**S-100 Implementation Strategy**



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# Background

* Scope of the document (SIP): why we need a Strategy (HSSC Chair in liaison with the Group)
* Reference to the current and revised IHO Strategic Plan (HSSC Chair in liaison with the Group)
* IMO directions and SOLAS obligations (Group)
* Governance (Group)

The first relevant standardization project of the IHO in the digital age was the transformation of nautical chart information from an analogue - paper charts - to a digital carrier - Electronic Navigational Charts (ENCs). The technical concept for ENCs was inspired from land based digital cadastre systems in the early nineties. The S-57 ENC characteristics are:

* The modelling of real world and administ
* rative entities in abstract object descriptions (S-57 Object Catalogue);
* The split (“late binding”) between attributed objects and their visual presentation (S-52 Presentation Library);
* The definition of conditional presentation modes for chart content encoded as functions of the end user system software (S-52 Conditional Symbology Procedures);
* The binary coding of chart content as attributed objects and their packaging in datasets (ENCs) according to the ISO/IEC 8211 standard;
* The peer-to-peer encryption and authentication of the datasets to preserve the content against intended and unintended changes along the distribution chain (S-63 Data Protection Scheme);
* The build-up of national capacities and the regular production of ENCs for domestic waters in more than fifty coastal states;
* The application of globally unified quality standards for ENC production;
* The regulated provision of the end user system (ECDIS) market with ENCs in close collaboration with industry according to agreed principles (WEND principles).

# Analysis

ENCs present and future: new requests from mariners word and industry challenges (S100 WG – ENC WG)

The ENC concept gained global acceptance and replaced any other format for the provision of official vector nautical chart data. The current ENC coverage is absolutely comparable with the coverage by paper charts but offers much greater detail and up to dateness in many areas.

However, the technical design of ENCs as defined by IHO Standards S-57 and S-52 stems conceptually from the nineties and due to technology advancement has a number of deficiencies compared to modern computer technology:

* The software for the production and application of ENC datasets is tailor made by design and therefore costly;
* Any amendment/modification of ENC embedded objects or their associated presentation requires an update of the software of the end user system. This is difficult since ECDIS are not as accessible for hardware and software maintenance as is the case for land-based GIS applications;
* The ENC encryption is not an inherent part of the binary coding and does not protect all elements of an ENC delivery package against malicious third party manipulation;
* S-57 ENCs are focused on the provision of charted information. Text oriented nautical information such as that traditionally provided by printed or pseudo digital (pdf) and web based technology (html) cannot be embedded into this format;
* To enable modern concepts of integrated navigation (IMO e-Navigation) all types of marine geoinformation such as nautical, oceanographic and meteorological information have to be correlated mutually in a variety of combinations. The phrase coined for this new level of integration for geodata out of different sources is “interoperability”. S-57 ENCs do not support such interoperability. Consequently, ECDIS in its current design is not able to gain the full potential of data integration;
* There are now many stakeholders who see a benefit in the use of ENCs beyond surface navigation at sea. The S-57 format is not flexible enough to facilitate such needs and the encryption paradigm in place adds to this barrier.

# Developments

## The concept of S-100

S-100 concept, PSs development, data interoperability, data management, data dissemination, data integrity (S100 WG, NIPWG, ENC WG, DQ WG)

The S-100 development concept started in 2005 with the aim to overcome the noted deficiencies for future digital nautical chart data products and allow their interoperability with a wide range of marine geodata. The anticipated solution should:

* Enable the use of lest costly (off the shelf) software technology for data production and handling at the end user system;
* Support easy software maintenance for ECDIS;
* Address issues of cyber-security through embedded encryption mechanisms;
* Provide a consistent modelling framework to incorporate digital text based nautical information (for example sailing directions);
* Allow the seamless integration of nautical chart data with compatible (“interoperable”) datasets carrying supporting marine geoinformation of other relevant sciences domains such as oceanography and meteorology.

One of the principal assumptions of the S-100 concept to achieve this is the strict alignment to global standards for geoinformation not limited to the marine domain only. S-100 has therefore become the most important application of the ISO 1900 series of Geographic Information Standards. The relevant elements to meet the focused aims of this series are:

* The web-based Geospatial Information (GI) Registry concept – a repository of:
  + real world and administrative entities (concepts);
  + associable attributes; and
  + presentations with the capacity for ongoing enhancement and modification.

