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The New Electronic Chart Product Specification S-101: An Overview

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ABSTRACT: The development of S-101 represents a major step forward in product specifications for Electronic Navigational Charts (ENC). Based on the IHO geospatial framework standard S-100, S-101 will become the eventual replacement to S-57 ENCs. This paper will discuss the phased development approach that will lead to an ENC with improved functionality and better data handling throughout the ENC supply chain from producer to end-user, and will touch on several transition options that are under development.

1 INTRODUCTION

The International Hydrographic Organization (IHO) is an intergovernmental consultative and technical organization established in 1921 to support the safety of navigational, and to contribute to the protection of the marine environment. One of its primary roles is to establish and maintain appropriate standards to assist in the proper and efficient use of hydrographic data and information. (Ward et al. 2009)

This paper will describe the genesis of S-101 the new Electronic Navigational Chart Product Specification including its evolution from S-57 and S-52 – "Specifications for Chart Content and Display Aspects of ECDIS." The primary purpose of the paper is to communicate with the ENC user community the activities underway at the IHO in the development of this product specification and promote comment and the involvement from the maritime user community. The intent is not to develop S-101 in a vacuum, but to actively solicit input from software and equipment manufacturers and the ultimate end-user: the mariner.

1.1 *S-57*

One of the primary standards that the IHO is responsible for is IHO standard S-57, which is the current IHO "Transfer Standard for Digital Hydrographic Data." It was formally adopted in May 1992 and since that time it has become universally adopted as the underpinning standard for Electronic Navigational Charts (ENCs). S-57 Edition 3.1 was "frozen" in November 2000 and will remain so until no longer required. (Ward et al. 2009)

In January 2007, in response to an IMO update, the IHO released a supplement to S-57 to include new features and attributes required to encode Archipelagic Sea Lanes and Particularly Sensitive Sea Areas on ENCs. One of the characteristic features of S-57 is that the object and attribute catalogues defining the content of all ENCs is an integral part of the standard – thus a new supplement to S-57 was required to implement these new features.

According to an information paper published by the IHO, the following are current limitations of S57:

- It has an inflexible maintenance regime. Any addition of new features and attributes to the solitary catalogue for new products would have serious consequences for users of the ENC product specification such as ECDIS manufacturers, data production software vendors and regulatory authorities. It would trigger continual new editions because it freezes the object and attribute catalogues of the standard. Freezing the allowable content within data standards for lengthy periods is counter-productive for the end user.
- As presently structured, S-57 cannot support future requirements (e.g., gridded bathymetry, or complex time-varying information).

– Embedding the data model within the encapsulation (i.e., file format) restricts the flexibility and capability of using a wider range of transfer mechanisms while retaining data structure and content.
– It is regarded by some as a limited standard focused exclusively for the production and exchange of ENC data.

As a result of these limitations, in 2000 the IHO approved a major revision to S-57, resulting in the new framework geospatial standard S-100 (Ed 1.0.0 - January 2010).

1.2 *S-100*

S-100 provides a contemporary hydrographic geospatial data standard that can support a wide variety of hydrographic-related digital data sources, and is fully aligned with mainstream international geospatial standards, in particular the ISO 19000 series of geographic standards, thereby enabling the easier integration of hydrographic data and applications into geospatial solutions such as coastal zone management. S-100 extends the scope of the existing S-57 Hydrographic Transfer Standard. S-100 is inherently more flexible than S-57 and makes provision for such things as the use of imagery and gridded data types, enhanced metadata and multiple encoding formats. It also provides a more flexible and dynamic maintenance regime for objects, attributes and portrayal via a dedicated on-line registry.

The S-100 standard provides a framework of components that are based on, and designed to be interoperable with, the ISO 19000 series of standards and specifications. These standards and specifications are also used as the basis for most contemporary geospatial standards development activities and are closely aligned with other standards development initiatives such as the Open Geospatial Consortium (OGC).

The IHO has also developed an associated Registry to be used in conjunction with the S-100 standard. The IHO Registry contains the following additional components;

– Feature Concept Dictionary (FCD) Register.
– Portrayal Register.
– Metadata Register
– Register of data producer codes.

A particularly significant aspect of S-100 is that it provides the framework for the development of the next generation of ENC products, as well as other related digital products required by the hydrographic, maritime and GIS communities.(Ward, Alexander, and Greenslade, 2009) S-100 contains all the components necessary to create conformant product specifications to exchange a variety of digital hydrographic and marine geo-spatial information. S-100 contains multiple parts that were profiled from the ISO 19000 set of standards.

