IHO S-101
The Next Generation ENC Product Specification

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 origins of S-101 the new Electronic Navigational Chart Product Specification including its evolution from S-57 - "Transfer Standard for Digital Hydrographic Data" and S-52 – "Specifications for Chart Content and Display Aspects of ECDIS". The intention 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. The primary purpose of this paper is to describe the concepts and developments made so far involve to the ENC stakeholders community thereby promoting comment and involvement from the stakeholder community.

2 S-57

One of the primary standards that the IHO is responsible for is IHO standard S-57. It was formally adopted in May 1992 and since that time it has become universally accepted 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 the need to incorporate additional IMO requirements, the IHO released a supplement to S-57 to enable Archipelagic Sea Lanes and Particularly Sensitive Sea Areas to be encoded and included in 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 perceived to be 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.

To overcome these limitations, in 2000 the IHO approved a revision programme for S-57, that resulted in a new framework geospatial standard called S-100 – Universal Hydrographic Data Model (Ed 1.0.0 - January 2010).

3 S-100 – Universal Hydrographic Data Model

S-100 provides a contemporary hydrographic geospatial data standard that can support a wide variety of hydrographic-related digital data sources. It 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 applications such as GIS-based 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. The new standard makes provision for 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).

In support of the S-100 framework, the IHO has established an associated on-line Registry. The IHO Registry contains the following components:

- Feature Concept Dictionary (FCD) Register.
- Portrayal Register – in development.
- Metadata Register – in development
- 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 ENCs, as well as other related digital products required by the hydrographic, maritime and GIS communities. (Ward, Alexander, and Greenslade, 2009) S-100 describes all the mechanisms necessary to create conformant product specifications that will enable the exchange of a variety of digital hydrographic and marine geo-spatial information. S-100 contains multiple parts that have been derived from and are compatible with, the ISO 19000 set of standards.

4 S-101 – Product Specification for the Electronic Navigational Chart

S-101 is a new Product Specification for the Electronic Navigational Chart. It is currently under development by the IHO Transfer Standards and Maintenance Applications Development Working Group (TSMAD). S-101 ENCs will remain, fundamentally, the basic navigation tool for ECDIS and therefore most of the features of the S-57 ENC are retained. However, using the experience and stakeholder feedback gained over a number of years many new concepts and constructs have been developed, aimed at improving the efficiency of the data and improving the user experience. Many of the changes may appear obscure or innocuous, but taken as a whole they will ensure that S-101 is, to a large extent future-proofed, unlike S-57 which is becoming ever more unmanageable.

S-101 draws heavily 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, improved functionality will lead to more efficient data handling and better portrayal definition in ECDIS equipment, by eliminating or reducing the number of conditional symbology procedures.

One of the major benefits in S-101 will be 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 S-100-based products are available 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. An ECDIS capable of handling multiple S-100 products will offer better navigational decision-making by including information such as real-time tides and sailing directions.

