and limitations associated with traditional paper based products, the carriage requirements set out by SOLAS differentiate between nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications. This distinction is no longer relevant when the information is managed and processed digitally through electronic display and information systems. The need to develop solutions which support mariners with an integrated real time situational awareness is recognized in the IMO e-navigation strategy implementation plan (SIP). It relates directly to one of the five prioritized e-navigation solutions on which the SIP is based, namely solution S4 - "integration and presentation of available information in graphical displays received via communication equipment". As indicated in the SIP, the implementation of solution S4 requires the development of the concept of Maritime Service Portfolios (MSP), which define and describe the sets of operational and technical services and their level of service provided by a stakeholder in a given sea area, waterway, or port, as appropriate. The implementation of MSPs will be supported by a Common Maritime Data Structure (CMDS) based on the S-100 Universal Hydrographic Data Model adopted by the IHO.

2. S-100 – the Universal Hydrographic Data Model

S-100 specifies, for hydrographic and related information, the methods and tools for data management, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. The S-100-based MSP related to hydrographic services will be structured in several products and services whose features, attributes and relationships are described in S-xxx product specifications. A new generation of ENCs, defined by the S-101 Product Specification, will be used as the basis which the mariner will be able to combine, as required, in an integrated display with

additional 'layers' related to a more detailed description of a feature (for instance: high resolution bathymetry replacing the ENC bathymetry) or to other products or MSPs (for instance meteorological forecast).

3. Adoption of the S-100 concept by other domains

Table 1 – Data Product Specifications based on S-100 (July 2016)

Product Specifications of IHO (Numbers S-101 to 199)	
S-101	Electronic Navigational Chart (ENC)
S-102	Bathymetric Surface
S-103	Sub-surface Navigation
S-104	Tidal Information for Surface Navigation
S-111	Surface Currents
S-112	Dynamic Water Level Data
S-121	Maritime Limits and Boundaries
S-122	Marine Protected Areas
S-123	Radio Services
S-124	Navigational Warnings
S-125	Navigational Services
S-126	Physical Environment
S-127	Traffic Management
S-128	Catalogues of Nautical Products
Product Specifications of International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) (Numbers S-201 to 299)	
S-201	Aid to Navigation Information
S-210	Inter-VTS Exchange Format
S-230	Application Specific Messages
S-240	DGNSS Station Almanach
S-245	eLoran ASF Data
S-246	eLoran Station Almanac
Product Specifications of Intergovernmental Oceanographic Commission (IOC) (Numbers S-301 to 399)	
Product Specifications of other Organizations (Numbers from S-401)	
S-401	Inland ENC (Inland ENC Harmonization Group)
S-411	Ice Information (Joint Technical Commission for Oceanography and Marine Meteorology)
S-412	Weather Overlay (JCOMM)

Compliance with the S-100 data model and the S-100 Registry structure warrants that the different product specifications are compatible and consistent. In order to ensure the harmonized display of the information related to different products and services within an ECDIS the IHO is developing the S-100 Interoperability Specification, which will define a machine readable set of rules for navigation displays. Though not all S-100 concept software tools such as the portrayal catalogue builder are readily available yet, several domains of the maritime community have already adopted the S-100 concept and started to derive product specifications for their particular purposes (Table 1). An excellent example is the initiative of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) to maintain the S-411 Product Specification for sea ice coverage. Digital ice charts of the Artic are regularly provided by means of this format and are freely accessible at http://www.bsis-ice.de/IcePortal/.

4. S-101 Next Generation ENC

S-101 is the new Product Specification for ENC data sets based on the overarching S-100 framework standard. In the future, S-101 compliant ENCs will succeed and ultimately replace S-57 compliant ENCs as official chart data for ECDIS. The development of S-101 is being coordinated by a dedicated Project Team under the IHO's S-100 Working Group (S-100WG). The development of S-101 reflects the experience and feedback of end-users and other stakeholders in regards to the current limitations of S-57 based ENCs. The ultimate goal is that an S-101 ENC will provide the base chart layer for S-100 integrated products and the underpinning of e-navigation. Its full potential will be realized as other types of products used within the maritime domain, such as aids to navigation, vessel traffic services, oceanography and meteorology, etc., adopt the concept and develop interoperable products and services modelled along the S-100 framework as well. It is expected that navigation equipment industry will develop S-100 ready devices when the S-101 Product Specification reaches maturity and regular provision of S-101 comes within sight.