2 S-101

S-101 is the new Electronic Navigational Chart Product specification, currently under development by the IHO TSMAD Working Group. S-101 draws upon the concepts of S-100 such as exchangeable and dynamic feature and portrayal catalogues, and richer geometric models, information types and complex attributes. The use of these new feature types will allow ENC producers to overcome a number of known encoding shortcomings in S-57 based ENCs such as the overuse of caution areas,. In addition, the improved functionality will lead to more efficient data handling and better portrayal definition within ECDIS equipment, by eliminating or reducing the number of conditional symbology procedures.

One of the major benefits in S-101 is the ability to introduce additional functionality that is not available in S-57 ENCs. S-101 ENCs will eventually be the base navigation layer within an S-100 enabled ECDIS, but the true potential will not be realized until additional product specifications are developed to interact with S-101. Currently, the IHO has approved work for S-100 based product specifications for high resolution bathymetry and for nautical publications. Other potential S-100 based product specifications may include real-time tidal information and port operations information. A system capable of handling multiple S-100 products will allow for better navigational decision making by containing information regarding real time tides and sailing directions.

The key to the successful development of S-101 is the involvement of the maritime stakeholder community. This list includes: Hydrographic Offices, production software manufacturers, ECDIS equipment manufacturers, end-users, such as mariners, port authorities, and any other interested parties. During this process both TSMAD and the IHO are engaging in a continuous dialogue with stakeholders. In each of the past two years the IHO has held S-101 stakeholder workshops in order to present the status of S-101, the phased development process, and to receive feedback and suggestions on how best to overcome the current limitations in S-57 ENCs and the associated ECDIS portrayal requirements.

2.1 *Dynamic ENC Content*

The biggest advantage S-101 will have over the existing S-57 ENC product specification is the introduction of dynamic feature and portrayal catalogues. The term dynamic is used to characterize continuous change. While similar in content to the current S-57 object catalogue and the S-52 presentation library, S-101 implements the dynamic constructs prescribed by S-100. In S-101, the relationship between features, attributes and enumerants are defined within a single feature catalogue. Although, part of the standard, the feature catalogue is built through a registry responsible for defining data content and is machine readable, thus allowing ECDIS to easily update onboard systems via a software update. Under the current S-57 ENC regime updates to feature content may take up to five years to implement through the existing supplement process. Under S-100 the content of the registry is continuously changing, but the S-101 Feature and Portrayal Catalogues will be versioned, enabling the IHO to take advantage of the dynamic register content, but implementing a controlled update process for the end-users.

S-101 also defines a dynamic portrayal catalogue. This catalogue will replace the S-52 standard presentation library. The portrayal catalogue is a machine readable file containing IHO approved symbology and look-up table instructions to properly render ENCs on an ECDIS. This and the machine readable feature catalogue will make S-100 based ECDIS systems truly "plug and play".

S-101 will also make use of two new S-100 features to enhance the encoding, transfer, and portrayal of data. The first is a complex attribute, which has similar characteristics to the ISO 19000 *attribute of attribute*. A complex attribute is an aggregation of other attributes, either simple or complex (Figure 1).

The second is the use of "information types". An information type does not have any spatial attribution and will provide information about a feature by association. This can be used to represent a note associated with a pipeline or a buoy, for example. Under S-57, chart notes are typically encoded as a Caution Area – which is an alarm feature in ECDIS. Many of these notes contain relevant information and the only way to convey that information is through a Caution Area, however, most of the time this information does not need to signal an alarm. The creation of additional information type features will help reduce the amount of caution areas, a known encoding limitation within the current standard.

3 THE PHASED APPROACH TO S-101 DEVELOPMENT

In order to address the concerns of stakeholders, at TSMAD 19 in October 2009, the membership agreed to a four-phase approach in the development, testing, and release of S-101. This approach will follow the methodologies of System Development Lifecycle Design.

The key benefits of this approach are: it allows for iterative development, where each iteration is usable and testable. It also allows for controlled and manageable change and does not try to solve everything at once. A phased approach will enable stakeholders to plan their development implementation of S-100 and will allow the hydrographic community to engage external stakeholders such as type approval authorities in the new standard.