The entities (concepts) included in the Registry constitute a managed and sustainable resource that is used (by several International geospatial communities) to model real world entities such that they can be:

* + described (in the form of a data model);
  + documented (in the form of a Product Specification); and
  + digitized (to be included in a data product).
* The modelling concept – where subject-specific Application Schema are developed and defined within S-100 based Product Specifications so as to describe a specific aspect of the real world; including guidance on interoperability for predefined combinations of datasets for these specific purposes, such as navigation.
* The automatic creation of customized subsets (catalogues) of combinations of attributed features and their association to presentation rules from the variety of GI Registry elements. These catalogues form the “dictionaries” of accepted attributed entity objects (features) and portrayal rules valid for the Product Specification of a specific digital dataset.
* A unique identifier system which unambiguously marks any real world and administrative entity used across all possible datasets under the S-100 concept.
* The machine readability of these catalogues and unique identifiers to automatically update the end user system in terms of the data model, the scope of accepted features within a dataset and their visual presentation (portrayal).
* The machine readability of application specific presentation rules in modern and popular script languages to replace the former “hardwired” Conditional Symbology Procedures.

This concept is not limited to the modelling, encoding and distribution of nautical information in the form of ENCs. By its generic nature it can be applied to a multitude of marine geodata. The obvious advantage of such datasets, which are all constructed on the basis of the same paradigm, is their mutual compatibility – called “interoperability”. Interoperability supports a multitude of possible combinations of the geoinformation encoded in datasets – independent from which science domain they belong to. This latter point is relevant for the smooth portrayal and easy functional interpretation of these datasets at the end user system (ECDIS); but likewise instrumental for future machine-to-machine communication as will be required for autonomous shipping.

## S-100 basic elements

The S-100 framework has been developed with the advantage of hindsight based on experience gained through the development and use of the existing IHO Transfer Standard for Digital Hydrographic Data (S-57). S-100 has been documented using an object-oriented notation known as the Unified Modelling Language (UML).

S-100 provides a theoretical framework of components that are based on the ISO 19100 series of Geographic Information Standards; and specifies the procedures to be followed for:

* establishing and maintaining registers of hydrographic and related information;
* creating product specifications, feature catalogues and a definition of the general feature model; and
* using spatial, imagery and gridded data; and metadata specifically aimed at fulfilling hydrographic requirements.

The components that make up the S-100 framework consist of the following basic elements (Parts):

* Part 1 Conceptual Schema Language
* Part 2 Management of IHO Geospatial Information Registers
* Part 3 General Feature Model and Rules for Application Schema
* Part 4 Metadata
* Part 5 Feature Catalogue
* Part 6 Coordinate Reference Systems
* Part 7 Spatial Schema
* Part 8 Imagery and Gridded Data
* Part 9 Portrayal
* Part 10 Encoding Formats
* Part 11 Product Specifications
* Part 12 S-100 Maintenance Procedures
* Part 13 S-100 Scripting Language
* Part 14 Online Communication Exchange
* Part 15 Encryption and Data Protection

More detail about each Part of S-100, including the relationship to relevant ISO 19100 Standards and details of allowable encoding and portrayal formats, can be found in S-100 Part 0.

## IHO Geospatial Information (GI) Registry

The operation of the GI Registry forms the basis for any further steps towards implementation of the S-100 concept. The IHO GI Registry is a fully web based application which is developed and currently hosted by the Korean Hydrographic and Oceanographic Authority (KHOA) on behalf of IHO. The operational maintenance is undertaken by the IHO Secretariat. The IHO GI Registry contains the following types of registers:

* Concept Register (includes descriptions and meta information about the real world entities used for data modelling).
* Data Dictionary Register (includes concepts that have been modelled in accordance with a specified Application Schema).
* Portrayal Registry (includes resources that can be used for building Portrayal entities within an information system).
* Producer Code Register - list of unique codes assigned to data producers.
* Product Specification Register - list of S-100 based Product Specifications and their associated resources (for example feature and portrayal catalogues).

### Concept dictionary

A “concept” is a definition of an object, information type or phenomena of nature without any relation to other concepts. It is the lowest level of abstraction for elements in the Registry that is used for data modelling purposes. Whereas one community may use the “seamount” concept as an enumerated value type to the attribute “sea bed type”, another community may use “seamount” as a feature type with its own rich set of descriptive attributes. Although both communities may have used the “seamount” concept in very different models, its description and associated metadata remains the same in the Registry.

