Working Draft 1.10

20176

INTERNATIONAL HYDROGRAPHIC ORGANIZATION

IHO GEOSPATIAL STANDARD

FOR HYDROGRAPHIC DATA

Edition ~~WD – xxxxx~~ 0.1.10 20176

Special Publication No. S-111

Surface Current Product Specification

Published by the
International Hydrographic Bureau
MONACO

Surface Current Product Specification

Revision History

Version Number	Date	Author/Editor	Purpose
Draft 1.0	December 2012	D. O'Brien, Auth.	Demonstration Version
Draft 1.1	April 2014	L. Maltais, Ed.	Revision for currents
Draft 1.2	August 2014	L. Maltais, Ed	Additional revision of previous version
Draft 1.3	December 2014	L. Maltais, Ed	Additional revision of previous version
Draft 1.4	March 2015	L. Maltais, Ed	Additional revision of previous version
Draft 1.5	March 2015	K. Hess, B. Sullivan, C. Kammerer, E. Mong, Eds.	Put into template format, numerous changes
Draft 1.6	September 2015	SCWG members, Eds.	Changes as result of SCWG3 discussions
Draft 1.7	December 2015	K. Hess, Ed.	Changes per review of Draft 1.6
Draft 1.8	February 2016	K. Hess, Ed.	Changes per review of Draft 1.7
Draft 1.9	September 2016	K. Hess, TWCWG members, Eds.	Changes as result of TWCWG1 discussions
Draft 1.10	January 2017	K. Hess, TWCWG members, Eds.	

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1. OVERVIEW

From ancient times of exploration to modern day shipping, surface currents have played an important role in navigation. With the advent of electronic navigation, surface current data and updates are more accessible and easier to integrate into navigation displays. This integration of the chart with other supplemental data improves decision making and results in more efficient navigation.

1.1 Introduction

A data product specification is a precise technical description that defines the requirements for a geospatial data product and forms the basis for producing or acquiring data. This product specification, S-111, conforms to S-100.

S-111 describes all the feature Surface Currentfeatures and its attributes Surface Current Speed and Surface Current Direction (ANNEX A - DATA CLASSIFICATION AND ENCODING GUIDE)., attributes and the relationships of surface currents and their mapping to a dataset. It includes general information for data identification as well as for data content and structure, reference system, data quality aspects, data capture, maintenance, encoding, delivery, metadata and portrayal. The framework, i.e., the relationships between these elements, is depicted in Figure 1.1Figure 1.1Figure 1.1. The framework identifies how the various elements of a coverage dataset fit together.

A A dataset containing Surface Current datathat describes a set of attribute values distributed over an area. The structure containing the values is either is called a Grid Ccoverage or a Point Set.

- There are many different types of coverages, but the most common structure is a regular grid. Gridded data is fundamentally simple. It consists of a set of attribute values organized in a grid together with metadata to describe the meaning of the attribute values and spatial referencing information to position the data. An essential characteristic of a regular grid is that the geographic position of any node can be computed from the values of the origin and point spacing. A coverage includes a function which provides values at geographic locations within the extent of the grid. A continuous function provides values at all locations, while a discrete function, which is used for Surface Currents, provides values at only specific points (e.g., grid nodes).

- Another type of coverage structure is a Ppoint Sset, which also contains metadata and attribute values, although the locations of the points are not organized into a regular grid. The location of all points must be explicitly specified. There is no coverage function.

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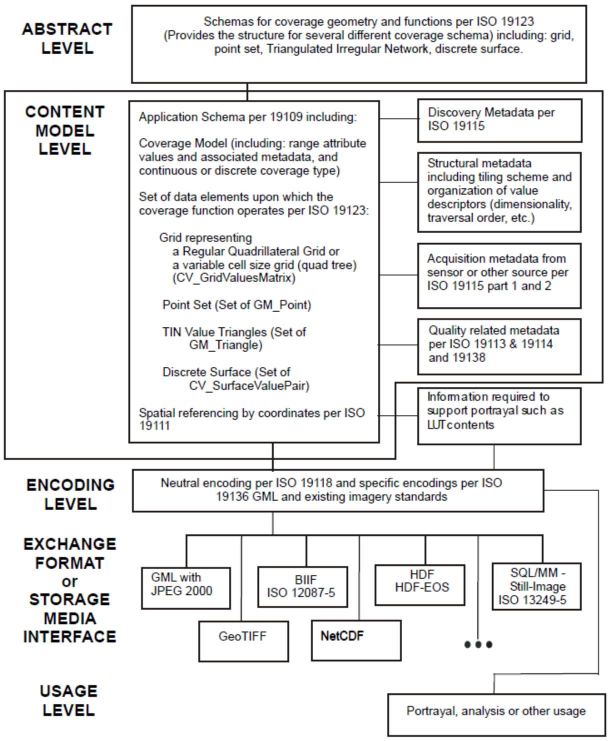

Figure 1.111 - Overall relationship between the elements of the framework (from S-100, Part 8).

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The Hierarchical Data Format version 5 (HDF5) promotes compatible data exchange due to its common neutral encoding format, and is the format used for this data product. HDF5 is object oriented and suitable for all many types of coverage data and forms the basis of NetCDF (a popular format used for scientific data).

1.2 Scope

This document describes an S-100 compliant product specification for surface currents and it specifies the content, structure, and metadata needed for creating a fully compliant S-111 ENC and for its portrayal within an S-100 Surface Current product. This product specification includes the content model, the encoding, the feature catalogue and metadata. The surface current product may be used alone or combined with an S-101 ENC or other S-100 compatible data.

1.3 References

1.3.1 Normative

S-44. *IHO Standards for Hydrographic Surveys,* 5th Edition February 2008.
S-100. *IHO Universal Hydrographic Data Model, ver. 3~~2~~.0.0.* (June~~January~~ 2017~~5~~).
~~**S-100.** *IHO Universal Hydrographic Data Model, Part 4a, Metadata (draft).*~~
~~**S-100.** *IHO Universal Hydrographic Data Model, Part 8, Grids (draft).*~~
S-101. *IHO Electronic Navigational Chart Product Specification*, July 2014.
S-102. *IHO Bathymetric Surface Product Specification,* April 2012.
ISO 8601. 2004. *Data elements and interchange formates - Information interchange - Representation of dates and times.* 2004.
ISO 3166-1. 1997. *Country Codes.* 1997.
ISO/TS 19103. 2005. *Geographic information - Conceptual schema language.* 2005.
ISO 19111. 2003. *Geographic information - Spatial referencing by coordinates.* 2003.
ISO 19115. 2003. *Geographic information - Metadata.* 2003.
ISO 19115-2. 2009. *Geographic information - Metadata - Part 2: Extension for imagery and gridded data.* 2009.
ISO/TS 19123. 2005. *Geographic information - Schema for coverage geometry and functions.* 2005.
ISO 19129. 2009. *Geographic information - Imagery, gridded and coverage data framework.* 2009.
ISO 19131. 2007. *Geographic information - Data product specifications.* 2007.
ISO/IEC 19501. 2005. *Information technology - Unified Modeling Language (UML) Version 1.4.2.* 2005.
netCDF – *Network Common Data Form: Unidata* – www.unidata.ucar.edu/software/netcdf
HDF5 – *Hierarchical Data Format version 5* – www.hdfgroup.org

1.3.2 Informative

ISO 19101. 2002. *Geographic information - Reference model.* 2002.
ISO 19103-2. 2005. *Geographic information - Conceptual schema language - Part 2.* 2005.
ISO 19105. 2000. *Geographic information - Conformance and testing.* 2000.
ISO 19107. 2003. *Geographic information - Spatial schema.* 2003.
ISO 19108. 2002. *Geographic information - Temporal schema.* 2002.
ISO 19109. 2005. *Geographic information - Rules for application schema.* 2005.
ISO 19110. 2005. *Geographic information - Methodology for feature cataloguing.* 2005.
ISO 19113. 2002. *Geographic information - Quality principles.* 2002.
ISO 19116. 2004. *Geographic information - Positioning services.* 2004.
ISO 19117. 2005. *Geographic information - Portrayal.* 2005.
ISO 19118. 2005. *Geographic information - Encoding.* 2005.
ISO 19128. 2005. *Geographic information - Web Map Server interface.* 2005.
ISO/TS 19130. 2010. *Geographic information - Imagery sensor models for geopositioning.* 2010.
ISO/TS 19130-2. 2010. *Geographic information - Imagery sensor models for geopositioning - Part 2.* 2010.
ISO 19132. 2007. *Geographic information - Location-based services – Reference model.* 2007.
ISO 19133. 2005. *Geographic Information - Location-based services - Tracking and navigation.* 2005.
ISO 19136. 2007. *Geographic information - Geography Markup Language (GML).* 2007.
ISO/TS 19138. 2006. *Geographic information - Data quality measures.* 2006.
ISO 19142. 2010. *Geographic information - Web Feature Service.* 2010.
ISO 19144-1. 2009. *Geographic information - Classification systems – Part 1: Classification system structure.* 2009.
ISO 19145. 2010. *Geographic information - Registry of representations of geographic point location.* 2010.
ISO 19153. 2010. *Geographic information - Geospatial Digital Rights Management Reference Model (GeoDRM RM) 1).* 2010.

ISO 19156. 2010. *Geographic information - Observations and measurements.* 2010.
ISO 19157. 2010. *Geographic information - Data quality.* 2010.
ISO 19158. 2010. *Geographic Information - Quality assurance of data supply.* 2010.
~~**2012.**~~ *Springer Handbook of Geographic Information.* 2012.
CO-OPS – Tide and Current Glossary 2000
Wikipedia. *Wikipedia.* [Online]

1.4 Terms, Definitions and Abbreviations

1.4.1 Use of Language

Within this document:

- "Must" indicates a mandatory requirement.
- "Should" indicates an optional requirement, that is the recommended process to be followed, but is not mandatory.
- "May" means "allowed to" or "could possibly", and is not mandatory.

1.4.2 Terms and Definitions

The S-100 framework is based on the ISO 19100 series of geographic standards. The terms and definitions provided here are used to standardize the nomenclature found within that framework, whenever possible. They are taken from the references cited in Cclause 1.3, modifications were made when necessary. Additional terms have also been included (see ANNEX ANNEX AB). Terms that are defined in this clause or in ANNEX ANNEX AB are highlighted in **bold**.

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coordinate
one of a sequence of n numbers designating the position of a point in n-dimensional space
NOTE: In a **coordinate reference system**, the **coordinate** numbers are qualified by units
[ISO 19107, ISO 19111]

coordinate reference system
coordinate system that is related to an **object** by a **datum**
NOTE: For geodetic and **vertical datums**, the **object** will be the Earth
[ISO 19111]

coverage
feature that acts as a **function** to return values from its **range** for any **direct position** within its spatial, temporal, or spatiotemporal **domain**
EXAMPLE: Examples include a raster **image**, polygon overlay, or digital elevation matrix
NOTE: In other words, a **coverage** is a **feature** that has multiple values for each **attribute** type, where each **direct position** within the geometric representation of the **feature** has a single value for each **attribute** type
[ISO 19123]

coverage geometry
configuration of the **domain** of a **coverage** described in terms of **coordinates**
[ISO 19123]

data product
dataset or **dataset series** that conforms to a **data product specification**

NOTE: The S-111 data product consists of metadata and one or more sets of speed and direction values
[ISO 19131]

depth-specific current
the water current at a specified **depth** below the **sea surface**

direct position
position described by a single set of **coordinates** within a **coordinate reference system**
[ISO 19107]

domain
well-defined set**. Domains** are used to define the **domain** set and **range** set of **attributes**, operators, and **functions**
NOTE: *Well-defined* means that the definition is both necessary and sufficient, as everything that satisfies the definition is in the set and everything that does not satisfy the definition is necessarily outside the set
[ISO/TS 19103, ISO 19107, ISO 19109]

feature
abstraction of real-world phenomena
EXAMPLE**:** The phenomenon named *Eiffel Tower* may be classified with other similar phenomena into a **feature type** named *tower*
NOTE 1: A **feature** may occur as a **type** or an **instance**. **Feature type** or feature instance shall be used when only one is meant
NOTE 2: In UML 2, a **feature** is a property, such as an operation or **attribute**, which is encapsulated as part of a list within a classifier, such as an interface, **class**, or **data type**
[ISO 19101, ISO/TS 19103, ISO 19110]

feature attribute
characteristic of a **feature**
EXAMPLE 1: A **feature attribute** named *colour* may have an **attribute** value *green* which belongs to the **data type** *text*
EXAMPLE 2: A **feature attribute** named *length* may have an **attribute** value *82.4* which belongs to the **data type** *real*
NOTE 1**:** A **feature attribute** may occur as a **type** or an **instance**. **Feature attribute** type or **feature attribute** instance is used when only one is meant
NOTE 2: A **feature attribute** type has a name, a **data type**, and a **domain** associated to it. A **feature attribute** instance has an **attribute** value taken from the **domain** of the **feature attribute** type
NOTE 3: In a **feature catalog**, a **feature attribute** may include a value **domain** but does not specify **attribute** values for **feature** instances
[ISO 19101, ISO 19109, ISO 19110, ISO 19117]

function
rule that associates each element from a **domain** (source, or **domain** of the **function**) to a unique element in another **domain** (target, codomain, or **range**)
[ISO 19107]

geometric object

spatial **object** representing a geometric set

NOTE: A **geometric object** consists of a **geometric primitive**, a collection of **geometric primitives**, or a **geometric complex** treated as a single entity. A **geometric object** may be the spatial representation of an **object** such as a ***feature*** or a significant part of a ***feature*** [ISO 19107]

georeferenced grid

grid for which node positions have been referenced to (i.e. have values in) the Earth's coordinate system

grid

network composed of a set of elements, or cells, whose vertices, or nodes, have defined positions within a coordinate system. See also **georeferenced grid, regular grid, irregular grid, node,** and **grid point**.

[ISO 19123]

NOTE 1: A rectangular grid has axes perpendicular to each other

NOTE 2: A uniform rectangular grid has constant spacing in the X-direction and constant spacing in the Y-direction, although the two spacing values are not necessarily equal

grid cell

element of a grid defined by its vertices, or **nodes**

grid point

point located at the intersection of two or more **grid cells** in a **grid.** Also called a **node**.

[ISO 19123]

irregular grid

a **georeferenced grid** with non-uniform spacing of points. Grid elements are defined by their three, four, etc. surrounding nodes. Compare to **regular grid**.

layer-averaged surface current

the water current averaged over the vertical, from the surface to a specified **depth** below the sea surface.

EXAMPLE: the current averaged from 0 metres (sea surface) down to 10 metres.

node

a point located at the vertex of a grid cell. Also called a **grid point**.

range <coverage>

set of **feature attribute** values associated by a **function** with the elements of the **domain** of a **coverage**

[ISO 19123]

record

finite, named collection of related items (**objects** or values)

NOTE: Logically, a **record** is a set of pairs <name, item>

[ISO 19107]

rectangular grid
an orthogonal grid whose cells are rectangles.

regular grid
a **georeferenced rectangular grid** with geodetic coordinates, with the X-axis directed eastward, the Y-axis directed northward, and uniform spacing of points in each direction. Spacing units are degrees of arc. Compare to **irregular grid**.

sea surface
a two-dimensional (in the horizontal plane) field representing the air-sea interface, with high-frequency fluctuations such as wind waves and swell, but not astronomical tides, filtered out.
EXAMPLE: sea surface, river surface, and lake surface
NOTE**:** This implies marine water, lakes, waterways, navigable rivers, etc.

surface current
the horizontal motion of water at a navigationally significant **depth** represented as a velocity **vector** (i.e., speed and direction). **Depths** may extend from the **sea surface** down to 25 metres.
NOTE: IHO Hydrographic Dictionary: current: surface. A current that does not extend more than a few (2-3) metres below the surface.

surface current direction
the direction toward which the surface current flows
[CO-OPS 2000]
NOTE: measured clockwise from true north. AKA set.

uncertainty
the interval about a given value that will contain the true value at a given **confidence** level
NOTE: **uncertainty** is the estimate of the **error** in any measurement or value; since the **error** (difference between true and observed value) depends on true value, which can never be measured. For practical purposes, the **confidence** level is 95% and the **uncertainty** is defined herein as 1.96 times the standard deviation of the differences between observed and predicted values (cf. S-44. *IHO Standards for Hydrographic Surveys*, 5th Edition, February 2008).

1.4.3 Abbreviations

This product specification adopts the following convention for symbols and abbreviated terms:

ECDIS	Electronic Chart Display Information System
ENC	Electronic Navigational Chart
HDF	Hierarchical Data Format (HDF5 is the fifth release)
IEEE	Institute of Electrical and Electronics Engineers
IHO	International Hydrographic Organization
ISO	International Organization for Standardization
NetCDF	Network Common Data Form
SCWG	Surface Currents Working Group
UML	Unified Modelling Language
UTC	Coordinated Universal Time

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1.5 General S-111 Data Product Description

This clause provides general information regarding the data product.

Title: Surface Current Information

Abstract: Encodes information and parameters for use with surface current data

Content: A conformant dataset may contain features associated with surface currents. The specific content is defined by the Feature Catalogue and the Application Schema.

Spatial Extent:

- **Description:** Global, marine areas only
- **East Bounding Longitude:** 180
- **West Bounding Longitude:** -180
- **North Bounding Latitude:** 90
- **South Bounding Latitude:** -90

Purpose: The data shall be collected/produced for the purposes related to surface current use.

1.6 Data Product Specification Metadata and Maintenance

1.6.1 Product Specification Metadata

This information uniquely identifies this Product Specification and provides information about its creation and maintenance. For further information on dataset metadata see the metadata clause.

Title: S-111 Surface Current Product Specification
S-100 Version: 32.0.0
S-111 Version: 1.0.0
Date: 20176-013-15
Language: English
Classification: Unclassified
Contact:
International Hydrographic Bureau,
4 quai Antoine 1er,
B.P. 445
MC 98011 MONACO CEDEX
Telephone: +377 93 10 81 00
Telefax: + 377 93 10 81 40
Role: Owner
URL: http://www.iho.int/mtg_docs/com_wg/SCWG/SCWG_Misc/S-111.pdf
Identifier: S111
Maintenance: For reporting issues which need correction, use the contact information.

1.6.2 IHO Product Specification Maintenance

1.6.2.1 Introduction

Changes to S-111 will be released by the IHO as a new edition, revision, or clarification.

1.6.2.2 New Edition

New Editions of S-111 introduce significant changes. New Editions enable new concepts, such as the ability to support new functions or applications, or the introduction of new constructs or data types. New Editions are likely to have a significant impact on either existing users or future users of S-111. All cumulative *revisions* and *clarifications* must be included with the release of approved New Editions.

1.6.2.3 Revisions

Revisions are defined as substantive semantic changes to S-111. Typically, revisions will change S-111 to correct factual errors; introduce necessary changes that have become evident as a result of practical experience or changing circumstances. A revision must not be classified as a clarification. Revisions could have an impact on either existing users or future users of S-111. All cumulative clarifications must be included with the release of approved corrections revisions.

Changes in a revision are minor and ensure backward compatibility with the previous versions within the same Edition. Newer revisions, for example, introduce new features and attributes. Within the same Edition, a dataset of one version could always be processed with a later version of the feature and portrayal catalogues. In most cases a new feature or portrayal catalogue will result in a revision of S-111.

1.6.2.4 Clarification

Clarifications are non-substantive changes to S-111. Typically, clarifications: remove ambiguity; correct grammatical and spelling errors; amend or update cross references; insert improved graphics in spelling, punctuation and grammar. A clarification must not cause any substantive semantic change to S-111.

Changes in a clarification are minor and ensure backward compatibility with the previous versions within the same Edition.

1.6.2.5 Version Numbers

The associated version control numbering to identify changes (n) to S-111 must be as follows:

New Editions denoted as **n**.0.0
Revisions denoted as n.**n**.0
Clarifications denoted as n.n.**n**

2. SPECIFICATION SCOPES

This product specification outlines the flow of data from inception, through the national Hydrographic Office (HO), to the end user. The data may be observed or modelled. Requirements for data and metadata are provided. This document does not include product delivery mechanisms.

Scope ID: Global
Level: 006 — series
Level name: Surface Current Dataset

3. DATASET IDENTIFICATION

A surface current dataset that conforms to this Product Specification uses the following general information for distinction:

Title: Surface Current Data Product

Alternate Title: None

Abstract: The data product is a file containing surface water current data for a particular geographic region and set of times, along with the accompanying metadata describing the content, variables, applicable times and locations, and structure of the data product. Surface current data includes speed and direction of the current, and may represent observed or mathematically-predicted values. The data may consist of currents at a small set of points where observations and/or predictions are available, or may consist of numerous points organized in a grid as from a hydrodynamic model forecast.

Topic Category: Transportation (ISO 19115 Domain Code 018).

Geographic Description: Areas specific to marine navigation.

Spatial Resolution: Varies (e.g., 0.1 km to 1000 km). The spatial resolution varies according to the model and the size of grid spacing, or on the number of observing locations adopted by the producer (Hydrographic Office).

Purpose: Surface current data are intended to be used as stand-alone data or as a layer in an ENC.

Language: English (mandatory).

Classification: Data may be classified as one of the following:

- Unclassified
- Restricted
- Confidential
- Secret
- Top Secret

Spatial Representation Types: Coverage

Point of Contact: Producing agency.

Use Limitation: Invalid over land.

4. DATA CONTENT AND STRUCTURE

4.1 Introduction

This Section discusses the application schema, which is described in UML; the feature catalogue; dataset types, in which there is an extensive discussion of the current data; dataset loading and unloading; and geometry.

Surface current data consist of the current speed and direction near the sea surface. The data may either be depth-specific current or layer-averaged surface current. Current data usually are represented as a time series of values for either a single point (i.e., one geographic location) or for an array of points contained in a grid. Additional information is included in ANNEX F – SURFACE CURRENT DATA.

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4.2 Application Schema

This application schema shall be expressed in UML. The details of the Application Schema are given in ANNEX B – APPLICATION SCHEMAANNEX C.

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4.3 Feature Catalogue

4.3.1 Introduction

The S-111 Feature Catalogue describes the feature types, information types, attributes, attribute values, associations and roles which may be used in a Surface Current Dataset. See ANNEX D – FEATURE CATALOGUE.

The S-111 Feature Catalogue is available in an XML document which conforms to the S-100 XML Feature Catalogue Schema and can be downloaded from the IHO website. It is also available in a human readable version.

4.3.2 Feature Types

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4.3.2.1 Geographic

Geographic (geo) feature types form the principle content of S-111 and are fully defined by their associated attributes and information types.

4.3.2.2 Meta

Meta features contain information about other features within a dataset. Information defined by meta features override the default metadata values defined by the dataset descriptive records. Meta attribution on individual features overrides attribution on meta features.

4.3.3 Feature Relationship

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A feature relationship links instances of one feature type with instances of the same or a different feature type. In S-111, there are no feature relationships.

4.3.4 Information Types

Information types define identifiable pieces of information in a dataset that can be shared between other features. They have attributes but have no relationship to any geometry; information types may reference other information types.

4.3.5 Spatial Quality

Spatial quality attributes (Figure 4.11) are carried in an information class called **spatial quality**. Only points, multipoints and curves can be associated with spatial quality. Currently no use case for associating surfaces with spatial quality attributes is known, therefore this is prohibited. Vertical uncertainty is prohibited for curves as this dimension is not supported by curves.

Surface currents are usually defined at one or more individual locations, so spatial quality applies to these locations.

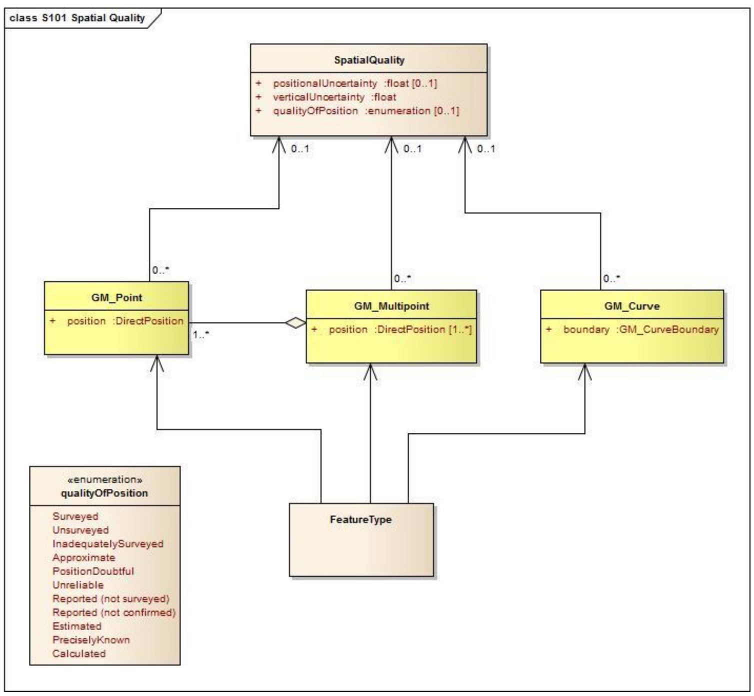

Figure 4.11 - Spatial Quality Information Type

4.3.6 Attributes

S-10011 defines attributes as either simple or complex. S-111 uses eight types of simple attributes; they are listed in Table 4.1. There are no complex attributes

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~~4.3.6.1 Simple Attributes~~

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~~S-111 uses eight types of simple attributes; they are listed in Table 4.1.~~

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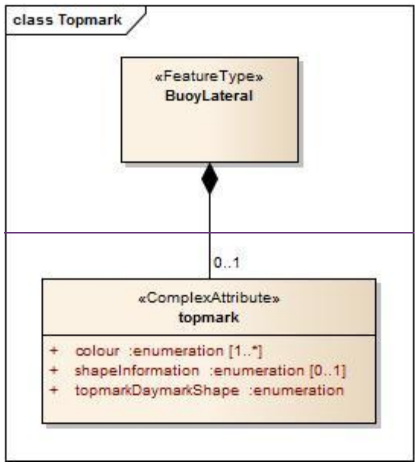
Table 4.1 -- Simple feature attribute types.