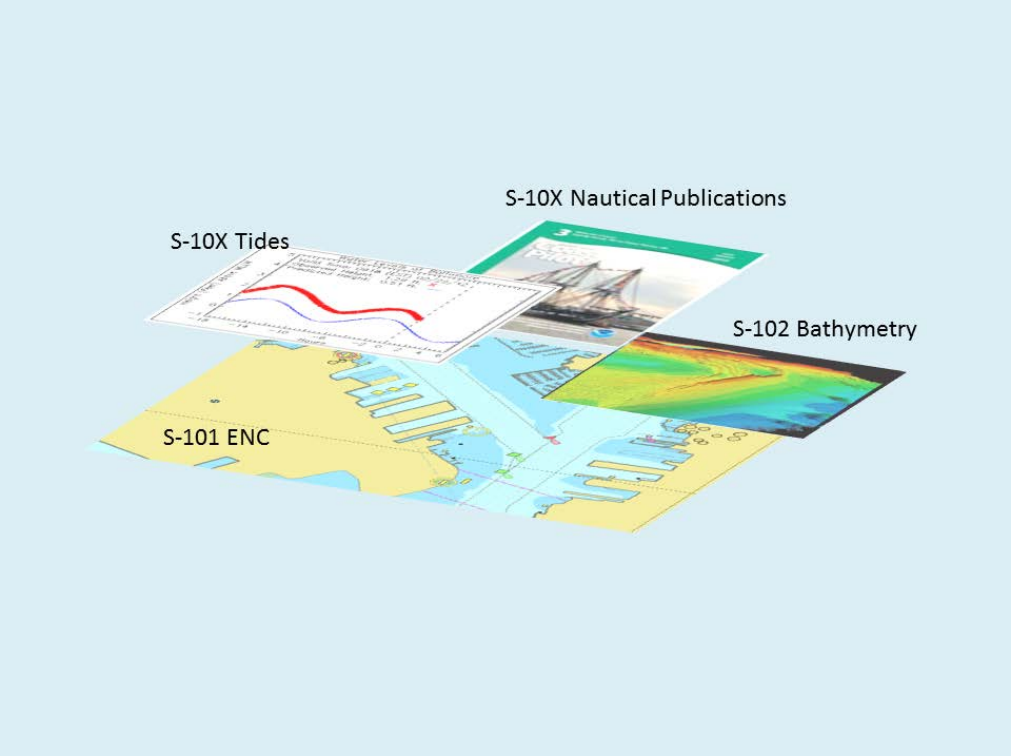


Figure 1 - S -100 Enabled ECDIS

The key to the successful development and implementation of S-101 is the involvement of the maritime stakeholder community. This includes: Hydrographic Offices, production software manufacturers, ECDIS equipment manufacturers, end-users, such as mariners, port authorities, and 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 user-requirements 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.

4.1 Dynamic ENC Content

The biggest advantage S-101 will have over the existing S-57 ENC product specification is the introduction of dynamic, machine readable feature and portrayal catalogues. The term dynamic is used to indicate the ability to support evolutionary change in an almost continuous way without impacting on existing users. While similar in content to the current S-57 object catalogue and the S-52 presentation library, S-101 will implement 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 will be built through reference to the registry that provides the definition of the data content in a machine readable form, thus allowing ECDIS to easily update onboard systems via a straightforward 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, while the content of the registry can be continuously changing, the S-101 Feature and Portrayal Catalogues will be versioned, enabling the IHO to take advantage of the dynamic register content, but implement it in a controlled update process for the benefit of the end-users.

S-101 will also define a dynamic, machine readable portrayal catalogue. This catalogue will replace the S-52 standard presentation library. The portrayal catalogue is a machine-readable file containing IHO approved conditional portrayal rules, look-up table instructions and symbology to properly render ENCs in an ECDIS. Many of the current issues that exist with some ECDIS in some vessels are due to either the misinterpretation of the standards or the use of out of date, un-maintained legacy software based on earlier versions of the standards. In an S-101 environment machine readable catalogues (tested and approved on shore) encoded in XML will be used to automatically update the relevant parts of the ECDIS software package.

As part of this exercise and taking into account experience gained over many years and through stakeholder input, the new portrayal catalogue will contain a much improve symbol set. For example buoys and beacons in traditional display will be coloured. Representation of the Category of Zone of Confidence (CATZOC) will be simplified to reduce clutter. This will not be finalized until properly evaluated by stakeholders using the test bed viewer.

The intention is to attempt to create an ECDIS chart display that is universally acceptable to all stakeholders thus negating the need for OEMs to provide bespoke versions. If this cannot be achieved then there is an option to develop a new default portrayal catalogue as well as any bespoke version provided and maintained by an OEM. However, the option of holding back the distribution of a default version until all OEMs have prepared a new bespoke version negates the advantage of quicker delivery. It also does not overcome the problem of maintaining legacy ECDIS software, particularly if the OEM is no longer in existence.

