Surface Current Product Specification

Proposed S-111

Draft 1.1

Version 1.0
8 May 2014

Overview

This document is a proposal for a ~~Navigationally Significant Surface Current~~ Surface Current Product Specification in accordance with the New Work Item Proposal submitted by Canada to a previous TSMAD meeting. The document takes into account the results of the online survey conducted by IHO on the requirements for ~~Navigationally Significant~~ Surface Currents as well as the input from members of the Surface Currents Working Group.

The structure of this proposed product specification follows the new template for Product Specifications developed by TSMAD. The data model follows the structure for coverage data as described in S-100 Part 8 and parallels the structure defined in S-102 Bathymetric Surface Product Specification.

As identified in the results of the survey both a fixed grid and a "streamline" representation for surface currents are defined. This requires the establishment of two different coverage types as part of the data model. Both a quadrilateral grid coverage and a point set coverage are defined.

Proposed Working Draft

INTERNATIONAL HYDROGRAPHIC ORGANIZATION

IHO GEOSPATIAL STANDARD

FOR HYDROGRAPHIC DATA

Edition WD – xxxxx 2014

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	Purpose

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Surface Current Product Specification

Introduction

An understanding of surface currents is an important factor in the safety of navigation as currents affect the motion of vessels. Surface current information (analogue and digital) is now used for more efficient and safe navigation (involving fuel economy, ice movement predictions, etc.). This product specification provides a standardized solution that can be integrated into ECS/ECDIS navigation. This information may be considered auxiliary information that complements the ENC. This document is an S-100 compliant product specification for ~~Navigationally Significant~~ Surface Currents for Navigation data which may be used alone or as an auxiliary layer of data with an S-~~-~~101 ENC or other S-100 compatible data including S-~~-~~102 Bathymetric Surface data. ~~This product specification serves as one of a plurality of additional layers that may be integrated with other S-100 products for use with ENC as supplementary aids to navigation.~~ It specifies a vector field coverage including orientation and intensity at each grid point vertex in a quadrilateral grid coverage structure or in a point set coverage structure as defined in S-100 Part 8.

Two different coverage types are defined. The quadrilateral gridded coverage represents the value of the orientation and intensity (direction and speed of the current) at each vertex point in a grid used to describe the coverage function~~.~~ and optionally the uncertainty. This data structure has the advantage of regularity which makes it easier to manage as a data set, but it is harder to read that the alternate point set coverage. This is illustrated in Figure 1.

Figure 1 - An Example of a Gridded Coverage of Surface Currents ~~in the St. Lawrence River (High Tide - Reverse Flow)~~

A point set coverage describes the coverage surface as a set of independent X, Y point values with the value of the orientation and intensity and optionally the uncertainty defined

at each point. This allows a higher density of point values to be defined for significant areas along the stream of the current. This has technical advantages and is easier for the user to interpret, but it also makes the coverage harder to process and more data intensive. This is illustrated in Figure 2.

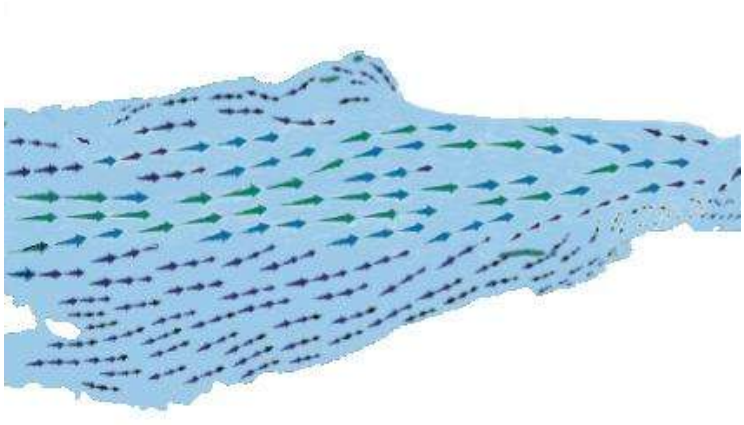

Figure 2 - An Example of a Point Set Coverage of Surface Currents

Figure 1 and Figure 2 are necessarily portrayals of the gridded and point set data because one cannot easily visualize the data itself. They are used only for illustration purposes in this document. The coverage data us actually a set of matrix values with the coverage function describing how the data is organized and interpolated. Portrayal is addressed in clause 13.

This surface current product specification is ~~separate~~distinct from a volumetric current representation that would represents currents in a three dimensional volume. Such a volumetric current representation has applications in oceanography but necessarily has a more complex grid structure. Volumetric currents are not addressed in this specification.

This surface current product specification makes use of a grid coverage in compliance with S-100 Part 8 Grid Coverage using S-100 Part 11 compliant product specification. The primary encoding specified is based on the HDF5 encoding standard. However, encoding is also permitted using the GeoTIFF and XML and other encoding standards especially for the grid coverage where there are many possible encodings. Since the content and encoding are separated, different encodings are permitted for the same data for use in different situations.

Surface Current Product Specification

1 Scope

This document is a product specification for ~~Navigationally Significant Surface Current~~ Surface Current data which may be used alone or as an auxiliary layer of data with an ENC. It specifies a vector field coverage including orientation and intensity at each grid point vertex[1] in a grid coverage or optionally at each point in a point set coverage. In addition an uncertainty coverage may also be included which describes the uncertainty of each grid or point set vertex value. The uncertainty may be bivariate, including a value of uncertainty for both orientation and direction. The surface may be certified by a using a digital signature. This product specification includes a content model and separate encodings.

2 Conformance

This product schema is conformant with IHO S-100 Sections 8-A-1.1 and 8-A-1.4.

Any data set claiming conformance with this Product Specification ~~shall~~must pass all the requirements described in the abstract test suites in Appendix A.

3 Normative References

The following referenced documents are indispensable for the application of this document.

IHO S-100 IHO Universal Hydrographic Data Model, January 2010

ISO 8601:2004 Data elements and interchange formats _ Information interchange _ Representation of dates and times

ISO 3166-1:1997 Country Codes

ISO/TS 19103:2005 Geographic information - Conceptual schema language

ISO 19111:2003 Geographic information - Spatial referencing by coordinates

ISO 19115:2003 Geographic information - Metadata

ISO 19115-2:2009 Geographic information - Metadata: Extensions for imagery and gridded data

ISO 19123:2005 Geographic information - Schema for coverage geometry and functions

ISO 19129:2009 Geographic information - Imagery gridded and coverage data framework

ISO 19131:2007 Geographic information - Data product specifications

[1] Note: This Surface Current coverage does not include a capability to manually adjust individual data values, as is available in S-102 via the tracking list function. Surface current information is very dynamic, changing frequently and such a capability is not required since update involves issuing an entire new data set.

4 Terms, Definitions and Abbreviations

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.

4.2 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.2.1 coordinate

one of a sequence of numbers designating the position of a point in N-dimensional space
[ISO 19111]

4.2.2 coordinate reference system

coordinate system which is related to the real world by a datum
[ISO 19111]

4.2.3 coverage

feature that acts as a function to return values from its range for any direct position within its spatial, temporal, or spatiotemporal domain
[ISO 19123]

EXAMPLE: Examples include a digital image such as set of sonar data representing bathymetric information, ~~polygon overlay, or~~a digital elevation matrix representing land surface or underwater topography, an uncertainity surface representing the probability of error over an area or a set of current measurements representing the current values over an area.

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. A coverage is a mathematical field.

4.2.4 coverage geometry

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

4.2.5 direct position

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

4.2.6 domain

well-defined set
[ISO 19103]

NOTE: Domains are used to define the domain set and range set of operators and functions.

4.2.7 feature

abstraction of real world phenomena
[ISO 19101]

NOTE A feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

4.2.8 feature attribute

characteristic of a feature
[ISO 19109]

NOTE 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 value domain of the feature attribute type.

4.2.9 function

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

NOTE The range is defined by another domain.

4.2.10 geometric object

spatial object representing a set of direct positions
[ISO 19107]

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 characteristics of an object such as a feature or a significant part of a feature

4.2.11 grid

network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in a systematic way
[ISO 19123]

NOTE The curves partition a space into grid cells.

4.2.12 grid point

point located at the intersection of two or more curves in a grid
[ISO 19123]

4.2.13 range

<coverage>
set of values associated by a function with the elements of the spatiotemporal domain of a coverage
[ISO 19123]

4.2.14 record

finite, named collection of related items (objects or values)
[ISO 19107]

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

4.2.15 rectified grid

grid for which there is a linear relationship between the grid coordinates and the coordinates of an external coordinate reference system
[ISO 19123]

NOTE If the coordinate reference system is related to the earth by a datum, the grid is a georectified grid.

4.3 Abbreviations

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

API Application Programming Interface

DS Digital Signature

DSS Digital Signature Scheme

ECDIS Electronic Chart Display Information System

ECS Electronic Chart System

ENC Electronic Navigational Chart

GML Geography Markup Language

HDF – Hierarchical Data Format

IEEE Institute of Electrical and Electronic Engineers

IHO International Hydrographic Organization

ISO International Organization for Standardization

NetCDF – Network Common Data Form

PK Public Key

SA Signature Authority

SK Secret Key

UML Universal Modelling Language

4.4 Notation

In this document conceptual schemas are presented in the Unified Modelling Language (UML). Several model elements used in this schema are defined in ISO standards developed by ISO TC 211, or in IHO S-100. In order to ensure that class names in the model are unique ISO TC/211 has adopted a convention of establishing a prefix to the names of classes that define the TC/211 defined UML package in which the UML class is defined. This prefix is not strictly required because UML packages define separate name spaces; however the prefix is a convenience. Since the IHO standards and this product specification make use of classes derived directly from the ISO standards this convention is also followed here. In the IHO standards the class names are identified by the name of the standard, such as "S-100" as the prefix optionally followed by the bialpha prefix derived from ISO. For the classes defined in this product specification the prefix is "S111". In order to avoid having multiple classes instantiating the same root classes, the ISO classes and S-100 classes have been used where possible; however, a new instantiated class is required if there is a need to alter a class or relationship to prevent a reverse coupling between the model elements introduced in this document and those defined in S-100 or the ISO model.