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values
Boolean	A value representing binary logic. The value can be either True or False. The default state for Boolean type attributes (i.e. where the attribute is not populated for the feature) is False.
Real	A signed Real (floating point) number consisting of a mantissa and an exponent
Integer	A signed integer number. The representation of an integer is encapsulation and usage dependent.
CharacterString	An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets
Date	A date provides values for year, month and day according to the Gregorian Calendar. Character encoding of a date is a string which must follow the calendar date format (complete representation, basic format) for date specified inS-100, Clause 4a-5.6.4). See also ISO 8601:1988. EXAMPLE 19980918 (YYYYMMDD)
Time	A time is given by an hour, minute and second. Character encoding of a time is a string that follows the local time (complete representation, basic format) format defined in S-100, Clause 4a-5.6.4). See also ISO 8601:1988. EXAMPLE: 183059Z
Date and Time	A DateTime is a combination of a date and a time type. Character encoding of a DateTime shall follow S-100, Clause 4a-5.6.4). See also ISO 8601:1988. EXAMPLE: 19850412T101530Z

~~**4.3.6.2 Complex Attributes**~~

~~Complex attributes (Figure 4.2) are aggregations of other attributes that are either simple or complex. The aggregation is defined by means of attribute bindings.~~



~~Figure 4.2 - Complex Attribute~~

~~EXAMPLE: In this example a *topmark* has three sub-attributes. The Buoy Lateral Feature may optionally include one instance of the complex attribute *topmark*.~~

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4.4 Datasets

Surface current data are represented in ~~three~~ two types of datasets: arrays of points contained in a regular grid, and sets ~~arrays~~ of ungridded points (or points in an irregular grid)~~, or a set of ungridded points~~. Further details on the data product are given in C~~c~~lause 10 – DATA PRODUCT FORMAT~~. Additional information is included in ANNEX F – SURFACE CURRENT DATA~~.

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4.4.1 Regular Grids

S-111 regular grid geometry is an implementation of S-100 Part 8-8 (Data Spatial Referencing). The spatial grids for the regular grid type are two dimensional, orthogonal,~~regular~~ and georeferenced~~detic~~ (with the X axis directed toward the east), and are defined by several attributes, including grid origin, spacing, grid indexing, and time information. ~~depicted in the S100_Grid/CurrentGrid block of the Surface Current Layer Model in Figure 4.3.~~ These parameters are explained in more detail below. For this type of dataset, the attribute *timeOfCurrent* carries the date and time for all points in each of the grids in the data product.~~To simplify the geometry model for cases where only one instance in time is needed, the time dimension is encoded as an attribute in each instance of the grid.~~

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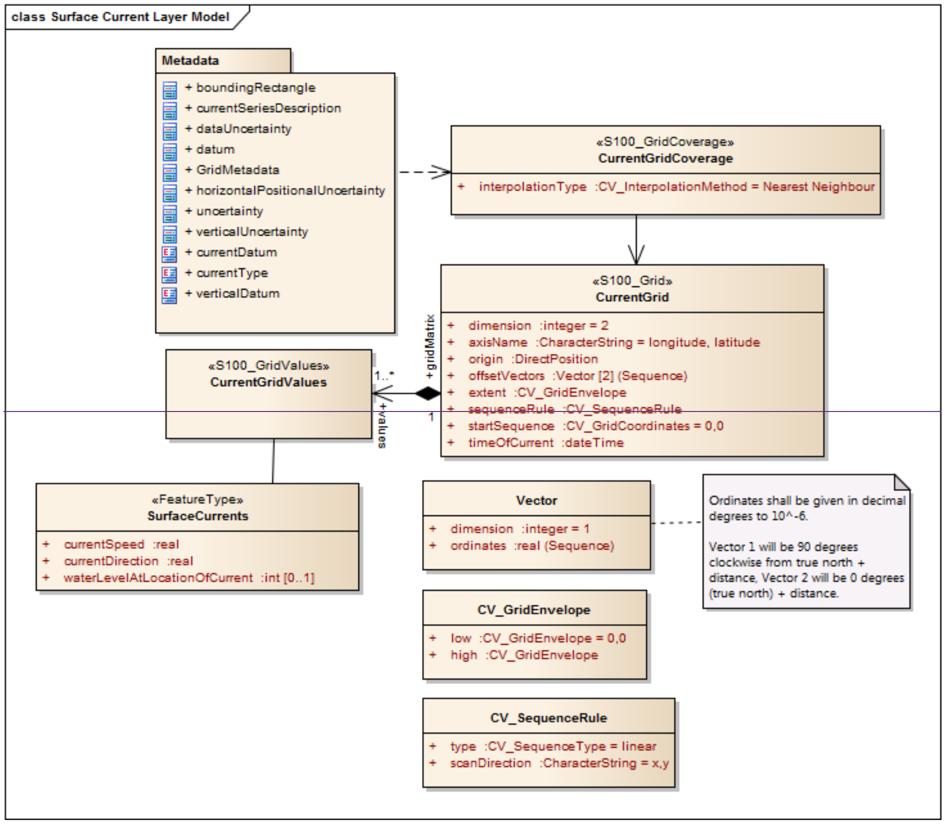

~~Figure 4.3 - UML schema for the Surface Current Layer (Fig. B.1).~~

A typical regular grid and some of its parameters are shown in Figure 4.2. The name of the axis in the S-111 grid is longitude for the X axis and latitude for the Y axis. The attribute *axisName* carry the names “Longitude” and “Latitude”, respectively~~ (Figure 4.4)~~.

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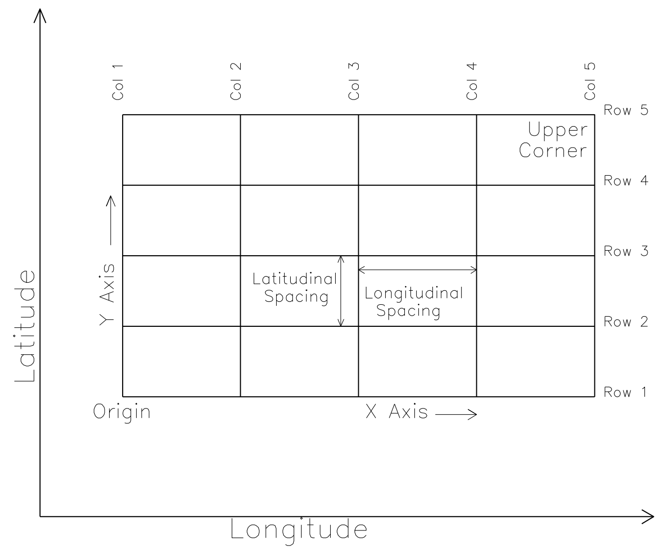

Figure 4.24 – Schematic of the regular grid and its attributes.

The extent of an S-111 grid is captured in the attribute *extent*. The attribute *extent* effectively defines a bounding rectangle describing where data is provided. The attribute extent carries two sub attributes; *low* and *high*. The sub attribute *low*, carries the value "0, 0" to indicate the start of the extent is the lower left corner of the grid. The sub attribute *high*, carries the value of the highest position along the X axis and the highest position along the Y axis. Together they form the grid coordinate of the upper right corner (Figure 4.4).

The attribute *origin* specifies the coordinates of the grid origin with respect to an external coordinate system. The grid origin is captured in the attribute *origin*, which contains the latitude and longitude as a *DirectPosition* containing a two-dimensional coordinate tuple (longitude, latitude). The grid origin is located at the lower extent of the grid (Figure 4.4).

S-111 grids allow for different spacing of points along the X axis and the Y axis. For rectangular grids the offset vector establishes the cell size. The attribute *offsetVectors* carries the two vectors for grid spacing. The attribute *offsetVectors* specifies the spacing between grid points and the orientation of the grid axis with respect to the external Coordinate Reference System (CRS) identified through the attribute *origin*. The first vector is 90 degrees clockwise from CRS north, and represents the distance between grid values on the X axis. The second vector is 0 degrees clockwise from CRS north, and represents the distance between the values on the Y axis (Figure 4.4). The distances are given in degrees.

The extent of an S-111 grid is captured in the attribute *extent*. The attribute *extent* effectively defines a bounding rectangle describing where data is provided. The attribute extent carries two sub attributes; *low* and *high*. The sub attribute *low*, carries the value "0, 0" to indicate the start of the extent is the lower left corner of the grid. The sub attribute *high*, carries the value of the highest position along the X axis and the highest position along the Y axis. Together they form the grid coordinate of the upper right corner.

The sequence rule for a regular cell size grid is straightforward. When the cells are all of the same size, the cell index can be derived from the position of the Record within the sequence of Records. The attribute *sequenceRule* has two subattributes; *type* and *scanDirection*. The sub attribute *type* carries the value "linear", and the subattribute *scanDirection* carries the value "X, Y". Together with the value "0, 0" stored in the attribute *startSequence*, they indicate that for S-111 the grid values along the X axis at the lowest Y axis position are stored first, starting with the left most value going right, followed by the values along the X axis at the next increment upward along the Y axis, and so on till the top of the Y axis. The last value in the value sequence of the grid will be at the top rightmost positon in the grid. In the figure, first all columns in row 1 are selected, then all columns in row 2, and so on.

4.4.2 Irregular Grid

For this type of grid coverage, the *axisNames* are the same as for the regular grid (Figure 4.5). However, the *origin* is arbitrary, and the extent (cf. the bounding rectangle) is defined by the minimum and maximum of the positions of the grid nodes. The total number of points, called nodes, is *numNodes*. Because the grid is not regular, attributes like spacing and scan direction have no meaning. The position of the nodes is carried in the one-dimensional arrays X and Y. For this grid, an attribute *timeOfCurrent* carries the date and time of the node values.

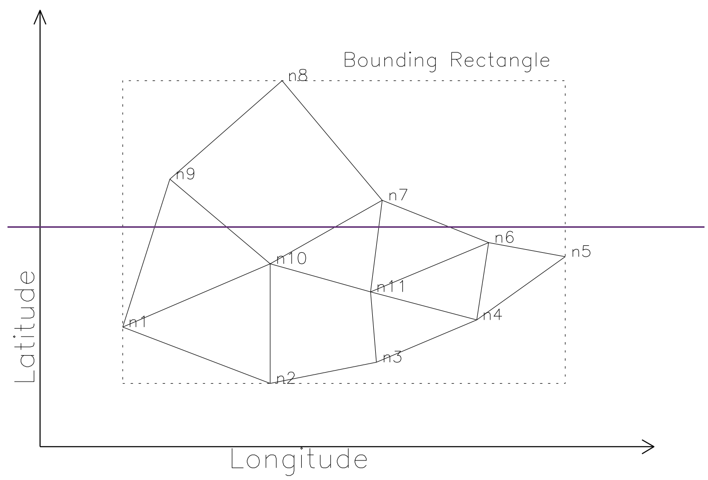

Figure 4.5 – Schematic of the irregular grid and some of its attributes.
Nodes are numbered and appear as 'n1', etc.

4.4.2~~3~~ Point Sets

For this type of ~~coverage~~data (Figure 4.3), the *axisNames* are the same as for the regular grid ~~(Figure 4.6)~~. However, the *origin* is arbitrary, and the *extent* (cf. the bounding rectangle) is defined by the minimum and maximum of the positions of the stations. The total number of ~~stations is *numStations*~~locations (tide stations, irregular grid points, or drifter locations) must be specified. Also, attributes like spacing and scan direction have no meaning. The position of the loca~~sta~~tions is carried in the one-dimensional arrays X and Y. For this dataset, the attribute *timeOfCurrent* may carry the date and time of (a) all the loc~~st~~ations in the set (for a number of fixed stations or for nodes in an irregular grid), or (b) each loc~~st~~ation individually (for a number of surface drifters).

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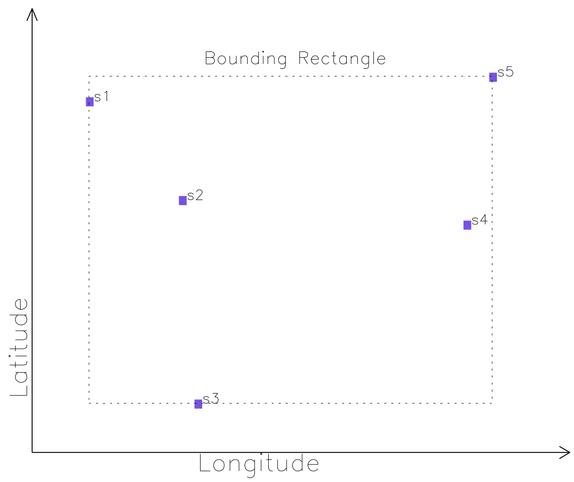

Figure 4.3~~6~~ – Schematic of the point set and its attributes. Stations appear as filled-in rectangles, are labeled and have a format such as ‘s1’.

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An irregular grid (Figure 4.4) is a special case of a Point Set. For this type of data, the *axisNames* are the same as for the regular grid. However, the *origin* is arbitrary, and the extent (cf. the bounding rectangle) is defined by the minimum and maximum of the positions of the grid nodes. The total number of points, called nodes, is *numNodes.* Because the grid is not regular, attributes like spacing and scan direction have no meaning. The position of the nodes is carried in the one-dimensional arrays X and Y. For this grid, an attribute *timeOfCurrent* carries the date and time of all the node values.

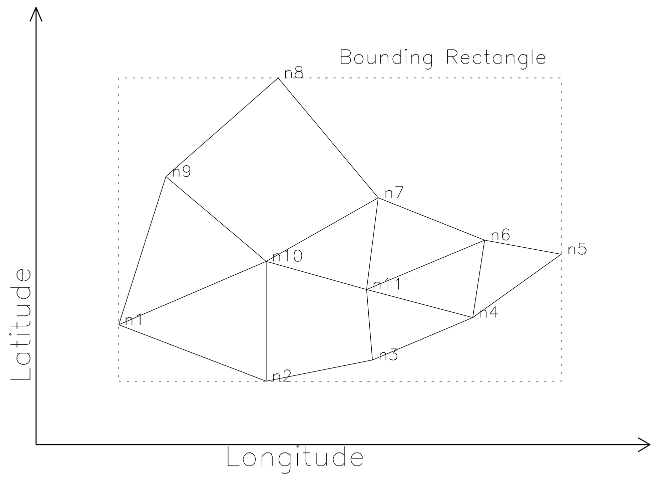

Figure 4.4 – Schematic of the irregular grid and some of its attributes. Nodes are numbered and appear as 'n1', etc.

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5. COORDINATE REFERENCE SYSTEMS (CRS)

The location of a feature in the S-100 standard is defined by means of coordinates, which relate a feature to a position. The S-111 CRS is a compound system, with a two-dimensional ellipsoidal horizontal component and a one-dimensional datum-related vertical component (cf. S-100, Part 6 – Coordinate Reference Systems).

5.1 Horizontal Reference System

For an ENC the horizontal CRS must be the ellipsoidal (geodetic) system EPSG: 4326 (WGS84). The full reference to EPSG: 4326 can be found at www.epsg-registry.org.

Horizontal coordinate reference system:	EPSG:4326 (WGS84)
Projection:	None
Coordinate reference system registry:	EPSG Geodetic Parameter Registry
Date type (according to ISO 19115):	002- publication
Responsible party:	International ~~Organisation~~ Association of Oil and Gas Producers (IOGP)

5.2 Vertical Reference System

The vertical coordinate is directed upward (i.e., away from the Earth's center) from its origin, the vertical datum, and has units of metres. That is, a positive value for the level of the current relative to the vertical datum means that the level is above the vertical datum. This is consistent with the bathymetric CRS in S-102. The vertical datum is not an ellipsoid but is one of the following: (a) the sea surface (defined in Clause 1.4.2), (b) a ~~standard tidal~~vertical, sounding, or chart datum (MSL, LAT, etc.), or (c) the sea floor.

5.3 Temporal Reference System

The temporal reference system is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with ISO 19108:2002, Temporal Schema clause 5.4.4. A date variable will have the following 8-character format: *yyyymmdd*. A time variable will have the following 7-character format: *hhmmssZ*. A date-time variable will have the following 16-character format: *yyyymmddThhmmssZ*.

6. DATA QUALITY

6.1 Introduction

Quality of surface current data for navigation consists of quality of the observed/predicted/forecast data, quality of the positional data, and quality of the time stamp. Quality of the observed data depends on the accuracy of the current meters and their processing techniques, and is normally available in field survey reports or QC analyses. Quality of predicted/forecast data depends on quality, timeliness, and spatial coverage of the input data as well as the mathematical techniques, and is normally described in technical reports describing the testing of the techniques. Temporal accuracy for observational data is normally available in field survey reports or QC analyses. Temporal accuracy for predicted/forecast data is normally described in technical reports.

6.2 Completeness

A Surface Current coverage data set is complete when the grid coverage value matrix contains direction and speed values or the null value for every vertex point defined in the grid, and when all of the mandatory associated metadata is provided. See ANNEX E~~D~~ - TESTS ~~FOR~~ OF COMPLETENESS (NORMATIVE).

7. DATA CAPTURE AND CLASSIFICATION

The Surface Current product contains data processed from sensors or derived from the output from mathematical models. In most cases, the data collected by the HO must be translated, sub-setted, reorganized, or otherwise processed to be made into a usable data format.

7.1 Data Sources

Surface current data comes primarily from three a few specific sources: observations, astronomical predictions, analyses, and forecast models and/or computational analysis. When such data are produced and quality-controlled by an HO, they are suitable for inclusion in the Surface Current data product. See ANNEX F – SURFACE CURRENT DATA.

Observational Data
Observational surface current data comes initially from *in situ* sensors in the field (e.g., current meters or drifting platforms) or from high-frequency radar, and such sensors are monitored by the HO. After reception, the data are quality-controlled and stored by the HO. Some of the observed data may be available for distribution within minutes of being collected and are thus described as being in real time. Other data may be days or years old, and are called historical data.

Astronomical Predictions Astronomical predictions are produced when a sufficiently long time series of observed currents has been obtained and the data has been harmonically analyzed by the HO to produce a set of amplitude and phase constants. There may be a single set of constants to represent flood and ebb currents along a principal direction, or two sets of constants to represent the northward and eastward components of the current. The harmonic values can then be used to predict the astronomical component of the current as a time series covering any desired time interval. In addition, the harmonic constants may be used to estimate tidal currents for a generic tidal cycle, with the specific amplitude and direction of the current based on the tide range at a specified nearby tide station, and the specific phase of the current based on the time of high water at the same nearby tide station. Data such as these may be available for single stations or, if the stations are numerous, they may be arranged by the HO into a gridded field or a tidal atlas.

Analyzed Values Analyzed current values may be produced from sea-surface topography, data assimilation, statistical correlations, or other means. A hybrid method combines two or more approaches.

Hindcast and Forecast Data Hydrodynamic forecast models numerically solve a set of fluid dynamic equations in two or three dimensions, and rely on observational data, including water levels and winds, to supply boundary conditions. Model grids may be either regular or irregular. Such models are often run several times per day, and in each run there is usually a hindcast and a forecast. The hindcast is a model simulation that attempts to recreate present conditions by using the most recent observational data, while a forecast is a simulation made for many hours into the future using predicted winds, water levels, etc. The results are saved for a limited number of times, and are stored as arrays that derive from the model's grid. Analyzed fields may be produced from sea-surface topography, data assimilation, or other means. These models and methods are developed, run, and monitored by the HO.

These descriptions are summarized in Table 7.1.

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Table 7.1 – Types of surface current data, based on the source of the data.

Type	Name	Description
1	Historical observation	Observation made hours, days, etc., in the past
2	Real-time observation	Observation no more than a few minutes old
3	Astronomical prediction	Value computed using harmonic constants only
4	Analysis or hybrid method	Calculation by statistical or other indirect methods, or a combination of methods
5	Hydrodynamic model hindcast	Gridded data from a two- or three-dimensional dynamic simulation of past conditions using only observed data for boundary forcing
6	Hydrodynamic model forecast	Gridded data from a two- or three-dimensional dynamic simulation of future conditions using predicted data for boundary forcing

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7.2 The Production Process

Nearly all available information on surface currents available from the HO must be reformatted to meet the standards of this Product Specification (Figure 10.1– the S-111 format). This means (a) populating the carrier metadata block (Error! Reference source not found.Clause 12.31) with the relevant data and (b) reorganizing the speed and direction data when using the encoding rules (see Annex ANNEX G – HDF5 ENCODINGC).

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7.2.1 Metadata

Metadata is derivable from the information available from the HO. The following variables will require additional processing:

- The bounding rectangle is computable from either the distribution of stations or nodes, or from grid parameters
- Position uncertainties may be available from the HO's metadata; otherwise they must be calculated
- Speed and direction uncertainties, if specified as a single value for the dataset, may be available from the HO; otherwise they must be calculated

7.2.2. Surface Current Data

Observational currents and astronomical tidal current predictions at a single location and gridded forecast data must normally be reformatted to fit the -S-111 standard. The following may require additional processingcalculations:

- Current depth level values (relative to a vertical datum) are often available in for the modeled data grid points, but and for observational data (such as for moored current meters) they may be referenced to the bottom and therefor require re-referencing to a different vertical datum.
- For gridded data, if a land mask array is included, the mask value is substituted into the gridded values as appropriate.

- Time stamps, if given in local time, must be converted to UTC.

7.2.3 Digital Tidal Atlas Data

Tidal atlas information may require additional processing to produce a time series. A tidal atlas typically contains speed and direction information for a number of locations, the valid time of which is expressed as a whole number of hours before and after time of high water, or current flood, at a reference tidal water level station (Table F.1). The speed and direction for any time are computed as a function of the daily predicted tides or currents at the reference station. The conversion into a time series is the responsibility of the HO.

8. MAINTENANCE

8.1 Maintenance and Update Frequency

Surface currents change rapidly, so more-or-less continual revision or updating of the data is essential. For real-time observations, new values are periodically collected (on the order of once every 5 minutes). For a forecast, the entire field of currents is created one or more times per day. New issues of real-time observations or forecasts should be considered new editions.

Tidal atlas or harmonic constant data are updated much less often, typically on an annual basis. Table 8.1 summarizes this information.

Table 8.1 – Typical update/revision intervals and related information for S-111 products produced by a single HO.

Data Types	Interval	Number Of Spatial Locations	Number Of Time Values Per Location
Harmonic Constant Tidal Predictions	1 year	100 to 1,000	8,760 (hourly data)
Model Forecasts	6 hr	100,000 to 1,000,000	1 to 24
Real-time Observations	0.1 hr	1 to 10	1 to 240
HF Radar Observations	0.1 hr	10,000 to 100,000	11 to 24

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8.2 Data Source

Data is produced by the HO by collecting observational values, predicting astronomical tides, or running analysis or /nowcasthindcast/forecast models. These data are typically quality-controlled and reformatted to conform to file size limitations and the S-111 standard encoding.

8.3 Production Process

S-111 data sets, including the metadata and the coverages for current speed and direction, are updated by replacement of the entire data product. HOs routinely collect observational data and maintain an analysis and/or forecast capability. When new data become available (often several times per day), the data is reformatted and made available for dissemination.

9. PORTRAYAL

9.1 Introduction

This section describes means of displaying surface current vectors to support navigation, route planning and route monitoring. Two types of data are discussed in depth. The first is point data, which would apply to historical data, astronomical predictions, and real-time data, and the second is regularly gridded data, which would apply to analyses, coastal radar observations, and model-based hindcasts and forecasts. For gridded or point set data, the current vector portrayal characteristics used for single-point data can be adapted to displaying data at multiple points.

For example, a point portrayal may be provided to display currents at significant locations such as turning points or where real-time observations are available. A gridded portrayal may be provided for voyage planning where a mariner's selection of routes may be influenced by an overview of the currents. Note that not all portrayal categories (point and gridded) may be available for all types of currents data (historical observations, real-time observations, astronomical predictions, and forecast total currents).

All recommended sizes are given assuming a minimum size ECDIS display of 270 by 270 mm or 1020 by 1020 pixels.

9.2 Display of Current at a Single Point

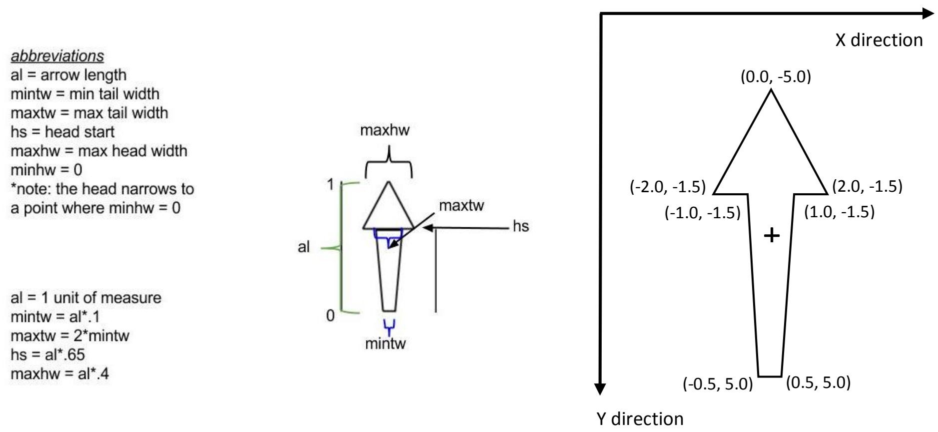
Portrayal of current using single point data should be used for instances where the data source is a current meter (e.g., a historical or real-time current measuring device) at a single geographic location.

The single-point current is represented by an image of an arrow placed at the position of the originating data. The direction of the current is represented by the orientation of the arrow. Current speed is represented by (a) the size of the arrow, (b) the colour, and (c) a numerical value. The numerical value of speed as a number, in knots and hundredths of a knot, in black text with a white border and be available when the cursor is held over the data point. Similarly, the numerical value of direction as a number, in degrees and tenths of a degree, in black text with a white border and be available when the cursor is held over the data point.

9.2.1 Arrow Shape

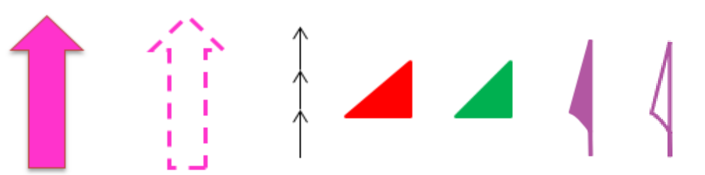
The generalized arrow shape must be created using the input dimensions shown (Figure 9.1) and scaled to any size. This shape is unique and so does not conflict with existing arrow and arrow-like shapes previously approved for use in ECDIS (Figure 9.2).