This and the machine-readable feature catalogue will make S-100 based ECDIS truly “plug and play”.

Comment [N1]: I’m not really sure what the point is here.

I would say that the IHO is developing a standard catalogue that the OEMs must implement for quicker delivery, however, that does not preclude the OEMs from offering a customized version as long as they can read the IHO one for situations that need a quick delivery.

Figure 2 - S-101 - Exchangeable Catalogues

4.2 Portrayal Rules

Some of the conditional procedures previously associated with S-52 will become attributes of features. Currently, in an S-57-based ECDIS considerable processing time is taken up during the data loading process identifying relationships between the geometries of certain features, for example, a wreck and its surrounding depth area. This is information already known by the ENC production system and in S-101 it will be exported with the data, thus increasing the efficiency in creating the SENC.

4.3 Complex Attributes

S-101 will also make use of new structures and features to improve the encoding and portrayal of data. One improvement will be the introduction of complex attributes which, conversely, simplify the encoding of certain real world features which required convoluted solutions in S-57. Some examples are the relationship between the nature and the quality of the seabed, light sectors, and tidal stream information (Figure 1).

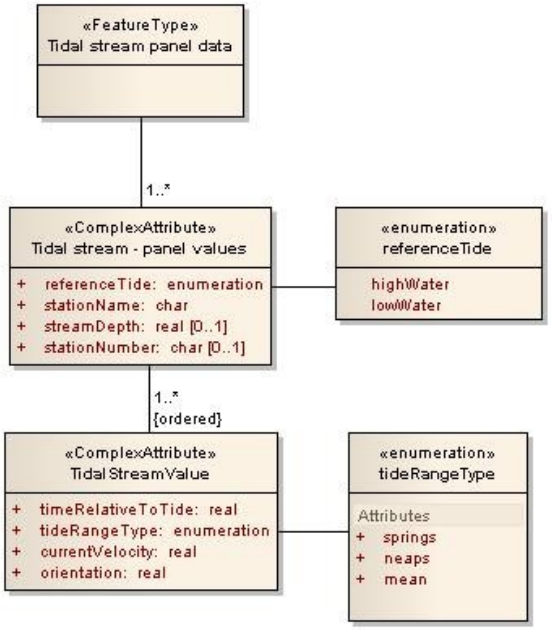


Figure 3: Example of a complex attribute for tidal stream information

This diagram above shows how tidal stream information will be encoded in S-101. It provides a more logical and efficient structure than the simple comma delimited text now in use. This structure will enable such things as richer data at all depths, the inclusion of neap and mean tides instead of just spring tides, and more frequent values.

4.4 Information Types

Another improvement will be the use of "information types". An information type does not have any spatial attribution and provides meta 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 then an alarm feature in ECDIS. Many of these notes contain relevant information and the only way to convey this information is through a Caution Area. However, most of the time this information does not need to trigger an alarm. The creation of additional information types will help reduce the need to use caution areas in this way, a known encoding limitation within the current standard.

4.5 Scale Dependant and Scale Independent Datasets

This new concept requires, at a minimum, the production of two datasets which cover the same geographic area. In most case it will be more efficient to have a one-to-many relationship between a scale independent dataset and scale dependant datasets.

Scale dependant datasets will contain features which are not easily generalized and their representation may change at different scales.

Meanwhile, scale independent datasets will contain features that remain unchanged regardless of the scale at which they are viewed. For example a light can be displayed with many different scale dependant datasets. The attribute *scale maximum* will be re-introduced to control the display of these features in conjunction with the existing attribute scale minimum. There are several advantages to this new approach:

The concept aligns with the ever increasing use of production systems operating with databases. However it does not preclude the use of a flat-file based system. Tests have shown that the different dataset can be produced in this way, but it does increase some overheads.