4.1 S-101 – How is it different from S-57?

S-101 compliant ENCs are not a radical reengineering of the S-57 concept. S-101 retains most of the characteristics that are currently used in S-57 ENCs, but also improves those elements of S-57 that benefit from the flexible framework, which has been established under S-100 and aligned with the current ISO 19100 series of geospatial standards. While S-100 encompasses a variety of new elements, this article will only cover a select few that are being utilized within S-101. Though limited by numbers, the features explained hereafter are typical for the scope of S-100´s advance in technology. They are expected to be absorbed by other Product Specifications in the future.

4.2 Machine Readable Catalogues

The biggest advantage that utilizing S-100 for S-101 has over the existing S-57 ENC product specification is the introduction of dynamic feature and portrayal catalogues. The term 'dynamic' is used to indicate the possibility of adapting them when required. While similar in

content to the current S-57 Object Catalogue and S-52 Presentation Library, S-101 implements the dynamic constructs prescribed by S-100. Under the current S-57 ENC regime, updates of such elements may take up to five years to implement – because these t catalogues are embedded in the ECDIS software. In S-101, the relationship between features, attributes and enumerants are defined within a single feature catalogue. The elements of the portrayal catalogues link the feature catalogue elements to their graphical representation. Although, part of the standard, the feature and the portrayal catalogues are built through a registry responsible for defining data set elements and are machine readable. Under S-100 the content of the registry is continuously adapted, but the S-101 feature and portrayal catalogues will be versioned, enabling the IHO to take advantage of the dynamic register content. In addition, to the feature and portrayal catalogues, S-101 will also provide another catalogue defining alerts and indications for use in the ECDIS. The advantage of moving to a fully machine readable catalogue system is that the ECDIS will be able to update new elements via a catalogue update which comes together with a regular data delivery. This "plug and play" mechanism will be much simpler to implement by both manufacturers and end users than the current process which requires prolonged software updates.

Table 2 - Common Terms used in S-100 and S-101

Term	Definition
Attribute	Describes the characteristics of features. E.g. The attribute "colour" would describe the colour of a light.
Ennumerant	A descriptive list of values. E.g. The enumerant "Red" or "Green" would be options for the attribute "colour"
Feature	The description of real world entities. E.g. The "Eiffel Tower" may be classified as a feature type "tower".
Feature Catalogue	A catalogue containing definitions and descriptions of feature types, feature attributes occurring in one or more sets of geographic data
Portrayal Catalogue	A catalogue containing the symbols and rules used to portray the features defined in the feature catalogue.
Registry	An entire information system which is a collection of data dictionaries or registers. The register is a database that contains descriptions of many types of information, including definitions of features and attributes.

4.3 Complex Attributes

S-101 will also make use of a new S-100 feature to enhance the encoding, transfer, and portrayal of data called a complex attribute. A complex attribute is an aggregation of other attributes, either simple or complex and is similar to the ISO 19000 attribute of attribute.

Complex attributes are a significant improvement to enhance S-101 applicability. It provides the ability to either replace multiple attributes or break down attributes into new sub-attributes.

For example, the existing S-57 attribute OBJNAM (name of the feature) is remodeled into a complex attribute. This is done to better control the display of the feature name on the ECDIS. It now includes two sub-attributes called “displayName” and “name”. The sub-attribute “displayName” is defined as a Boolean and when toggled in the data it indicates that this is the name to be displayed on the screen. By having the feature name as a complex attribute, it allows producers to store multiple names of the same feature. So instead of the ECDIS showing “San Francisco Approach Lighted Whistle Buoy “SF” (Figure 1) the ECDIS will only display the “SF” (Figure 2) and the full name of the buoy will be discoverable via the pick report.