The arrow's 'pivot point' is located on the arrow symbol along the vertical centreline and is at a distance from the bottom equal to one-half the quantity 'al'. The pivot point is placed at the corresponding position (longitude and latitude) on the chart image.



(a) (b)

Figure 9.1 – (a) Generalized arrow shape for use in representing surface currents. (b) The arrow with vertex coordinates (x, y) in mm. The '+' shows the location of the pivot point at (0.0, 0.0) and the y axis is pointing downward.



(a) (b) (c) (d) (e) (f) (g)

Figure 9.2 – Existing arrow types and approximate colours approved for use in ECDIS: (a) and (b) for traffic separation schemes, (c) for recommended (one-way) tracks, (d) and (e) for conical buoys, and (f) and (g) for magnetic variation and anomaly.

9.2.2 Arrow Direction

The direction of the arrow symbol must be the direction (relative to true north) toward which the current is flowing (Figure 9.3). If the map projection is Mercator, angles are preserved, so current direction is identical to direction on the screen. For other map projections, the portrayed direction must be computed.

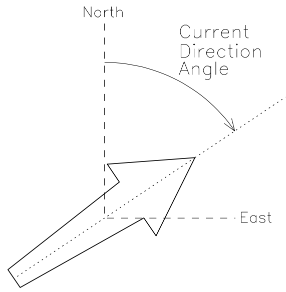


Figure 9.3 – Portrayal of the arrow's direction, based on the current direction. The dashed line is the arrow's centerline, and the origin of the East-North axis is at the arrow's pivot point.
True north has a direction of 0 degrees.

9.2.3 Arrow Colour

The colour of the arrow must be based on the speed value of the data, and must have 9 ~~steps~~ bands corresponding to the speed ranges (Table 9.1). The range of speeds (Table 9.1) was selected to (a) emphasize differences at low speeds (0.0 to 3 kn), and (b) be capable of displaying large currents (13 kn and above).

NOTE: The largest tidal currents may be those in the strait near Saltstrumen, Norway, which reach 22 kn.

Table 9.1 – Speed ranges (knots) for the 9-~~step~~ band display.

Speed ~~Step~~Band	**Minimum Speed (kn)**	**Maximum Speed (kn)**	**Appx. Interval (kn)**
1	0.00	0.49	0.5
2	0.50	0.99	0.5
3	1.00	1.99	1
4	2.00	2.99	1
5	3.00	4.99	2
6	5.00	6.99	2
7	7.00	9.99	3
8	10.00	12.99	3
9	13.00	99.99	87

Colours are associated with each speed band, and must be distinguishable in the three viewing environments: day~~time~~, dusk, and night~~time~~. Color values for ~~these~~ day conditions are shown in Table 9.2. Colours for dusk and night conditions are given in ANNEX H – COLOUR TABLES. (The monitor gamma values need to be taken into account – refer to IHO standards).

Table 9.2 – (a) Colour schema for day conditions~~light and dusk viewing~~.

Speed ~~Step~~Band	Colour	Colour Scale Intensity			Hex RBG	Displayed Colour
		Red	Green	Blue		
1	purple	118	82	226	#7652E2	
2	dark blue	72	152	211	#4898D3	
3	light blue	97	203	229	#61CBE5	
4	dark green	109	188	69	#6DBC45	
5	light green	180	220	0	#B4DC00	
6	yellow-green	205	193	0	#CDC100	
7	orange	248	167	24	#F8A718	
8	pink	247	162	157	#F7A29D	
9	red	255	30	30	#FF1E1E	

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~~(b) Colour schema for nighttime viewing.<<needs values>>~~

9.2.4 Arrow Size

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The arrow size must be a function of the speed the arrow represents, and for a given speed must be the same regardless of the source of the data. The standard arrow (Figure 9.1) is scaled up or down in size, depending on the speed it is intended to represent. The scale factor shall be a linear function of the speed.

An upper limit on the size of the arrow is imposed by requiring the scaling input speed value to not exceed a reference high value, S_{high}. The recommended value for S_{high} is the lower limit value in the highest group in Table 9.2, which is 13.0 kn. The value of S_{high} should be the same for all data sets from multiple sources so that the same speed in different data will be displayed with the same arrow length.

A second parameter is the reference speed, S_{ref}, at which the arrow symbol has a length equal to the scaling length parameter, L_{ref}. Here S_{ref} is chosen to be 5 kn and L_{ref} is taken to be 10.0 mm.

Let S be the current speed to be displayed. If S exceeds S_{high}, then S_{high} is substituted for that speed, since areas of extremely high current speeds are rare and are likely to be avoided by navigators anyway. Therefore, a current with a speed of S will be displayed with a length, L (mm), computed by:

$$L = L_{ref} \cdot \min(S, S_{high}) / S_{ref}. \qquad \text{[Eqn. 9.1]}$$

A summary of recommended values is given in Table 9.3.

Table 9.3 – Summary of recommended values for arrow display size (see Eqn. 9.1). With these values, an arrow representing 5 kn will have a length of 10 mm.

Variable	**Description**	**Recommended Value**
L_{ref}	Reference length for arrow scaling	10 mm
S_{ref}	Reference speed for arrow scaling	5 kn
S_{high}	Maximum speed to be used for arrow length computations	13 kn

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9.2.5 Numerical Values

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Current speed and direction, and additional data related to uncertainty and other metadata, should be visible when selected by placing the cursor within the solid area of the arrow shape (Figure 9.5). The data are invisible initially, and when the cursor is placed on the arrow, the data will be shown temporally. If the arrow is clicked, data will be shown continuously until another point is clicked. The information shown when the arrow is clicked will be displayed in black text inside a box with a white (or other colour for dusk and/or night viewing) background and a black border with a 1 pixel line thickness. The box must have zero transparency.

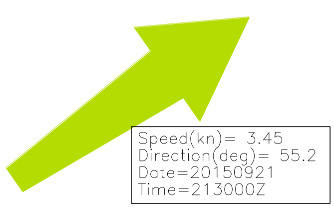

Figure 9.5 – Example of the display of the first level of numerical information available by cursor selection. Note: Arrow length is not to scale.

There should be at least three levels of detail of information (Table 9.2). In the first level, speed (kn) and direction (arc-degrees clockwise from true north) shall be displayed. In the second level, there are six additional items, each with appropriate units: data source/station name, latitude, longitude, date, time, and current depth or layer thickness. In the third level, there are at least five additional items: uncertainty in speed, direction, horizontal position, vertical position and time. A sample image showing a vector with the first level of information is shown in Figure 9.5. The additional levels are accessed by a cursor pick capability (cf. S-101. IHO Electronic Navigational Chart Product Specification).

Table 9.2 – Sample of numerical information displayed at the location of a current vector, organiszed into levels of priority.

~~Priority Level~~	~~Information Displayed~~
~~1~~	~~Speed~~ ~~Direction~~ ~~Valid Date~~ ~~Valid Time~~
~~2~~	~~Data source or station name~~ ~~Latitude~~ ~~Longitude~~ ~~Depth of current~~
~~3~~	~~Uncertainty in speed~~ ~~Uncertainty in direction~~ ~~Uncertainty in horizontal position~~ ~~Uncertainty in vertical position~~ ~~Uncertainty in time~~

Priority Level	**Information Displayed**
1	Speed, Direction, Valid Date, Valid Time
2	Data source or station name, Latitude, Longitude, Depth of current
3	Uncertainty in speed, Uncertainty in direction, Uncertainty in horizontal position, Uncertainty in vertical position, Uncertainty in time

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NOTE: The text box in Figure 9.5 requires the use of two additional colours: black for the text and box outline, and white for the interior of the box. Standard ISO colours are to be used. The interior of the box will have zero transparency.

9.2.6 Transparency

The symbol transparency must be adjusted according to the background chart/image used (Table 9.3). The value alpha represents the level of opaqueness (relative to the background image) of the arrow and the numerical values displayed. An alpha value of 1 denotes zero transparency and an alpha value of 0 denotes 100% transparency.

Table 9.3 - Alpha (opaqueness) values for arrows with various display backgrounds. Transparency is 1.0 minus the alpha value.

Background	Alpha
Satellite image	1.0
Raster Nautical Chart	1.0
ENC Day	1.0
ENC Dusk	0.4
ENC Night	0.2

9.2.7 Scalable Vector Graphics

In ECDIS, the arrow symbol (e.g. Figure 9.5) is drawn using Scalable Vector Graphics (SVG) instructions. SVG allows a symbol of any given size, orientation, and colour to be displayed by only a few instructions. The coordinate system for the symbol is defined as follows. The overall width and height of the symbol are defined in mm. The viewbox covers the range of coordinates used for the symbol. The pivot point of the symbol is designed to be at the 0.0, 0.0 position.

The default coordinate system used for S-100 SVG has the origin in the upper left corner with the x-axis pointing to the right and the y-axis pointing down.

For example, the using the image coordinates shown in Figure 9.1b, the SVG coordinate system, and L_{ref} of 10 mm, a 'path' command would contain

M -0.5, 5. L -0.5, 5.0 -1.0,-1.5 -2.,-1.5 0.,-5.0 2.0,-1.5 1.0,-1.5 0.5,5.0 -0.5, 5.0 Z

where M is the *moveto* instruction, L is the *lineto* instruction, and Z denotes the end of the drawing. The coordinates are given in mm. See ANNEXnnex I – SCALABLE VECTOR GRAPHICSH for more details.

9.3 Display of Regularly Gridded Data

The display of gridded data depicts a surface current field of multiple arrows (Figure 9.6), with each individual current arrow having the qualities described in Clause 9.2. The acceptable arrowhead style for gridded arrows is the style defined in Figure 9.1. As with single-point data, the speed and direction values at individual vectors must be available when the cursor is placed over a vector.

NOTE: current direction angles cannot be interpolated (in either space or time) directly, but must be derived using the X and Y components of current. That is, interpolation must be of the east/west and north/south components of current separately, with the interpolated components then used to calculate speed and direction.

9.3.1 High Resolution

A high-resolution display (i.e., zooming in) of regularly gridded data display produces a lower density of data (Figure 9.7). It is not recommended that linear spatial interpolation be used to fill in sparse data. Linear interpolation in space could be used to obtain data points from the model grid for generating additional grid points in the portrayal.

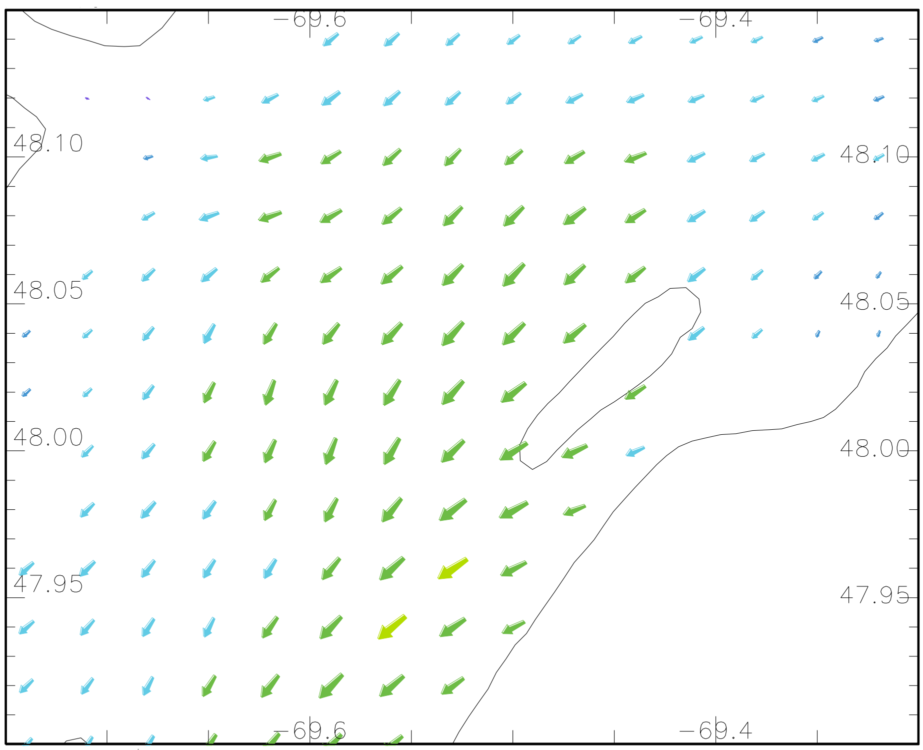


Figure 9.6 - Arrows representing gridded current data, with length increasing with speed, and S_{ref} is 5 kn, L_{ref} is 10 mm, and the maximum speed in the data in the image is 3.15 kn. Coastline added for clarity. (data courtesy of St. Lawrence Global Observatory, Canada)

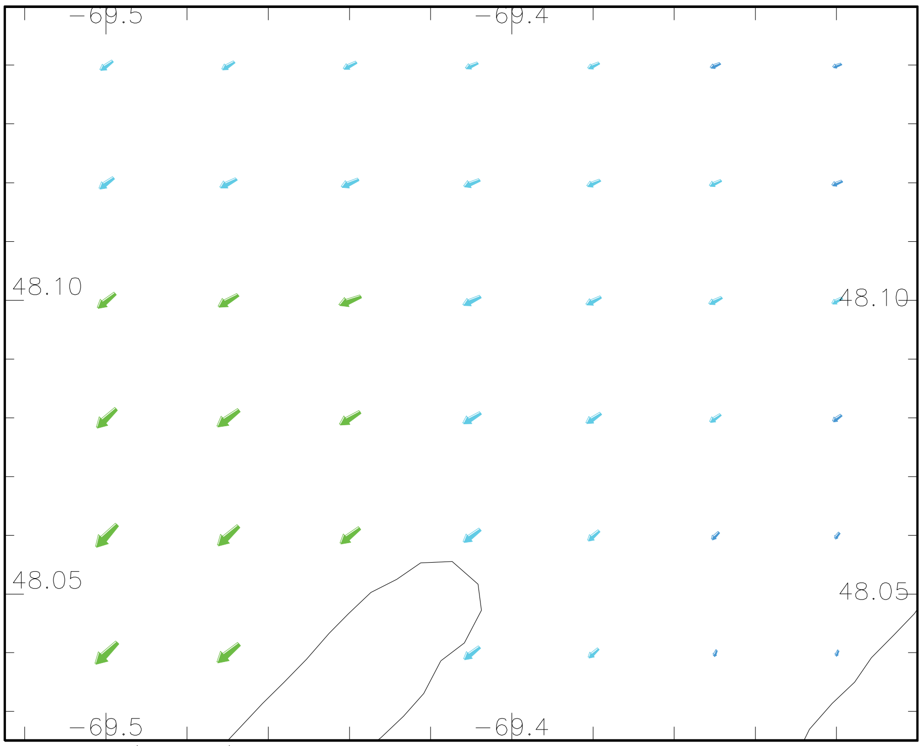


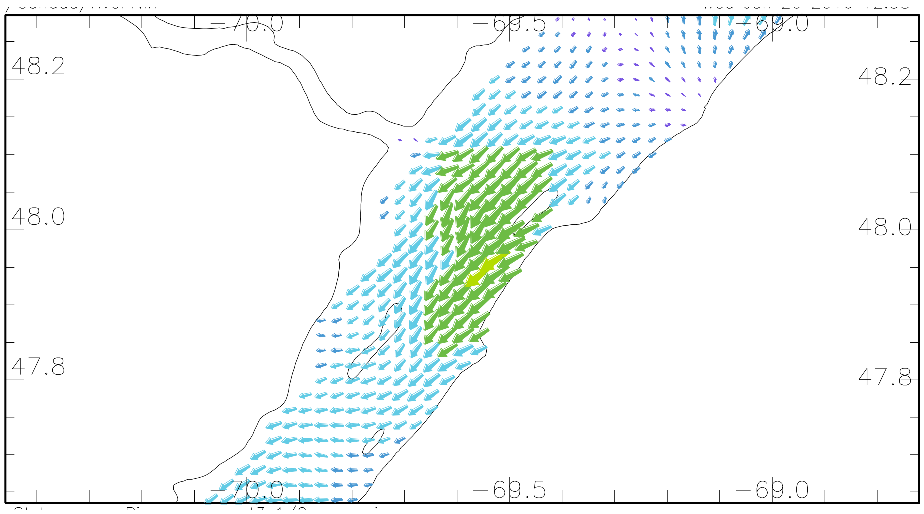
Figure 9.7 – Display of current data (see Figure 9.6) but at a higher resolution (data courtesy of St. Lawrence Global Observatory, Canada).

9.3.2 Low Resolution

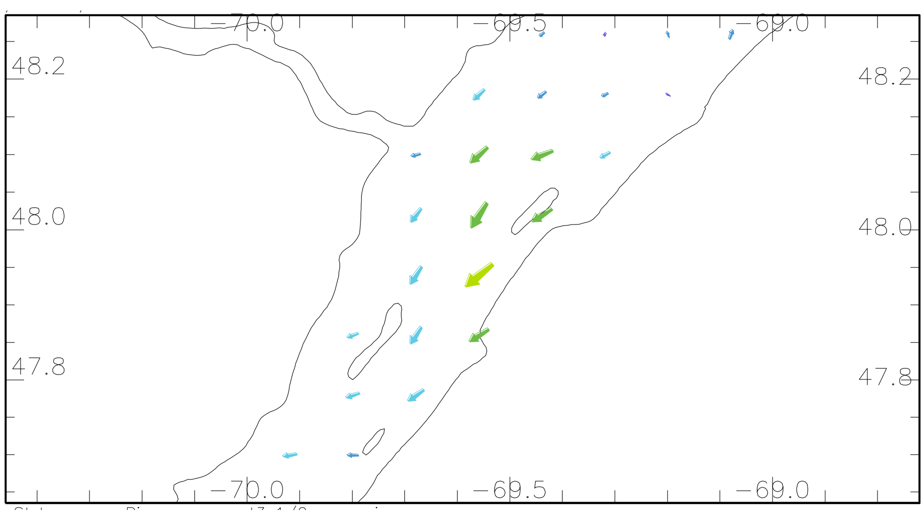
Displaying at a low resolution (i.e., zooming out) increases the density of symbols (Figure 9.8a). However, by applying a thinning algorithm, the number of vectors may be reduced (Figure 9.8b). In this case, every fourth vector was plotted.

Thinning for regularly gridded data is as follows. Suppose that the grid cell's diagonal as displayed has a distance of D mm and represents the grid spacing. Note that D is dependent on the specific geographic area and the size of the viewing monitor. If every n^{th} cell is displayed, the displayed spacing is nD. Next, suppose the length of the arrow representing the maximum speed in the displayed field is L_{smax} mm. Then the ratio of the maximum arrow length to the displayed grid spacing is constrained to be less than a prescribed maximum value, R_{max}, here taken to be 0.5. Thus

$$R = L_{smax}/(nD) \leq R_{max} \quad \text{[Eqn. 9.2]}$$



(a)



(b)

Figure 9.8 – (a) Current vectors (see Figure 9.6) displayed with identical parameters, but at low resolution. (b) Current vectors as in (a), but ‘thinned’ by plotting every fourth point. (data courtesy of St. Lawrence Global Observatory, Canada).

If the above inequality cannot be met with increment n equal to 1, then a new value for n is computed by the following formula:

$$n = 1 + fix(L_{smax}/(DR_{max})) \quad \text{[Eqn. 9.3]}$$

where fix() is a function that returns the truncated integer value. For plotting, arrows at every n^{th} column and every n^{th} row are drawn, making sure that the row and column with the maximum vector is drawn (Figure 9.8b).

9.4 Temporal Considerations

The time selected for display (i.e., past, present, or future) of the surface currents by the system will typically not correspond exactly to the timestamp of the input data. For data with only a single record (i.e., the timestamp of the earliest value equals that of the latest value) such as real-time data, the surface current values are displayed only if the absolute time difference between the display time and the data timestamp is less than a discrimination interval (e.g., 5 minutes). For a single record, the variable *timeRecordInterval* (see Clause 12.3) can be used to set the discrimination interval.

For data with multiple times, if the selected display time is later than the first timestamp and earlier than the last timestamp, then the closest two timestamps (i.e., one earlier and one later) in the data are found and the current values are linearly interpolated using the vector components (cf. clause 9.3.1). However, if the selected display time is earlier than the first timestamp or later than the last timestamp, then surface current values at the closest time are displayed only if the absolute time difference between the display time and the data timestamp is less than a discrimination interval (e.g., half of the value of the variable *timeRecordInterval*).

9.5 Placement of Legend

The legend must consist of, at a minimum, the colour scale, with speed values, as shown in Figure 9.4. The precise position of the legend as it appears on the monitor will be determined so as to minimize the obscuring of other important navigational information.

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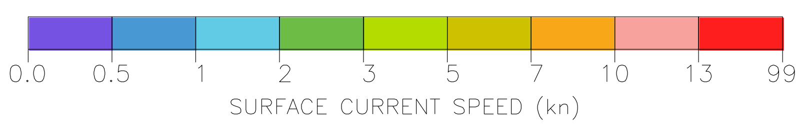

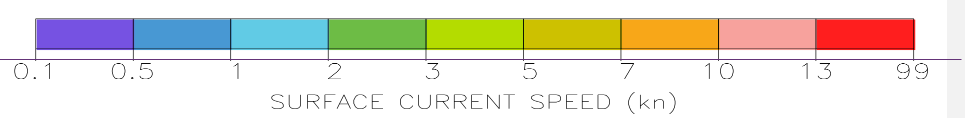

Figure 9.4 – Sample surface current speed scale based on the colours and speed ~~ranges~~ bands in Table 9.1.

9.6 Interoperability

Interoperability principles determine priority in display of elements so that important image elements, such a depth numerals, are no obscured by current vectors. Surface current portrayal will conform to interoperability rules when they are established.

9.7 Sample Representation

Surface currents vectors comprise a layer to be displayed on demand on top of other data and layers. Consideration must be made so as not to obscure critical navigational data nor create confusion by using symbols similar to those in other layers. Figure 9.9 shows a sample display.

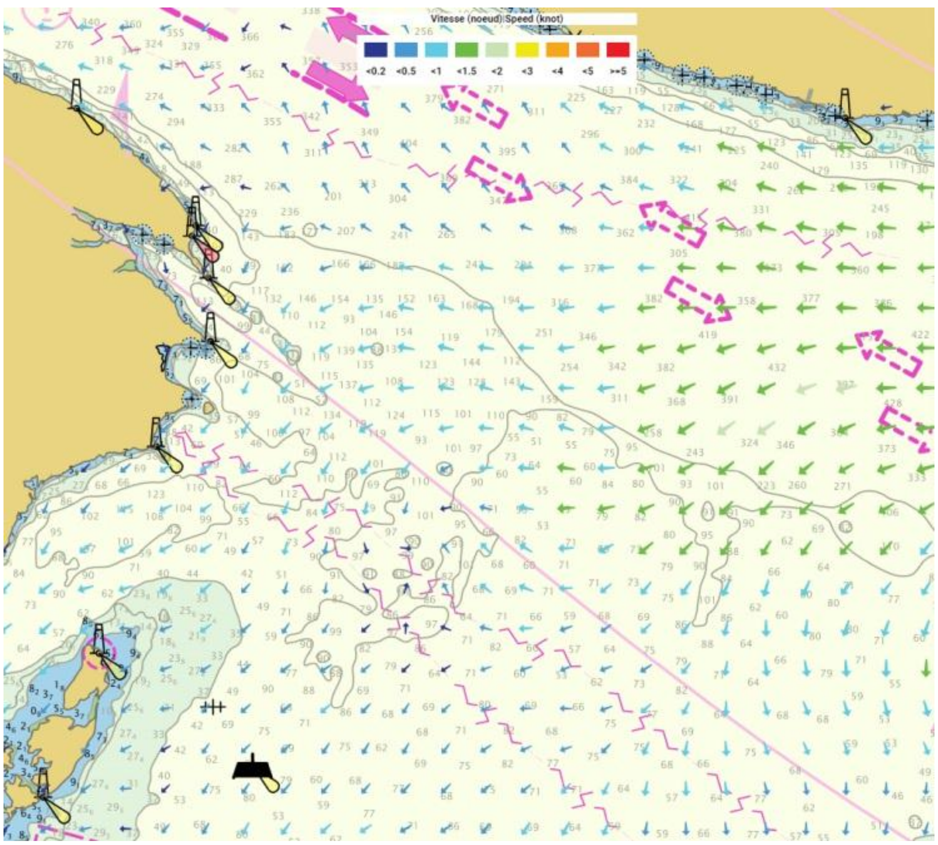

Figure 9.9 – Sample depiction of gridded surface current data in an electronic chart. (Image courtesy of the University of New Hampshire, US)

10. DATA PRODUCT FORMAT (ENCODING)

10.1 Introduction

The Surface Current Data Product must be encoded using the Hierarchical Data Format standard, Version 5 (HDF5). The structure of the data product is discussed in the next section.

Format Name: HDF-5

Character Set: MD_CharacterSetCode (ISO 19115)

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Specification: S-100 profile of HDF-5

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10.2 Product Structure

The key idea at the core of the structure is this: the organization of the information is substantially the same for each of the various types of data, but the information itself will be interpreted differently.

10.2.1 Data Type Definition

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The product format is designed to be flexible enough to apply for (a) time series data for one or more individual, fixed stations, (b) regularly-gridded data for multiple times, (c) irregularly-gridded data for multiple times, and (d) moving platform (e.g., surface drifter) data with a constant time interval. This approach contains, for each type, data in a similar format but which is interpreted differently. Since each type of data will be interpreted differently, the type of data must be identified by the variable *dataCodingFormat,* as shown in Table 10.1.

Table 10.1 - Values of the variable *dataCodingFormat.*

dataCodingFormat	Type of Data
1	Time series data at one or more fixed stations
2	Regularly-gridded data at one or more times
3	Irregularly-gridded data at one or more times
4	Time series data at one moving platform

For all data types, the product structure in HDF5 includes (a) a metadata block, which is followed by (b) one or more Groups which contain the actual surface current data. The speed and direction information are saved in arrays that hold either gridded data or a time series.