Studies have shown that a large percentage of Notices to Mariners effect the features which will be resident in the single scale independent dataset, thus significantly reducing the number of NtMs required. For example a light which normal appears in three different datasets at different scales need only be updated once. This will save time in production in encoding and quality control would be more consistent.

It would provide a more cost-effective and efficient way to transmit updates via satellite-based communications.

Vertical consistency between datasets would be improved. The light will be in the same position at all scales.

There are also discussion taking place to ascertain whether text e.g. a light description can be abridged using the complex attribute described above. For example “Fl. 3sec 5M” could be shortened to “Fl”. At smaller scales.

5 S-101 and the Mariner

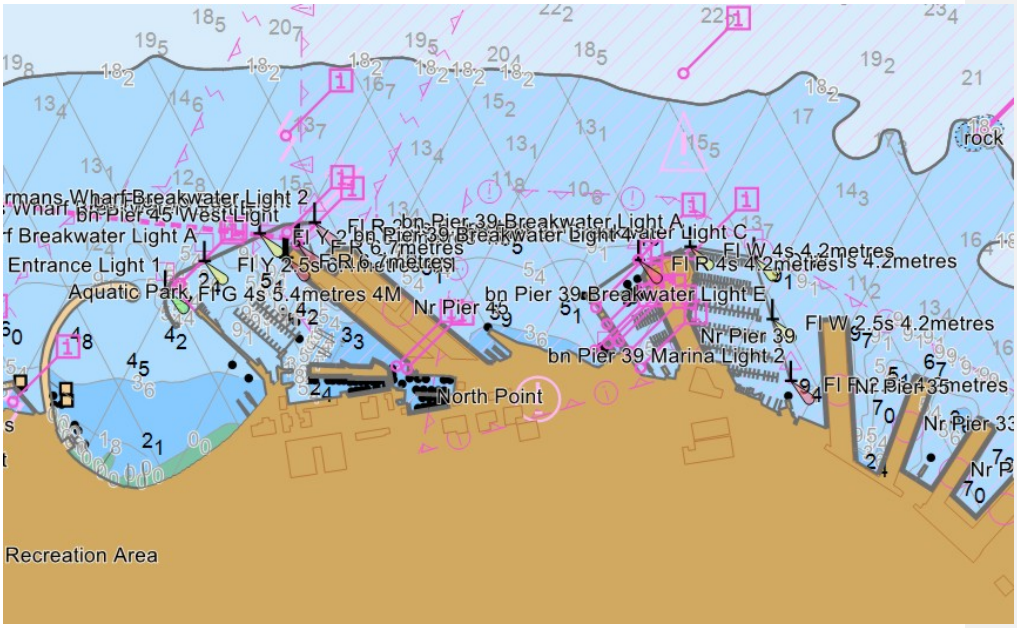
S-101 will eventually replace S-57 ENCs as the fundamental nautical chart data used in ECDIS. However, it will provide more than a simple replacement. One has to look at the full scope of the S-100 environment to appreciate the benefits.