Table 1 - Sources of externally defined UML classes

Prefix	Standard	Package
CI	ISO 19115	Citation and Responsible Party
CV	ISO 19123	Coverage Core & Discrete Coverages
DQ	ISO 19115	Data Quality Information
DS	ISO 19115	Metadata Application Information
EX	ISO 19115	Metadata Extent information
IF	ISO 19129	Imagery Gridded and Coverage Data Framework
LI	ISO 19115	Linage Information
MD	ISO 19115	Metadata entity set information
MI	ISO 19115-2	Metadata entity set imagery
S100	IHO S-100	IHO Standard for Hydrographic Data
SC	ISO 19111	Spatial Referencing by Coordinates

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5 General Data Product Description

5.1 Title

S-111 - Surface Current Product Specification

5.2 Abstract

This document describes a product specification for ~~Navigationally Significant~~ Surface Currents as part of a suite of product Specifications that comply with the general Hydrographic model specified in IHO S-100 and which are complementary to the IHO Electronic Navigational Chart product specification S-101. This product specification is based on S-100 Part 8. The data described in this product specification could also be used as complementary data to the older IHO S-57 standard with some conversion to align with the older "Matrix data" data model[2]. This product specification defines two coverage structures, a grid structure and a point set structure which are established as conformance classes in Appendix A.

5.3 Spatial Extent

This product specification applies to marine areas globally. It can be used both to describe ocean currents as well as river and estuary currents. The boundaries of the spatial extent are described as an instance of the ISO Metadata element EX_Extent as an EX_GeographicBoundingBox in clause 5.3.1.

The geographic extent of this product specification is worldwide. Producers, in particular national hydrographic offices, ~~shall~~must establish the bounding box defining the geographic extent of the data series they produce.

Different instances of data products (those for the same data producer as well as those from different data producers) include separate coverages. If two adjacent coverages are combined the values on the shared boundary follow the common point rule defined in B 2.9.4. If two coverages overlap, they must be evaluated and either one should be given precedence over another or they need to be mathematically combined. The conditions under which multiple data sets are combined is application dependant.

5.3.1 Description

A ~~Navigationally Significant Surface Current Data Product~~Surface Current Product contains a coverage feature type that includes a set of value items required to define a coverage data set representing the orientation and intensity (direction and speed) of the current, and optionally the associated uncertainty at each grid point, of the sea or other navigable waterway, together with associated metadata. There are also provisions for a digital signature to certify that the data and associated uncertainty information together compose a consistent set issued by the appropriate authority. The data product may be use independently or as a part of a set of auxiliary data layers to be used with ENC data

[2] The Matrix data model in S-57 is vague, so S-111 data might be used directly with S-57 ENC data.

or other S-100 data. The metadata data and structure required to support the aggregation of a set of auxiliary data layers are described in S-100 Part 8 Section 8.7.

A ~~Navigationally Significant Surface Current Data Product~~Surface Current Product may exist anywhere in the maritime domain. There are no limitations to its extent. A particular supplier, such as a national hydrographic office, may establish its own series of ENCs and auxiliary data that can be used together or with other S-100 data. These series may include Surface Current data. When used together with other data layers the requirement is that the reference system be the same or be directly convertible for all layers and that the tiling schemes align.

5.3.1.1 West Bound Longitude

-180

5.3.1.2 East Bound Longitude

180

5.3.1.3 South Bound Latitude

-90

5.3.1.4 North Bound Latitude

+90

5.4 Temporal extent

The temporal extent of this product specification is unbounded. Producers, in particular national hydrographic offices, ~~shall~~must establish the beginning and end dates defining the temporal extent of the data series they produce.

Time for a particular product must be referenced. For tidal streams for instance, it must be referenced to a specific high tide or low tide, and as such it must be linked to tide predictions or a specific time (i.e. time of high tide or low tide) if it is calculated by an outside means. The “beginning” and “end” date establish the temporal reference for the data product.

5.5 Purpose

This product specification defines a content model and exchange file format for the exchange of surface current coverage data. The coverage type is either a quadrilateral grid coverage or a point set coverage together with attributes.

A single surface current coverage object represents one contiguous area of the skin of the earth at a single resolution, but can represent data at any stage of the process from raw grid to final product. The stage of the processing is indicated in the metadata (see 12.3 and 1B.3.5). The data may be model-derived forecasts, as well as observations, results based on tidal predictions, min/max, etc.

In order to support the certification of surface current data as an aid to navigation a Digital Certification Block may be included with the surface current data. This digital certification

is done in the same manner as is done in S-102 Bathymetric Surface Product Specification, except that in this product specification the Digital Certification Block is optional. That is, if the Digital Certification Block is included then the certification of the data set can be verified. Otherwise the data set is unverified.

Each data supplier, such as a national hydrographic office, may establish its own series of ~~surface current data product~~Surface Current Products that may be used independently or in conjunction with other auxiliary data layers.

5.6 Data Product Specification Metadata

The following metadata ~~shall~~must be included in each instance of a ~~Navigationally Significant Surface Current data product~~Surface Current Product.

	Item Name	Description	Multiplicity	Type	Content
1	title	Title of the data product specification	1	CharacterString	S-111 Navigationally Significant Surface Current Product Specification
2	S-100 version	The version of S-100 upon which the product is based	1	CharacterString	Version 1.0.0
3	version	Version of the data product specification	1	CharacterString	Version 1.0
4	date	Date the product specification was created / last updated	1	Date	31 March 2014[3]
5	language	Language(s) of the data product specification, e.g. translations	1..*	CharacterString	Eng This does not exclude instances of data being in multiple languages in objects that permit national language use.
6	classification	Security classification code on the data product specification	0..1	MD_Classification Code (ISO 19115)	The default value is "unclassified" however any value from the code list MD_ClassificationCode may be used, see clause 7.9.
7	contact	Party responsible for the data product specification	1	CI_Responsible Party (ISO 19115)	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
8	URL	Online-address where the resource is downloadable	0..1	URL	http://www.iho.int/iho_pubs/IHO_Download.htm
9	identifier	Persistent unique identifier for a published version of the product specification.	1	CharacterString	S-111

[3] This is the date for the Working Draft. The final date will be revised when the document is published (and this footnote will be removed).

10	maintenance	Description of the maintenance regime for the product specification.	1	MD_Maintenance Information (ISO 19115)	The product specification is maintained by the IHO ~~TSMAD committee~~.

Table ~~1~~ 2 – Data Product Metadata

5.7 Product Specification Maintenance

The product specification is maintained by the IHO ~~TSMAD committee~~. Data compiled in accordance with the product specification is maintained by the Hydrographic Office that issued the data.

6 Specification Scope

6.1 Scope General

The ~~Navigationally Significant Surface Current Data Product~~Surface Current Product specification defines a content model and exchange file format for the exchange of surface current coverage data.

6.2 Scope ID

Global

Note: "Global" means that this scope refers to all parts of this data product specifications.

6.3 Level

This scope refers to the following level according to the ISO 19115:2003 standard:

006 - series

6.4 Level name

Surface Current

7 Dataset Identification

7.1 Title

S-111 ~~Navigationally Significant Surface Current~~ Surface Current Product Specification

7.2 Alternate title

S-111

7.3 Abstract

The ~~Navigationally Significant Surface Current Data Product~~Surface Current Product consists of a set of grid matrix values organized to form a quadrilateral grid coverage or a set of point values organized to form a point set coverage with associated metadata representing a surface current model for a depth or 0 up to ~~10~~ 25 meters for an area of the sea, river, lake or other navigable water. The data set includes both surface current values

of orientation and intensity (direction and speed of current) and optionally accuracy measures associated with the surface current values. The optional data may also include current type, source, valid time.

7.4 Topic category

Main topics for the product, as defined by the ISO 19115 MD_TopicCategoryCode:

012– oceans;

014– inlandWaters

7.5 Geographic description

The extent element of MD_DataIdentification is conditional; either the EX_GeographicBoundingBox or the EX_GeographicDescription subclass of extent's geographicElement Role ~~shall~~must be included if the dataset is spatially referenced. If necessary both may be used. If a code is used then the code ~~shall~~must be taken from ISO 3166-1:1997.

7.6 Spatial resolution

The spatial resolution, or the spatial dimension on the earth covered by the size of a grid matrix cell (nominal ground sample distance), varies according to the implementation of the model by the producer (hydrographic office).

7.7 Purpose

The primary purpose of the ~~Navigationally Significant Surface Current Data Product~~Surface Current Product is to support safe navigation as an auxiliary aid to navigation that may be used together with an ENC. The secondary use is as an independent source of current information that may be used for other purposes.~~:~~

7.8 Language

Data products conforming to this product specification are available in English and additionally in other national languages together with English. That is, English or English plus another language or languages ~~shall~~must be used in the metadata associated with the set of coverage values defining the surface current coverage.

Other language information will be included as required as locale information (See ISO 19115:2003 Annex J) or as attributes of S-100 objects defined to carry "national" or other language text.

7.9 Classification

The default value of the Maritime Boundaries and Limits data is "unclassified"; however, any value from the code list MD_ClassificationCode may be used. Certain types of data may be "forOfficialUseOnly, or of "limitedDistribution". The full list of classification codes from ISO 19115:2003 are:

- unclassified,
- restricted,

- confidential,
- secret,
- topSecret,
- sensitiveButUnclassified,
- forOfficialUseOnly,
- protected,
- limitedDistribution.

7.10 Spatial representation type

Type of spatial representation for the product, as defined by the ISO 19115:2003 are:

002 – grid

- Other coverage[4]

Note: The ISO 19115:2003 metadata standard does not yet have a code for any other coverage type than a grid, so a point set coverage must be described as an "other coverage" in the metadata, with a description that the "other" is of the type "point set coverage".

7.11 Point of 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

7.12 Use Limitation

There are no restrictions on the general use of this data other than those imposed by the Hydrographic Office which produced that particular data set. If the data is to be used as an aid to navigation it must be issued and certified by a Hydrographic Office.