10.2.2 Sample Types

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For regularly gridded data, the speed and direction arrays are two dimensional, with dimensions *num~~ber~~PointsLongitudinal* and *num~~ber~~PointsLatitudinal*. By knowing the grid origin and the grid spacings, the position of every point in the grid can be computed by simple formulae.

However, for time series data, irregularly gridded data, and moving platform data (i.e., when *dataCodingFormat* is 1, 3 or 4), the location of each point must be specified individually. This is accomplished by the data in Group XY, which gives the individual longitude (X) and latitude (Y) for each location. For time series data, the X and Y values are the positions of the stations; the number of stations is *numberOfStations.* For irregularly-gridded data, the X and Y values are the positions of each point in the grid; the number of grid points is *numberOfNodes*. For drifter data, X and Y values are the positions of the drifters at each time; the number of drifters is *numberOfStations*.

NOTE: If *dataCodingFormat* is 2, Group XY is not present.

The remaining Groups each contain a title, a date-time value, and the speed and direction arrays. The title can be used to identify each individual station with time-series data. For *dataCodingFormat* = 2 or 3, the date-time is for the entire grid. The speed and direction arrays are two dimensional, with a number of columns (*numCOL*) and rows (*numROW*). For a time series, the speed and direction values will be for each time in the series. For a grid, the speed and direction values will be for each point in the grid.

The Groups are numbered 1, 2, etc., up to the maximum number of Groups, *numGRP*. For fixed station data, the number of Groups is the number of stations. For regular and irregular grids, the number of Groups is the number of time records. For moving platform data, aside from Group XY, there is only one Group, corresponding to a single drifter; additional drifters can be accommodated in additional data products.

10.2.3 Generalized Dimensions

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To summarize, for non-regularly gridded data only, there is an initial Group with X and Y position, stored in one-dimensional arrays of size *numPOS*. Following that, there are data Groups containing the speed and direction data, which are stored in two-dimensional arrays of size *numROWS* by *numCOLS*. The total number of data Groups is *numGRPS*.

The four variables that determine the array sizes (*numROWS*, *numCOLS*. *numPOS,* and *numGRPS)* are different, depending upon which coding format is used. Their descriptions are given in Table 10.2.

Table 10.2 – The array dimensions used in the data product.

Coding Format	Data Type	numPOS	numCOL	numROW	numGRP
1	Fixed ~~Platforms~~Stations	numberOfStations	numberOfTimes	1	numberOfStations
2	Regular Grid	(not used)	num~~ber~~PointsLongitudinal	num~~ber~~PointsLatitudinal	numberOfTimes
3	Irregular Grid	numberOfNodes	numberOfNodes	1	numberOfTimes
4	Moving Platform	numberOfTimes	numberOfTimes	1	1

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The overall structure of the surface current data product is created by assembling the data and metadata. The product structure is compliant with the HDF5 data architecture, which allows multi-dimensional arrays of data to be grouped with metadata. The format of the data product (cf. Figure F.5) described above is portrayed in Figure 10.1. The Carrier Metadata is discussed in Clause 12.3.

NOTE: The name of each Group is the 'Group n', where n is numbered from 1 to *numGRP*. The length of the name is six plus the number of digits in n.

Data Product

Carrier Metadata

Group XY (conditional)
X values array (*m*=0,*numPOS*-1)
Y values array (*m*=0,*numPOS*-1)

Group 1
Title$_1$
Valid Date-Time$_1$
Surface current speed array (*i*=0,*numCOL*-1, *j*=0,*numROW*-1)
Surface current direction array (*i*=0,*numCOL*-1, *j*=0,*numROW*-1)

Group 2
Title$_2$
Valid Date-Time$_2$
Surface current speed array (*i*=0,*numCOL*-1, *j*=0,*numROW*-1)
Surface current direction array (i=0,*numCOL*-1, *j*=0,*numROW*-1)

Group *numGRP*
Title$_{numGRP}$
Valid Date-Time$_{numGRP}$
Surface current speed array (*i*=0,*numCOL*-1, *j*=0,*numROW*-1)
Surface current direction array (*i*=0,*numCOL*-1, *j*=0,*numROW*-1)

Figure 10.1 - Schematic of the S-111 data product structure. The four parameters *numPOS, numCOL, numROW*, and *numGRP* are explained in Table 10.2.
Group XY appears only for *dataCodingFormat* = 1, 3 or 4 (Table 10.1).

10.3 Digital Certification Block

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Information here is used to certify the validity or integrity of the data.

10.4 HDF5 Encoding

The HDF-5 encoding of the data set is discussed in ANNEX G – HDF5 ENCODINGG.

11. DATA PRODUCT DELIVERY

11.1 Introduction

This section describes how the Surface Current Data Product is to be delivered from the HO to the end user (i.e., navigation officer, route planner, etc.). HDF5 is the standard format for surface current data exchange.

Due to the cost of transmitting data via Internet, it is desirable to limit file size and updating frequency whenever possible. The file size, as created by the HO and before compression, is limited to 10 MB.

Updating of files typically means issuing a new forecast, or disseminating the latest observed current for a specific geographic region. This may occur several times per day. Therefore, all files must contain a date-time of issuance of the product.

11.2 Exchange Datasets

Datasets, or data products, produced by the HO consist of files containing both the exchange catalogue and one or more data products (of possibly different S-100 types), with each product covering a specific geographic region and specific period of time (Figure 11.1). The Exchange Catalogue lists the products and contains the discovery metadata.

The name of the exchange dataset will have the character string ‘S-111’ somewhere in it (e.g., ‘S111_ExchangeDataset’), and this will identify the data as containing surface currents.

Exchange Dataset

Exchange Catalogue
Metadata (includes list of files in Exchange Dataset)

Data Products
Data Product No. 1
Data Product No. 2

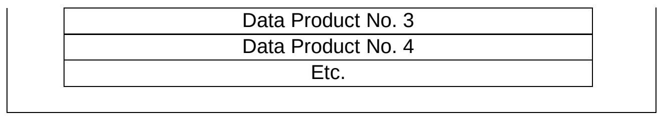

Figure 11.1 – Schematic diagram of the Exchange Dataset.

The dataset size is limited to 10 MB~~bytes~~. The size of each file can vary widely, depending on the data. Using the sample HDF5 file (see Figure F.3), a file containing, along with metadata, a single speed array and a single direction array, each with 100,000 grid points would have a size of approximately 0.21 Mbytes. Exchange files may be compressed using zip methodology. Doing so can reduce file size by 80% or more.

11.3 Exchange Catalogue

The exchange catalogue (normally in XML format) acts as the table of contents for the exchange set. The catalogue file of the exchange set must be named S111ed1.CAT; no other file in the exchange set may have the same name. The contents of the exchange catalogue are described in Clause 12.

11.4 Data Product File Naming

The data product file contains both a metadata block and one or more sets of speed and direction arrays. The file naming convention described here must be used for all surface current files from all sources. The file naming convention consists of from 20 to 22 characters. The characters are used to identify the following: the country code (two characters), followed by HO specific characters to uniquely define the dataset (15 characters). The filename extension (e.g., .hdf5) denotes the file format. Characters may be lower or upper case. This is summarized in Table 11.1.~~. <<may need to increase number of characters to make unique names for archival>>~~

Table ~~0~~11.1 - Characters used in the file naming convention.

N	DESCRIPTION	LENGTH	EXAMPLE
1	Country Code	2	CA
2	Unrestricted	15	Gulf20141106ABC
3	Extension	3 to 5	.h5, .hdf5
	Total =	20 to 22	

The unrestricted characters may be used to denote geographical region, valid time, source of the data, version numbers, and/or any other relevant information.

11.5 Support Files

This Data Product requires no support files.

12. METADATA

12.1 Introduction

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. The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, e.g. decrypt, decompress, load etc. Other catalogues can be included in the exchange set in support of the datasets such as feature, portrayal, coordinate reference systems, codelists etc. The attribute "purpose" of the support file metadata provides a mechanism to update support files more easily.

This clause defines the mandatory and optional metadata needed for S-111. 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, if any, that make up the package. In some cases the metadata may be repeated in a national language.

12.2 Discovery Metadata

An outline the overall concept of an S-111 exchange set for the interchange of geospatial data and its relevant metadata is explained in the following figures. Figure 12.1 depicts the realization of the ISO 19139 classes which form the foundation of the exchange set. The overall structure of the S-111 metadata for exchange sets is modelled in Figures 12.2 and 12.3. More detailed information about the various classes is shown in Figure 12.4 ~~and a textual description in the tables at Clause 12.3~~.

~~The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, e.g. decrypt, decompress, load etc. Other catalogues can be included in the exchange set in support of the datasets such as feature and portrayal. The attribute "purpose" of the support file metadata provides a mechanism to update support files more easily.~~

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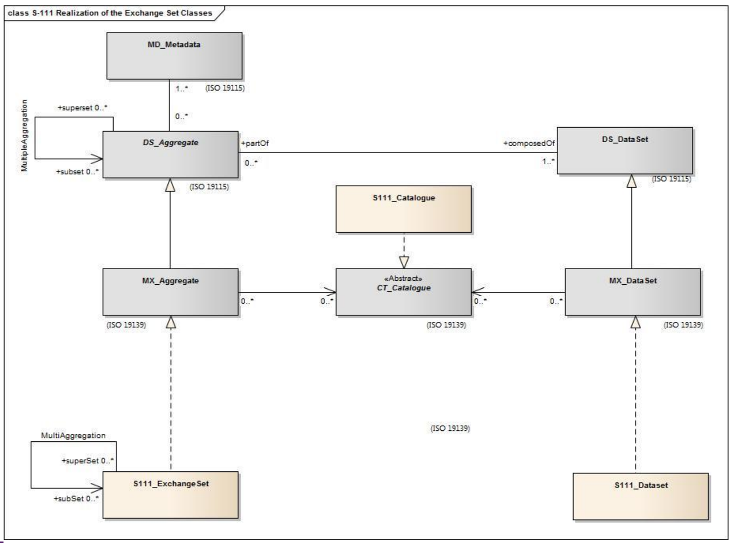

Figure 12.1 - Realization of the exchange set classes. Note that there are no support files.

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The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, e.g. decrypt, decompress, load etc. Other catalogues can be included in the exchange set in support of the datasets such as feature and portrayal. The attribute "purpose" of the support file metadata provides a mechanism to update support files more easily.

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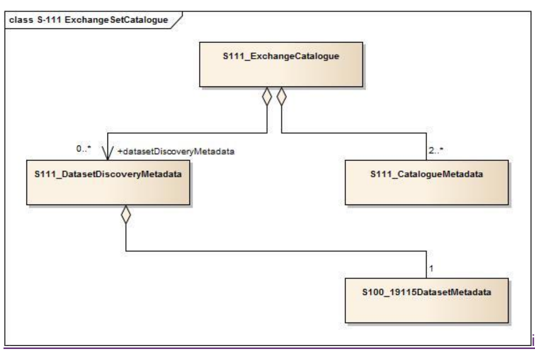

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Figure 12.2 - S-111 ExchangeSet Catalogue.

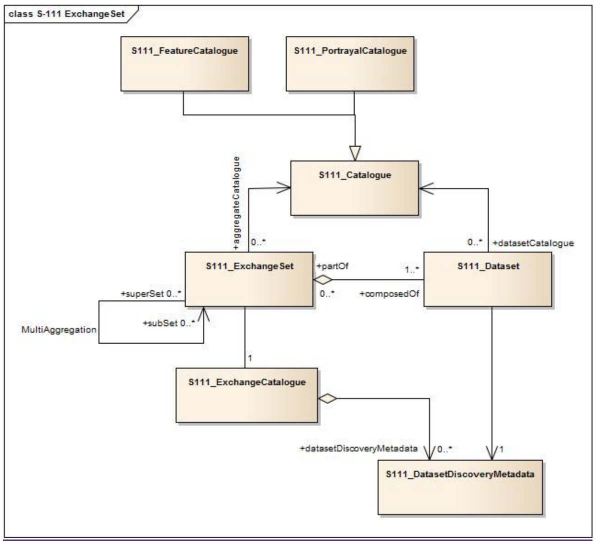

Figure 12.3 – S-111 ExchangeSet.

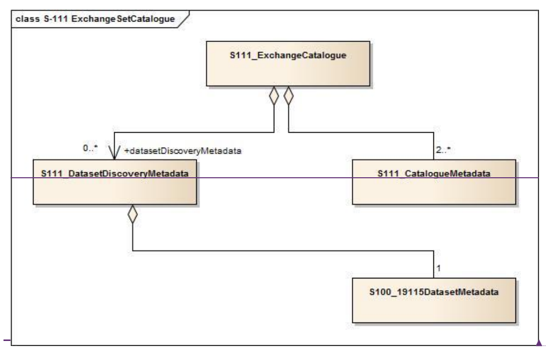

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Figure 12.2 - S-111 ExchangeSet Catalogue.

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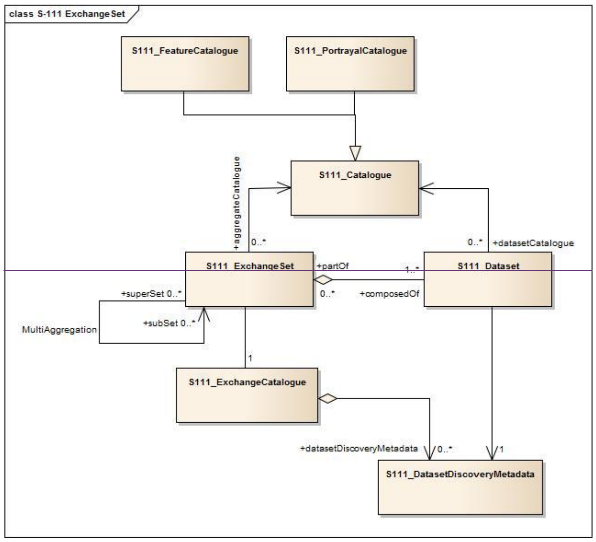

Figure 12.3 – S-111 ExchangeSet.

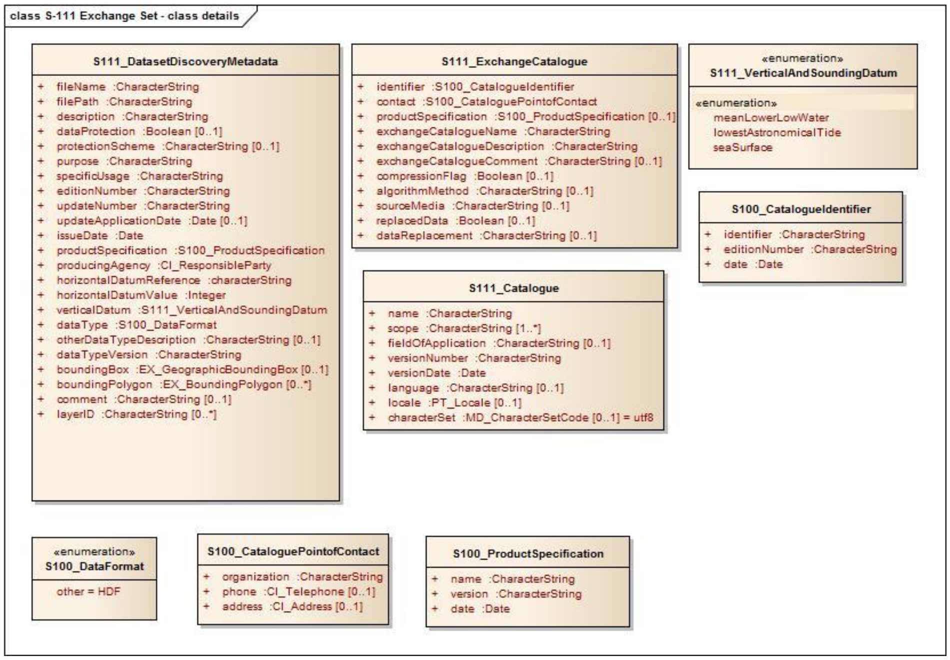

Figure 12.4 - S-111 Exchange Set: Class details.
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12.1.1 S111_ExchangeCatalogue

Each exchange set has a single S100_ExchangeCatalogue which contains meta information for the data and support files in the exchange set.

Name	Description	Mult	Value	Type	Remarks
S100_ExchangeCatalogue	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-		-	-
Identifier	Uniquely identifies this exchange catalogue	1		S100_CatalogueIdentifier	
Contact	Details about the issuer of this exchange catalogue	1		S100_CataloguePointOfContact	
productSpecification	Details about the product specifications used for the datasets contained in the exchange catalogue	0..1		S100_ProductSpecification	Conditional on all the datasets using the same product specification
exchangeCatalogueName	Catalogue filename	1		CharacterString	In S-101 it would be CATLOG.101
exchangeCatalogueDescription	Description of what the exchange catalogue contains	1		CharacterString	
exchangeCatalogueComment	Any additional Information	0..1		CharacterString	
compressionFlag	Is the data compressed	0..1		Boolean	Yes or No
algorithmMethod	Type of compression algorithm	0..1		CharacterString	Eg. RAR or ZIP
sourceMedia	Distribution media	0..1		CharacterString	
replacedData	If a data file is cancelled is it replaced by another data file	0..1		Boolean	
dataReplacement	Cell name	0..1		CharacterString	

12.1.2 S100_CatalogueIdentifier

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueIdentifier	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-	-	-
Attribute	identifier	Uniquely identifies this exchange catalogue	1	CharacterString	
Attribute	editionNumber	The edition number of this exchange catalogue	1	CharacterString	
Attribute	date	Creation date of the exchange catalogue	1	Date	

12.1.3 S100_CataloguePointofContact

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CataloguePointOfContact	Contact details of the issuer of this exchange catalogue	-	-	-
Attribute	organization	The organization distributing this exchange catalogue	1	CharacterString	This could be an individual producer, value added reseller, etc.
Attribute	phone	The phone number of the organization	0..1	CI_Telephone	
Attribute	address	The address of the organization	0..1	CI_Address	

12.1.4 S100_DatasetDiscoveryMetaData

Data in the Discovery Metadata are used to identify the relevance of the dataset to the particular application.

Name	Description	Mult	Value	Type	Remarks
S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the exchange catalogue	-		-	-
fileName	Dataset file name	1		CharacterString	
filePath	Full path from the exchange set root directory	1		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<filename>
description	Short description giving the area or location covered by the dataset	1		CharacterString	E.g. a harbour or port name, between two named locations etc.
dataProtection	Indicates if the data is encrypted	0..1		Boolean	0 indicates an unencrypted dataset 1 indicates an encrypted dataset
protectionScheme	specification or method used for data protection	0..1		CharacterString	Eg S-63
digitalSignature	Indicates if the data has a digital signature	0..1		Boolean	0: unsigned 1: datafile is digitally signed [to be reconciled when S-100 finalizes digital signature elements]
digitalSignatureValue	Digital signature	0..1		CharacterString	This contains a base64 encoding of the hexadecimal numbers comprising the digital signature itself. The content of these fields are defined, along with the algorithms for their calculation, in S-63 ed2.0 Part (C). [to be reconciled when S-100 finalizes digital signature elements]
classification	Indicates the security classification of the dataset	0..1		Enumeration	One of the following from ISO 19115 MD_SecurityConstraints> MD_ClassificationCode (codelist) 1. unclassified 2. restricted 3. confidential 4. secret 5. top secret
purpose	The purpose for which the dataset has been issued	1		MD_Identification >purpose CharacterString	E.g. new, re-issue, new edition, update etc.
specificUsage	The use for which the dataset is intended	1		CharacterString	E.g. in the case of ENCs this would be a navigation purpose classification.

Name	Description	Mult	Value	Type	Remarks
editionNumber	The edition number of the dataset	1		CharacterString	When a data set is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each new edition. Edition number remains the same for a re-issue.
issueDate	date on which the data was made available by the data producer	1		Date	
productSpecification	The product specification used to create this dataset	1		S111_ProductSpecification	
producingAgency	Agency responsible for producing the data	1		CI_ResponsibleParty	
horizontalDatumReference	Reference to the register from which the horizontal datum value is taken	1		characterString	EPSG
horizontalDatumValue	Horizontal Datum of the entire dataset	1		Integer	4326
verticalDatum	Vertical Datum of the entire dataset	1		S100_VerticalAndSoundingDatum	
soundingDatum	Sounding Datum of the entire dataset	1		Enumeration S100_VerticalAndSoundingDatum	Not relevant to S-111. Fixed value corresponding to literal localDatum from S100_VerticalAndSoundingDatum.
dataType	The encoding format of the dataset	1		S100_DataFormat	
otherDataTypeDescription	Encoding format other than those listed.	0..1		CharacterString	
dataTypeVersion	The version number of the dataType.	1		CharacterString	
dataCoverage	Area covered by the dataset	1		S100_DataCoverage	
comment	Any additional information	0..1		CharacterString	

12.1.5 S111_DataCoverage

Name	Description	Mult	Value	Type	Remarks
S100_DataCoverage		-		-	-
ID	Uniquely identifies the coverage	1		Integer	-
boundingBox	The extent of the dataset limits	1		EX_GeographicBoundingBox	-
boundingPolygon	A polygon which defines the actual data limit	1..*		EX_BoundingPolygon	-
optimumDisplayScale	The scale with which the data is optimally displayed	0..1		Integer	
maximumDisplayScale	The maximum scale with which the data is displayed	0..1		Integer	
minimumDisplayScale	The minimum scale with which the data is displayed	0..1		Integer	

12.1.5.1 EX_GeographicBoundingBox

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_GeographicBoundingBox	geographic position of the dataset	-	-	Defined in ISO 19115
westBoundLongitude	western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees
eastBoundLongitude	eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees
southBoundLatitude	southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees
northBoundLatitude	northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees

12.1.5.2 EX_BoundingPolygon

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_BoundingPolygon	boundary enclosing the dataset, expressed as the closed set of (x,y) coordinates of the polygon (last point replicates first point)	-	-	Defined in ISO 19115
polygon	sets of points defining the bounding polygon	1	GM_Object	Must be a GM_Polygon (See S-100 Part 7, ISO 19107, ISO 19136)

12.1.6 S100_VerticalAndSoundingDatum

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	-	-
Value	meanLowWaterSprings		-	-	1-
Value	meanSeaLevel		-	-	2-
Value	meanLowerLowWaterSprings		-	-	3-
Value	lowestLowWater		-	-	4-
Value	meanLowWater		-	-	5-
Value	lowestLowWaterSprings		-	-	6-
Value	approximateMeanLowWaterSprings		-	-	7-
Value	indianSpringLowWater		-	-	8-
Value	lowWaterSprings		-	-	9-
Value	approximateLowestAstronomicalTide		-	-	10-
Value	nearlyLowestLowWater		-	-	11-
Value	meanLowerLowWater		-	-	12-
Value	lowWater		-	-	13-
Value	approximateMeanLowWater		-	-	14-
Value	approximateMeanLowerLowWater		-	-	15-
Value	meanHighWater		-	-	16-
Value	meanHighWaterSprings		-	-	17-
Value	highWater		-	-	18-
Value	approximateMeanSeaLevel		-	-	19-
Value	highWaterSprings		-	-	20-
Value	meanHigherHighWater		-	-	21-
Value	equinoctialSpringLowWater		-	-	22-
Value	lowestAstronomicalTide		-	-	23-
Value	localDatum		-	-	24-
Value	internationalGreatLakesDatum1985		-	-	25-

Value	meanWaterLevel		-	-	26-
Value	lowerLowWaterLargeTide		-	-	27-
Value	higherHighWaterLargeTide		-	-	28-
Value	nearlyHighestHighWater		-	-	29-
Value	highestAstronomicalTide		-	-	30(HAT)

12.1.7 S111_DataFormat

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_DataFormat	Encoding format	-	-	
Value	HDF5	Format	1	Character	

12.1.8 S100_ProductSpecification

Name	Description	Mult	Type	Remarks
S100_ProductSpecification	The Product Specification contains the information needed to build the specified product	-	-	-
name	The name of the product specification used to create the datasets	1	CharacterString	S-111 Surface Current Product Specification
version	The version number of the product specification	1	CharacterString	1.0.0
date	The version date of the product specification	1	Date	

12.1.9 S100_CatalogueMetadata

Identifies components of the Catalogue.

Name	Description	Mult	Value	Type	Remarks
S100_CatalogueMetadata		-		-	-
filename	The name for the catalogue	1..*		CharacterString	
fileLocation	Full location from the exchange set root directory	1..*		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<filename>
scope	Subject domain of the catalogue	1..*		S111_CatalogueScope	
versionNumber	The version number of the product specification	1..*		CharacterString	
issueDate	The version date of the product specification	1..*		Date	
productSpecification	The product specification used to create this file	1..*		S100_ProductSpecification	
digitalSignatureReference	Digital Signature of the file	1		CharacterString	Reference to the appropriate digital signature algorithm
digitalSignatureValue	Value derived from the digital signature	1		CharacterString	

12.1.10 S100_CatalogueScope

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Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueScope		-	-	-
Value	featureCatalogue				
Value	portrayalCatalogue				

12.1.110 S100_19115DatasetMetadata

Information here pertains to the data product, and repeats some of the variables in the Carrier Metadata (Clause 12.2).

Name	Description	Mult	Value	Type	Remarks
S100_19115DatasetMetadata		-		-	-
typeOfCurrentData	Type or source of current data (Table 7.1)	1		Enumeration	1: Historical observation 2: Real-time observation 3: Astronomical prediction 4: Analysis or hybrid method 5: Hydrodynamic model hindcast 6: Hydrodynamic model forecast
dataCodingFormat	Data organization index, used to read the data (Table 10.1)	1		Enumeration	1: Time series at fixed stations 2: Regularly-gridded arrays 3: Irregularly-gridded arrays 4: Moving platform
methodCurrentsProduct	Methodology	1		CharacterString	Brief description of current meter type, forecast method or model, etc.
minSurfCurrentSpeed	Minimum current speed in the dataset	0..1		Real	-1.0 (unknown) or positive value (kn)
maxSurfCurrentSpeed	Maximum current speed in the dataset	0..1		Real	-1.0 (unknown) or positive value (kn)

12.32 Carrier Metadata

The carrier metadata (Table 12.1, Figure 12.5) consists of the data and parameters needed to read and interpret the information in the surface currents data product even if the other S-111 MetaData files are unavailable.