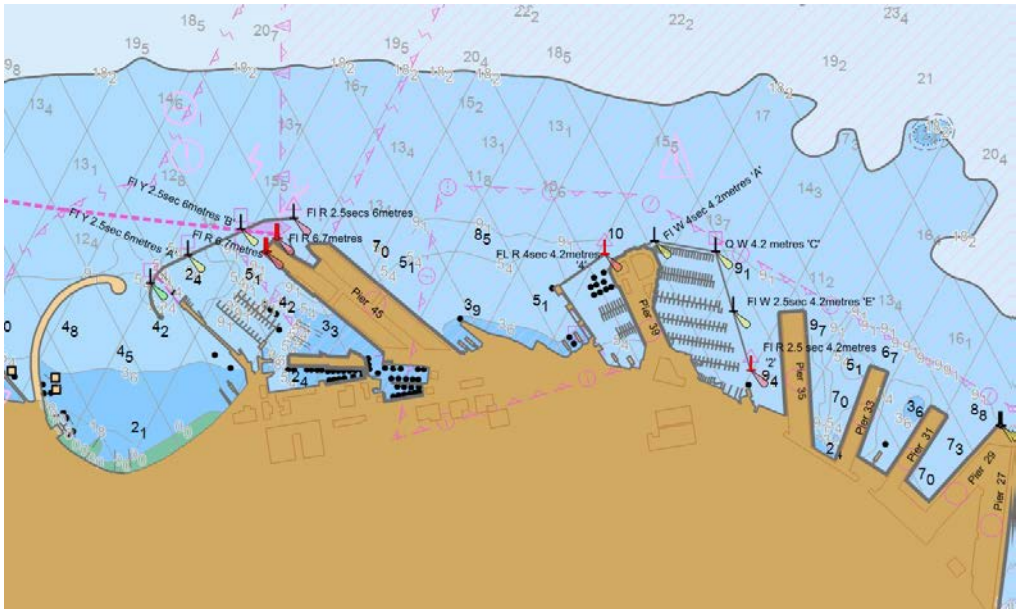
Many of the new features of S-101 such as Information types and complex attributes enable the presentation of the same data in a new format that will improve its usability to the mariner. For example, the structure of the data will enable more intuitive and clearer pick reports. Other benefits include:

5.1 Updating: a new feature is being included that enables a user to clearly see what changes have been applied by way of a Notice to Mariners (NtM), including any features which may have been deleted. If necessary the text of an NtM can be included with all source references and dates.

5.2 Improved pick reports: S-101 cursor pick reports will be based on a number of user customizations allowing the returned data to be filtered by, feature types, pick radius, themes etc. The use of a curser hover over function will combine feature types to give the real world representative information which at present is contained in a number of disparate objects, for example sectored lights.

5.3 Reduced clutter: a new cartographic text feature will control the positioning of text enabling ENC producers to improve the overall look and feel of ENCs in ECDIS. So instead of the name of a light appearing by default in a critical navigable area, such as a channel, only the light number will be displayed and the light name will be viewed via the pick report.





5.4 Data loading; new methodology based only on producer defined scales will be introduced. This will enable clear and concise rules on how and when ENC data is loaded and unloaded in an ECDIS. The concept of navigation purpose codes will be restricted for use only in presenting ENCs in a visual catalogue. The number of navigation purpose codes will also be reduced to three; Port and Approaches, Coastal Passage and Ocean Passage/Routing.

6 S-101 and the ENC Producers

In many respects the changes introduced by S-101 will be transparent to the encoders of ENCs. The largest percentage of features and attributes will remain unchanged. However, there will be a need to change the techniques used where information types and complex attributes are introduced. The new cartographic text feature could enable newer multi-product database solutions to re-use parameters stored during the text placement process for other products like a derived nautical paper chart.

S-57 to S-101 Converter. An S-57 to S-101 data converter has already been developed for the IHO that can either be used stand alone or built into the data export process. This has been done to avoid a requirement for ENC producers (HO's) to switch immediately to producing S-101 datasets and to enable an orderly transition from S-57 to S-101 to take place. The converter provides an S-101 version of any existing S-57 ENC including updates for use in an S-100/S-101

compatible ECDIS until such time as an HO moves to providing full specification S-101 ENCs. S-57 will continue to be supported by the IHO until phased out at a date yet to be decided.

7 S-101 and the Distributors

Until there is 100% availability of S-100 based ECDIS there will be a need to support the distribution of both S-57 and S-101 based ENCs. Since S-101 is still in development, a definitive end date for S-57 would be premature. IHO procedures require that determining such an end date must involve full consultation with the stakeholder community.