8 Data Content and Structure

8.1 Introduction

~~Navigationally Significant Surface Current~~ Surface Current data describes the orientation and intensity (direction and speed) of currents in the top 0 up to ~~10~~ 25 meters of the water column. This is described as a coverage data set represented as a quadrilateral grid or point set coverage and optionally the associated uncertainty at each grid point. In addition a digital signature block may be used to certify that the data is issued by the appropriate authority. The coverage structure is built upon S-100 Part 8 Section 8.7 which describes the general structure of auxiliary data layers of coverage data compliant with S-100.

[4] ~~ISO 19115 does not yet have a code for other coverage type.~~

The overall structure of the ~~Navigationally Significant Surface Current~~ Surface Current product specification is shown in Figure ~~2~~3. The same tagged structure used in S~~-~~-102 for bathymetric data is used, compliant with the HDF5[5] data architecture. The HDF5 data structuring technique allows multidimensional arrays of data to be grouped within a tagged container structure. Metadata may be described with these hierarchical data groups.

Although the HDF structure provides a binding to an encoding technique, the overall structure does not specify any particular encoding. This allows for the separation of the encoding from the data content as required in S~~-~~-100 and the ISO TC211 suite of geographic information standards.

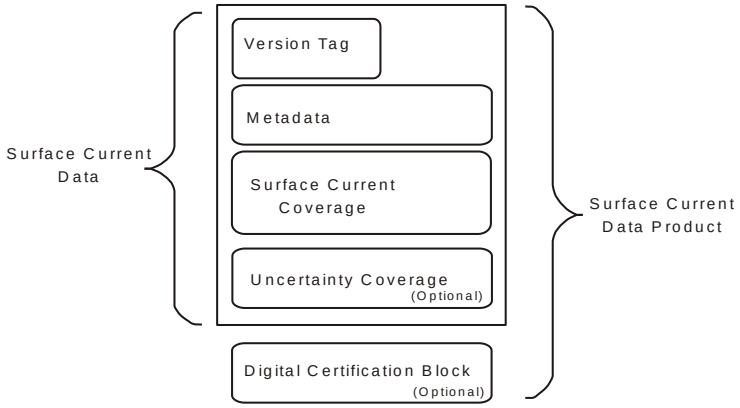

Figure 3 - Overview of Structure of ~~Surface Current Data Product~~Surface Current Product

The ~~Navigationally Significant Surface Current data product~~Surface Current Product is a hybrid of coverage(s), as defined in IHO S-100 Part 8 and Information Types as defined in IHO S-100 Part 4. Application Schema

8.2 Application schema

The application schema for the ~~Navigationally Significant Surface Current~~ Surface Current Product Specification is a template application schema. A profile can be developed that further refines the application schema. For example, the choice of whether to use a grid coverage or a point set coverage and the choice of using a tiling scheme and which tiling scheme to use is left open. The tiling scheme, extent, resolution of the coverage of points at which current values are provided, the availability of the optional associated uncertainty coverage and the optional Digital Certification Block are left to the national hydrographic office defining the profile or data producer to specify. Software that claims conformance to this template application schema should be able to interpret and process all of the optional elements. The details of the Application Schema are given in Appendix B.

[5] The Hierarchical Data Format version 5 (HDF5) is a widely used data structuring technique.

8.2.1 Feature catalogue

A coverage is a type of feature so a Surface Current Product specification does contain features. There are two coverages defined which are the surface current coverage and the uncertainty coverage. These two entries compose the feature catalogue. The description of the two feature types in the feature catalogue are defined in Appendix ~~X~~C.

8.2.2 Dataset Types

The data types used in a surface current coverage are vectors of orientation and intensity. Orientation is defined as an angular rotation from North in a positive clockwise sense[6]. Intensity is measured in units of velocity defined for a particular data set. Uncertainty is a statistical measure. All the data types are Real numbers.

8.2.3 Geometry

The geometry types that may be associated with the current coverage and the uncertainty coverage are either a grid coverage or a point set coverage. The data model for each of these coverage types is described in Appendix B.

Coverages are a very simple type of geometry, although operating with coverages can be complex. A coverage consists of two parts, a set of data values, called the Values Matrix in the ISO standards, and a grid or other construct that distributes the values over an area, so that it "Covers" the area. A grid describes how the values matrix values in a grid type coverage are distributed. For a regular quadrilateral grid this is simply by row and column. In a point set coverage the X, Y position of each value from the Values Matrix must be carried with the data value. These values covering an area define a mathematical surface, and interpolation may be used to determine values at intermediate points between those given in the grid or point set. A common example of a point set coverage is a set of soundings used to describe a surface corresponding to the depth of the sea.

9 Coordinate Reference System (CRS)

9.1 Horizontal reference system

Positional data is expressed in latitude (φ) and longitude (λ) geographic coordinates in reference to the one of the reference horizontal reference systems defined in the HORDAT attribute associated with coverage and with the metadata of the data set.

The reference system used should match the reference system used for the other hydrographic products with which the data may be used. For example if Surface Current data is used together with S-102 Bathymetric data the horizontal reference system should match.

9.2 Projection

Surface Current data is ~~unprotected~~ unprojected data.

[6]This is the geographic method of describing orientation. Mathematicians use a different convention of positive counter clockwise orientation measured from the X axis.

9.3 Vertical coordinate reference system

Surface Current data is two dimensional data. There is no vertical component.

Note: The top 25 meters for which the Surface Current Product Specification applies relates to the surface of the water (a real world object) that is not related to a vertical reference as part of the surface current product specification. The surface of the water may be related to a vertical datum in another S-100 product specification such as S-101, but such a reference to a vertical datum is not necessary in this product specification.

9.4 Temporal reference system

Time is measured by reference to Calendar dates and Clock time in accordance with ISO 19108:2002 Temporal Schema clause 5.4.4.

10 Data Quality

10.1 Completeness

A Surface Current coverage data set is complete when the grid or point set coverage value matrix contains orientation and intensity values for every vertex point defined in the grid or point set, and when all of the mandatory associated metadata is provided.

10.1.1 Commission

Evaluation methods used for the detection of data in excess of the product specification only occurs in the point set coverage case. For a grid coverage there is no possibility of having excess data since every grid vertex is significant. In a point set coverage it is possible to have redundant point data where two point set values are coincident. In the case where two point set values are coincident the first value (in the encoded order of the data set) ~~shall~~must be considered valid and the second or other values ~~shall~~must be ignored.

10.1.2 Omission

Evaluation methods used for the detection of missing data applies to the metadata and separately to the coverage data in a Surface Current data set.

Any missing mandatory metadata ~~shall~~must mean that the data set is in error.

In a grid coverage all of the grid matrix values defined for the grid (Row and Column) are required.

In a point set coverage at least one vertex point with X, Y position, orientation and intensity is required.

10.2 Logical consistency

10.2.1 Conceptual consistency

The implementation of the ~~Surface Current data product~~Surface Current Product is required to align with one of the two conformance classes defined in Appendix A. That is,

an instance of the data product ~~shall~~must consist of a set of value matrix elements in accordance with either a gridded or a point set coverage with associated metadata.

10.2.2 Domain consistency

The attributive values are validated to ensure they are within defined range. The attribute value for orientation is a Real number of 0 to 360 degrees. The value ranges for intensity and current are defined in the particular data product established as a profile of this template data product.

10.2.3 Format consistency

The structure of this product specification is independent from the data format. The data format encoding may be in accordance with different encoding specification. Conformance rules for each particular encoding are different and dependent on the particular encoding.

10.3 Positional accuracy

10.3.1 Absolute external 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 coverage positional accuracy may be defined for the accuracy of the position of a point vertex in the coverage.

10.4 Temporal accuracy

Each point in a point set coverage, or different cells in a gridded coverage may be collected at different times. A single creation date/time may be assigned as the collection date for the entire coverage. This specification does not provide a mechanism to distinguish between the collection date/time of individual vertex points.

10.5 Thematic accuracy

10.5.1 Thematic classification correctness

The measurement accuracy for each of the parameters of the current orientation and intensity may be specified in a separate uncertainty coverage. This optional second coverage may be combined with the base surface current coverage as additional values in each value record in the coverage. This is described in the Application Schema in Appendix B.

10.5.2 Non quantitative attribute accuracy

The method used for evaluating the accuracy of the non-quantitative attribute values may be expressed in the metadata.

10.5.3 Quantitative attribute accuracy

The method used for evaluating the accuracy of the quantitative attribute values with respect to reality is determined by the method of acquisition, and may be expressed in the metadata.

11 Data Capture and Classification

11.1 Description

The Surface Current product specification may be used to carry data captured from sensors, processed data derived from sensor data or to carry the output from predictive mathematical models.

12 Maintenance

12.1 Maintenance and Update Frequency

The maintenance and update frequency of Surface Current data ~~shall~~must be defined by the Hydrographic Office implementing this specification for their particular data series.

12.2 Data Source

Data from sensors, processed data derived from sensor data or the output from ~~predictive~~ forcasting mathematical models maybe the data source for instances of data sets complying with this specification. The particular data source ~~shall~~must be defined by the Hydrographic Office implementing this specification.

12.3 Production Process

The production process used to generate processed data derived from sensor data or the output from ~~predictive~~ forcasting mathematical models maybe described in the metadata associated with the particular data product specification defined ~~a~~ by the Hydrographic Office implementing this template specification. The stages of processing is part of the description of the production process.

13 Portrayal

Portrayal is very complex for surface currents because the extreme volume of data associated with the mathematical vector fields that describe currents are hard to visualize. Several options are permitted. The geometry of a gridded coverage necessarily places the data points at regular positions. This is hard for a user to visualize because they must interpolate in their mind between positions. A point set coverage is somewhat better because vectors can be positioned along the stream flow of the current to better illustrate the current.

The current at a particular position can be represented by a vector with an orientation in the direction of the current and with some mechanism to represent the intensity. Several options are permitted such as the length of the vector, its thickness (or boldness), and possibly its colour.

Since surface surrents are described by coverages, they may be evaluated at any position. It is therefore possible in a system that portrays a surface current coverage to allow a “mouse-over” capability where the value of the coverage may be queried at any location within the area enclosed by the coverage function.