Table 12.1 – Carrier metadata. Latitude and longitude values are precise to 10^{-7} deg. The data type conforms to HDF terminology..

N	Name	Camel Case	Data Type	Remarks and/or Units
1	Product specification number and version	productSpecification	Character	This must be encoded as 'S-111.X.X.X', with Xs representing the version number
2	Date-Time of data product issue	dateTimeOfIssue	Character	DateTime. Must be consistent with issueDate in discovery metadata.
3	Name of geographic region	nameRegion	Character	
4	Name of geographic sub-region	nameSubregion	Character	
5	Horizontal datum	horizontalDatumReference	Character	EPSG
6	Horizontal datum number	horizontalDatumValue	Integer	4326 (for WGS84)
7	Indicates if the data is encrypted	dataProtection	Enumeration	0: unencrypted dataset 1: encrypted dataset
8	Specification or method used for data protection	protectionScheme	Character	Eg. S-63
9	Valid Time of Earliest Value	dateTimeOfFirstRecord	Character	DateTime
10	Valid Time of Latest Value	dateTimeOfLastRecord	Character	DateTime
11	Time interval	timeRecordInterval	Integer	Seconds. Cf. discrimination time
12	Number of time records	numberOfTimes	Integer	
13	Type of current data (see Table 7.1)	typeOfCurrentData	Enumeration	1: Historical observation 2: Real-time observation 3: Astronomical prediction 4: Analysis or hybrid method 5: Hydrodynamic model hindcast 6: Hydrodynamic model forecast
14	Data organization index, used to read the data (see Table 10.1)	dataCodingFormat	Enumeration	1: Time series at fixed stations 2: Regularly-gridded arrays 3: Irregularly-gridded arrays 4: Moving platform
15	Number of fixed stations	numberOfStations	Integer	Used only if dataCodingFormat = 1
16	Vertical reference	depthTypeIndex	Enumeration	1: Layer average 2: Sea surface 3: Vertical datum (see verticalDatum) 4: Sea bottom
17	Depth value	surfaceCurrentDepth	Real	Layer thickness (depthTypeIndex=1), or height (depthTypeIndex=2, 3, 4) (m)
18	Vertical datum reference	verticalDatum	IntegerEnumeration	See S111_VerticalAndSoundingDatum
19	Longitude of grid origin	gridOriginLongitude	Real	Arc Degrees (if dataCodingFormat=2)
20	Latitude of grid origin	gridOriginLatitude	Real	Arc Degrees (if dataCodingFormat=2)
21	Grid spacing, long.	gridSpacingLongitudinal	Real	Arc Degrees (if dataCodingFormat=2)
22	Grid spacing, lat.	gridSpacingLatitudinal	Real	Arc Degrees (if dataCodingFormat=2)
23	Number of points, long.	numPointsLongitudinal	Integer	iMax (if dataCodingFormat=2)
24	Number of points, lat.	numPointsLatitudinal	Integer	jMax (if dataCodingFormat=2)
25	First grid point num., long.	minGridPointLongitudinal	Integer	0 (if dataCodingFormat=2)
26	First grid point num., lat.	minGridPointLatitudinal	Integer	0 (if dataCodingFormat=2)
27	Nodes in irregular grid	numberOfNodes	Integer	Used if dataCodingFormat=3

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28	Land mask value	gridLandMaskValue	Real	Negative value (e.g. -1.0 or -99.999). Also denotes a missing value.
29	Speed uncertainty	uncertaintyOfSpeed	Real	-1.0 (unknown) or positive value (kn)
30	Direction uncertainty	uncertaintyOfDirection	Real	-1.0 (unknown) or positive value (arc deg)
31	Horizontal position uncertainty	uncertaintyOfHorzPosition	Real	-1.0 (unknown) or positive value (m)
32	Vertical position uncertainty	uncertaintyOfVertPosition	Real	-1.0 (unknown) or positive value (m)
33	Time uncertainty	uncertaintyOfTime	Real	-1.0 (unknown) or positive value (s)
34	Methodology	methodCurrentsProduct	Character	Brief description of current meter type, forecast method or model, etc.
35	Minimum current speed in the dataset	minSurfCurrentSpeed	Real	-1.0 (unknown) or positive value (kn)
36	Maximum current speed in the dataset	maxSurfCurrentSpeed	Real	-1.0 (unknown) or positive value (kn)

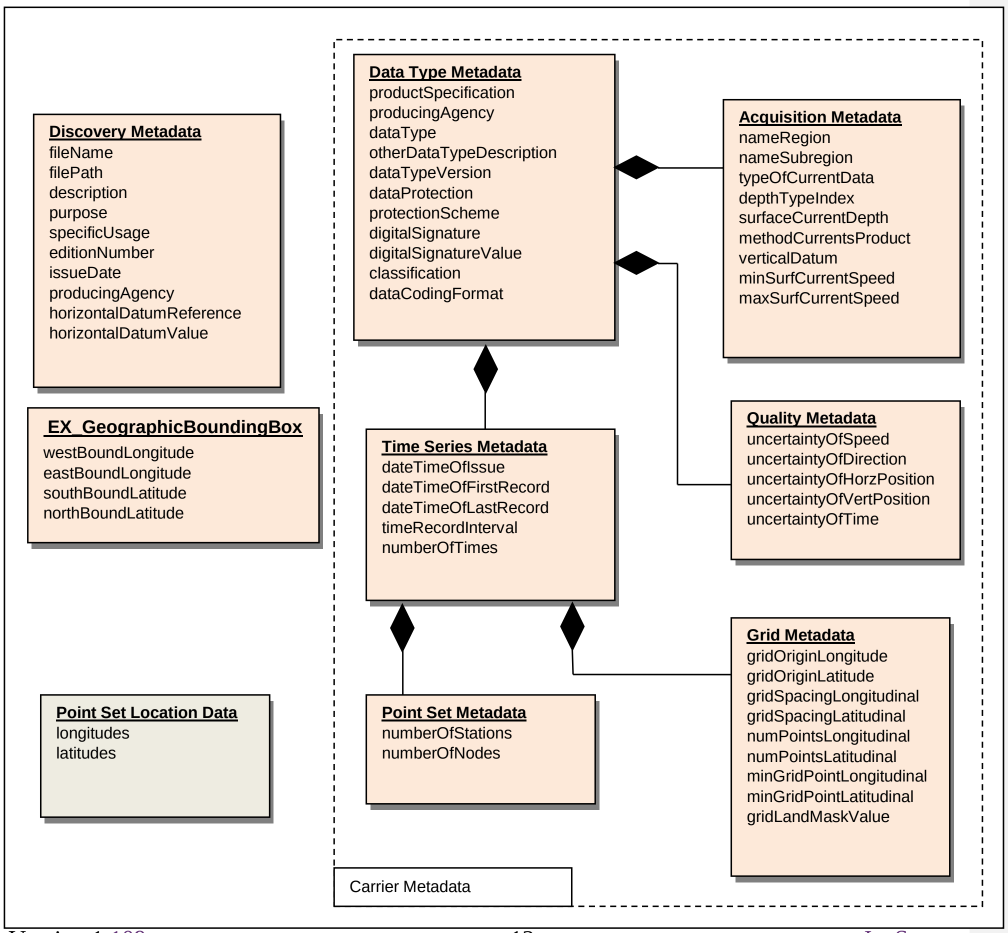

Figure 12.5 – Surface Current Model Metadata.

12.43 Language

The language used for the metadata is English.

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ANNEX A. DATA CLASSIFICATION AND ENCODING GUIDE

A.1 Features

IHO Definition: FEATURE: **SURFACE CURRENT:** a set of value items required to define a dataset representing direction and speed of the surface water current.			
S-111 Geo Feature: Surface Current			
Primitives: S-100_Grid Coverage, S-100_PointSet			
S-111 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Surface Current Speed	must be in decimal Knots, max resolution 0.01 knot	RE	1
Surface Current Direction	must be in decimal degrees, max resolution 0.1 degree	RE	1

A.2 Feature Attributes

1.Surface Current Speed (*surfaceCurrentSpeed*)

Surface Current Speed: IHO Definition: SPEED**.** Rate of motion. The terms speed and VELOCITY are often used interchangeably, but speed is a scalar, having magnitude only, while VELOCITY is a vector quantity, having both magnitude and direction. Speed may either be the ship's speed through water or the SPEED MADE GOOD over ground.
Unit: knot (kn)
Resolution: 0.01 kn
Format: xxx.xx
Examples: 2.54
Remarks:

- Valid speed always non-negative
- Negative number denotes land mask
- 0.01 kn equals 0.5144 cm/s

2.Surface Current Direction (*surfaceCurrentDirection*)

Surface Current Direction: IHO Definition: DIRECTION OF CURRENT. The direction toward which a CURRENT is flowing, called the SET of the CURRENT. Also called current direction
Unit: degree (of arc) (˚)
Resolution: 0.1 ˚
Format: xxx.x
Examples: 298.3
Remarks:

- direction clockwise from true north
- Valid direction always non-negative
- Negative number denotes land mask

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~~ANNEX A.~~ANNEX B. ADDITIONAL TERMS AND DEFINITIONS

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Terms that are defined in this Annex or in Clause 1.4.2 are highlighted in **bold**.

accuracy
closeness of agreement between an observed value and the true value or a reference value accepted as true
NOTE 1: A test result can be observations or measurements
NOTE 2: For positioning services, the test result is a measured value or set of values
NOTE 3: For observations and measurements, true values are not obtainable. In their place reference values which are accepted as true values are used
[ISO 19157, ISO 19116]

application
manipulation and processing of **data** in support of user requirements
[ISO 19101]

application schema
conceptual **schema** for **data** required by one or more **applications**
[ISO 19101]

attribute
a named element within a classifier that describes a **range** of values that **instances** of the classifier may hold
NOTE: An **attribute** is semantically equivalent to a composition association; however, the intent and usage are normally different
[ISO/TS 19103]
named property of an entity
NOTE: Describes a geometrical, topological, thematic, or other **characteristic** of an entity
[ISO/TS 19130]

attribute <**UML**>
feature within a classifier that describes a **range** of values that **instances** of the classifier may hold
[ISO/TS 19103]

characteristic
abstraction of a property of an **object** or of a set of **objects**
NOTE: **Characteristics** are used for describing concepts
[ISO 1087-1, ISO 19146]
distinguishing **feature**
NOTE 1: A **characteristic** can be inherent or assigned
NOTE 2: A **characteristic** can be qualitative or Quantitative
NOTE 3: There are various classes of **characteristics**, such as the following: physical (e.g., mechanical, electrical, chemical, or biological), sensory (e.g., related to smell, touch, taste, sight, or hearing), behavioral (e.g., courtesy, honesty, or veracity), temporal (e.g., punctuality, reliability, or availability), ergonomic (e.g., physiological, or related to human safety), and functional (e.g., maximum speed of an aircraft)
[ISO 19113]

class <**UML**>
description of a set of **objects** that share the same **attributes**, operations, methods, relationships, and semantics
NOTE: A **class** may use a set of interfaces to specify collections of operations it provides to its environment. See: interface
[ISO/TS 19103-2]

classification
abstract representation of real-world phenomena using **classifiers**
[ISO 19144-1]

classifier
a **model** element that describes behavioral and structural features
[ISO/TS 19103]
definition used to assign **objects** to legend **classes**
NOTE: **Classifiers** can be defined algorithmically or according to a set of classification system-specific rules
[ISO 19144-1]

classifier <**UML**>
mechanism that describes behavioral and structural features
NOTE: Classifiers include interfaces, classes, data types, and components
[ISO/TS 19103-2]

conceptual model
model that defines concepts of a universe of discourse
[ISO 19101]

confidence
accuracy of a **data** quality result
[ISO 19157]

conformance
fulfilment of specified requirements
[ISO 19105]

constraint
condition or restriction expressed in natural-language text or in a machine-readable language for the purpose of declaring some of the semantics of an element
[ISO/TS 19103]
restriction on how a link or turn may be traversed by a vehicle, such as a vehicle **classification**, or physical or temporal **constraint**
[ISO 19133]

constraint <**UML**>
condition or restriction expressed in natural-language text or in a machine-readable language for the purpose of declaring some of the semantics of an element
[ISO/TS 19103]
NOTE: Certain **constraints** are predefined in the UML; others may be user defined. **Constraints** are one of three extensibility mechanisms in UML. See: tagged value, stereotype
[retired version of ISO/TS 19103]

content model
information view of an **application schema**
NOTE: The term "information view" comes from the ISO Reference **model** for Open distributed processing (RM-ODP) as specified in ISO 19101-2
[ISO/TS 19129]

continuous coverage
coverage that returns different values for the same **feature attribute** at different **direct positions** within a single spatial **object**, temporal **object**, or spatiotemporal **object** in its **domain**

NOTE: Although the **domain** of a **continuous coverage** is ordinarily bounded in terms of its spatial and/or temporal extent, it can be subdivided into an infinite number of **direct positions**
[ISO 19123]

coverage domain
Consists of a collection of **direct positions** in a coordinate space that may be defined in terms of up to three spatial dimensions as well as a temporal dimension.
[Springer 2012]

curve
one-dimensional **geometric primitive**, representing the continuous **image** of a line
NOTE: The boundary of a **curve** is the set of **points** at either end of the **curve**. If the **curve** is a cycle, the two ends are identical, and the **curve** (if topologically closed) is considered to not have a boundary. The first **point** is called the start **point**, and the last is the end **point**. Connectivity of the **curve** is guaranteed by the *continuous **image** of a line* clause. A topological theorem states that a continuous **image** of a connected set is connected
[ISO 19107]

data
reinterpretable representation of **information** in a formalized manner suitable for communication, interpretation, or processing
[ISO 19115]

data product specification
detailed description of a **dataset** or **dataset series** together with additional **information** that will enable it to be created, and supplied to and used by another party
NOTE: A **data product specification** provides a description of the universe of discourse and a specification for mapping the universe of discourse to a **dataset**. It may be used for production, sales, end-use, or other purpose
[ISO 19131]

data type
a descriptor of a set of values that lack identity (independent existence and the possibility of side-effects)
EXAMPLE: Integer, Real, Boolean, String, and Date
NOTE: **Data types** include primitive predefined **types** and user-definable **types**
[ISO/TS 19103]
specification of a value **domain** with operations allowed on values in this **domain**
EXAMPLE: Integer, Real, Boolean, String, and Date
NOTE 1: **Data types** include primitive predefined ***types*** and user-definable **types**
NOTE 2: A **data type** is identified by a term, e.g., Integer. Values of the **data types** are of the specified value **domain**, e.g., all integer numbers between −65 537 and 65 536. The set of operations can be +, -, *, and /, and is semantically well defined. A **data type** can be simple or complex. A simple **data type** defines a value **domain** where values are considered atomic in a certain context, e.g., Integer. A complex **data type** is a collection of **data types** which are grouped together. A complex **data type** may represent an **object** and can thus have identity
[ISO 19118]

data value
an **instance** of a **data type**; a value without identity
NOTE: A value may describe a possible state of an **object** within a **class** or **type** (**domain**)
[ISO/TS 19103]

dataset
identifiable collection of **data**
NOTE: A **dataset** may be a smaller grouping of **data** which, though limited by some **constraint** such as spatial extent or **feature type**, is located physically within a larger **dataset**. Theoretically, a **dataset** may be as small as a single **feature** or **feature attribute** contained within a larger **dataset**. A hard-copy map or chart may be considered a **dataset**
NOTE: The principles which apply to **datasets** may also be applied to **dataset series** and reporting groups
[ISO 19101, ISO 19115, ISO 19117]

dataset series
collection of **datasets** sharing the same **product specification**
[ISO 19115]

datum
parameter or set of parameters that define the **position** of the origin, the scale, and the orientation of a **coordinate** system
NOTE 1: A **datum** defines the **position** of the origin, the scale, and the orientation of the axes of a **coordinate** system
NOTE 2: A **datum** may be a geodetic **datum**, a **vertical datum**, an engineering **datum**, an **image datum**, or a temporal **datum**
[ISO 19111, ISO 19116]

depth
distance of a **point** from a chosen reference surface measured downward along a line perpendicular to that surface
NOTE: A **depth** above the reference surface will have a negative value
[ISO 19111]

element <**XML**>
basic **information** item of an XML document containing child **elements**, **attributes**, and character **data**
NOTE: From the XML **information** set: "Each XML document contains one or more **elements**, the boundaries of which are either delimited by start-tags and end-tags, or, for empty **elements**, by an empty-element tag. Each **element** has a **type**, identified by name, sometimes called its *generic identifier* (GI), and may have a set of **attribute** specifications. Each **attribute** specification has a name and a value."
[ISO 19136]

elevation
the altitude of the ground level of an object, measured from a specified vertical datum.
[IHO:S100 GFM]

encoding
conversion of **data** into a series of codes
[ISO 19118]

error
discrepancy with the universe of discourse
[ISO 19138]

feature catalog
catalog containing definitions and descriptions of the **feature types**, **feature attributes**, and feature relationships occurring in one or more sets of geographic **data**, together with any **feature** operations that may be applied
[ISO 19101, ISO 19110]

feature type
classifier for **features**, defined by the set of **characteristic** properties that all **features** of this type carry
[ISO 19109]
class of **features** having common **characteristics**
[ISO 19156]

format

a language construct that specifies the representation, in character form, of **data objects** in a record, file, message, storage device, or transmission channel
[ISO 19145]

framework
relationship between the elements of the **content model** and the separate **encoding** and **portrayal** mechanisms
[ISO/TS 19129]

geographic location
longitude, latitude, and **elevation** of a ground or elevated **point**
[ISO/TS 19130-2]
NOTE: For the purpose of this document elevated **point** will be a **depth** based on a specified **datum**.
[CARL 2015]

geometric complex
set of disjoint **geometric primitive**s where the boundary of each **geometric primitive** can be represented as the union of other **geometric primitives** of smaller dimension within the same set
NOTE: The **geometric primitives** in the set are disjoint in the sense that no **direct position** is interior to more than one **geometric primitive**. The set is closed under boundary operations, meaning that, for each element in the **geometric complex**, there is a collection (also a **geometric complex**) of **geometric primitives** that represents the boundary of that element. Recall that the boundary of a **point** (the only 0-D primitive **object** type in geometry) is empty. Thus, if the largest dimension **geometric primitive** is a solid (3-D), the composition of the boundary operator in this definition terminates after at most three steps. It is also the case that the boundary of any **object** is a cycle
[ISO 19107]

geometric object
spatial **object** representing a geometric set
NOTE: A **geometric object** consists of a **geometric primitive**, a collection of **geometric primitives**, or a **geometric complex** treated as a single entity. A **geometric object** may be the spatial representation of an **object** such as a ***feature*** or a significant part of a ***feature***
[ISO 19107]

geometric primitive
geometric object representing a single, connected, homogeneous element of space
NOTE: **Geometric primitives** are non-decomposed **objects** that present **information** about geometric configuration. They include **points**, **curves**, surfaces, and solids
[ISO 19107]

georectified
corrected for positional displacement with respect to the surface of the Earth
[ISO 19115-2]

gridded data
data whose **attribute** values are associated with **positions** on a **grid coordinate** system
[ISO 19115-2]

image
gridded **coverage** whose **attribute** values are a numerical representation of a physical parameter
NOTE: The physical parameters are the result of measurement by a sensor or a prediction from a **model**
[ISO 19115-2]

implementation
realization of a specification
NOTE: In the context of the ISO geographic **information** standards, this includes specifications of geographic **information** services and **datasets**
[ISO 19105]

information
knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning
[ISO 19118]

instance
individual entity having its own identity and value
NOTE: A classifier specifies the form and behavior of a set of **instances** with similar properties
[ISO/TS 19103]
object that realizes a **class**
[ISO 19107]

layer
basic unit of geographic **information** that may be requested as a map from a server
[ISO 19128]

lineage
chain of legal ownership of content; history of ownership
[ISO 19153]

metadata
data about **data**
[ISO 19115]

metamodel <**UML**>
model that defines the language for expressing other models
NOTE: A **metamodel** is an instance of a meta-metamodel
[ISO/TS 19103]

model
abstraction of some aspects of reality
[ISO 19109]

navigation
combination of routing, route transversal, and tracking
NOTE: This is essentially the common term **navigation**, but the definition decomposes the process in terms used in the packages defined in this international standard
[ISO 19133]

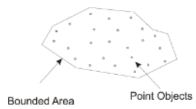
object
entity with a well-defined boundary and identity that encapsulates state and behavior
NOTE 1: An **object** is an **instance** of a **class**
NOTE 2: This term was first used in this way in the general theory of object-oriented programming, and later adopted for use in this same sense in UML. **Attributes** and relationships represent state. Operations, methods, and state machines represent behavior
NOTE 3: A GML **object** is an XML **element** of a **type** derived from AbstractGMLType
[ISO 19107]

object <**UML**>
a discrete entity with a well-defined boundary and identity that encapsulates state and behavior; an **instance** of a **class**
[ISO/TS 19103]

point
zero-dimensional **geometric primitive**, representing a **position**
NOTE: The boundary of a **point** is the empty set
[ISO 19107]

point coverage
coverage that has a **domain** composed of **points**
[ISO 19123]

point set
set of 2, 3 or n dimensional points in space.
[S-100]



point set coverage
coverage function associated with point value pairs in 2 dimensions.
[S-100]
NOTE: a coverage function is driven by a set of points (with X, Y position) together with a record of one or more values at that position.

portrayal
presentation of **information** to humans
[ISO 19109, ISO 19117]

portrayal catalogue
collection of defined **portrayals** for a feature catalogue
NOTE: Content of a portrayal catalogue includes **portrayal functions**, **symbols**, and **portrayal context.**
[ISO 19117]

portrayal context
circumstances, imposed by factors extrinsic to a geographic dataset, that affect the **portrayal** of that dataset.
EXAMPLE: Factors contributing to portrayal context may include the proposed display or map scale, the viewing conditions (day/night/dusk), and the display orientation requirements (north not necessarily at the top of the screen or page), among others
NOTE: Portrayal context may influence the selection of portrayal functions and construction of symbols
[ISO 19117]

portrayal function
function that maps geographic features to symbols
NOTE: Portrayal functions can also include parameters and other computations that are not dependent on geographic feature properties
[ISO 19117]

portrayal function set
function that maps a feature catalog to a symbol set
[ISO 19117]

portrayal rule
specific kind of portrayal function expressed in a declarative language
NOTE: A declarative language is rule based and includes decision and branching statements
[ISO 19117]

portrayal service
generic interface used to portray features
[ISO 19117]

portrayal specification
collection of operations applied to the feature instance to portray it
[ISO 19117]

position
data type that describes a **point** or geometry potentially occupied by an **object** or person
NOTE: A **direct position** is a semantic subtype of **position**. **Direct positions** as described can only define a **point**, and therefore not all **positions** can be represented by a **direct position**. That is consistent with the *is type of* relation. An ISO 19107 geometry is also a **position**, but not a **direct position**
[ISO 19132]

positional accuracy
closeness of **coordinate** value to the true or accepted value in a specified reference system
NOTE: The term *absolute accuracy* is sometimes used for this concept to distinguish it from relative **positional accuracy**. Where the true **coordinate** value may not be perfectly known, **accuracy** is normally tested by comparison with available values that can best be accepted as true
[ISO 19116]

product
result of a process
[ISO 19158]

product specification
description of the universe of discourse and a **specification** for mapping the universe of discourse to a **dataset**
[ISO 19158]

profile
set of one or more base standards or subsets of base standards, and, where applicable, the identification of chosen clauses, classes, options, and parameters of those base standards, that are necessary for accomplishing a particular **function**
NOTE: A **profile** is derived from base standards so that, by definition, **conformance** to a **profile** is **conformance** to the base standards from which it is derived
[ISO 19101, ISO 19106]

profile <**UML**>
definition of a limited extension to a reference **metamodel** with the purpose of adapting the **metamodel** to a specific platform or **domain**
[ISO/TS 19103]

quadrilateral grid coverage
may be a **rectified grid** or a **referenceable grid**.
[Springer 2012]

quality
totality of **characteristics** of a **product** that bear on its ability to satisfy stated and implied needs
[ISO 19101, ISO 19109]
Degree to which a set of inherent **characteristics** fulfills requirements
NOTE 1: The term ***quality*** can be used with adjectives such as poor, good or excellent
NOTE 2: *Inherent*, as opposed to *assigned*, means existing in something, especially as a permanent **characteristic**
[ISO 19157]
NOTE 3: For the purposes of this technical specification the quality **characteristics** of **product** include:
– **Data** quality (the elements of which are described by ISO 19113)
– Volume of delivery
– Schedule of delivery
– Cost of production and/or update
[ISO 19158]

range
set of all values a **function** *f* can take as its arguments vary over its **domain**
[ISO 19136]

referenceable grid
requires a formula of higher order that transforms into a coordinate reference system.
EXAMPLE: the perspective transformation with eight parameters.
[Springer 2012]

render
conversion of digital graphics data into visual form
EXAMPLE Generation of an image on a video display
[ISO 19117]

schema
formal description of a **model**

NOTE: In general, a **schema** is an abstract representation of an **object**'s **characteristics** and relationship to other **objects**. An XML **schema** represents the relationship between the **attributes** and **elements** of an XML **object** (for example, a document or a portion of a document)
[ISO 19101]

sequence
finite, ordered collection of related items (**objects** or values) that may be repeated
NOTE: Logically, a **sequence** is a set of pairs <item, offset>. LISP syntax, which delimits **sequences** with parentheses and separates elements in the **sequence** with commas, is used in this international standard
[ISO 19107]

set
unordered collection of related items (**objects** or values) with no repetition
[ISO 19107]

specification
declarative description of what something is or does
NOTE: Contrast: **implementation**
[retired version of ISO/TS 19103]

timestamp
value of time at which an **object**'s state is measured and recorded
[ISO 19132]

symbol
portrayal primitive that can be graphic, audible, or tactile in nature, or a combination of these
[ISO 19117]

tuple
ordered list of values
NOTE 1: The number of values in a tuple is immutable
NOTE 2: the ordered list will generally be a finite **sequence** of **features,** each of a specific **feature type**
[ISO 19136, ISO 19142]

type
a specification of the general structure and behavior of a **domain** of **objects** without providing a physical **implementation**
NOTE: A **type** may have **attributes** and associations
[ISO/TS 19103]

UML
The Unified Modeling Language (**UML**) is a general-purpose modeling language in the field of software engineering, which is designed to provide a standard way to visualize the design of a system.