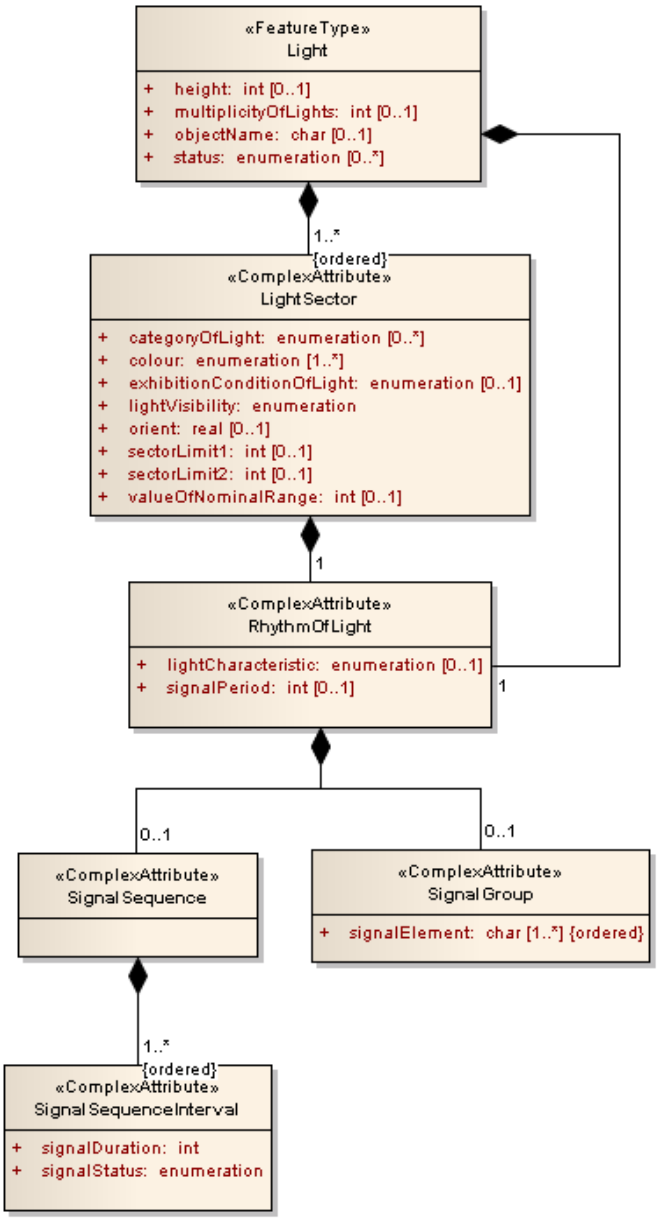

Figure 1: Example of a complex attribute for light sectors

3.1 *Phase 1: S-57 Content Equivalent*

Phase one of the development of S-101 is the "S-57 content equivalent". During this phase the existing feature content of S-57 is being replicated in an S-101 based product, using S-100 as its underlying framework.

The constraints for phase 1 are:

- The S-101 XML Feature Catalogue will be limited to only those features and attributes that are currently in S-57
- Introduction of S-100 geometry and the utilization of compound curves
- Use of the modified S-100 8211 encoding
- Use of complex attributes for light sectors and structured text attributes.

The major deliverables for this phase are an initial product specification and a content equivalent feature catalogue. The following benefits will be realized from phase one development:

- Proof of Concept and validation of S-100,
- Feature Catalogue can be exchanged as data – not specification,
- Utilization of a new 8211 encoding,
- Creation of an S-100 compliant product specification (which can also be used as a template for other S-100 product specifications),
- Proof that an S-57 based product can be built using S-100 mechanisms.

The last point is important as it will be the proof of concept for the ECDIS stakeholder community that S-101 will be similar to S-57, yet utilize the new functionality that is provided in S-100. In doing so it will pave the way for the development of additional product specifications that will be interoperable with S-101.

3.2 *Phase 2: Enhanced Packaging and Data Loading Mechanisms*

Phase 2 of S-101 will include

- the addition of the S-101 new support file formats and management,
- improved discovery metadata, from which ECDIS manufactures can inform the mariner which notice the dataset is corrected through.
- The S-101 portrayal catalogue
- New ENC display scales matching standard radar ranges that will be utilized for ECDIS loading.

During this phase TSMAD will also investigate the possibility of introducing scale independent and scale dependent data. If agreed by both TSMAD and the associated ECDIS stakeholders, ENC producers will be able to make the decision to partition a set of navigational data into two separate datasets based on whether their associated geometry is dependent on the compilation scale of the chart or not. The primary advantage of this structure is that receiving systems only need hold the scale independent features once, whereas in the current model multiple occurrences of features are required for different display scales. This in turn effectively reduces the size of the ENC dataset and increases the speed at which updates can be applied to datasets.