### Domains

The purpose of designating domains is to ensure that key stakeholders (as represented by the domains) have a level of autonomy with the items that they submit to the Registry; and to ensure that they are consulted in any subsequent proposals to adjust items contained in a Register. Currently the following organizations and groups have registered as domain owners within the Registry; IHO, IALA, WMO, Inland ENC, Port ENC, IEC and NATO (AML).

### Catalogues

The development of machine readable catalogues makes provision for a type of “plug and play” mechanism that enables remote systems (such as ECDIS) to be easily upgraded. If a data product is extended to include a new feature type with new symbology, then a new feature catalogue, portrayal catalogue and “alerts and indicator” catalogue will have to be produced. An ECDIS will have to install the new machine readable catalogues before it is able to read and display the new features in the dataset.

### Script language for portrayal

The S-52 Standard and its associated Presentation Library were developed at a time when there were very few terrestrial or maritime dynamic navigation systems available. It introduced new and innovative concepts such as Conditional Symbolization Procedures, standardized line and area patterns and a comprehensive library of point symbols. Although S-52 has stood the test of time, the development of contemporary graphics standards has opened the door for S-100 portrayal to adopt a more standardized approach. One of the most complex issues has been the development of conditional portrayal procedures. S-100 currently makes provision for these to be developed using the XSLT (Extensible Style sheet Language Transformations) and Lua scripting languages. These are documented in Part 9 of S-100. The S-101 ENC Product Specification implements its conditional procedures using the Lua scripting language.

### Product Specifications

An S-100 Product Specification provides a precise technical description of the elements that define a geospatial data product. It should include a descriptions of all elements (such as features, attributes enumerated values and code lists) that are used in the data model. A Product Specification should constitute a set of human readable documentation and in many cases will include machine readable files that encapsulate resources such as a Feature Catalogue, Portrayal Catalogue, Application Schema and Coordinate Reference System (CRS) parameters.

## Hydrographic S-100 based Product Specifications

All products belonging the S-100 Domain “Hydrography” are under the authority of the IHO. The indication for this is their specific data product number: All data Product Specifications which have a S-**1**XX number are under the IHO regime. Their technical development and maintenance is executed by several dedicated IHO Working Groups and Project Teams under operational control of the IHO Hydrographic Services and Standards Committee (HSSC). Endorsement and approval of all such S-1XX Product Specifications is managed according to IHO Resolution 2/2007.

### S-101 next generation ENC

S-101 next generation ENC is without doubt the flagship project of IHOs technical standardization activities for the years to come. The S-101 ENC Product Specification is the most complex application of the S-100 Concept. The final goal – the regular production and population of S-101 ENCs - will be instrumental for the success of the whole S-100 concept. In contrast to any other potential S-100 applications, S-101 next generation ENCs will provide the fundamental data product to satisfy the rigid carriage requirement regime of the IMO.

### S-1XX interoperable Hydrographic Data Products

Right from the beginning, interoperable Product Specifications with a hydrographic context have been proposed to support S-101. They are registered with an S-1**XX** number. There is a maintained official list of registered hydrographic Data Product Specifications to be developed by means of IHO GI Registry elements. These Product Specifications are currently at varying levels of maturity:

|  |  |
| --- | --- |
| **S-101** | Electronic Navigational Chart (ENC) |
| **S-102** | Bathymetric Surface |
| **S-104** | Water Level Information for Surface Navigation |
| **S-111** | Surface Currents |
| **S-121** | Maritime Limits and Boundaries [keep it for the time being] |
| **S-122** | Marine Protected Areas |
| **S-123** | Radio Services |
| **S-124** | Navigational warnings |
| **S-129** | Under Keel Clearance Management |

In contrast to S-101 next generation ENC, none of the products based on these specifications are under any legal obligation of application for IMO regulations in the context of SOLAS Chapter V Regulation [9]. However, in order to make the anticipated Maritime Services of IMOs e-Navigation concept a reality, their definition and the anticipated future provision of such datasets with sufficient coverage and content appears indispensable. In comparison to S-101 ENCs all of these datasets are less complex and there is no ruling precedence for their presentation as is the case for ENCs. On the other hand, the regular system in place for global ENC production, update and distribution is mature and acknowledged and it is anticipated that there will be a smooth transition to regular S-101 ENC production under these established arrangements. All other S-1XX products are so far lacking these preconditions.

## S-100 based Product Specifications of other domains

As part of the S-100 philosophy and in order to facilitate the overarching e-Navigation concept of the IMO, other scientific and engineering domains were encouraged to make use of the S-100 framework – in particular the GI Registry system and the means to create machine readable catalogues. In order to address these requests but at the same time to clearly separate the maintenance of the domain content from the core definitions within hydrography, separate Product Specification numbering domains have been introduced and have been reflected in the IHO GI Registry Domain structure.