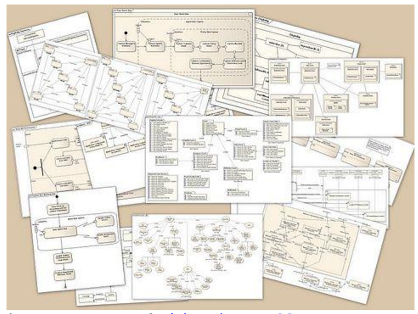


image courtesy of Kishorekumar 62

[Wikipedia 2015]

UML application schema
application schema written in UML in accordance with ISO 19109
[ISO 19136]**valid time**
time when a fact is true in the abstracted reality
[ISO 19108]

vector
quantity having direction as well as magnitude
NOTE: A directed line segment represents a **vector** if the length and direction of the line segment are equal to the magnitude and direction of the **vector**. The term *vector data* refers to **data** that represents the spatial configuration of **features** as a set of directed line segments
[ISO 19123]

vertical coordinate system
one-dimensional **coordinate** system used for gravity-related height or **depth** measurements
[ISO 19111]

vertical datum
datum describing the relation of gravity-related heights or **depths** to the Earth
NOTE: In most cases the **vertical datum** will be related to mean sea level. Ellipsoidal heights are treated as related to a three-dimensional ellipsoidal **coordinate** system referenced to a geodetic **datum**. **Vertical datums** include sounding **datums** (used for hydrographic purposes), in which case the heights may be negative heights or **depths**
[ISO 19111]

ANNEX B. APPLICATION SCHEMA

Surface Currents are described using a regularly spaced grid over the areas of interest. The Surface Current Model (SCM) has been broken into parts for easier reading. The core of SCM is described in Figure B.1.

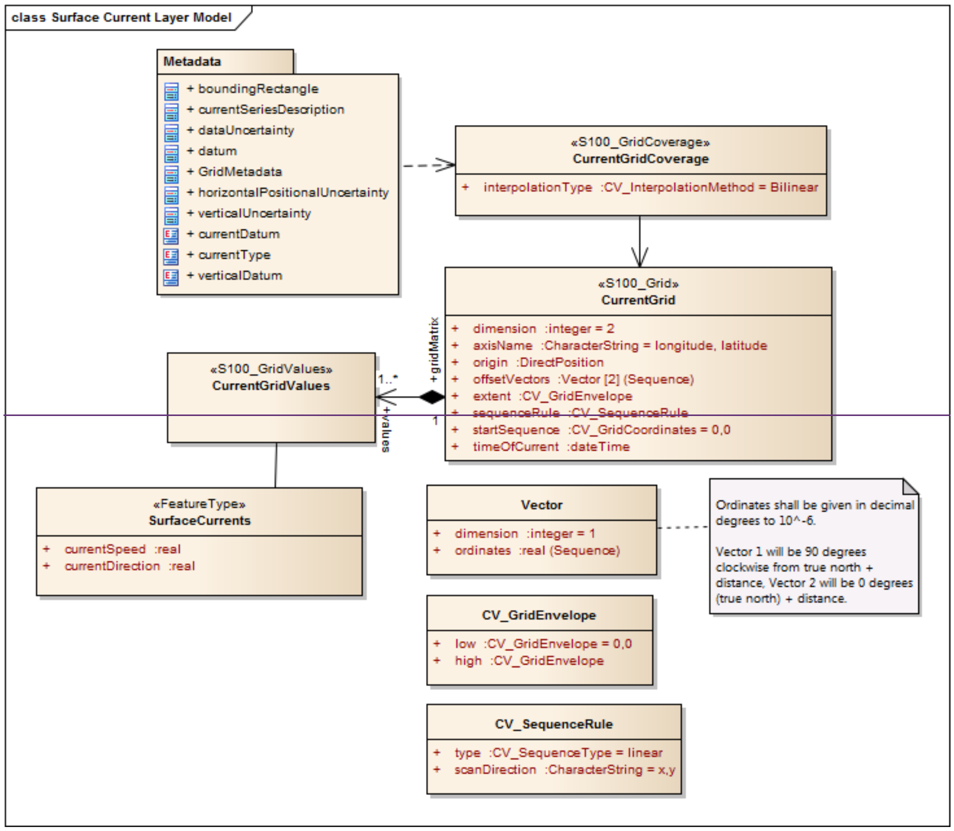


Figure B.1 – Surface Current Model.

The Surface current feature class has two mandatory attributes; *currentSpeed* and *currentDirection* used to capture the speed of current over ground and the general direction of the current at the grid point. Each instance of surface current is only valid for a specific moment in time and may be part of a time series, as described in the grid metadata.

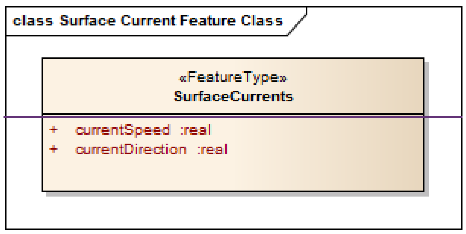


Figure B.2 – Surface Current Feature Class.

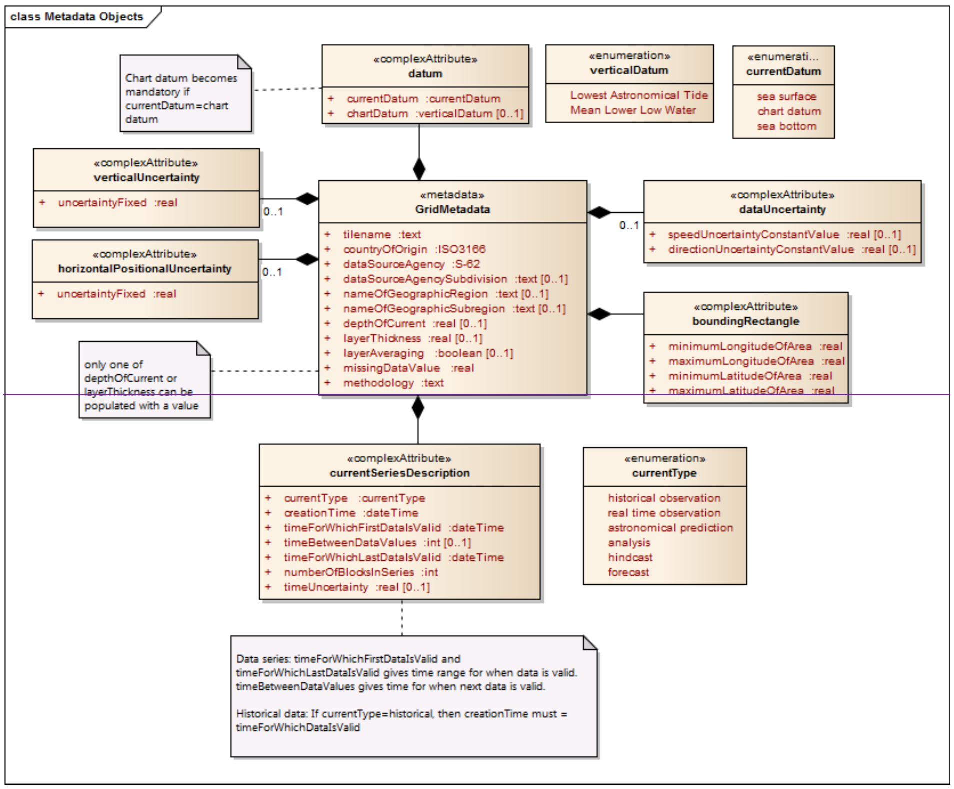
The metadata model for a specific grid is shown in Figure B.3.

There are four mandatory simple attributes for the metadata. The first one is a name of the station or grid. The second is *countryOfOrigin* using a code according to ISO3166, the third is *dataSourceAgency* using a code according to S-62, and the last is a description of the methodology used to create the data, usually from an instrument or calculations from a model.

The complex attribute *currentSeriesDescription* is used to describe type of current, and time series attributes with any known time uncertainty. The complex attribute datum gives the current depth origin. The attribute *depthOfCurrent* can be used to capture how deep the current is referenced to chart datum, alternatively the attribute *layerThickness* can be used to encode the thickness of the current zone. Only one of *depthOfCurrent* or *layerThickness* can be encoded for an instance of GridMetadata. The optional attribute *timeBetweenDataValues* is an integer that captures whole minutes between the data values in a series.

The optional complex attributes *verticalUncertainty*, *horizontalPositionUncertainty* and *dataUncertainty* can be used to capture uncertainties for the various aspects of the data.

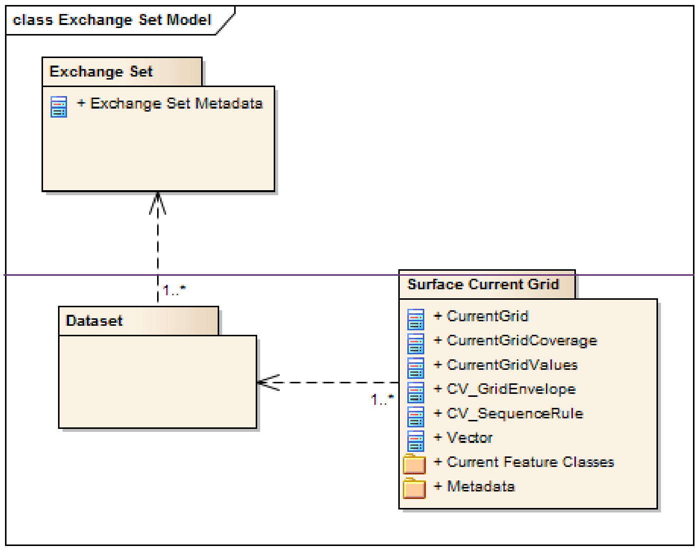
The mandatory complex attribute *boundingRectangle* carries the sides of a bounding rectangle indicating the general area where the current information is located. <<above paragraphs need to be updated to reflect the latest variables and terminology>>



~~Figure B.3 – Surface Current Metadata.~~

~~The exchange set structure of Surface Current data is described in Figure B.4.~~

~~<<TBD – Discovery metadata for surface current datasets/exchange sets and checking for S-100 core metadata compliancy.>>~~



~~Figure B.4 – Surface Current Exchange Set Model.~~

ANNEX C. DATA CLASSIFICATION AND ENCODING GUIDE

C.1 Features

IHO Definition: FEATURE: **CURRENT (Water Current):** a set of value items required to define a coverage dataset representing direction and speed of the current.			
S-111 Geo Feature: Surface Currents			
Primitives: S-100_Grid Coverage, S-100_PointSet			
S-111 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Surface Current Speed	must be in decimal Knots, max resolution 0.01 knot	RE	1
Surface Current Direction	must be in decimal degrees, max resolution 0.1 degree	RE	1

C.2 Feature Attributes

1. Surface Current Speed (*surfaceCurrentSpeed*)

Surface Current Speed: IHO Definition: SPEED. Rate of motion. The terms speed and VELOCITY are often used interchangeably, but speed is a scalar, having magnitude only, while VELOCITY is a vector quantity, having both magnitude and direction. Speed may either be the ship's speed through water, or the SPEED MADE GOOD over ground.
Unit: knot (kn)
Resolution: 0.01 kn
Format: xxx.xx
Examples: 2.54
Remarks:

- Valid speed always non-negative
- Negative number denotes land mask
- 0.01 kn equals 0.5144 cm/s

2. Surface Current Direction (*surfaceCurrentDirection*)

Surface Current Direction: IHO Definition: DIRECTION OF CURRENT. The direction toward which a CURRENT is flowing, called the SET of the CURRENT. Also called current direction
Unit: degree (of arc) (°)
Resolution: 0.1 °
Format: xxx.x
Examples: 298.3
Remarks:

- direction clockwise from true north
- Valid direction always non-negative
- Negative number denotes land mask

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C.3 Metadata

IHO Definition: METADATA **QUALITY OF SURFACE CURRENT DATA**. An area within which a uniform assessment of the quality of the surface current data exists.				
S-111 Metadata Feature: Quality of Surface Current Data				
Primitives: Surface				
S-111 Attribute	**S-57 Acronym**	**Allowable Encoding Value**	**Type**	**Multiplicity**
Surface current speed uncertainty			RE	1
Surface current direction uncertainty			RE	1
Horizontal positional uncertainty	(POSACC)		RE	1
Vertical positional uncertainty	(VERACC)		RE	1
Time uncertainty			RE	1

C.4 Metadata Attributes

1. Surface Current Speed Uncertainty (*dataUncertainty*)

Surface Current Speed Uncertainty: IHO Definition:
Unit: knot (kn)
Resolution: 0.01 kn
Format: xx.xx
Examples: 0.05
Remarks: Uncertainty value is always positive. Negative value denotes unknown.

2. Surface Current Direction Uncertainty (*dataUncertainty*)

Surface Current Direction Uncertainty: IHO Definition:
Unit: degree (of arc) (°)
Resolution: 0.1 °
Format: xxx.x
Examples: 9.5
Remarks: Uncertainty value is always positive. Negative value denotes unknown.

ANNEX D.

ANNEX E.

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3.Horizontal Positional Uncertainty (*horizontalPositionalUncertainty*)

Horizontal Positional Uncertainty
Unit: metre
Resolution: 0.1 m
Format: xxxxx.x
Example: 120.2
Remarks: Uncertainty value is always positive. Negative value denotes unknown.

4.Vertical Positional Uncertainty (*verticalUncertainty*)

Vertical Positional Uncertainty
Unit: metre
Resolution: 0.1
Format: xxx.x
Example: 1.2
Remarks: Uncertainty value is always positive. Negative value denotes unknown.

5.Time Uncertainty

Time Uncertainty
Unit: minute
Resolution: 0.1
Format: xxx.x
Example: 1.0
Remarks: Uncertainty value is always positive. Negative value denotes unknown.

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ANNEX C. APPLICATION SCHEMA

Feature Class

The Surface Current feature class (Figure C.1) has two mandatory attributes: *surfaceCurrentSpeed* and *surfaceCurrentDirection*. These variables are used to capture the speed of current over ground and the general direction of the current at the location of the data. Each instance of surface current is only valid for a specific moment in time and may be part of a time series, as described in the metadata.

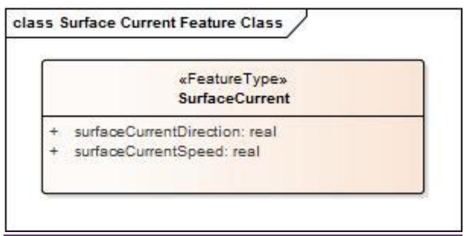

Figure C.1 – Surface Current Feature Class.

Surface Current Models

Surface Currents are described, for the area of interest, using either (1) a regularly spaced grid or a (2) point set. The Surface Current Model (SCM) has been divided into two parts to reflect this dichotomy. The core of SCM for gridded data is described in Figure C.2 and for point set data in Figure C.3.

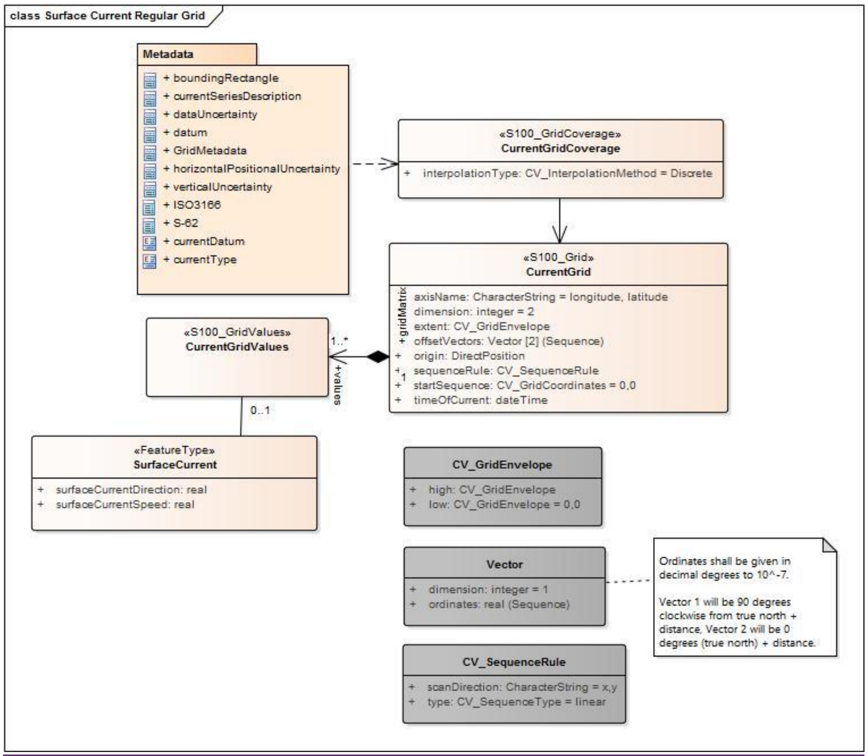

Figure C.2 – Surface Current Model for regularly gridded data.

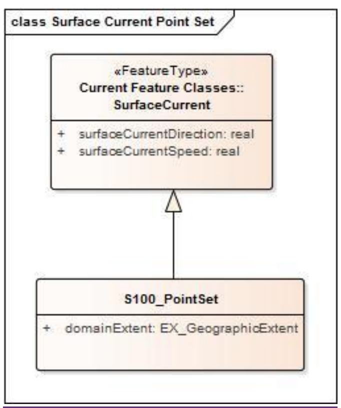

Figure C.3 - Surface Current Model for point set data.

Metadata

The metadata model is shown in Figure C.4.

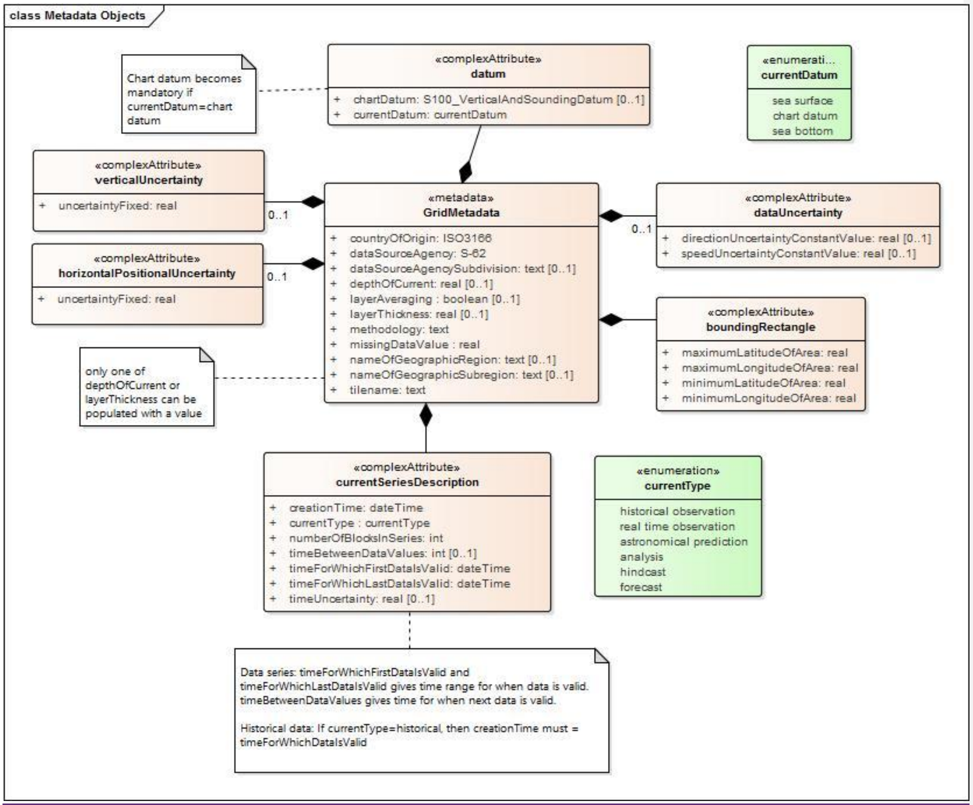

Figure C.4 – Metadata model for Surface Currents.

Exchange Set

The exchange set structure of Surface Current data is described in Figure C.5.

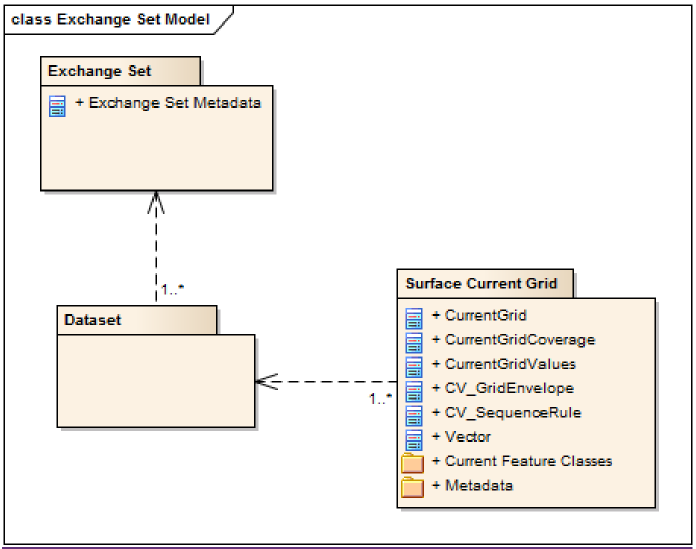

Figure C.5 – Surface Current Exchange Set Model

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ANNEX D. FEATURE CATALOGUE

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```
<?xml version="1.0" encoding="utf-8"?>
<S100FC:S100_FC_FeatureCatalogue xmlns:S100FC="http://www.iho.int/S100FC"
xmlns:S100Base="http://www.iho.int/S100Base" xmlns:S100CI="http://www.iho.int/S100CI"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:S100FD="http://www.iho.int/S100FD"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.iho.int/S100FC
S100FC.xsd">
    <S100FC:name>S111</S100FC:name>
    <S100FC:scope>Navigationally Significant Surface Current which may be used alone or as an auxiliary layer of
data with an ENC.</S100FC:scope>
    <S100FC:fieldOfApplication>Ocean Navigation</S100FC:fieldOfApplication>
    <S100FC:versionNumber>0.1</S100FC:versionNumber>
    <S100FC:versionDate>2016-12-15</S100FC:versionDate>
    <S100FC:producer>
        <S100CI:organisationName>IHO</S100CI:organisationName>
        <S100CI:contactInfo>
            <S100CI:phone>
                <S100CI:voice>+337 93 10 81 00</S100CI:voice>
                <S100CI:voice>+337 93 10 81 00</S100CI:voice>
                <S100CI:voice>+337 93 10 81 00</S100CI:voice>
                <S100CI:voice>+337 93 10 81 00</S100CI:voice>
                <S100CI:voice>+337 93 10 81 00</S100CI:voice>
                <S100CI:facsimile>+337 93 10 81 40</S100CI:facsimile>
            </S100CI:phone>
            <S100CI:address>
                <S100CI:deliveryPoint>via TWCWG</S100CI:deliveryPoint>
                <S100CI:deliveryPoint>via TWCWG</S100CI:deliveryPoint>
                <S100CI:deliveryPoint>via TWCWG</S100CI:deliveryPoint>
                <S100CI:deliveryPoint>via TWCWG</S100CI:deliveryPoint>
                <S100CI:deliveryPoint>via TWCWG</S100CI:deliveryPoint>
                <S100CI:postalCode>B.P.445</S100CI:postalCode>
                <S100CI:country>MONACO</S100CI:country>
            </S100CI:address>
            <S100CI:onlineResource>
                <S100CI:url>www.iho.int</S100CI:url>
            </S100CI:onlineResource>
        </S100CI:contactInfo>
        <S100CI:role>pointOfContact</S100CI:role>
    </S100FC:producer>
    <S100FC:classification>unclassified</S100FC:classification>
    <S100FC:S100_FC_SimpleAttributes>
        <S100FC:S100_FC_SimpleAttribute>
            <S100FC:name>Surface current direction</S100FC:name>
            <S100FC:definition>DIRECTION OF CURRENT. The direction toward which a CURRENT is flowing,
called the SET of the CURRENT. Also called current direction</S100FC:definition>
            <S100FC:code>surfaceCurrentDirection</S100FC:code>
            <S100FC:valueType>Real</S100FC:valueType>
        </S100FC:S100_FC_SimpleAttribute>
        <S100FC:S100_FC_SimpleAttribute>
            <S100FC:name>Surface current speed</S100FC:name>
            <S100FC:definition>Rate of motion. The terms speed and VELOCITY are often used interchangeably,
but speed is a scalar, having magnitude only, while VELOCITY is a vector quantity, having both magnitude and
```

