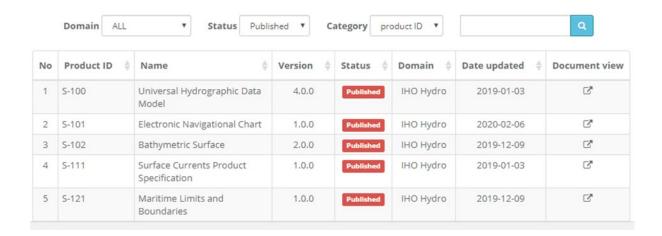# Implementing NOAA's S-100 based product suite

Introduction

S-100, the Universal Hydrographic Data Model, is a hydrographic geospatial data standard that can support a wide variety of hydrographic-related digital data sources, and aligns with mainstream international geospatial standards, in particular the ISO 19000 series of geographic standards. This alignment enables easier integration of hydrographic data and applications into geospatial solutions. 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 features, attributes and portrayal via a dedicated online registry. S-100 provides a framework of components that enables the building of standardized product specifications for the modelling of hydrographic data, thus providing true interoperability between different data standards and systems.

Where can I find the latest Edition of S-100?

Because different product specifications are tied to different editions of S-100, the latest valid editions can be found on the IHO website within the IHO Geospatial Information Registry:

http://registry.iho.int/beta/productspec/list.do

No	Product ID	Name	Version	Status	Domain	Date updated	Document view
1	S-100	Universal Hydrographic Data Model	4.0.0	Published	IHO Hydro	2019-01-03	⬏
2	S-101	Electronic Navigational Chart	1.0.0	Published	IHO Hydro	2020-02-06	⬏
3	S-102	Bathymetric Surface	2.0.0	Published	IHO Hydro	2019-12-09	⬏
4	S-111	Surface Currents Product Specification	1.0.0	Published	IHO Hydro	2019-01-03	⬏
5	S-121	Maritime Limits and Boundaries	1.0.0	Published	IHO Hydro	2019-12-09	⬏

This is the same location where officially published IHO product specifications are located.

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Where can I find the official UML Models and S-100 XSD Schemas?

S-100 is a multi-part model based framework that uses the Unified Modelling Language (UML) to describe the different elements that are used within different product specifications. S-100 also maintains a set of schemas that describes how specific parts of S-100 are put together – such as the feature catalogues and the discovery metadata.

Currently, the baselined UML models and Schemas for Edition 4.0.0 of S-100 are stored on GitHub. The IHO maintains links to the relevant repositories here:

http://s100.iho.int/S100/home/other-associated-resources

Where can I find the S-100 Data Product Encodings?

S-100 maintains a set of common data encodings to minimize the need for system developers to implement different flavors of data. Currently, S-100 maintains the following encodings:

Encoding	Product Specification
ISO 8211 Binary	S-101, S-401
HDF5	S-102, S-104, S-111
GML (profile of ISO 19136)	S-122, S-412, S-421

It is important to realize that each of these encodings are a profile and have been adapted to fit the S-100 framework. For example, the ISO 8211 profile in S-100 is different than the one that is contained within S-57 as S-100 includes new types of features and attributes – such as complex and information types.

The full encodings for S-100 are found in Part 10.

What is a Feature Catalogue?

Every product specification must have a feature catalogue. The feature catalogue contains definitions and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data. Therefore, the feature catalogue acts as a machine-readable representation of the application schema, and gives a system the means to describe the elements of a dataset that conforms to the feature catalogue.

Feature catalogues are created for each product specification and are found in the IHO GI Product Specification Register.

What is a Portrayal Catalogue?

Portrayal is an optional part of a product specification. However, if consistent portrayal across all user platforms is important to an S-100 based data product, then specifying how portrayal is done becomes mandatory. Within S-100 Product Specifications, this is in part done by including a portrayal catalogue. The Portrayal Catalogue is a collection of defined portrayal instructions for a feature catalogue, and includes portrayal functions, symbols, and portrayal context.

Two types of portrayal catalogues are possible in S-100; XSLT and LUA. Part 9 of S-100 provides instructions for how a product specification can include an input Schema derived from the abstract schema provided, a set of mapping rules (defined in XSLT or LUA), a set of symbols (defined in SVG format), line styles, colors etc. and makes it available for use with product datasets.

In order for systems to leverage S-100 portrayal they must implement both XSLT and LUA mechanisms. LUA is generally used for product specifications that need to implement complex rules that interface with outside parameters and XSLT is used for simple portrayal rule generation.

If a product specification has defined a portrayal catalogue, it is found in the IHO GI Product Specification Register.

What is Discovery Metadata?

For information exchange, there are several categories of metadata required: metadata about the overall exchange catalogue, metadata about each of the datasets contained in the catalogue, and metadata about the support files that make up the package. These are called discovery metadata in S-100 and they are used within the exchange set to enable users to learn about the content without having to open each dataset or support file.

Discovery metadata for datasets
S-100 specifies that discovery metadata for datasets is contained within an external XML file created in accordance with the S-100 metadata schema. This metadata set complies with the minimum metadata and extends it in a few places to provide more details, for example about reference datums and issue dates of the data. More information about discovery metadata for datasets can be found in the normative Appendix 4a-D Discovery Metadata for Information Exchange Catalogues of S-100.

Discovery metadata for support files
S-100 specifies that discovery metadata for support files is contained within an external XML file created in according with the S-100 metadata schema. This metadata set complies with the minimum metadata and extends it to provide information about the management of the support file in order to update these. More details can be found in the normative Appendix 4a-D Discovery Metadata for Information Exchange Catalogues of S-100.