14 Data Product Format (encoding)

14.1 Encoding Principles

The ISO suite of geographic information standards is built on the concept of the separation of the "carrier" from the "content". This is reiterated in S-100 where several encoding approaches are identified. The content is defined in the product specification for any Surface Current Product Specification data in terms of an encoding neutral UML model. Elements from this model are then used to create an Application Schema that is then encoded. Different layers of other auxiliary data may have different encodings.

An encoding based on the Hierarchical Data Format and NetCDF is a preferred implementation approach because it corresponds to the approach used for S-102 Bathymetric data, and as such tools will likely be available to interpret the data. The possibility of using JPEG 2000 + XML is considered as a future longer term option, but is not yet viable until software tools become commonplace. It is possible, but probably not practical to develop a coding using ISO 8211 data descriptive file for information interchange standard, that is used for S-101 ENC data. Not only are there no tools available to handle coverage data using ISO 8211 but the standard is not widely used for this type of information, so there are not likely to be any such tools available in the future.

Surface Current data described using a grid coverage can be encoded in several different ways because there exist many encoding schemes that support grid coverages; however, most are for imagery and few support the multi-value records that are needed to describe the orientation and intensity of a current vector at a point. There is almost nothing else except HDF that can encode a point set coverage of multi-valued records in a point set.

14.2 Encoding Null Data

The shape of tiles and data sets is rectangular, which of course does not correspond to the irregular shape of rivers and coastal areas. There is no current data over the land, but there will need to be data entries in the quadrilateral grid coverage data values matrix corresponding to areas over land when using a grid coverage. It is not appropriate to simply put a zero in the data values for these grid value points since zero is a valid velocity. These data values need to be padded with a special non-data value.

A non-data value can be encoded in several different ways. The simplest approach, which might be used in some encodings, is to add a third Boolean data attribute to each data record that indicates that the data value is valid. This can be simply done at the expense of the need to carry additional data since each grid value matrix element would be longer. This is illustrated in Figure 4.

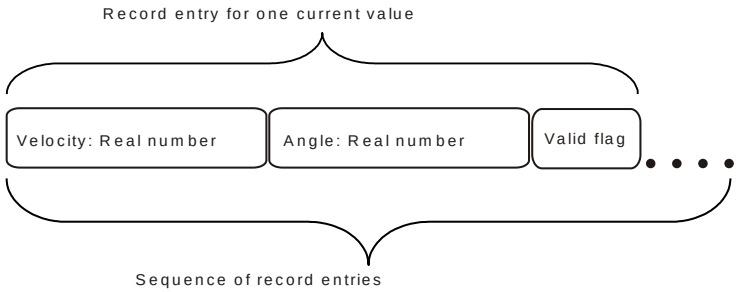

Figure 4 - Encoding Null Values in the Data Record

Since the data values are real numbers a more elegant approach is to make use of the "Not a Number" state that is available in the standard for encoding real numbers. The standard for encoding real numbers, as used in all modern computer systems is IEEE 754-2008. The standard includes a special case where the exponent field is all 1s and a non-zero fraction to signal a Not a Number (NAN) state. A Signalling NAN (SNAN) has the most significant fraction bit cleared. A signalling NAN can be used to denote an invalid state. Special software drivers are needed to be able to write a NAN data value, but the NAN is carried and processed like any other data.

A third option is to develop a separate Boolean coverage that acts as a mask. This coverage would operate the same as the valid flag in the data record, but it could be extracted as an image to be able to easily see the difference between land and water. However, this approach incurs the entire overhead of a coverage and is the least efficient.

There is no difference at the data content level for any of these approaches the difference relates to how the structure can be efficiently encoded.

The method of encoding Null Data is encoding format dependant.

15 Data Product Delivery

The Product Specification only addresses the information content of the product. Multiple encodings and product delivery mechanisms for the data are permitted.

16 Metadata

Metadata is described as part of the Application Schema in Appendix B.

Appendix A - **Abstract Test Suite and Conformance Classes**

(Normative)

A 1. Test case for coverage geometry

a) Test purpose: Verify that the coverage geometry corresponds to one of two conformance classes:

- Conformance class 1 – Gridded coverage;

- Conformance class 2 – Point Set coverage.

b) 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..

c) Reference: 8.2.3

d) Test type: Basic.

A 2. Test case for completeness

a) Test purpose: Verify that a Surface Current coverage data set is complete by testing that the grid or point set coverage value matrix contains orientation and intensity values for every vertex point defined in the grid or point set, and when all of the mandatory associated metadata is provided.

b) Test method: Check that each feature all of the mandatory metadata is provided and that all of the vertex points required to define either the grid coverage (all the rows and columns exist) or that the set of point set values exist.

c) Reference: Clause 10.1

d) Test type: Basic.

A 3. Test case for feature commission

a) Test purpose: Verify that point set vertex positions are not duplicated within a point set coverage.

b) Test method: Check that each point set vertex position is not duplicated.

c) Reference: Clause 10.1.1

d) Test type: Basic.

A 4. Test case for omission

a) Test purpose: Verify that data is not missing.

b) Test method: Check all mandatory metadata is provided, and test that all grid matrix values for the grid established in the metadata are provided.

c) Reference: Clause 10.1.2 and 10.2.1

d) Test type: Basic.

A 5. Test case for domain consistency

a) Test purpose: Verify that attribute values are within specified ranges.

b) Test method: Check that the orientation value attribute is within the range 0 to 360 degrees or are a Null (NAN) value and that other values are within the range ~~specifies~~ specified or are a Null (NAN) value for the particular product specification defined by a Hydrographic Office. This would be validated by means of test software.

c) Reference: Clause 10.2.2

d) Test type: Basic.

A 6. Test case for format consistency

a) Test purpose: Verify that format is compliant with the formats allowed for encoding coverage data. The formats allowed depend upon whether the data is point set coverage data or gridded data.

b) Test method: The format consistency test is done by encoding test software.

c) Reference: Clause 10.2.3

d) Test type: Basic.

A 7. Test case for data accuracy

a) Test purpose: Verify that the grid reference point and offset vector (defining a cell) in a grid coverage or the position of a vertex in a point set coverage are defined and in accordance with the accuracy established for the data set by the producing Hydrographic Office.

b) Test method: Verify that the positional accuracy of the defining points of the coverage are within the accuracy established for the data set by the producing Hydrographic Office by the use of test software.

c) Reference: Section 10.3

d) Test type: Basic.

A 8. Test case for thematic accuracy

a) Test purpose: Optionally verify that a second uncertainty coverage is available to describe the uncertainty of the elements of the coverage and that other aspects of accuracy are described in the metadata.

b) Test method: Verify that the uncertainty coverage exists and is coincident with the surface current coverage (i.e. the additional value record elements are present).

c) Reference: Section ~~10.3~~10.5

d) Test type: Basic.

Appendix B - **Application Schema Model**

(Normative)

B 1. Overview

The Surface Currents Application Schema model is based on the General Feature Model defined in ISO 19109 and on the conceptual model for Imagery, Gridded and Coverage data defined in IHO S-100 Part 8 and ISO 19129 and 19123. This model is similar to the model defined for Bathymetric Data in S-102. All of the auxiliary layers of data that may be used in conjunction with S-101 and which are based on S-100 should use a similar model so that the data can be integrated.

B 2. Model description

In a coverage data application schema there are really only two parts, the coverage description, which is actually just a values matrix, and some associated metadata. It is really a very simple structure of some values (pixels if the coverage is an image) and metadata. This simple structure is all that gets implemented. At the higher level there is a much more complex model that describes the structure of a coverage and how the components of a coverage relate. Only a few attribute values from this complex structure appear as metadata or attributes in the actual classes that get implemented.

Figure B-1 presents the high level of the application schema for surface currents derived from S-100 Part 8. The lower part of the model contains five boxes called implementation classes. These implementation classes “implement” the classes defined in S-100 Part 8. In the S-111_CoverageData. A choice is allowed of two coverage types, a grid or a point set coverage. The optional Uncertainty Coverage should be of the same type as the current coverage. That is, a surface current value could be a vector of direction and intensity (two numbers of orientation and intensity). An uncertainty coverage value item could be a single number giving an uncertainty of the coverage value pair (or two numbers giving the uncertainty of the orientation and separately of the intensity). In the grid coverage one knows the location of the vertex point from the order of the traversal of the grid. In the Point Set coverage the location of the point must be provided using GM_Point.

Conceptually it is possible for the uncertainty coverage and the current value coverage to be of two different types, but integration of two different types of coverages involves interpolation and may be difficult, so this product specification requires that the Surface Current Coverage and the Uncertainty coverage be of the same type. This also allows the two coverages to be merged so that the uncertainty information becomes additional information within the Grid values record or the vertex point values record.