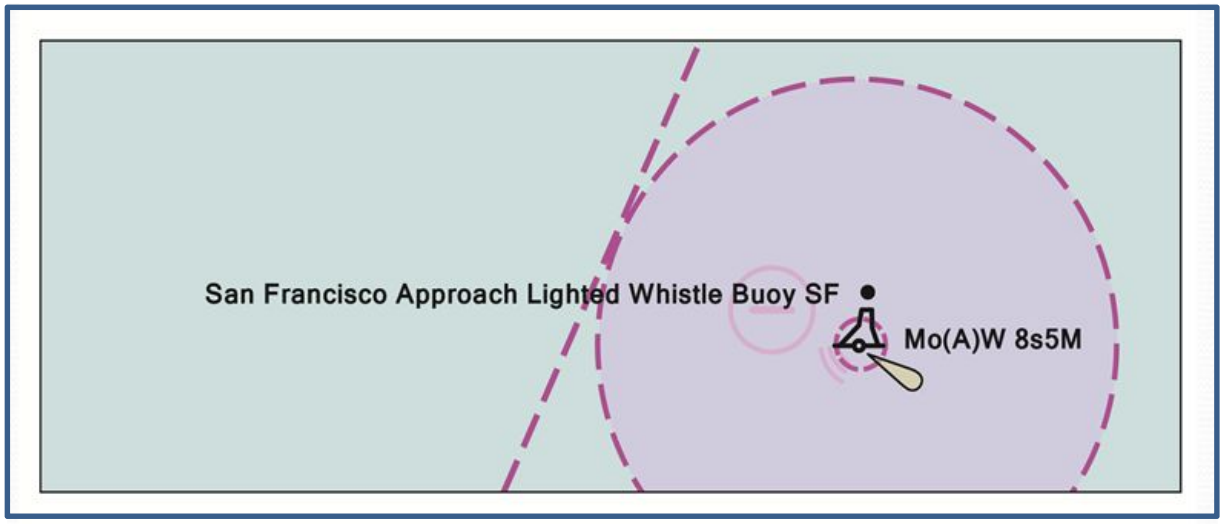

Figure 1 – Display of Buoy Name in S-57/S-52

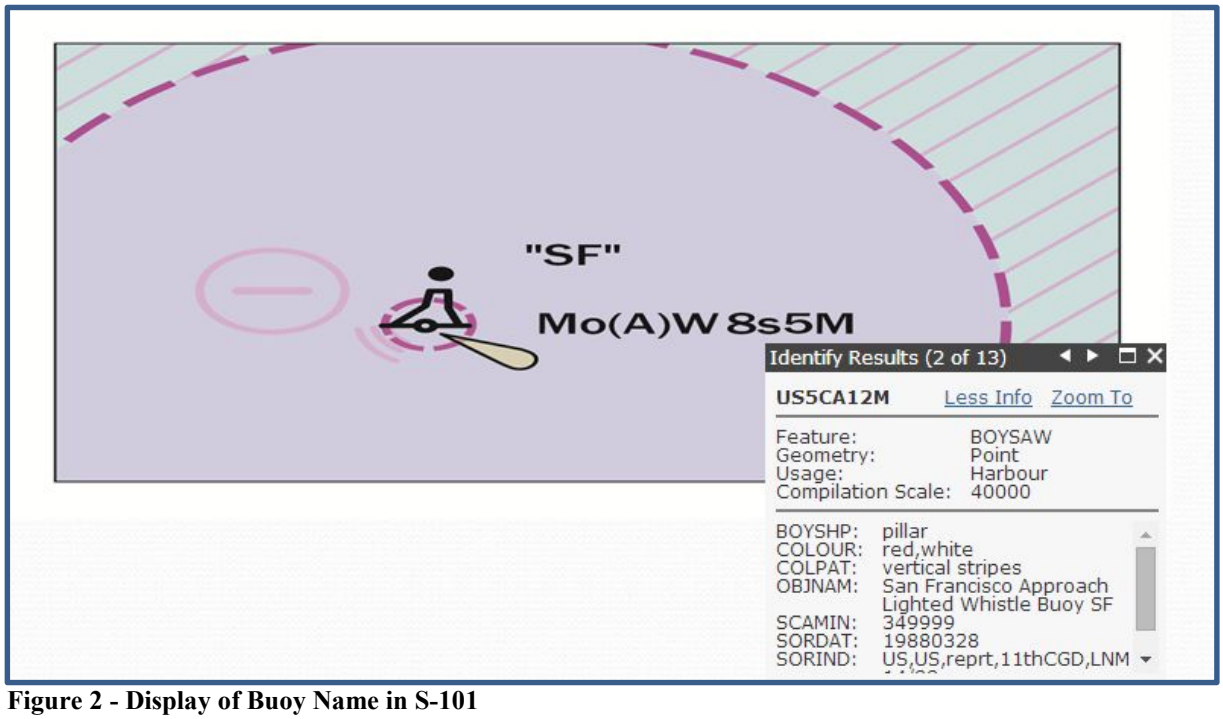

Figure 2 - Display of Buoy Name in S-101

4.4 Update Feature

One of the biggest problems users have with S-57 data is ascertaining what changes have been made after an update has been applied to the data. In this case, the ECDIS does not have enough information to properly depict or highlight what are commonly important changes. The main problem is that in order to update a simple feature in S-57, it may affect underlying geometry that is also transmitted as part of the update. This results in unrelated information depicted in the highlight update routine that the ECDIS performs. In order to streamline this function and enable users to clearly see what changes have been applied to a data set via a notice to mariners, including any features that have been deleted, S-101 has introduced the update feature carrying this meta information. The update feature will enable the ENC producer to clearly indicate what has been updated and if necessary the source of that update – such as a notice to mariners. For example, this will be particularly useful for detecting changes that may affect a route defined during passage planning.