The following S-**XXX** numbers have been designated to other domains:

|  |  |
| --- | --- |
| **S-2XX** | International Association of Light House Authorities (IALA) |
| **S-3XX** | Oceanography |
| **S-4XX** | Other, including Marine Meteorology and Inland ENC |

Activities to define Product Specifications are known for:

|  |  |
| --- | --- |
| **S-201** | Aids to Navigation Information |
| **S-211** | Port Call Message Format |
| **S-240** | DGNSS Station Almanac |
| **S-401** | Inland ENC |
| **S-402** | Bathymetric Contour Overlay for Inland ENC |
| **S-411** | Sea Ice (WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology[JCOMM]) |
| **S-412** | Met-ocean forecasts(JCOMM) |

## S-98 Standard for Data Products Interoperability

PSs: interoperability, (backward) compatibility, quality and harmonization (DQWG, S100 WG, NIPWG, ENCWG)

Description of purpose, interrelation to the registry [to be expanded]

## Unique Identifier System

Description of purpose, interrelation to the registry [to be expanded]

# Strategic priorities

As previously mentioned, the origins of the S-100 Concept relates to a time now well in the past. However the reasoning as to why and how this concept should be technically applied remains valid and has been adapted in the course of development under the supervision of the IHO Member States. The most notable changes are the full acceptance of a digital means for the handling of hydrographic information at sea – ECDIS is now under full carriage requirement regime since 1st of July 2018; S-100 has been adopted as the Universal Data Model for the IMO e-Navigation framework; and other science and engineering domains have been associated to the concept. It is now time to rationalize the available S-100 based Product Descriptions including the associated elements and to define a strategy to turn the concept into an operative mode through regular provision and use of S-100 based datasets.

## Hydrographic Offices

HOs role, Future of RENC role, PSs dissemination and distribution (Group; but contribution from all WGs is welcome)

Hydrographic offices are principally committed to new concepts for the production of nautical information datasets. Since the request for paper based materials is continuously decreasing, the focus changes to the regular provision of a full suite of datasets comprising nautical chart information, text oriented nautical information and the provision of navigational messages – ideally out of a consistent production environment. The concern is the parallel maintenance of a diversity of printed (paper charts and sailing directions) and digital (S-57 ENCs; and S-101 ENCs in the longer term) products. Harmonization and consistent data production workflow is a compelling need.

The greater percentage of all ENC producing Hydrographic Offices liaise or is a full member of a RENC. Besides the quality assurance and harmonization aspect resulting from RENC operations, it is the easy and efficient provision to the end user market and the effective billing process which makes the RENC system attractive.

Additional Data Products providing dense bathymetry are now being requested by the shipping industry to increase efficiency of transportation through Under Keel Clearance Management, but there are additional stakeholders other than those for classic surface navigation who have a strong request for such datasets. The facilitation of these requests indicates a changing role of numerous hydrographic offices towards being the principal national data providers for marine geodata for a multitude of marine purposes.

## Other domains

Science and engineering domains, other than hydrography, have so far not reached a level of international technical standardization as has been achieved for nautical information under the IHO. In order to set up effective cross border cooperation in times of global digitization and to associate with wider developments such as IMO e-Navigation and the validation of the United Nations Sustainable Goals, these domains have developed strategies to maintain their relevance and visibility through provision of interoperable datasets. The use of an existing infrastructure such as the IHO GI Registry; the exposure of the existing IHO interface to industry partners in software development; IHO expertise in survey and cartographic technology development; and the credibility of the IHO as the acknowledged institution for technical standardization, will help them to justify their own activities and to establish regular dataset provisions based on the S-100 concept.

## Regions

Some regions have set up ambitious projects to facilitate safety and efficiency of navigation through modern technology. Examples are the Maritime Highway projects in Asia and Smart Ships Traffic Management in the Baltic Sea. Those projects are substantially funded due to evidence of the application of new concepts such as S-100 based applications.

WEND principles and RHCs role (Group; but contribution by all WGs is welcome)

## Industry

Industry involvement (S100WG, NIPWG, ENCWG)

The industries that can be associated with S-100 based product implementation can be divided into numerous segments such as:

* Developers of data production software (embedded software in measurement devices, dataset creation and maintenance);
* Developers of data application software (ECDIS, GIS services);
* Data distributors;
* Communication providers;
* End users hardware suppliers.