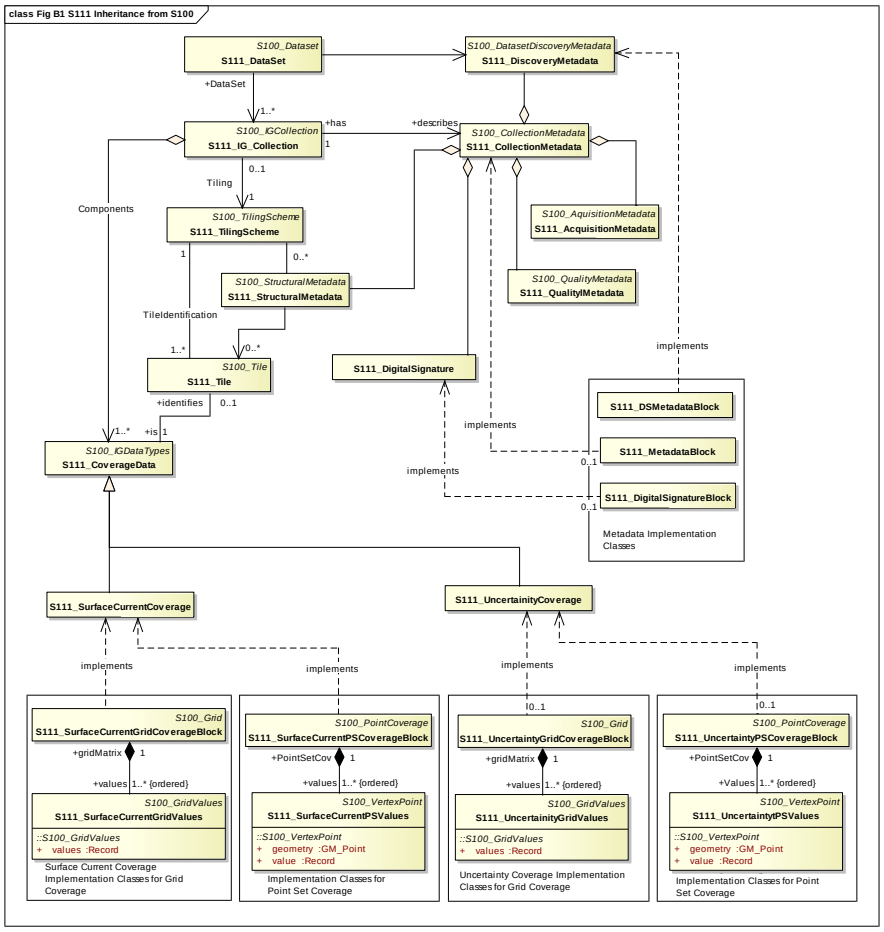

Figure B1 – S-111 Inheritance from S-100

The root class of this model is the **S111_DataSet**. This class is a subtype of the **S100_DataSet** class and represents the entire data set. The S111_DataSet class references the **S111_DiscoveryMetadata** class to carry the essential metadata that allows for identification and discovery of the data set. The S111_DataSet class also references the **S111_IG_Collection** class with a 1 to many multiplicity. This allows for multiple instances of S111 data collections, which allows for multiple tiles within a tiling scheme being included within a single data set. The description of the tiling scheme is contained in **S111_StructuralMetadata** and the identification of the tile is contained in **S111_Tile**.

An instance of the **S111_IG_Collection** is described by one instance of the **S111_CollectionMetadata**. The S111_CollectionMetadata class has as components the **S111_DiscoveryMetadata**, **S111_AcquisitionMetadata**, **S111_QualityMetadata**,

S111_StructuralMetadata and the metadata describing the **S111_DigitalSignature** information.

The classes **S111_DSMetadataBlock**, **S111_MetadataBlock**, and **S111_DigitalSignatureBlock** are implementation classes that allow the metadata to be grouped for encoding. The S111_MetadataBlock carries all the metadata that is not otherwise carried in the S111_DSMetadataBlock, and S111_DigitalSignatureBlock classes. The discovery metadata as represented by S111_DSMetadataBlock is required to be implemented in any data set.

An **S111_IG_DataCollection** class also optionally makes reference to a tiling scheme (**S111_TilingScheme**) through a multiplicity of 0..1. The details of a particular tiling scheme need to be described in an implementation profile of this generic product specification.

The class **S111_DigitalSignature** class provides encryption information which may be used to verify the authenticity of the data. The use of a Digital Signature is optional at the S-111 template application schema level. It may be used in a specific profile in order to ensure traceability of authenticity for information used for navigation. Data complying with this template application schema could be used for other purposes so the usage of the capability is not mandatory at this level. However, systems that claim to support S-111 are required to support the capability to decode and verify the data using the digital signature information.

The S111_CoverageData class is a component of the S111_IG_Collection. It carries the actual data values that drive the coverage function. Four coverages are defined, a gridded coverage for the surface current dta values and for uncertainity and also a point set coverage for the values and for uncertainity. The grid coverages are quadrilateral grid coverages. The implementation of the **S111_UncertainityGridCoverageBlock** and **S111_UncertainityPSCoverageBlock** are optional. The classes **S111_SurfaceCurrentGridValues** and the **S111_UncertainityGridValues** represent grid value matrices that contain the values that drive the surface current grid coverage function and the uncertainty grid coverage function respectively. The classes **S111_SurfaceCurrentPSValues** and the **S111_UncertainityPSValues** represent point set vertex value sets that contain the values that drive the surface current point set coverage function and the uncertainty point set coverage function respectively.

B.2.1 Application Schema Implementation Classes

The data model provides the structure of the data set and links it to S-100 and the base ISO Geographic Information standards. However, only the implementation classes need to be produced in the implementation of the surface current data set. These implementation classes are deliberately simplified so that they can easily be represented in different encoding schemes providing a high level of flexibility[7] .

Figure B-2 illustrates the combination of the values record for the S111_SurfaceCurrentValues with the S111_UncertainityValues for a grid coverage, and also the S111_SurfaceCurrentPSValues with the S111_UncertainityPSValues for a point

[7] Since there exist many different encoding formats which are widely used for Imagery and Gridded data popular within different communities of interest, it is necessary to have flexibility to accommodate the different environments in which the data may be used.

set coverage. That is, all that needs to be implemented for a surface current coverage is the coverage block that describes the parameters of the coverage (type of grid etc.) and the set of values, together with the appropriate metadata for the whole data set.

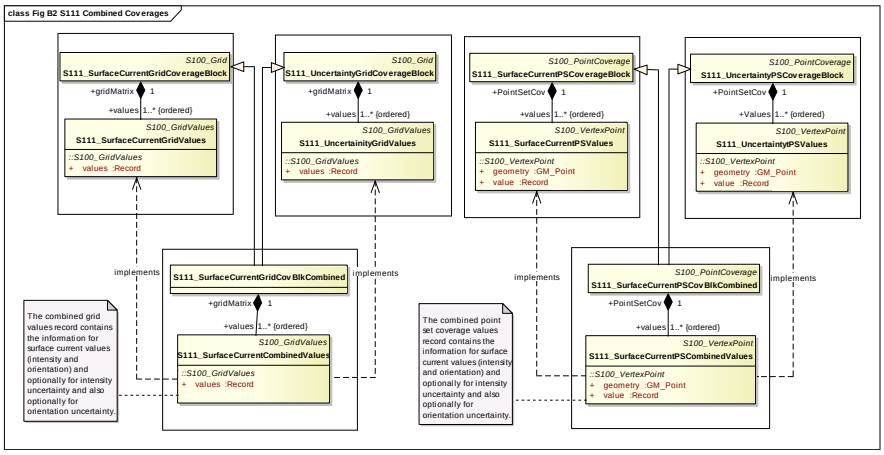

Figure B2 - S-111 Combined coverage values

The details of the implementation classes for the coverage portion of the Surface Current template application schema are shown in Figure B-3 and B-5. The attributes are shown for the coverage related classes together with the attribute classes.

Figure B-3 defines all of the attributes that need to be implemented for a gridded surface current coverage.

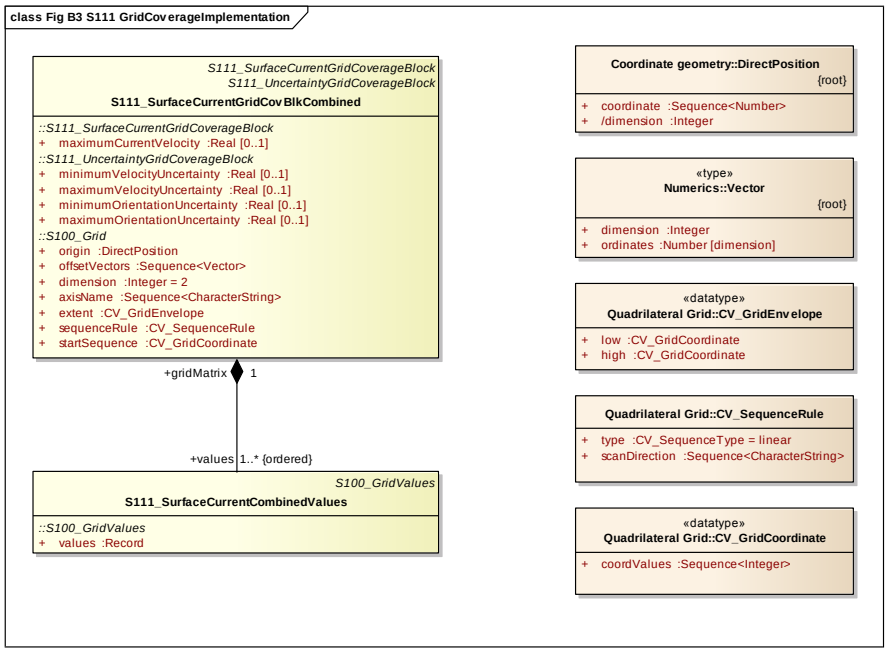

Figure B3 - S-111 Grid Coverage Implementation

The primary coverage is the surface current coverage as represented in the class **S111_SurfaceCurrentGridCoverageBlock**. This class inherits from the S-100 class S100_Grid, and adds the optional attribute **maximumCurrentVelocity** as a Real number value. The units are described in the metadata and are by default ~~Km/hr~~knots. The attributes inherited from S100_Grid describe the origin of the grid as a **DirectPosition** and the grid cell size as **offsetVectors**. The dimensionality of the grid is 2 dimensions as represented in the attribute dimension. The grid axis may be named using the attribute **axisName**. The minimum and maximum of the grid envelope are defined in the attribute extent using the attribute type **CV_GridEnvelope**. The traversal method of the grid are defined by the attributes **sequenceRule** and **startSequence**. The attribute types **CV_GridEnvelope**, **CV_SequenceRule**, and **CV_GridCoordinate** are inherited from the ISO coverage geometry standard ISO 19123 through S-100.

The class **S111_SurfaceCurrentGridValues** defines a grid value matrix as a set of records. Each record consists of an orientation and direction for the current value and optionally the uncertainty.

The secondary coverage is the optional uncertainty coverage as represented in the class **S111_UncertainityGridCoverageBlock**. This class also inherits from the S-100 class S100_Grid, and adds the attributes minimumVelocityUncertainity, maximumVelocityUncertainity and minimumOrientationUncertainity, maximumOrientationUncertainity as a Real number values. The units of the uncertainty are described in the metadata and are by default ~~Km/hr~~knots for the velocity uncertainty and decimal degrees for the angle uncertainty. The attributes inherited from S100_Grid

describe the origin, offsetVectors, dimension, axisName, extent, sequenceRule and startSequence in the same manner as per the primary coverage.