```
direction. Speed may either be the ship's speed through water, or the SPEED MADE GOOD over
ground.</S100FC:definition>
            <S100FC:code>surfaceCurrentSpeed</S100FC:code>
            <S100FC:valueType>Real</S100FC:valueType>
        </S100FC:S100_FC_SimpleAttribute>
    </S100FC:S100_FC_SimpleAttributes>
    <S100FC:S100_FC_FeatureTypes>
        <S100FC:S100_FC_FeatureType isAbstract="false">
            <S100FC:name>Surface Current</S100FC:name>
            <S100FC:definition>Water or other fluid in essentially horizontal motion.</S100FC:definition>
            <S100FC:code>SurfaceCurrent</S100FC:code>
            <S100FC:attributeBinding sequential="false">
                <S100FC:multiplicity>
                    <S100Base:lower>1</S100Base:lower>
                    <S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
                </S100FC:multiplicity>
                <S100FC:attribute ref="surfaceCurrentSpeed"/>
            </S100FC:attributeBinding>
            <S100FC:attributeBinding sequential="false">
                <S100FC:multiplicity>
                    <S100Base:lower>1</S100Base:lower>
                    <S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
                </S100FC:multiplicity>
                <S100FC:attribute ref="surfaceCurrentDirection"/>
            </S100FC:attributeBinding>
            <S100FC:featureUseType>Geographic</S100FC:featureUseType>
            <S100FC:permittedPrimitives>coverage</S100FC:permittedPrimitives>
            <S100FC:permittedPrimitives>pointSet</S100FC:permittedPrimitives>
        </S100FC:S100_FC_FeatureType>
    </S100FC:S100_FC_FeatureTypes>
</S100FC:S100_FC_FeatureCatalogue>
```


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~~ANNEX F.~~ANNEX E. TESTS OF COMPLETENESS (NORMATIVE)

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E~~D~~.1 Coverage Consistency

E~~D~~.1.1 Test case for coverage geometry

Test purpose:	Verify that the coverage geometry corresponds to the conformance class
Conformance class	Gridded coverage, point set
Test method:	Check that the coverage geometry type complies with one of the two coverage types defined in the Application Schema defined in ~~Appendix B~~Annex C.
Test type:	Basic

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E~~D~~.1.2 Test case for extra data

Test purpose:	Verify that a ~~Surface Current~~Gridded coverage data set is complete by testing that the grid coverage value matrix contains direction and speed values, or null values, for every vertex point defined in the grid, and when all of the mandatory associated metadata is provided. Verify that a Point Set~~–~~ is complete by testing that the points containing direction and speed values are matched with a longitude-latitude pair, and when all of the mandatory associated metadata is provided.
Test method:	Check that for each feature, all of the mandatory metadata is provided, and that all of the vertex points ~~required to define the grid coverage (all the rows and columns) is provided~~have corresponding values.
Test type:	Basic

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E~~D~~.1.3 Test case for empty data

Test purpose:	Verify that data is not missing
Test method:	Check that all mandatory metadata is provided, and test that all ~~grid matrix~~data values for the grid or point set established in the metadata are provided
Test type:	Basic

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E~~D~~.2 Logical Consistency

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Check that grid extent defined in the metadata is consistent with grid spacing and number of points. Check that the number of null values in the speed grid equals the number in the direction grid. Check that the point set envelope is consistent with the minimum and maximum point locations.

E~~D~~.2.1 Conceptual Consistency

The implementation of the Surface Current Product is required to align with one of the two conformance classes defined in ~~(~~the appendix with the Abstract Test Suite and Conformance Classes~~)~~.

E~~D~~.2.2 Domain Consistency

The attributive values are validated to ensure they are within defined range.

~~Test case for range~~

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Test purpose:	Verify that attribute values are within specified ranges
Test method:	Check that the ~~orientation~~ surface current direction value attribute is within the range 0 to 360 degrees or are a n~~N~~ull ~~(NAN)~~ value and that the speed~~other~~ values are within the range specified or are a n~~N~~ull ~~(NAN)~~ value for the particular product specification defined by a producer~~-~~. This would be validated by means of test software
Test type:	Basic

E~~D~~.2.3 Positional Accuracy

For a gridded coverage the positional accuracy for the grid reference point and the length of the offset vectors defining the size of each grid cell, when specified, are defined in the metadata. For a Point Set the positional accuracy for the point is defined in the metadata.

~~Test case for positional accuracy~~

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Test purpose:	Verify that the grid reference point and offset vector ~~(defining a cell)~~ in a grid coverage, and the points in a point set, are defined and in accordance with the accuracy established for the data set by the producer.~~ducer~~
Test method:	Verify that the positional accuracy of the defining points of the coverage ~~are~~ is within the accuracy established for the data set by the producer, in particular the Hydrographic Office, by the use of test software.
Test type:~~:~~	Basic ~~Basic~~

ED.2.4 Temporal Accuracy

ANNEX G.For a gridded coverage the temporal reference time for the data at all grid points is the same. Temporal accuracy is not defined.

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~~ANNEX H. FEATURE CATALOGUE~~

~~<<XML code. This information is awaiting the completion of the Feature Catalogue Builder>>~~

ANNEX F. SURFACE CURRENT DATA

~~ANNEX I.~~

This Annex describes the sources of data, methods of organizing surface current data (the time series and the grid), how the data product format is derived. In the last section we discuss additional features of current data.

~~F.1.~~F.1 Data Sources

For the purposes of this Product Specification, surface current data categorized as one of three types, depending on the source of production. These are:

- Historical and real-time observation,
- Astronomical prediction, and
- Model-based forecast or prediction.

An historical observation consists of a time series of values at a specific location or area, often at a specific elevation above the bottom or below the surface. Observations can be for a fixed point (current meter), a moving point (e.g., a Lagrangian drifter), along a vertical or horizontal line (Doppler profiler), or an area (coastal radar). A real-time (or near-real-time) observation is actually a historical observation but for the very recent past. The astronomical tidal current prediction is often a time series computed by a mathematical formula using harmonic constants. This prediction applies to a specific location and depth, and is often produced many months ahead of time.

The astronomical predictions for multiple stations are often combined into a digital tidal atlas, and the individual predicted currents are usually keyed to the time and amplitude of tidal water levels at a nearby station.

Finally, model-based forecasts or predictions are usually produced by a two- or three-dimensional numerical hydrodynamic model, and include astronomical tide, meteorological forcing, river inflow, spatially varying water density, and open ocean boundary inputs. A model-based hindcast, including an analysis, is based on historically-observed conditions. A forecast is usually produced to predict conditions a few hours or days ahead into the future.

~~F.2.~~F.2 Data Organization

Data are usually organized by the HO producer into either (a) a time series of values, such as for historical and real-time observations at a single point, or (b) a gridded set of values, such as from a model-based forecast or sea-surface analysis.

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FF.2.1 Time Series Data

An historical observation consists of a time series of values at a specific location or area, often at a specific elevation above the bottom or below the surface. Observations can be for a single point (current meter), along a line (Doppler profiler), or an area (coastal radar).

The data for individual current meter stations are most conveniently organized in a time series. For example, for historical observations and astronomical predictions, each record in the series consists of a time for which the data are valid and the water current data itself: speed and direction. Descriptive data may be contained in a metadata block at the beginning of the file.

Real-time data is similar to historical data in that, in addition to dataset metadata, they include either a single near-real-time value or a time series of values for speed and direction, with the most recent being the near-real-time value. A sample file containing observations is shown in Figure FF.1.

```
# Station ID:        cb1101
# # Orientation:       Down (Buoy-Mounted)
# # Time Zone:         UTC
# # Approx. Depth:     Near Surface
# # Blank rows indicate missing data. See our data
# # disclaimer online.
# #
# # Date      Time        Speed (knots) Dir (true)
# 2014-12-01 00:00:00      1.08        215
# 2014-12-01 00:06:00      1.00        225
# 2014-12-01 00:12:00      0.83        226
# 2014-12-01 00:18:00      0.73        230
# 2014-12-01 00:24:00      0.80        223
# 2014-12-01 00:30:00      0.77        236
# 2014-12-01 00:36:00      0.73        229
# 2014-12-01 00:42:00      0.61        224
# 2014-12-01 00:48:00      0.71        224
# 2014-12-01 00:54:00      0.71        220
# 2014-12-01 01:00:00      0.67        230
```

Figure FF.1 – Portion of an actual text file containing surface current observations at 6-minute intervals. The native format is ASCII text (other options were available). Data courtesy of the Center for Operational Oceanographic Products and Services, US.

The sample file contains (a) a metadata block, with information on the station, location, instrument type, and depth, and (b) a header line followed by multiple lines of values which include the date and time, the current speed, and the current direction.

The file shown in Figure FF.1 can be reformatted so that the metadata appears at the beginning of the file, and the speed at direction data is group for each time (Figure FF.2a).

```
[Metadata block for station # 1]

Value of Time 1: 2014-12-01 00:00:00
Speed at Time 1 =      1.08
Direction at Time 1 = 215

Value of Time 2: 2014-12-01 00:06:00
Speed at Time 2 =      1.00
Direction at Time 2 = 225

Value of Time 3: 2014-12-01 00:12:00
Speed at Time 3 =      0.83
Direction at Time 3 =  226
```

Figure FF.2a - Reformatted time series or real-time data.

The data in Figure FF.2a can be rearranged so that all the speeds and all the directions appear in a sequence, as in Figure F.F2b.

```
[Metadata block for station # 1]

Value of Time 1: 2014-12-01 00:00:00
Speed  =    1.08, 1.00, 0.83
Direction = 215, 225, 226
```

Figure FF.2b - Reformatted time series data

FF.2.2 Gridded Data

For certain data products that cover a specific geographic area, the data are most likely to be gridded. Examples are nowcasts hindcasts and forecasts produced by a hydrodynamic model, currents derived from the analysis of sea-surface topography, and currents derived from high-frequency coastal radar observations.

Many spatial grids are regular (i.e., having uniform spacing in each direction) and geodetic (with the X axis directed toward the east and Y axis directed toward the north). Such grids are defined by several parameters: the origin (longitude and latitude of a geographic point), the grid spacing along each axis (degrees), and the number of points along each axis. Given an uncertainty in the location of the origin and in the spacing, there will be an uncertainty on the precise position of the grid points. A portion of the metadata and the current speed data from a forecast model is shown in Figure FF.3. There are similar data for the current direction grid.

NOTE: some datasets contain a land mask array, for the purpose of determining whether a grid point represents land or water. Herein the product specification uses a land mask value (e.g., -99.999), which is substituted for a gridded value which is on land, to represent land, thus reducing the number of arrays required.

```
        Dataset 'speed(knots)'
           Size:  500x325
           MaxSize:  500x325
           Datatype:   H5T_IEEE_F32LE (single)
           ChunkSize:  1x325
           Filters:  deflate(9)
           FillValue:  0.000000
           Attributes:
              'organization':  'Center Canadian Meteorological Service - Montreal (RSMC) (54) '
              'Delta_Longitude':  '0.02993999933078885 '
              'Delta_Latitude':  '0.019938461092802194 '
              'forecastDateTime':  '20140611_180000 '
              'Product':  'Type: Forecast products Status: Operational products '
              'Minimum_Latitude':  '45.5 '
              'Maximum_Latitude':  '51.97999985516071 '
              'Maximum_Longitude':  '-56.030000334605575 '
              'Number_Of_Cells_South_North':  '325 '
              'Minimum_Longitude':  '-71.0 '
              'Number_Of_Cells_West_East':  '500 '
              'generatedDateTime':  '20140611_000000 '
              'units':  'mm/s '
    speed(knots) =
       0, 0, 0, 0.5191959, 0.5159838, 0.5159435, 0.5186388,
       0.5209069, 0.5167338, 0.5114825, 0.4738558, 0.378551, 0.2911682,
       0.204335, 0.1294665, …
```

Figure FF.3 - A portion of the actual metadata and the gridded current speed data produced by the Canadian Meteorological Service from a model-based forecast. The native format is HDF5.

Note that the data for current speed in Figure FF.3 is organized similarly to that for time series: (a) metadata followed by (b) a header record and then the data. However, unlike the time series, the data are valid for a single time (the value of which appears elsewhere in the metadata).

Current data produced on irregular grids or on unstructured grids, or for surface drifters, may be incorporated by spatially referencing each individual velocity location by explicitly giving its latitude and longitude in the metadata.

For gridded data in general, the metadata for both speed and direction will be the same, so only one metadata block is required to describe both the speed and direction data (Figure FF.4). The data for speed in Figure FF.3 is a series of values at grid points, starting from the lower left corner of the grid and proceeding along the first row until the end, then starting with the first point in the second row, and so on. Note that for the two fields (speed and direction) in this example, the memory required is 0.325 mb.

[Metadata block for gridded fields]
Value of Time 1
Speed at T1 = 0, 0, 0, 0.5191959, 0.5159838, 0.5159435, 0.5186388, 0.5209069, 0.5167338, 0.5114825, 0.4738558, 0.378551, 0.2911682, 0.204335, 0.1294665, …
Direction at T1 = 0, 0, 0, 32.7725, 30.33029, 27.84417, 26.28601, 26.46908, 26.46744, 26.56505, 25.9423, 24.28312, 23.54004, 24.69553, 28.52312, …

Figure FF.4 - A portion of a generalized file with the metadata and the gridded current speed and direction data at one specific time from a model-based forecast shown in Figure FF.3.

F.3.F.3 Digital Tidal Atlas Data

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A digital tidal atlas typically contains speed and direction information for a number of locations, the valid time of which is expressed as a whole number of hours before and/or after either time of high water at a reference tidal water level station or time of maximum flood current at a reference station. Often the speed and direction are given for both neap and spring tide conditions (Table FF.1).

Data in the atlas format, when used with daily predictions of tidal water levels or currents at a reference station, can be converted into time series data (see Figure FF.2b), and thus into the S-111 format. This conversion is to the responsibility of the HO.

Table FF.1 – Example of digital tidal data for a station off the French coast. Speed and direction vary by hour relative to high water at a reference station, and by tide range. Data courtesy of Service Hydrographique et Océanographique de la Marine, France.

Hour	Speed (ms^{-1})		Direction (deg)	
	Neap	**Spring**	**Neap**	**Spring**
-6	0.924	0.991	234.0	232.8
-5	0.991	1.047	235.4	233.5
-4	1.015	1.104	233.1	234.8
-3	0.939	1.132	233.4	233.0
-2	0.447	0.947	233.7	233.3
-1	0.302	0.061	232.8	200.1
0	0.444	0.292	232.5	56.0
1	0.562	0.044	232.5	68.2
2	0.596	0.469	232.4	231.2
3	0.620	0.662	232.5	231.3
4	0.705	0.779	232.7	231.6
5	0.797	0.886	233.0	232.1
6	0.876	0.967	233.5	232.6

~~F.4.~~F.4 Moving Platform Data

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Moving platforms (e.g., surface Lagrangian drifters) float along with the currents and represent the motion at some depth depending on the specific design. The data are often available, in the raw form, as a list with locations and (usually non-equally-spaced) times (Figure F~~F~~.5). The data are often telemetered from the drifter to a collection station.

```
OBJECTID,ARID,YR,MON,DD,HH,MM,SS,LAT,LON,ACC
127134,52299,2005,9,25,7,18,16,15.57400000000,142.82200000000,2
127135,52299,2005,9,25,8,58,0,15.57400000000,142.80000000000,2
127136,52299,2005,9,25,18,47,37,15.54300000000,142.72100000000,2
127137,52299,2005,9,25,19,47,45,15.54100000000,142.71100000000,2
127138,52299,2005,9,25,21,27,29,15.53300000000,142.69200000000,2
127139,52299,2005,9,26,6,55,6,15.49900000000,142.65500000000,1
127140,52299,2005,9,26,8,34,6,15.48600000000,142.64400000000,2
127141,52299,2005,9,26,18,35,27,15.43800000000,142.59300000000,1
127142,52299,2005,9,26,19,23,51,15.43300000000,142.59000000000,2
```

Figure F~~F~~.5 - Portion of an Argos System CLS file describing the positions and times of a specific Lagrangian drifter.

In the raw form, the data must be converted into speed and directions. This can be accomplished by cubic spline interpolation of the longitudes and latitudes separately, then dividing the difference in position by the differences in time. The data can be converted into time series data (see ~~Figure~~ Figure F~~F~~.2b), and thus into the S-111 format.

F~~F~~.5 Preliminary Data Product Format

Two forms (Figures F~~F~~.2b and F~~F~~.4) are similar, the main difference being that the multiple values for each variable in ~~Figure~~ Figure F~~F~~.4 correspond to multiple grid points, rather than the multiple times in ~~Figure~~ Figure F~~F~~.2b (at a single station). Thus the two forms can be combined into a single form (~~Figure~~ Figure F~~F~~.6, although the data are interpreted differently. Other forms (Figures E.4~~4~~ and E.5) must be processed to fit the format.

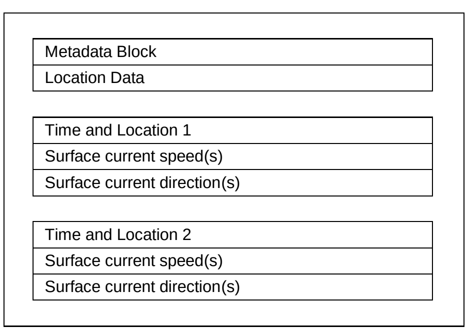

Figure F~~F~~.6 – Schematic of the preliminary product data set. The product can represent either a time series at a number of stations or gridded data.

~~F~~F.6 Additional Features of the Data

The following sections described additional features of current data and types.

~~F~~F.6.1 Vertical Reference Datums

The vertical location of the current in the water column is normally referenced to some vertical datum. In this Product Specification, the datum is selectable: it can be the sea surface, the sea bottom, or any of 30 standard tidal datums. The coordinate system axis is directed upward, so if the level of the current is below the datum, the depth will have a negative value. Levels referenced above the sea bottom will have a positive value. For a layer average, the thickness of the layer is specified as a positive value.

In principle, it is possible to transform elevations between the different datums. The separation between a standard tidal datum and the sea surface varies with time, and can be obtained by a prediction of the water level at the location of the current. In the case of a hydrodynamic model for currents, the model itself usually includes a water level prediction. The separation between the sea bottom and the standard tidal datum is often contained automatically in bathymetric data that is reference to a chart datum. If chart datum and the selected currents datum are different, an estimation of the difference in elevation is required.

~~F~~F.6.2 Uncertainty

Uncertainty is the estimate of the error in any measurement or value; since the error (difference between true and observed value) depends on true value, which can never be measured. For practical purposes, the confidence level is 95% and the uncertainty is defined herein as 1.96 times the standard deviation of the differences between observed and predicted values (cf. S-44. *IHO Standards for Hydrographic Surveys*, 5th Edition February 2008). For multiple sources of uncertainty, the total propagated uncertainty is the relevant value.

For example, the comparison between a predicted speed and the observed speed is normally based on an analysis using the time series for each. The standard deviation of the speed differences at each point in the series can be computed by the common formula. The calculation is similar for direction. It should be noted that for model-based predictions, uncertainty usually increases with the projection into the future.

Uncertainty for location is somewhat different. Horizontal locations of fixed or drifting observing stations are determined by surveying or GPS. The inherent uncertainties in these types of measurements are normally documented. For gridded hydrodynamic model data, uncertainties are based on the precision of the grid parameters (origin and spacing) and, if used, on any transformation from Cartesian (flat plane) position to geographic location. For coastal radar, uncertainty in position may be estimated by the local geometry and radar's accuracy in computing distances and angles.

Vertical locations of fixed or drifting observing stations are determined by surveying or GPS, and by configuration geometry. For gridded hydrodynamic model data, uncertainties are determined in a manner similar to the horizontal positions, but with consideration for uncertainties in instantaneous sea surface height, actual water depth, and vertical (if used).

Uncertainties in time are based on instrumentation and GPS parameters, record keeping, and computer/processing accuracy.

ANNEX GG. HDF-5 ENCODING

G.1G.1 Introduction

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The Hierarchical Data Format 5 (HDF5) has been developed by the HDF Group as a file format for the transfer of imagery and gridded data. This Annex specifies an interchange format to facilitate the moving of files containing data records between computer systems. It defines a specific structure which can be used to transmit files containing data type and data structures specific to S-100.

For S-111 purposes, an HDF5 file is structured to consist of Groups and sub-Groups, each of which may consist of Attributes and Datasets. Datasets are designed to hold large amounts of numerical data and may be used to hold the speed and direction data. Attributes are designed to hold single-valued information which apply to Groups and may be used to hold the metadata, although Datasets could also be used to hold the metadata.

It should be noted that not all S-100 data formats are readily available in HDF5. Predefined HDF5 formats include Integer, Float (cf. Real in S-100), Character (cf. CharacterString in S-100), and Enumeration but not Boolean, Date, Time, or DateTime formats. In S-111, Integer shall be used for Boolean variables, and Character shall be used for the date and time variables. These differences are summarized in Table GG.1.

Table GG.1 – Variable types in S-111 and equivalent types in HDF5. If If no HDF5 equivalent exists, –the HDF5 type in parentheses is to be used.

S-100 Variable Types	HDF5 Variable Types
Real	Float
Integer	Integer
CharacterString	Character
Enumeration	Enumeration
Date	(Character)
Time	(Character)
Boolean	(Integer)

The general structure of the data product (Figure 10.1) may be expressed as an organized HDF5 file as shown in Table GG.2. The root directory contains the carrier metadata as Attributes, and each Group contains a title and date-time as attributes, and the speed and direction values of the currents. Depending on the data type, there may be an additional Group XY.

Table G~~G~~.2 - HDF5 encoding scheme for Surface Currents. The total number of groups with speed and direction data is *numGRP*. Group XY appears only when *dataCodingFormat* is 1, 3 or 4.

Group	HDF5 Category	Data Type	Data Space
'/' *(root)*	Attributes. See Table 12.1.	Integer, Float, Enumeration, or Character	-
'/Group XY'	Dataset: X	Float	Vector (1-d): n=0, *numPOS-1*
	Dataset: Y	Float	Vector (1-d): n=0, *numPOS-1*
'/Group 1'	Attribute: Title	Character	
	Attribute: Date-Time	Character	
	Dataset: Speed	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*
	Dataset: Direction	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*
'/Group 2'	Attribute: Title	Character	
	Attribute: Date-Time	Character	
	Dataset: Speed	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*
	Dataset: Direction	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*
'/Group *numGRP*'	Attribute: Title	Character	
	Attribute: Date-Time	Character	
	Dataset: Speed	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*
	Dataset: Direction	Float	Vector (2-d): i=0, *numCOL-1*, j=0,*numROW-1*

~~G.2~~G.2 Carrier Metadata

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The carrier metadata (Table 12.2) is contained as attributes in the root directory (Table G.2). The carrier metadata consists of the data and parameters (a) needed to read and interpret the information in the product even if the S-111 MetaData file is unavailable, and, mostly, (b) are not included elsewhere in the metadata.

~~G.3~~G.3 Datasets

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Depending on the data format, there can be an initial group of longitudes and latitudes, Group XY. This group contains no attributes but two datasets, X (longitude and Y (latitude). The number of values is *numPOS*. This group appears for values of *dataCodingFormat* of 1, 3, and 4 (Table 10.1).

For each individual Group, there are two datasets: a set of speed values and a set of direction values. The values are storred in two-dimensional arrays, with a given the number of rows (*numROW*) and columns (*numCOL*). For one-dimensional arrays (*dataFormatType* not 2), *numROW* equals one. ~~The number of individual values in the speed and direction arrays is given by the parameter *numVAL*.~~

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The number of individual Groups is given by the metadata variable, *numGRP*. The time interval between individual times is given by the metadata variable *timeRecordInterval*.

Values which represent different times are stored sequentially, from oldest to newest. The initial date value is contained in the Character format mimicking the DT format: *yyyymmddThhmmssZ*. By knowing the time interval (seconds) between each record, the time applicable to each value can be computed. In addition, the Groups, if they represent different times, are also arranged sequentially, from oldest to newest.

Speed Values The speed values are contained in a Float array of length equal to *numVAL*. Each number representing speed (knots) has two digits to the right of the decimal point, and to the left of the decimal point, either a one- or two-digit number representing a valid speed, or a negative one denoting a null value or land location. Table GG.3 shows a sample one-dimensional dataset.

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Table GG.3 – Sample one-dimensional speed dataset, where a negative one ('-1.00') denotes a null value or land location.

-1.00	-1.00	2.34	5.67	8.99	12.34	9.87

Direction Values The directions values are contained in a Float array of length equal to *numVAL*. Each number representing direction (degrees, clockwise from true north) has one digit to the right of the decimal point, and to the left of the decimal point, either a one-, two-, or three-digit number representing a valid direction, or a negative one ('-1') denoting a null value or land location. Table GG.4 shows a sample dataset.

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Table G.4G.4 – Sample one-dimensional direction dataset where a negative one ('-1.0') denotes a null value or land location.

-1.0	-1.0	345.1	356.2	4.3	8.9	12.3

G.4G.4 Samples of HDDHF Data Files

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The following are examples of HDF5 files data for each of the four data coding formats. Files were produced by Matlab®.

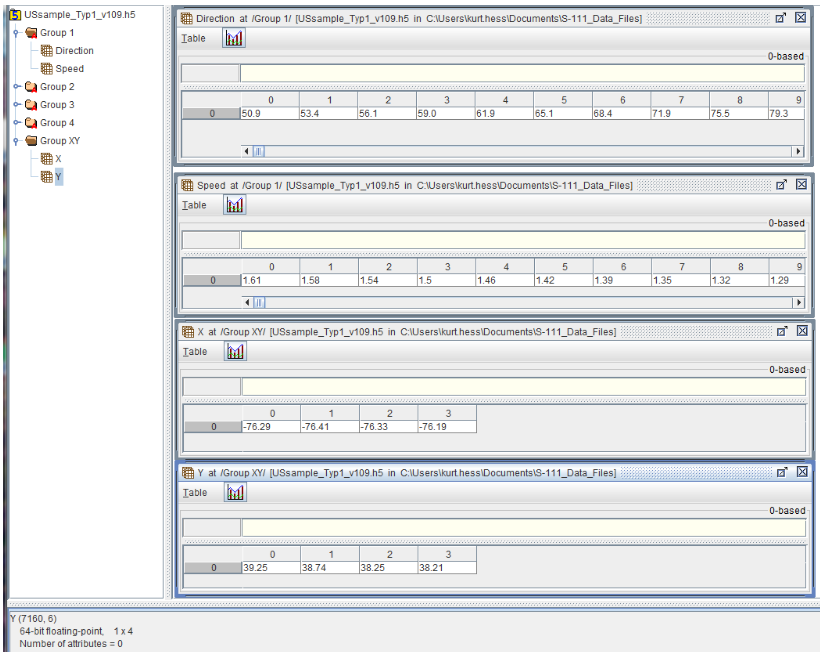


Figure GG.1 – Display of a sample file (using HDFView) containing speed and direction data at four fixed observing stations, along with the longitudes and latitudes of the stations (*dataCodingFormat* = 1).