8 S-101 and the ECDIS Original Equipment Manufacturers (OEMs)

While S-101 represents a significant change for ECDIS OEMs, the IHO has already held a number of stakeholders' forums seeking the input of the OEMs in order to create a product specification that will enable a seamless transition to an S-100 enabled ECDIS. A number of leading OEMs are also involved in the development work being undertaken by TSMAD. One of the key aspects of S-101 is that it will continue to use the ISO/IEC 8211 encoding for data, thereby enabling existing knowledge and existing ISO/IEC 8211 encoding tools for S-57 to be brought forward for use in S-100/S-101 based ECDIS. The ISO/IEC 8211 encoding has been updated to align with S-100 and in particular uses the new geometry model which will improve efficiency in finding the relationships between features and shared geometry.

S-101 will also eliminate the need for OEMs to refer to multiple IHO standards as part of developing and implementing new systems. Currently, OEMs must comply with both S-57, S-52 and other related standards; however, S-101 will provide a single unified reference for OEMs that should contain all the information necessary to implement S-101. In addition, since S-101 is built using S-100, any newly developed ECDIS will be S-100 enabled, thus allowing for additional S-100-based products to be integrated in the ECDIS. Under the current, S-57 based structure; this type of implementation has been sporadic and inconsistent.

9 S-101 and Type Approval

As S-101 will eventually replace S57 and is intended to be used for primary navigation, it will still be necessary to type approve ECDIS to the relevant IMO/IEC standards. However, as described earlier, the machine-readable feature and portrayal catalogues will enable an S-100/S-101 ECDIS to treat revised versions of S-101 as a software update, rather than the requirement for current ECDIS to undergo further type approval if significant changes are made to the operating software as a result of changes to the IHO standards. It will not be necessary to undergo additional type approval every time a feature or portrayal catalogue is issued

S-101 will have a full test dataset and instruction manual to guide type approval authorities through the type-testing process.

10 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 ESRI to develop an S-57 to S-101 open source converter. Once completed, NOAA intends to offer the converter to the IHO to be placed in the public domain. The converter 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 S-101 development project plan. The converter will also utilize the ISO8211 encoding and provide samples of S-101 test data for interested stakeholders. The converter will be validated in consultation with OEMs and other stakeholders to ensure that it is fit for purpose, prior to the IHO adopting S-101 as an international standard.

TSMAD has also recognized the need for an S-101 data editor and an S-101 viewer to enable the creation of S-101 data from first principles. This is required to enable testing and validation of the functionality of the exchangeable feature and portrayal catalogues and the creation of test data that supports new S-101 functionality.

The test bed, when completed will, in effect, be a reference S-100 ECDIS. It will enable TSMAD to test the updateable feature and portrayal catalogues in an environment and a platform that can mimic those systems being submitted for type approval and subsequent use by mariners.