4.5 Text Placement

Another new feature that has been introduced in S-101 is the cartographic feature type. This new feature type, and its associated attributes, will enable S-100 based ECDIS to have better control over the way text is positioned on the display. Gaining individual control about the positioning of text will improve the overall look and feel of ENCs in ECDIS. For example, instead of description of channel buoy lights appearing across a channel area, it will be possible to move them away from the channel area (Figure 3 and 4).

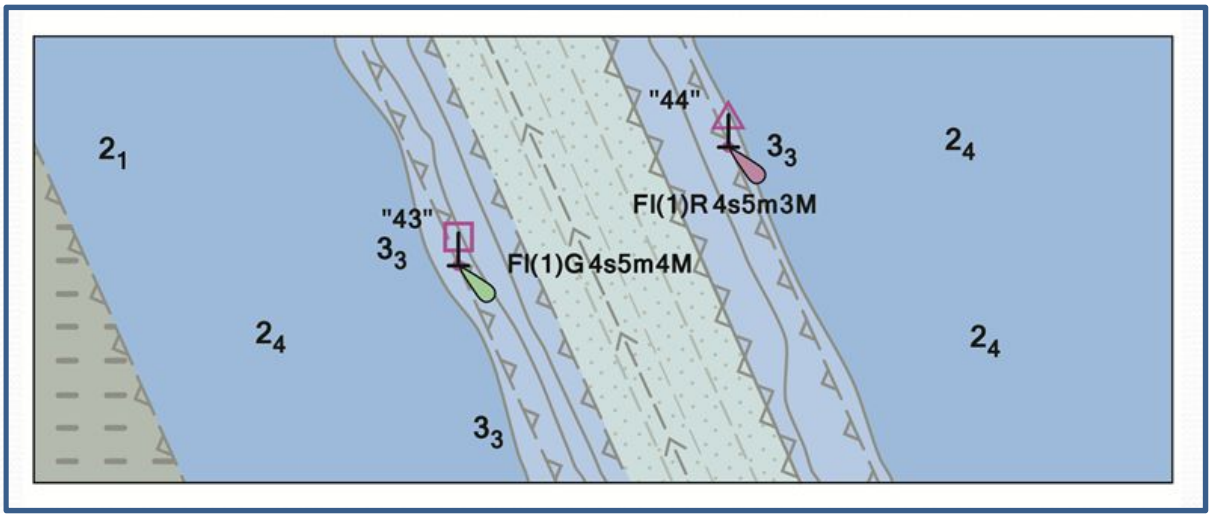

Figure 3 - S-57/S-52 Text Placement

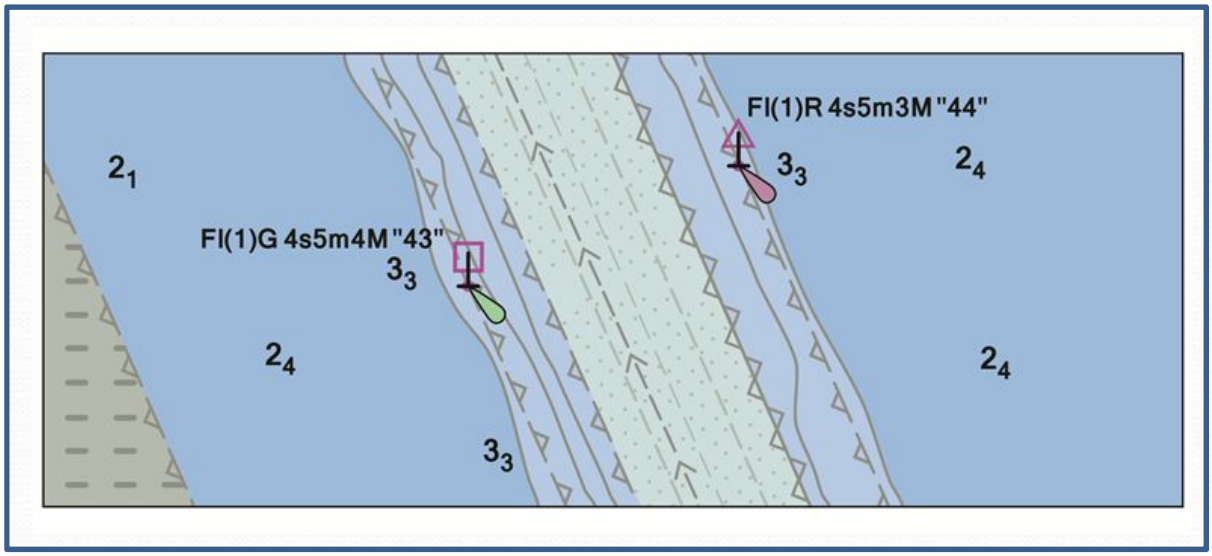

Figure 4 - S-101 Text Placement

4.5 Production System Attributes

Currently an S-57 based ECDIS has to spend considerable time during loading to identify the relationships between the geometries of certain features e.g. a wreck and its surrounding depth area. This is done in order for the System ENC (SENC) to pre-determine the appropriate display criteria so that the system can execute the S-52 Conditional Symbology Procedures (CSP) correctly. In order to reduce the need to call up these complex procedures that need to be calculated by the ECDIS at any change of the presentation, the ENC production systems will pre-calculate the values describing this relationship; store them as an attribute of the feature and export it as part of the S-101 dataset. This will increase the efficiency of creating the SENC, reduce the need for a significant number of CSPs and contribute to a faster and simpler loading process.

4.6 S-100 Test Bed

Before the IHO Member States can finally approve S-101 as a functional standard, it must undergo a rigorous testing process that will require the implementation of test bed projects. It is important to understand that this test bed will need to be S-100 based, capable of testing other product specifications which