The class **S111_UncertainityGridValues** defines a grid value matrix as a set of records. Each record consists of the variance in velocity and orientation for the corresponding current value in the primary coverage.

The **S111_SurfaceCurrentGridCoverageBlock** and the **S111_UncertainityGridCoverageBlock** may be combined to form a single coverage where the values defined in **S111_SurfaceCurrentGridValues** and in **S111_UncertainityGridValues** are combined into a single record structure. This is illustrated in Figure B-4.

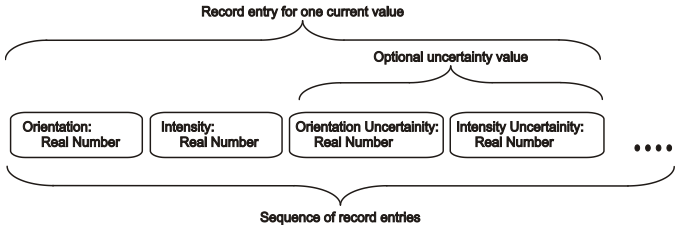

Figure B4 - S-111 Surface Current Grid Coverage Record Structure with the optional uncertainty value(s).

The structure for the Point Set coverage is similar except that additional data is required to position each point vertex. Figure B-5 defines all of the attributes that need to be implemented for a point set surface current coverage.

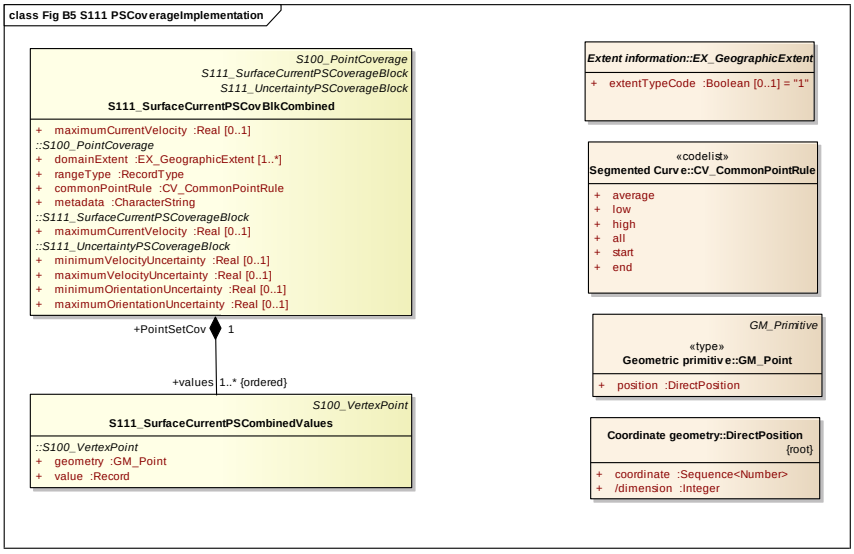

Figure B-5 - S-111 Point Set Coverage Implementation

For for the point set coverage the primary coverage is the surface current coverage as represented in the class **S111_SurfaceCurrentPSCoverageBlock**. The inheritances from S-100 are similar to that of the grid coverage except that the point set coverage inherits from **S100_PointCoverage**. The domain extent is defined by **EX_GeographicExtent**. This has a multiplicity greater than 1 so multiple areas (patches) may be defined. **CV_CommonPointRule** defines what happens when points are on boundaries and additional metadata information about the coverage can be included as a **CharacterString**.

The class **S111_SurfaceCurrentPSValues** defines a set of point values as a set of records. Each record consists of the location of the point and the orientation and direction for the current value.

The secondary coverage is the optional uncertainty coverage as represented in the class **S111_UncertainityPSCoverageBlock**. This class also inherits from the S-100 class S100_PointCoverage, and adds the attributes minimumVelocityUncertainity, maximumVelocityUncertainity and minimumOrientationUncertainity, maximumOrientationUncertainity as a Real number values. The units of the uncertainty are described in the metadata and are by default ~~Km/hr~~knots for the velocity uncertainty and decimal degrees for the angle uncertainty. The attributes inherited from S100_PointCoverage describe the domainExtent, rangeType, commonPointRule, and additional metadata in the same manner as per the primary coverage.

The class **S111_UncertainityPSValues** defines a set of point values as a set of records. Each record consists of the variance in velocity and orientation for the corresponding current value in the primary coverage.

The **S111_SurfaceCurrentPSCoverageBlock** and the **S111_UncertainityPSCoverageBlock** may be combined to form a single coverage where the values defined in **S111_SurfaceCurrentPSValues** and in **S111_UncertainityPSValues** are combined into a single record structure. This is illustrated in Figure B-6.

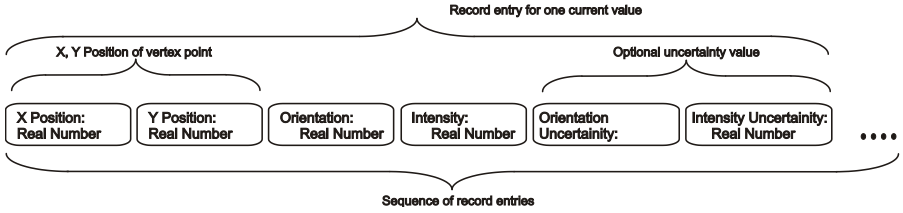

Figure B-6 - S-111 Surface Current Point Set Coverage Record Structure with the optional uncertainty value(s).

B.2.2 S111_SurfaceCurrentGridCovBlkCombined semantics

The class **S111_SurfaceCurrentGridCovBlkCombined** has the attribute **maximumCurrentVelocity**. The minimum current velocity is of course zero. These values bound the velocity attribute from the surface current coverage value attribute record from **S111_SurfaceCurrentValues** grid value matrix. The other attribute of the surface current coverage value attribute record is orientation which needs no boundary definition since it

is an angle measure from 0 to 360 degrees. This class also has the inherited attributes **origin**, **offsetVectors**, **dimension**, **axisName**, **extent**, **sequenceRule**, and **startSequence** from S100_Grid and CV_Grid. The origin is a position in a specified coordinate reference system, and a set of offset vectors specify the direction and distance between the grid lines. It also contains the additional geometric characteristics of a rectified grid.

B.2.2.1 maximumCurrentVelocity

The attribute **maximumCurrentVelocity** has the value type **Real** and describes the upper bound of the current velocity for all the velocity values in **S111_SurfaceCurrentCombinedValues** record. This attribute is optional. There is no default.

B.2.2.2 minimumVelocityUncertainty

The attribute **minimumVelocityUncertainty** has the value type **Real** and describes the lower bound of the current velocity uncertainty for all the current velocity uncertainty values in values record. This attribute is optional. There is no default.

B.2.2.3 maximumVelocityUncertainty

The attribute **maximumVelocityUncertainty** has the value type **Real** and describes the upper bound of the current velocity for all the velocity values in values record. This attribute is conditional on the existence of a value for the minimumVelocityUncertainty attribute. There is no default.

B.2.2.4 minimumOrientationUncertainty

The attribute **minimumOrientationUncertainty** has the value type **Real** and describes the lower bound of the current orientation uncertainty for all the orientation uncertainty values in values record. This attribute is optional. There is no default.

B.2.2.5 maximumOrientationUncertainty

The attribute **maximumOrientationUncertainty** has the value type **Real** and describes the upper bound of the current orientation for all the orientation values in values record. This attribute is conditional on the existence of a value for the minimumOrientationUncertainty attribute. There is no default.

B.2.2.6 origin

The attribute **origin** has the value class **DirectPosition** which is a position that locates the origin of the rectified grid in the coordinate reference system. This attribute is required. There is no default

B.2.2.7 offsetVectors

The attribute **offsetVectors** has the value class **Sequence<Vector>** that is a sequence of offset vector elements that determine the grid spacing in each direction. The data type Vector is specified in ISO/TS 19103. This attribute is required. There is no default.

B.2.2.8 dimension

The attribute **dimension** has the value class **Integer** that identifies the dimensionality of the grid. The value of the grid dimension in this product specification is **2**. This value is fixed in this product specification and does not need to be encoded

B.2.2.9 axisName

The attribute **axisName** has the value class **Sequence<CharacterString>** that is used to assign names to the grid axis. The grid axis names ~~shall~~must be "Latitude" and "Longitude" for unprojected data sets.

B.2.2.10 extent

The attribute **extent** has the value class **CV_GridEnvelope** that contain the extent of the spatial domain of the coverage. It provides the grid coordinate values for the diametrically opposed corners of the grid. This inherited attribute is optional. The default is that this value is derived from the bounding box for the data set or tile in a multi tile data set.

B.2.2.11 sequenceRule

The attribute **sequenceRule** has the value class **CV_SequenceRule** that describes how the grid points are ordered for association to the elements of the sequence values. The default value is "**Linear**". No other values are allowed.

B.2.2.11.1 startSequence

The attribute **startSequence** has the value class **CV_GridCoordinate** that identifies the grid point to be associated with the first record in the values sequence. The default value is the lower left corner of the grid. No other values are allowed.

B.2.3**S111_SurfaceCurrentCombinedValues semantics**

The class **S111_SurfaceCurrentCombinedValues** is related to S111_SurfaceCurrentGridCovCovBlkCombined by a composition relationship in which an ordered sequence of values provide data for each grid cell. The class S111_SurfaceCurrentCombinedValues inherits from S100_GridValues.

B.2.3.1 values

The attribute **values** has the values class Record which is a sequence of value items that assigns values to the grid points. There is a pair of value in each record in the S111_SurfaceCurrentCombinedValues class which provides the current velocity and orientation for the grid cell followed optionally by a single or pair of uncertainty values for that grid vertex point. See Figure B-4.

B.2.4**CV_GridEnvelope semantics**

The class **CV_GridEnvelope** provides the grid coordinate values for the diametrically opposed corners of an envelope that bounds a grid. It has two attributes.