The deliverables for phase 2 will be an updated S-101 product specification addressing metadata and support file functionality, a revised feature catalogue and the first portrayal catalogue – effectively a translation of the current S-52 standard. The anticipated benefits from phase 2 are:

- Improved data delivery
- Improved data discovery
- Easily Accessible Metadata
- Comprehensive support for auxiliary file formats (xhtml, jpeg)

3.3 *Phase 3: Extending the Model*

During phase 3 the following will be included:

- More complex attributes introduced into the feature catalogue as well as the introduction of information types.
- Support for multiple languages
- Cartographic attributes that will support text placement, similar to a paper chart and alleviating the current cluttered text display associated with S-57/S-52 portrayal
- Revised guidance on pick reports enhancing better end user experience.

The updated feature and portrayal catalogues will allow for testing of the dynamic nature of S-101. The expected benefits from this phase are:

- Prove dynamic updating of feature and portrayal catalogues
- Enhanced language support

3.4 *Phase 4: Scalability and Finalization*

Phase 4 is the final phase in the development of S-101. At this point the first version of the product specification, feature catalogues and portrayal catalogues will be ready for approval by the IHO member states - probably in 2013. A tentative schedule for the entire development process is listed in Table 1.

Table 1. Tentative S-101 development schedule

Phase	Start Date	End Date
	MM/YYYY	MM/YYYY
Phase 1	01/2009	12/2010
S-57 convertor	11/2010	04/2011
Phase 2	01/2011	08/2011
Phase 3	09/2011	03/2012
Phase 4	04/2012	12/2012

4 TEST BEDS

Another important element in the development of the S-101 product specification is the requirement for test beds during the development lifecycle and beyond. TSMAD has begun the process of identifying items needed for the test beds. The main items are as follows:

- S-57 to S-101 open-source convertor
- S-101 open source data editor
- S-101 open source data viewer
- S-100/101 ECDIS reference Test Bed

In recognizing the need for test beds and to help promote the development of the S-101 Product Specification, the National Oceanic and Atmospheric Administration (NOAA) contracted with ESRI to develop an S-57 to S-101 open source convertor. Once completed, NOAA will turn this over to the IHO to be placed in the public domain. This convertor is intended to convert existing S-57 ENC data into S-101 ENC data by utilizing the feature catalogue developed in phase one of the project plan. It will also utilize the new ISO8211 encoding and provide samples of S-101 test data for interested stakeholders. It is expected that this convertor will be completed in March 2011.

TSMAD has also recognized the need for both an S-101 data editor and a viewer to enable the creation of S-101 data from scratch. This is so the functionality of the exchangeable feature and portrayal catalogues can be proved and to allow the creation of test data using new S-101 functionality.

The final test bed required will, in effect, be a reference S-100 ECDIS. It will enable TSMAD to test the updateable feature and portrayal catalogues in an environment that is modeled on genuine displays suitable for type approval.

5 TRANSITION

Although, S-101 is not expected to be adopted by the IHO as a standard before at least 2013, it is not too early to begin the process of informing the maritime community of the development of S-101. That is the purpose of this paper.

One of the major issues that will need to be agreed by the IHO and relevant stakeholders is how to transition from S-57 ENCs to S-101 ENCs. Obviously current S-57 enabled ECDIS will not be able to view S-101 data and there will have to be a lengthy transition period to enable both end-users, manufacturers, ENC producing countries and regulatory authorities to changeover. The successful development of S-57 to S-101 data converters will likely play a key part in determining how quickly the changeover could be made.

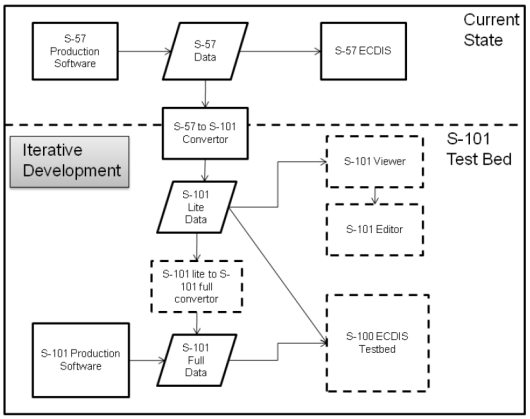

Figure 2: S-101 Test Bed

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