Discovery metadata allows for machine to machine data discovery. This will allow for system developers to script against the discovery metadata to query if new data has been made available and then be able to download the data directly to the system.

What about Encryption and Authentication?

Encryption and authentication are described in Part 15 of S-100. It defines the standardized methods and algorithms for the encryption of file based components of datasets as well as feature and portrayal catalogues. Algorithms and methods for the production of digital signatures are defined as well as the surrounding infrastructure required for key management and identity assurance within the IHO Data Protection Scheme.

As part of its S-100 dissemination system NOAA intends to leverage the IHO's digital signature scheme to authenticate its products and will continue to provide its products unencrypted. It should be noted that users that receive NOAA data through authorized value added resellers will receive encrypted data using the IHO's encryption scheme.

![Precision Marine Navigation header]

S-111 Surface Currents

NOAA's Precision Marine Navigation Data Dissemination System is providing a service to disseminate NOS Operational Forecast System (OFS) surface currents leveraging the IHO's S-100 framework. The IHO has developed the S-111 Surface Current Product Specification that provides the methodology to store and send water current data and metadata. This standard has been designed for interoperability with Electronic Navigation Charts and other IHO S-100 product specifications. S-111 aims to standardize surface currents for use in navigation systems in order to improve Navigation Decision Support for mariners.

The S-100/S-111 complaint HDF5 datasets produced by NOAA have been converted to a regular grid and subsetted to provide an easily digestible size and format that can be used by Electronic Chart Systems such as Electronic Chart Display and Information Systems (ECDIS), portable pilot units (PPU), and electronic charting systems (ECS).

The following tables outline the basic information for a subset of the OFS models that have been prototyped for operations. A full list of the available models is provided at the end of this document.

The official IHO product specification and associated files can be found here:

[S-111 Product Specification](#)

NOAA has developed a set of open source python scripts to convert native netCDF data into S-111 Edition 1.0.0 datasets. The scripts are available here:

https://github.com/noaa-ocs-s100/s100py/tree/feature/s100api

Chesapeake Bay Operational Forecast System (CBOFS)

IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Discovery Metadata	https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/cbofs/catalog.xml
Format	HDF5
Model	ROMS
Observation Parameter	Surface currents

Coordinate System	WGS 84

Time Zone	UTC
Frequency	4 times daily cycle (0, 6, 12, 18 UTC)
Forecast	48 hours
Spatial Resolution	~500 m
Depth	-4.5 m
Data Coverage	Chesapeake Bay VA and MD
HDF5 Files	63

Delaware Bay Operational Forecast System (DBOFS)

IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Discovery Metadata	https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/dbofs/catalog.xml
Format	HDF5
Model	ROMS
Observation Parameter	Surface currents
Coordinate System	WGS 84
Time Zone	UTC
Frequency	4 times daily cycle (0, 6, 12, 18 UTC)
Forecast	48 hours
Spatial Resolution	~500 m
Depth	-4.5 m

Data Coverage	Delaware Bay DE, NJ and PA
HDF5 Files	27

Northern Gulf of Mexico Operational Forecast System (NGOFS)

IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Discovery Metadata	https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/ngofs/catalog.xml
Format	HDF5
Model	FVCOM
Observation Parameter	Surface currents
Coordinate System	WGS 84
Time Zone	UTC
Frequency	4 times daily cycle (3, 9, 15, 21 UTC)
Forecast	48 hours
Spatial Resolution	~1000 m
Depth	-4.5 m
Data Coverage	Northern Gulf of Mexico
HDF5 Files	7

New York Operational Forecast System (NYOFS)

IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0

Discovery Metadata	https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/nyofs/catalog.xml
Format	HDF5
Model	POM
Observation Parameter	Surface currents
Coordinate System	WGS 84
Time Zone	UTC
Frequency	4 times daily cycle (5, 11, 17, 23 UTC)
Forecast	54 hours
Spatial Resolution	~500 m
Depth	-4.5 m
Data Coverage	NY and NJ
HDF5 Files	6

Global Real-Time Operational Forecast System (RTOFS)

IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Discovery Metadata	https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/rtofs_east/catalog.xml https://noaa-s111-pds.s3.amazonaws.com/ed1.0.1/model_forecast_guidance/rtofs_west/catalog.xml
Format	HDF5
Model	HYCOM

Observation Parameter	Surface currents
Coordinate System	WGS 84
Time Zone	UTC
Frequency	Daily cycle (0 UTC)
Forecast	72 hours /6hr interval
Spatial Resolution	~8500 m
Depth	-4.5 m
Data Coverage	US East and US West
HDF5 Files	US East: 39, US West: 28

The full list of OFS models available include:
- Chesapeake Bay Operational Forecast System (CBOFS)
- Delaware Bay Operational Forecast System (DBOFS)
- Gulf of Maine Operational Forecast System (GOMOFS)
- Lake Erie Operational Forecast System (LEOFS)
- Lake Michigan and Huron Operational Forecast System (LMHOFS)
- Lake Ontario Operational Forecast System (LOOFS)
- Lake Superior Operational Forecast System (LSOFS)
- Northeast Gulf of Mexico Operational Forecast System (NEGOFS)
- Northern Gulf of Mexico Operational Forecast System (NGOFS)
- Northwestern Gulf of Mexico Operational Forecast System (NWGOFS)
- New York/New Jersey Harbor Operational Forecast System (NYOFS)
- San Francisco Bay Operational Forecast System (SFBOFS)
- Tampa Bay Operational Forecast System (TBOFS)
- Global Real-Time Ocean Forecast System (RTOFS)