B.2.4.1 low

The attribute **low** describes the minimal coordinate values for all grid points within the envelope. For this specification this represents the Southwestern coordinate.

B.2.4.2 high

The attribute **high** describes the maximal coordinate values for all grid points within the envelope. For this specification this represents the Northeastern coordinate.

B.2.5 **CV_GridCoordinate semantics**

The class **CV_GridCoordinate** is a data type for holding the grid coordinates of a **CV_GridPoint**.

B.2.5.1 coordValues

The attribute **coordValues** has the value class **Sequence <Integer>** that holds one integer value for each dimension of the grid. The ordering of these coordinate values ~~shall~~must be the same as that of the elements of axisNames. The value of a single coordinate ~~shall~~must be the number of offsets from the origin of the grid in the direction of a specific axis.

B.2.6 **CV_SequenceRule semantics**

The class **CV_SequenceRule** contains information for mapping grid coordinates to a position within the sequence of records of feature attribute values. It has two attributes.

B.2.6.1 type

The attribute **type** identifies the type of sequencing method that ~~shall~~must be used. A code list of scan types is provided in S-100 Part 8. Only the value "**linear**" ~~shall~~must be used in S-111, which describes scanning row by row by column.

B.2.6.2 scanDirection

The attribute **scanDirection** has the value class **Sequence<CharacterString>** a list of axis names that indicates the order in which grid points ~~shall~~must be mapped to position within the sequence of records of feature attribute values. The scan direction for all layers in S-111 is "Longitude" and "Latitude" or west to east, then south to north.

B.2.7 **DirectPosition semantics**

The class **DirectPosition** hold the coordinates for a position within some coordinate reference system.

B.2.7.1 coordinate

The attribute **coordinate** is a sequence of Numbers that hold the coordinate of this position in the specified reference system.

B.2.7.2 dimension

The attribute **dimension** in the DirectPosition class is a derived attribute that describes the length of coordinate.

B.2.8 **Vector semantics**

The class **Vector** is an ordered set of numbers called coordinates that represent a position in a coordinate system.

B.2.8.1 dimension

The attribute **dimension** in the Vector class is a derived attribute that describes the length of the sequence of vector coordinates.

B.2.8.2 ordinates

The attribute **ordinates** in the Vector class is a set of numbers (a pair in the case of the offset vectors that define the size of a cell in a grid).

B.2.9 **S111_SurfaceCurrentPSCovBlkCombined semantics**

The class **S111_SurfaceCurrentPSCovBlkCombined** has the attribute **maximumCurrentVelocity** inherited from S111_SurfaceCurrentPSCoverageBlock, **minimumVelocityUncertainity**, **maximumVelocityUncertainity**, **minimumOrientationUncertainity,** and **maximumOrientationUncertainity** inherited from S111_UncertainityPSCoverageBlock. This class also has the inherited attributes **domainExtent**, **rangeType**, **commonPointRule**, and **metadata** from S100_PointCoverage.

B.2.9.1 shared attributes

The attributes **maximumCurrentVelocity, minimumVelocityUncertainty**, **maximumVelocityUncertainty**, **minimumOrientationUncertainty** and **maximumOrientationUncertainty** are the same as those defined B.2.2.1 to B.2.2.5 respectively.

B.2.9.2 domainExtent

The attribute **domainExtent** describes the spatial extent of the domain of the coverage.

B.2.9.3 rangeType

The attribute **rangeType** describes the range of the coverage. It uses the data type RecordType specified in ISO/TS 19103. An instance of RecordType is a list of name:data type pairs each of which describes an attribute type included in the range of the coverage.

B.2.9.4 commonPointRule

The attribute **commonPointRule** describes the procedure used for evaluating the coverage at a position that falls on the boundary or in an area of overlap between geometric objects in the domain of the coverage. It takes a value from the code list

CV_CommonPointRule specified in ISO 19123. The rule ~~shall~~must be applied to the set of values that results from evaluating the coverage with respect to each of the geometric objects that share a boundary. Appropriate values of the CV_CommonPointRule include 'average', 'high', and 'low'. For example, data used for bathymetric purposes may make use of the 'high' value to ensure that obstructions such as rocks or shoals are emphasised. See S-100 Part 8 clause 7.1.2.

B.2.9.5 metadata

The attribute **metadata** provides a link to metadata that describes the coverage. Logically the link is any URI, but it may be implemented as a CharacterString data type that identifies the associated files of metadata.

B.2.10 S111_SurfaceCurrentPSCombinedValues semantics

The class **S111_SurfaceCurrentPSCombinedValues** is related to S111_SurfaceCurrentPSCovCovBlkCombined by a composition relationship in which an ordered sequence of values provide data for each grid cell. The class S111_SurfaceCurrentCombinedValues inherits from S100_VertexPoint.

B.2.10.1 geometry

The attribute **geometry** has the values class GM_Point which is a coordinate position in the coordinate reference system of the data set. See S-100 Part 7 clause 5.2.10.

B.2.10.2 values

The attribute **values** has the values class Record which is a sequence of value items that assigns values to the ~~grid~~ data points. There is a pair of value in each record in the S111_SurfaceCurrentCombinedValues class which provides the current velocity and orientation for the ~~grid cell~~data point followed optionally by a single or pair of uncertainty values for that ~~grid vertex~~data point. See Figure B-6.

B.2.11 EX_GeographicExtent semantics

The class **EX_GeographicExtent** indication of whether the bounding polygon encompasses an area covered by the data or an area where data is not present.

B.2.11.1 extentTypeCode

The attribute **extentTypeCode** is a Boolean flag which takes the value 0 – exclusion or 1 inclusion. In this case the value defined to be “1” indicating that the point set coverage is the area where data is present.

B.2.12 CV_CommonPointRule

The class **CV_CommonPointRule** is a code list which describes the procedure used for evaluating the coverage at a position that falls on the boundary or in an area of overlap between geometric objects in the domain of the coverage. The values are: average, low, high, all, start, end.

B.2.13 GM_Point semantics

The class **GM_Point** is a 0-dimension geometric primitive as defined in S-100 Part 7 clause 5.2.10. It contains the attribute **position**.

B.2.13.1 position

The attribute **position** is a coordinate position which takes the value **DirectPosition**. See S-100 Part 7 clause 5.1.2.

B.2.14 DirectPosition semantics

The class **DirectPosition** hold the coordinates for a position within some coordinate reference system.

B.2.14.1 coordinate

The attribute **coordinate** is a sequence of Numbers that hold the coordinate of this position in the specified reference system.

B.2.14.2 dimension

The attribute **dimension** in the DirectPosition class is a derived attribute that describes the length of coordinate.

B 3. Metadata Implementation Classes

The metadata elements are derived from S-100 and from the ISO standards ISO 19115 Geographic information - Metadata and ISO 19115-2 Geographic information - Metadata - Part 2: Extensions for imagery and gridded data. The data discovery metadata described in ISO 19115 is mandatory to allow the data set to be identified. This includes only a few basic pieces of information. Some additional metadata is required to locate the surface current coverage and define appropriate units of measure.

Since this is a template application schema, the option is left open for the national hydrographic offices or other producers of data to add additional metadata in their specific product specifications developed as profiles of this document by selecting metadata elements from the ISO metadata standards or from the other related ISO standards such as ISO 19130 Sensor and data models for imagery and gridded data.

Table B 1 describes the core metadata elements from ISO 19115 required for describing a geographic information data set. The codes indicate: "M" mandatory, "O" optional' "C" conditional as defined in ISO 19115. The table indicates how the ISO mandatory and conditional core metadata are handled in S-111. Reference is made to clause 8 where appropriate. Because S-111 makes use of a grid coverage some of the metadata elements that ISO 19115 identifies as optional are required in this product specification where a grid coverage is used. Also some of the metadata elements are implicit in the product specification.

Table B-1 - ISO TC211 Core Metadata as applied in S-10y

Dataset title (M) S111_DS_DiscoveryMetadata > citation > CI_Citation.title S-111 - Surface Current Data from: (MD_Metadata > MD_DataIdentification.citation > CI_Citation.title)
Metadata date stamp (M) S111_DS_DiscoveryMetadata > dateStamp from: (MD_Metadata.dateStamp)
Metadata point of contact (M) S111_DS_DiscoveryMetadata > contact from: (MD_Metadata.contact > CI_ResponsibleParty)
Abstract describing the dataset (M) S111_DS_DiscoveryMetadata > abstract from: (MD_Metadata > MD_DataIdentification.abstract)
Dataset topic category (M) S111_DS_DiscoveryMetadata > topicCategory: MD_TopicCategoryCode 012– oceans; 014– inlandWaters from: (MD_Metadata > MD_DataIdentification.topicCategory)
Spatial representation type (O) S111_DS_DiscoveryMetadata > spatialRepresentationType : MD_ SpatialRepresentationType Code 002– Grid; (quadrilateral grid coverage) from: (MD_Metadata > MD_DataIdentification.spatialRepresentationType) This metadata element is optional in ISO 19115; however, because this product specification uses a grid coverage the spatial representation type needs to be identified as a quadrilateral grid.
Spatial resolution of the dataset (O) (MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance) Since this data set is a grid coverage resolution is defined by the coveraqe grid parameters.
Dataset reference date (M) S111_DS_DiscoveryMetadata > citation > CI_Citation.date from: (MD_Metadata > MD_DataIdentification.citation > CI_Citation.date)
Dataset responsible party (O) S111_DS_DiscoveryMetadata > pointOfContact > CI_ ResponsibleParty from: (MD_Metadata > MD_DataIdentification.pointOfContact > CI_ResponsibleParty)
Geographic location of the dataset (by 4 coordinates or by geographic identifier) (C) S111_DS_DiscoveryMetadata > extent > EX_Extent from: (MD_Metadata > MD_DataIdentification.extent > EX_Extent > EX_GeographicExtent > EX_GeographicBoundingBox or EX_GeographicDescription)
Reference system (O) S111_StructureMetadataBlock > hRefSystem from: (MD_Metadata > MD_ReferenceSystem)
Lineage (C) S111_QualityMetadataBlock > S111_LI_Source and S111_QualityMetadataBlock > S111_LI_ProcessStep from: (MD_Metadata > DQ_DataQuality.lineage > LI_Lineage)
Dataset language (M) S111_DS_DiscoveryMetadata > language from: (MD_Metadata > MD_DataIdentification.language)
Dataset character set (C) set to default = "utf8". [not required when set to default from ISO 19115] from: (MD_Metadata > MD_DataIdentification.characterSet)