These groups liaise on different levels of involvement with IHO S-100 standardization activities guided by their interests. Common for them are the following motives:

* Create new business cases for an enhanced number of users for marine geoinformation not limited to surface navigation;
* Make software development and maintenance less costly / more effective;
* Generate requests for enhanced data provision and end user applications in hardware and software.

The regular provision of S-101 ENCs will deliver the key motivation for industry to invest into development in all of the above segments. However, in the short term, S-101 ENC will basically provide the same content as S-57 ENCs and their visual appearance will be more or less identical. In order to convince the users of the overall advantages of the new approach, other datasets out of the S-100 based data products bouquet are of reasonable attraction, in particular S-102, S-104, S-111, S-129 and S-412. Though their full integration into an interoperable ECDIS is the principal aim, there will be improving effects for other applications – namely land based GIS services – which will take advantage of the regular provision of the named datasets: Under Keel Clearance Management, Ship Traffic Management, Near and far coast activities in marine spatial planning, marine resource exploration and exploitation. In conclusion: to make the S-100 concept commercially successful, beside regular S-101 ENC provision on similar coverage as for S-57 ENCs, strategic priority should be placed on data products which are designed to interoperate with S-101 ENCs. The expected advent of some of them before complete S-101 ENC coverage paves the way for the whole concept. Given that these products are far less complex than ENCs, they deliver a good playground for industry to become prepared for the greater solution – full S-100 compliant ECDIS fuelled with S-101 ENCs and complemented by interoperable datasets of the hydrographic and associated domains.

# Implementation

# According to the categories given under 3.4 this paragraph now presents real steps to implementation and timelines.

* Roadblocks to implement and support the plan
* Provision of standards
* Operationalisation of data

# (S100WG, NIPWG, TWCWG)

## S-101 next generation ENC (S100 WG - ENC WG)

### Affected Bodies

* National hydrographic services.
* IHO.
* IMO

Main actors to implement the strategy (Industry, RENC?): All

### Technical standardization

* Release Edition 1.0.0 of S-101 in December 2018.
* Work on S-98 (Interoperability Specification for S-100).
* Operational Edition 3.0.0 of S-101 in 2022.
* S-57 to S-101 converter.
* Liaise with IEC for the generation of S-101 test datasets.

## Operational Services

* IHO GI Registry.

## Legal issues

* Initiate adoption process of S-101 ENCs as equivalent to S-57 at IMO.
* Agree with IEC about a roadmap for an updated IEC 61174

## Capacity Building

* Enable Hydrographic Offices to produce S-101
  1. Through conversion of S-57 ENCs to S-101 ENCs;
  2. Educate on new elements in S-101 ENCs compared to S-57 ENCs.

## Regional activities

Test beds for S-101 ENCs and interoperable datasets on a regional basis.

RHCs and RENCs role (Group, but contribution from WGs is welcome)

[EAHC quote: Our collective view was that we should set a strategy for all EAHC MSs to be S-100 ready by 2025. For a start, we are proposing to evaluate where the gaps are from using the conversion software from ESRI and CARIS for S-57 to S-100. Based on preliminary assessment by ROK on ENCs from Singapore and Hong Kong under the EAHC, the different software produced different results. These could be attributed to different interpretation of the current S-57 standards. Therefore, we identified that there is a need for some work on harmonization. Moving forward from there, we are proposing to establish a testbed for S-100 ENCs of the Malacca and Singapore Straits. I understand from ROK that there is opportunity to park this programme under the S-100 testbed segment. At the end of the day, we want all EAHC MSs to be S-100 ready by 2020. ]

## Regular provision

* Parallel production of S-57 datasets and S-101 for an indeterminate period of time.
* Apply RENC concept to S-101 ENC distribution.
* Specific consideration of the fact that S-101 Product Specification offers additional concepts, attributes and geometry features for S-101 datasets which are not backward compatible with S-57 datasets.

## S-1XX interoperable Hydrographic Data Products

## S100WG, NIPWGWG and TWCWG, each within its competence (PSs)

### Affected Bodies

* …

### Technical standardization

* …

### Operational Services

* …

### Legal issues

* …

### Capacity Building

* …

### Regional activities

* …

### Regular provision

* …

## S-100 compatible Data Products of other domains

### Affected Bodies

* …

### Technical standardization

* …

### Operational Services

* …

### Legal issues

* …

### Capacity Building

* …

### Regional activities

* …

### Regular provision

* …