can be either supplementary to S-101 ENCs or non-related GIS applications. The testing process has been divided into five phases that cover the entire end-to-end process. Breaking out the testing through phases allows for the iterative development of future ECDIS as a system by gradually expanding requirements and the different types of test scenarios that are needed to validate S-101 as a functional standard. The overarching test bed strategy is depicted in the following figure which shows the logical progression from test sample creation to use within an ECDIS from 2019 onwards.

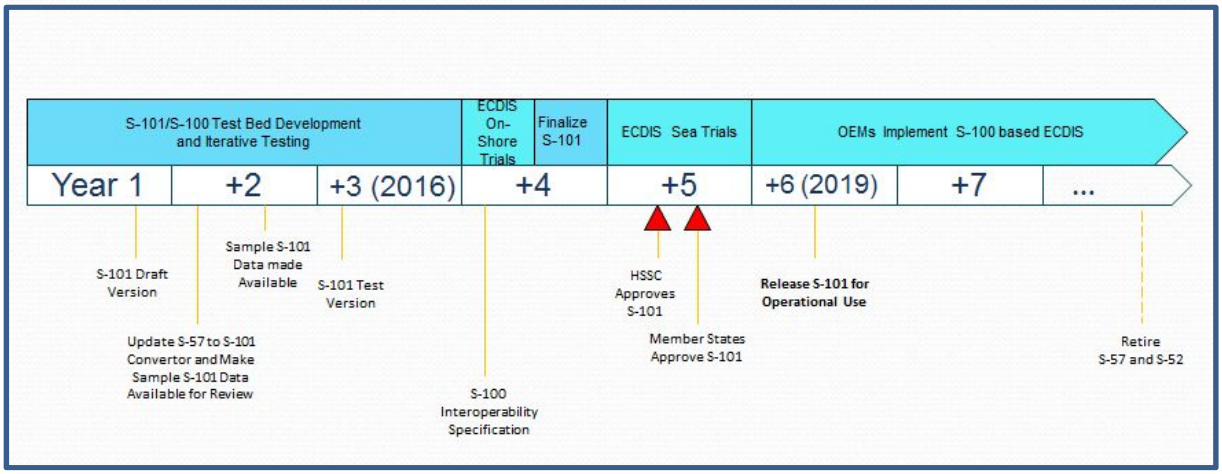

Figure 5 - S-100 Test Strategy Phases

The outcome of testing will also enable a more detailed impact study to provide a clear picture of the effects on the various stakeholders involved in data production, dissemination and use in the process of eventual introduction of S-101.

5. CONCLUSION

The hydrographic element as one of the core enabler of the e-navigation strategy is taking shape. Future production and use of S-101 next generation ENC will trigger industry to implement S-100 based solutions and paves the way for high level integration of all information related to the maritime domain. Since the S-100 concept itself is based on accepted ISO Geoinformation standards wider acceptance beyond the remits of hydrography can be expected. Recent adoptions of the framework by IALA and JCOMM for their specific purposes prove this impressively. It should be noted however, that the breakthrough of the full concept is highly dependent from the wide and affordable availability of broadband communication at sea. Like ashore, the advent of modern internet technology at sea for everyone will become the final game changer.

References:

[1] J. Powell, “S-101 – The new IHO Electronic Navigational Chart product specification”, Hydro International, October 2014, Vol. 18, No. 7, p. 22-25