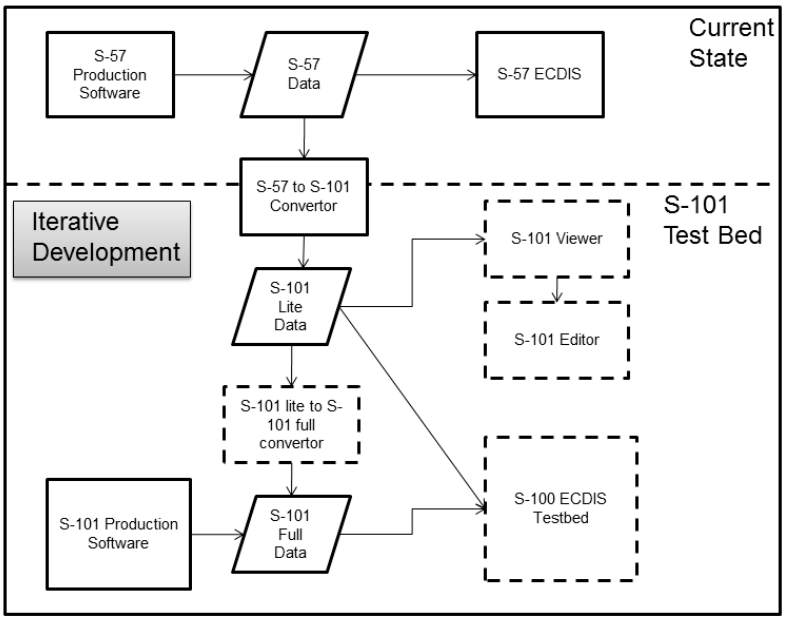


Figure 4: S-101 Test Bed

11 S-101 Development Timeline

While S-101 is under development, the ENC/ECDIS stakeholder community must be kept informed of the timetable and progress of the development, test, implementation and transition phases moving from S-57 to S-101. These timelines will be subject to change and have yet to be approved by IHO Member States.

The following timeline represents the current planning schedule adopted by TSMAD for:

- S-101 Development
- S-101 Test Beds
- S-101 Review and Comment Period
- S-101 approval by HSSC
- S-101 approval by the IHO Member States
- S-101 ENC Software Implementation
- S-101 ECDIS Implementation
- S-101 Data Production by the Hydrographic Offices

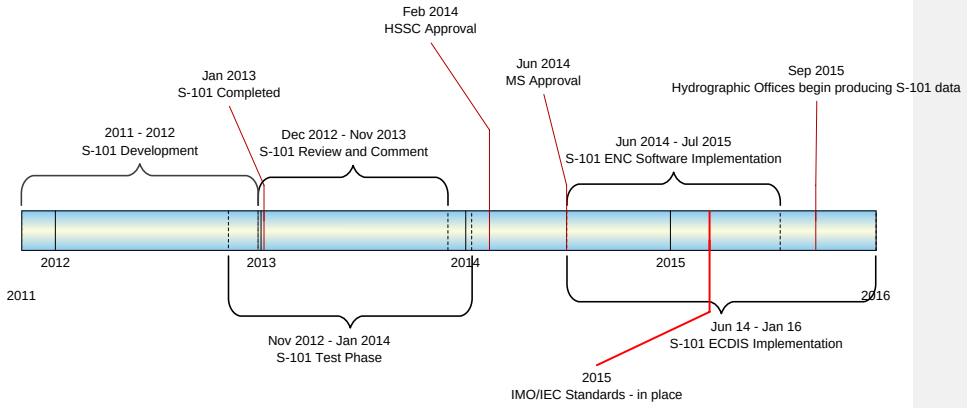


Figure 5 - S-101 Implementation Timeline

The following timeline provides an initial estimate of the minimum timescale for the data transition from S-57 and S-101. For a period of time, both S-57 and S-101 will coexist, until such time as IHO, in consultation with the ENC stakeholder community, determines that S-57 ENCs are no longer valid or required.

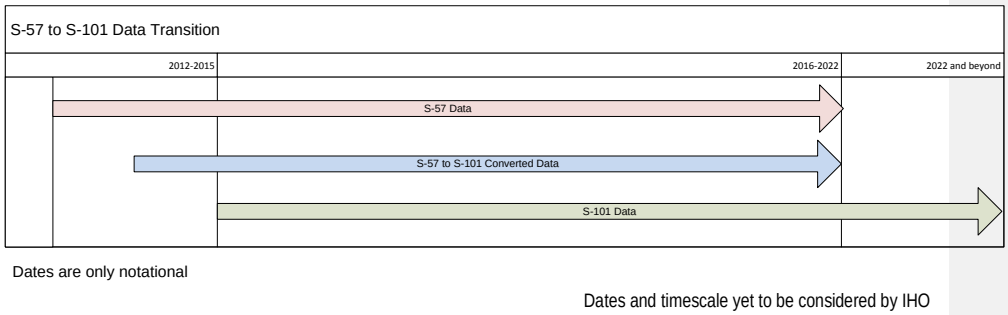


Figure 6 - S-57 to S-101 Data Transition