```
/ (96)
  Group size = 5
  Number of attributes = 36
    dataCodingFormat = 1
    dataProtection = 0
    dateTimeOfFirstRecord = 20130205T060000Z
    dateTimeOfIssue = 20160914T180600Z
    dateTimeOfLastRecord = 20130209T060000Z
    depthTypeIndex = 2
    gridLandMaskValue = -1.0
    gridOriginLatitude = 0.0
    gridOriginLongitude = 0.0
    gridSpacingLatitudinal = 0.0
    gridSpacingLongitudinal = 0.0
    horizDatumReference = ESPG
    horizDatumValue = 4326
    maxSurfCurrentSpeed = 2.41
    methodCurrentsProduct = harmonic_constant_pred
    minGridPointLatitudinal = 0
    minGridPointLongitudinal = 0
    minSurfCurrentSpeed = 0.03
    nameRegion = US_East_Coast
    nameSubregion = Chesapeake_Bay
    numPointsLatitudinal = 0
    numPointsLongitudinal = 0
    numberOfNodes = 0
    numberOfStations = 4
    numberOfTimes = 481
    productSpecification = S-111_version_1.0.0
    protectionScheme = Not_Applicable
    surfaceCurrentDepth = 0.0
    timeRecordInterval = 360
    typeOfCurrentData = 3
    uncertaintyOfDirection = -1.0
    uncertaintyOfHorzPosition = -1.0
    uncertaintyOfSpeed = -1.0
    uncertaintyOfTime = -1.0
    uncertaintyOfVertPosition = -1.0
    verticalDatum = 0
```

Figure GG.2 – Display of a sample file (using HDFView) containing the 36 dataset root directory attributes (listed in alphabetical order) for fixed stations (*dataCodingFormat* = 1).

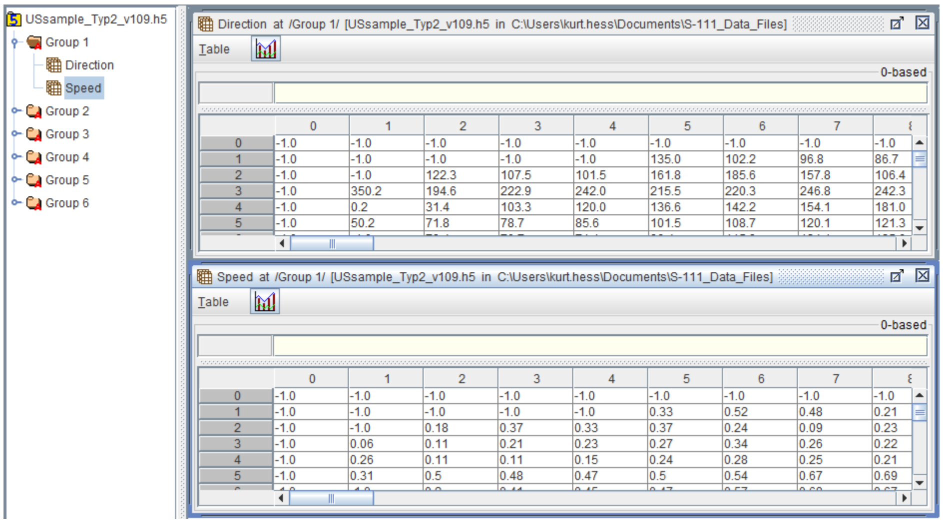
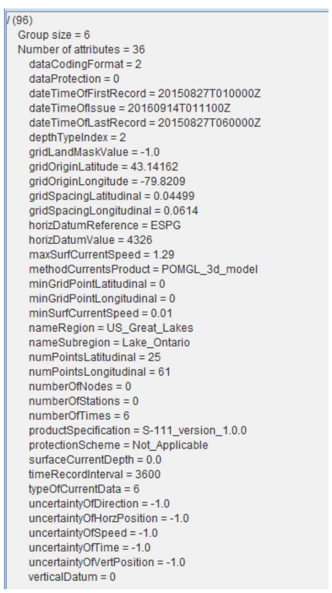


Figure G~~G~~.3 – Display of a sample file (using HDFView) containing speed and direction data for a regular grid (*dataCodingFormat* = 2).



/ (96)
Group size = 6
Number of attributes = 36
dataCodingFormat = 2
dataProtection = 0
dateTimeOfFirstRecord = 20150827T010000Z
dateTimeOfIssue = 20160914T011100Z
dateTimeOfLastRecord = 20150827T060000Z
depthTypeIndex = 2
gridLandMaskValue = -1.0
gridOriginLatitude = 43.14162
gridOriginLongitude = -79.8209
gridSpacingLatitudinal = 0.04499
gridSpacingLongitudinal = 0.0614
horizDatumReference = ESPG
horizDatumValue = 4326
maxSurfCurrentSpeed = 1.29
methodCurrentsProduct = POMGL_3d_model
minGridPointLatitudinal = 0
minGridPointLongitudinal = 0
minSurfCurrentSpeed = 0.01
nameRegion = US_Great_Lakes
nameSubregion = Lake_Ontario
numPointsLatitudinal = 25
numPointsLongitudinal = 61
numberOfNodes = 0
numberOfStations = 0
numberOfTimes = 6
productSpecification = S-111_version_1.0.0
protectionScheme = Not_Applicable
surfaceCurrentDepth = 0.0
timeRecordInterval = 3600
typeOfCurrentData = 6
uncertaintyOfDirection = -1.0
uncertaintyOfHorzPosition = -1.0
uncertaintyOfSpeed = -1.0
uncertaintyOfTime = -1.0
uncertaintyOfVertPosition = -1.0
verticalDatum = 0

Figure G~~G~~.4 – Display of a sample file (using HDFView) containing the 36 dataset root directory attributes (listed in alphabetical order) for a regular grid (*dataCodingFormat* = 2).

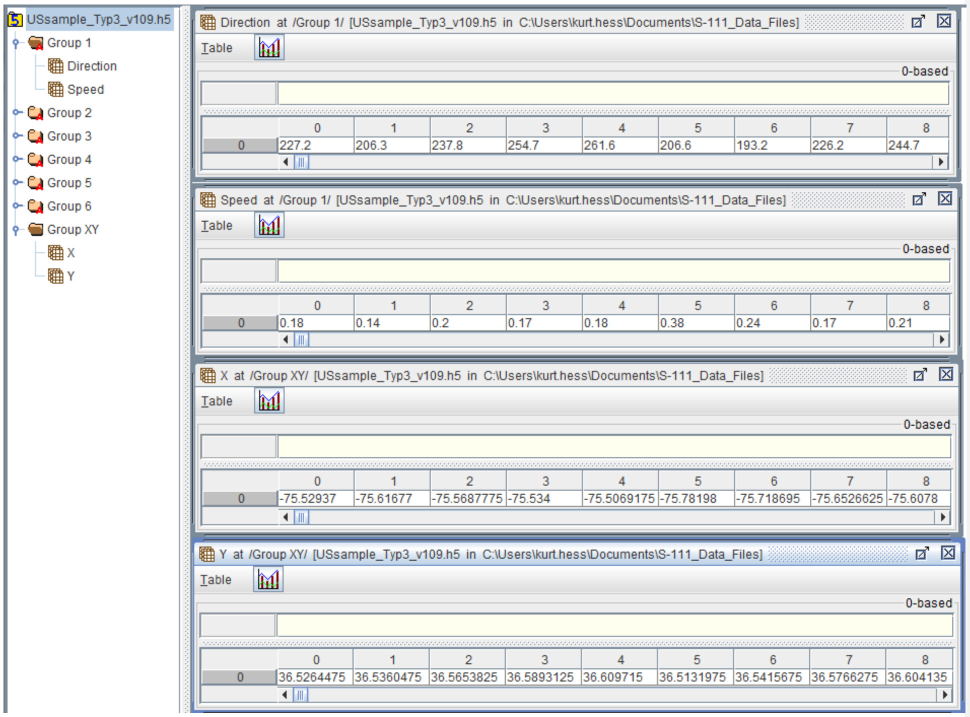


Figure GG.5 – Display of a sample file (using HDFView) containing speed and direction data for an irrregular grid along with the longitudes and latitudes of the grid nodes (*dataCodingFormat* = 3).

```
/ (96)
  Group size = 7
  Number of attributes = 36
    dataCodingFormat = 3
    dataProtection = 0
    dateTimeOfFirstRecord = 20151201T060000Z
    dateTimeOfIssue = 20160914T011300Z
    dateTimeOfLastRecord = 20151201T110000Z
    depthTypeIndex = 2
    gridLandMaskValue = -1.0
    gridOriginLatitude = 36.5131975
    gridOriginLongitude = -76.748445
    gridSpacingLatitudinal = 0.0
    gridSpacingLongitudinal = 0.0
    horizDatumReference = ESPG
    horizDatumValue = 4326
    maxSurfCurrentSpeed = 1.24
    methodCurrentsProduct = ROMS_3d_fcst
    minGridPointLatitudinal = 0
    minGridPointLongitudinal = 0
    minSurfCurrentSpeed = 0.0
    nameRegion = Chesapeake_Bay
    nameSubregion = Lower_bay_entrance
    numPointsLatitudinal = 0
    numPointsLongitudinal = 0
    numberOfNodes = 1560
    numberOfStations = 0
    numberOfTimes = 6
    productSpecification = S-111_version_1.0.0
    protectionScheme = Not_Applicable
    surfaceCurrentDepth = 0.0
    timeRecordInterval = 3600
    typeOfCurrentData = 6
    uncertaintyOfDirection = -1.0
    uncertaintyOfHorzPosition = -1.0
    uncertaintyOfSpeed = -1.0
    uncertaintyOfTime = -1.0
    uncertaintyOfVertPosition = -1.0
    verticalDatum = 0
```

Figure G~~G~~.6 – Display of a sample file (using HDFView) containing the 36 dataset root directory attributes (listed in alphabetical order) for an irregular grid (*dataCodingFormat* = 3).

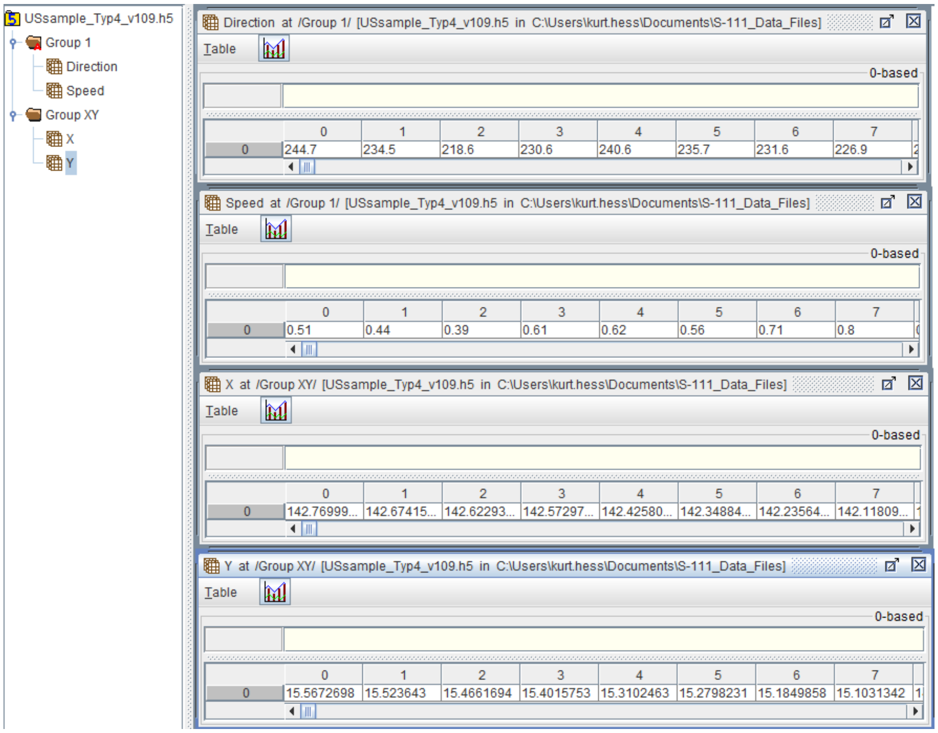


Figure G~~G~~.7 – Display of a sample file (using HDFView) containing speed and direction data for drifters, with the longitudes and latitudes of the drifters (*dataCodingFormat* = 4).

```
/ (96)
  Group size = 2
  Number of attributes = 36
    dataCodingFormat = 4
    dataProtection = 0
    dateTimeOfFirstRecord = 20050925T120000Z
    dateTimeOfIssue = 20160914T000200Z
    dateTimeOfLastRecord = 20060404T240000Z
    depthTypeIndex = 2
    gridLandMaskValue = -1.0
    gridOriginLatitude = 13.445
    gridOriginLongitude = 123.9642635
    gridSpacingLatitudinal = 0.0
    gridSpacingLongitudinal = 0.0
    horizDatumReference = ESPG
    horizDatumValue = 4326
    maxSurfCurrentSpeed = 1.88
    methodCurrentsProduct = Argos_Lagrangian_Dri
    minGridPointLatitudinal = 0
    minGridPointLongitudinal = 0
    minSurfCurrentSpeed = 0.03
    nameRegion = Western_Pacific_Ocean
    nameSubregion = Phillipine_Sea
    numPointsLatitudinal = 0
    numPointsLongitudinal = 0
    numberOfNodes = 0
    numberOfStations = 0
    numberOfTimes = 384
    productSpecification = S-111_version_1.0.0
    protectionScheme = Not_Applicable
    surfaceCurrentDepth = 0.0
    timeRecordInterval = 43200
    typeOfCurrentData = 4
    uncertaintyOfDirection = -1.0
    uncertaintyOfHorzPosition = -1.0
    uncertaintyOfSpeed = -1.0
    uncertaintyOfTime = -1.0
    uncertaintyOfVertPosition = -1.0
    verticalDatum = 0
```

```
/ (96)
  Group size = 2
  Number of attributes = 36
    dataCodingFormat = 4
    dataProtection = 0
    dateTimeOfFirstRecord = 20050925T120000Z
    dateTimeOfIssue = 20170123T200000Z
    dateTimeOfLastRecord = 20060405T000000Z
    depthTypeIndex = 2
    gridLandMaskValue = -1.0
    gridOriginLatitude = 0.0
    gridOriginLongitude = 0.0
    gridSpacingLatitudinal = 0.0
    gridSpacingLongitudinal = 0.0
    horizDatumReference = ESPG
    horizDatumValue = 4326
    maxCurrentSpeed = 1.88
    methodCurrentsProduct = Argos_Lagrangian_Drifters
    minCurrentSpeed = 0.03
    minGridPointLatitudinal = 0
    minGridPointLongitudinal = 0
    nameRegion = Western_Pacific_Ocean
    nameSubregion = Phillipine_Sea
    numPointsLatitudinal = 0
    numPointsLongitudinal = 0
    numberOfNodes = 0
    numberOfStations = 1
    numberOfTimes = 384
    productSpecification = S-111_version_1.0.0
    protectionScheme = Not_Applicable
    surfaceCurrentDepth = 0.0
    timeRecordInterval = 43200
    typeOfCurrentData = 1
    uncertaintyOfDirection = -1.0
    uncertaintyOfHorzPosition = -1.0
    uncertaintyOfSpeed = -1.0
    uncertaintyOfTime = -1.0
    uncertaintyOfVertPosition = -1.0
    verticalDatum = 0
```

Figure GG.8 – Display of a sample file (using HDFView) containing the 36 dataset root directory attributes (listed in alphabetical order) for drifters (*dataCodingFormat* = 4).

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ANNEX H. COLOUR TABLES

Below are the colour tables for the day, dusk, and night conditions. The estimates for dusk and night were obtained by first converting the values for RGB colours for day conditions (Clause 9.2.3) to xyL values, where L is luminance. Existing xyL data for dusk and night conditions for approximately 50 colors from S-52 (S-52 Presentation Library Edition 4.0.0, Part 1, Appx. A) demonstrate that luminance is reduced while the x and y values (mostly) remain constant. For each S-111 colour, the closest S-52 colour for day conditions (based on the x and y values) was then found, and that colour's luminance reduction factors for other conditions were used to calculate the xyL values. Finally, the new xyL values were converted back to RGB.

Table H.1 – Colour parameters for DAY conditions for each speed band.

Band	Token	Colour	x	y	L	R	G	B	RGB Hex
1	SCBN1	purple	0.21	0.14	15	118	82	226	7652E2
2	SCBN2	dark blue	0.21	0.24	29	72	152	211	4898D3
3	SCBN3	light blue	0.23	0.29	51	97	203	229	61CBE5
4	SCBN4	dark green	0.33	0.52	40	109	188	69	6DBC45
5	SCBN5	light green	0.39	0.53	61	180	220	0	B4DC00
6	SCBN6	yellow-green	0.43	0.50	51	205	193	0	CDC100
7	SCBN7	orange	0.49	0.45	48	248	167	24	F8A718
8	SCBN8	pink	0.40	0.33	48	247	162	157	F7A29D
9	SCBN9	red	0.64	0.33	21	255	30	30	FF1E1E

Table H.2 – Colour parameters for DUSK conditions for each speed band.

Band	Token	Colour	x	y	L	R	G	B	RGB Hex
1	SCBN1	purple	0.21	0.14	7	81	55	159	51379E
2	SCBN2	dark blue	0.21	0.24	3	20	52	76	14344C
3	SCBN3	light blue	0.23	0.29	1	6	24	29	06181C
4	SCBN4	dark green	0.33	0.52	13	64	114	39	3F7126
5	SCBN5	light green	0.39	0.53	21	110	136	0	6E8700
6	SCBN6	yellow-green	0.43	0.50	18	126	119	0	7E7600
7	SCBN7	orange	0.49	0.45	15	147	97	1	936100
8	SCBN8	pink	0.40	0.33	5	86	53	51	553533
9	SCBN9	red	0.64	0.33	9	178	1	1	B10101

Table H.3 – Colour parameters for NIGHT conditions for each speed band.

Band	Token	Colour	x	y	L	R	G	B	RGB Hex
1	SCBN1	purple	0.21	0.14	1	26	15	59	190F3A
2	SCBN2	dark blue	0.21	0.24	1	4	17	28	03101B
3	SCBN3	light blue	0.23	0.29	0	1	6	8	010607
4	SCBN4	dark green	0.33	0.52	2	19	40	8	122708
5	SCBN5	light green	0.39	0.53	3	38	49	0	263000
6	SCBN6	yellow-green	0.43	0.50	2	45	42	0	2C2900
7	SCBN7	orange	0.49	0.45	2	54	33	0	352000
8	SCBN8	pink	0.40	0.33	1	33	17	17	201110
9	SCBN9	red	0.64	0.33	1	63	0	0	3F0000

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ANNEX IH. SCALABLE VECTOR GRAPHICS (SVG) CODING

The following shows a sample XML file for creating a layer with surface current arrows, along with a sample figure showing the arrows, and the .CSS file.

~~H.1 Sample SVG file~~

~~The sample .svg file shown describes a screen measuring 200 mm wide by 130 mm high. The basic arrows are 10 mm high, and are rotated clockwise by a certain number of degrees to show the current direction. They are also translated in the x- and y-directions by a number of mm to show position, and scaled in length to denote speed relative to the reference speed. The color is denoted by the *fstep* parameter (see the .css file).~~

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet href="SVGStyle_S111.css" type="text/css"?>
    <!-- width and height of viewport, in mm. The viewBox is x-min y-min width height -->
<svg xmlns="http://www.w3.org/2000/svg" version="1.2" baseProfile="tiny"
   xml:space="preserve"  style="shape-rendering:geometricPrecision; fill-rule:evenodd;"
   width="200.0mm" height="130.0mm"  viewBox="-1.0  -1.0  200.0  130.0">
 <title>ARROW tests3</title>
 <desc>Surface Current direction and speed vector</desc>
 <metadata>
    <iho:S100SVG xmlns:iho="http://www.iho.int/SVGMetadata">
    <iho:Description iho:publisher="IHB" iho:creationDate="2016-04-26"
      iho:source="S111Register" iho:format="S100SVG" iho:version="0.1"/>
    </iho:S100SVG>
 </metadata>
<path class="sl f0 fSTEP9" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(10.0 10.0) rotate(65.0) scale (1.  1.)"/>
<path class="sl f0 fSTEP8" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(60.0 10.0) rotate(90.0) scale (0.90 0.90)"/>
<path class="sl f0 fSTEP7" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(10.0 60.0) rotate(125.0) scale (0.70 0.70)"/>
<path class="sl f0 fSTEP5" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(60.0 60.0) rotate( 85.0) scale (0.60 0.60)"/>
<path class="sl f0 fSTEP3" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(110.0 60.0) rotate( 85.0) scale (0.40 0.40)"/>
<path class="sl f0 fSTEP3" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(160.0 60.0) rotate( 105.0) scale (0.50 0.50)"/>
<path class="sl f0 fSTEP5" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(160.0 120.0) rotate( 75.0) scale (0.70 0.80)"/>
</svg>
```

IH.12 SVG Image

A sample image showing the vector arrows generated by the SVG and CSS codes appears in Figure IH.1.

Figure IH.1 – Image showing the arrows generated by the .svg and .css codes in this Annex.

I.2 Sample SVG file

The sample .svg file shown describes a screen measuring 200 mm wide by 130 mm high. The basic arrows are 10 mm high, and are rotated clockwise by a certain number of degrees to show the current direction. They are also translated in the x- and y-directions by a number of mm to show position, and scaled in length to denote speed relative to the reference speed. The color is denoted by the *fstep* parameter (see the .css file).

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet href="SVGStyle_S111.css" type="text/css"?>
        <!-- width and height of viewport, in mm. The viewBox is x-min y-min width height -->
<svg xmlns="http://www.w3.org/2000/svg" version="1.2" baseProfile="tiny"
     xml:space="preserve"  style="shape-rendering:geometricPrecision; fill-rule:evenodd;"
     width="200.0mm" height="130.0mm"  viewBox="-1.0  -1.0  200.0  130.0">
  <title>ARROW tests3</title>
  <desc>Surface Current direction and speed vector</desc>
  <metadata>
      <iho:S100SVG xmlns:iho="http://www.iho.int/SVGMetadata">
      <iho:Description iho:publisher="IHB" iho:creationDate="2016-04-26"
        iho:source="S111Register" iho:format="S100SVG" iho:version="0.1"/>
      </iho:S100SVG>
  </metadata>
<path class="sl f0 fSTEP9" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(10.0 10.0) rotate(65.0) scale (1.  1.)"/>
<path class="sl f0 fSTEP8" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(60.0 10.0) rotate(90.0) scale (0.90 0.90)"/>
<path class="sl f0 fSTEP7" fill='none' style="stroke-width: 0.05"  d=" M -.5,5.  L  -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z"  transform="translate(10.0 60.0) rotate(125.0) scale (0.70 0.70)"/>
```

<path class="sl f0 fSTEP5" fill='none' style="stroke-width: 0.05" d=" M -.5,5. L -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z" transform="translate(60.0 60.0) rotate(85.0) scale (0.60 0.60)"/>
<path class="sl f0 fSTEP3" fill='none' style="stroke-width: 0.05" d=" M -.5,5. L -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z" transform="translate(110.0 60.0) rotate(85.0) scale (0.40 0.40)"/>
<path class="sl f0 fSTEP3" fill='none' style="stroke-width: 0.05" d=" M -.5,5. L -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z" transform="translate(160.0 60.0) rotate(105.0) scale (0.50 0.50)"/>
<path class="sl f0 fSTEP5" fill='none' style="stroke-width: 0.05" d=" M -.5,5. L -.5,5. -1.,-1.5 -2.,-1.5 0.,-5. 2.,-1.5 1.,-1.5 .5,5. -.5,5. Z" transform="translate(160.0 120.0) rotate(75.0) scale (0.70 0.80)"/>
</svg>

IH.3 CSS File

Below is the .css file used in the above display.

```
.layout {display:inline} /* used to control visibility of symbolBox, svgBox, pivotPoint (none or inline) */
.symbolBox {stroke:none;stroke-width:0.03;}  /* show the cover of the symbol graphics */
.svgBox {stroke:none;stroke-width:0.01;}  /* show the entire SVG cover */
.pivotPoint {stroke:none;stroke-width:0.01;}  /* show the pivot/anchor point, 0,0 */
.sl {stroke-linecap:round;stroke-linejoin:round} /* default line style elements */
.f0 {fill:none}  /* no fill */
.sSTEP1 {stroke:#7652E2}  /* sRGB line colour for colour token STEP1: S111 Step 1 color */
.fSTEP1 {fill:#7652E2} /* sRGB line colour for colour token STEP1: S111 Step 1 color */
.sSTEP2 {stroke:#4898D3}  /* sRGB line colour for colour token STEP2: S111 Step 2 color */
.fSTEP2 {fill:#4898D3} /* sRGB line colour for colour token STEP2: S111 Step 2 color */
.sSTEP3 {stroke:#61CBE5}  /* sRGB line colour for colour token STEP3: S111 Step 3 color */
.fSTEP3 {fill:#61CBE5} /* sRGB line colour for colour token STEP3: S111 Step 3 color */
.sSTEP4 {stroke:#6DBC45}  /* sRGB line colour for colour token STEP4: S111 Step 4 color */
.fSTEP4 {fill:#6DBC45} /* sRGB line colour for colour token STEP4: S111 Step 4 color */
.sSTEP5 {stroke:#B4DC00}  /* sRGB line colour for colour token STEP5: S111 Step 5 color */
.fSTEP5 {fill:#B4DC00} /* sRGB line colour for colour token STEP5: S111 Step 5 color */
.sSTEP6 {stroke:#CDC100}  /* sRGB line colour for colour token STEP6: S111 Step 6 color */
.fSTEP6 {fill:#CDC100} /* sRGB line colour for colour token STEP6: S111 Step 6 color */
.sSTEP7 {stroke:#F8A718}  /* sRGB line colour for colour token STEP7: S111 Step 7 color */
.fSTEP7 {fill:#F8A718} /* sRGB line colour for colour token STEP7: S111 Step 7 color */
.sSTEP8 {stroke:#F7A29D}  /* sRGB line colour for colour token STEP8: S111 Step 8 color */
.fSTEP8 {fill:#F7A29D} /* sRGB line colour for colour token STEP8: S111 Step 8 color */
.sSTEP9 {stroke:#FF1E1E}  /* sRGB line colour for colour token STEP9: S111 Step 9 color */
.fSTEP9 {fill:#FF1E1E} /* sRGB line colour for colour token STEP9: S111 Step 9 color */
```