Distribution format (O) (MD_Metadata > MD_Distribution > MD_Format.name and MD_Format.version) Optional - not applicable to maintain the separation of carrier and content the content model does not contain any format information. This would be included in a transmittal or by file types.
On-line resource (O) (MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource) Optional - not required
Metadata file identifier (O) (MD_Metadata.fileIdentifier) Implicit in S-111 product specification reference to ISO 19115 as a normative reference
Metadata standard name (O) (MD_Metadata.metadataStandardName) Implicit in S-111 product specification reference to ISO 19115 as a normative reference
Metadata standard version (O) (MD_Metadata.metadataStandardVersion) Implicit in S-111 product specification reference to ISO 19115 as a normative reference
Metadata language (C) (MD_Metadata.language) The language is set to English. In addition additional languages may be used in accordance with the structure for handling multi-languages per ISO 19115 Annex J.
Metadata character set (C) set to default = "utf8". [not required when set to default from ISO 19115] from: (MD_Metadata.characterSet)

B.3.1 **Discovery Metadata**

Metadata is used to identify a data set so that it can be distinguished from other data sets. This is necessary so the data can be found in a catalogue service, and is particularly important for compatibility with a Catalogue Service for the Web in alignment with OGC[8] .

There is discovery data for the whole data set at the S111_DataSet level and at the S111_IG_Collection level for individual tiles for those data sets that are composed of several tiles.

The S111_DiscoveryMetadataBlock has two subtypes S111_DS_DiscoveryMetadata and S111_Tile_DiscoveryMetadata. This is shown in Figure B-7. The only difference is that the hierachyLevel code is set to "dataset" for the whole data set and "tile" for a tile. These two classes implement the metadata classes from ISO 19115. These implementation classes have been developed corresponding to each of the ISO 19115 classes that have been referenced in which only the applicable attributes have been included. The classes S111_DS_DiscoveryMetadata and S111_Tile_DiscoveryMetadata inherit their attributes from these S-111 specific implementation classes which implement the ISO 19115 MD_Metadata, MD_Identification, and MD_DataIdentification classes.

This model provides the minimum set of metadata for a Surface Current coverage data product. Any of the additional optional metadata elements from the source ISO 19115 metadata standard and from S-100 Part 4 can also be included.

[8] Open Geospatial Consortium < http://www.opengeospatial.org/ >

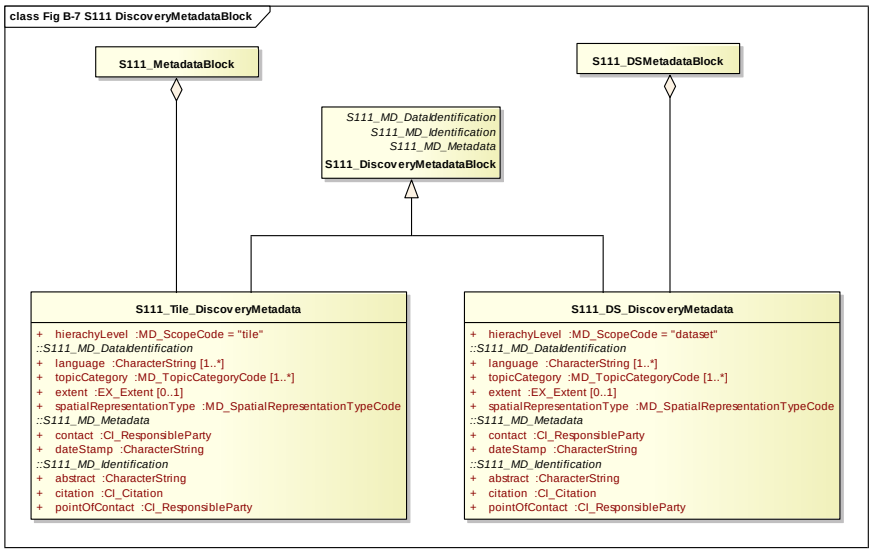

Figure B-7 - S-111 Discovery Metadata Block

Table B-2 provides a description of each attribute of the S111_DiscoveryMetadataBlock class attributes.

Table B-2 - Discovery Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S111_DiscoveryMetadataBlock	Container class for discovery metadata	-	-	
Class	S111_DS_DiscoveryMetadata	Container class for discovery metadata related to an entire data set	-	-	
Class	S111_Tile_DiscoveryMetadata	Container class for discovery metadata related to a particular tile when there are multiple tiles in a data set.	-	-	
attribute	hierachyLevel		1	MD_ScopeCode	"dataset" for S111_DS_DiscoveryMetadata or "tile" for S111_Tile_DiscoveryMetadata
attribute	contact	party responsible for the metadata information	1	CI_ResponsibleParty	
attribute	dateStamp	date that the metadata was created	1	CharacterString	
attribute	abstract	brief narrative summary of the content of the resource(s)	1	CharacterString	
attribute	citation	citation data for the resource(s)	1	CI_Citation	CI_Citation <<DataType>> Required items are Citation.title,

Role Name	Name	Description	Cardin-ality	Type	Remarks
					& Citation.date,
attribute	pointOfContact	identification of, and means of communication with, person(s) and organization(s) associated with the resource(s)	1	CI_ResponsibleParty	CI_Responsible Party <<DataType>>
attribute	language	language(s) used within the dataset	1-*	CharacterString	ISO 639-2 list of languages, default "English" plus others as used.
attribute	topicCategory	main theme(s) of the dataset	1-*	MD_TopicCategoryCode	MD_TopicCategoryCode <<Enumeration>> 006– elevation; 012– oceans; 014– inlandWaters
attribute	extent	extent information including the bounding box, bounding polygon, vertical, and temporal extent of the dataset	0-1	EX_Extent	EX_Extent <<DataType>>
attribute	spatialRepresentationType	method used to spatially represent geographic information	1	MD_SpatialRepresentationTypeCode	MD_SpatialRepresentation TypeCode <<CodeList>> 002– Grid;

B.3.2 **DiscoveryMetadataBlock semantics**

The class **S111_DiscoveryMetadataBlock** is a container class for discovery metadata. It has two subtypes, S111_Tile_DiscoveryMetadata and S111_DS_DiscoveryMetadata. Both classes are identical except for the heirachyLevel attribute, which is "tile" for the tile discovery metadata and "dataset" for the dataset discovery metadata. That is, the same discovery metadata applies to a single tile of data or a whole dataset comprised of several tiles. The meaning of each attribute described in Table B-2.

Figure B-8 illustrates the support classes taken from the ISO 19115 Geographic information - Metadata standard, referenced by the discovery metadata attributes.

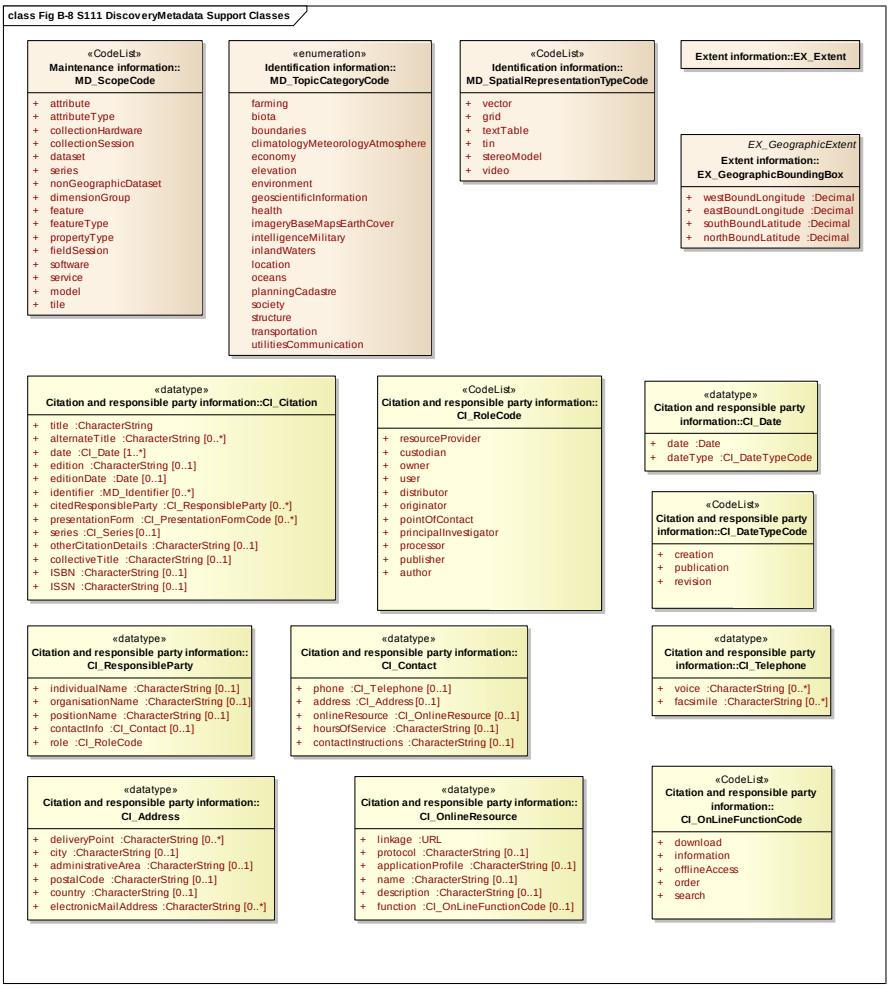

Figure B-8 - S-111 Discovery Metadata Support Classes

B.3.2.1 MD_SupportCode

The code list **MD_SupportCode** is taken from ISO 19115 and it provides the permissible data values to the attribute heirachyLevel. Only the two codes "dataset" and "tile" are used from the code list.

B.3.2.2 MD_TopicCategoryCode

The enumeration **MD_TopicCategoryCode** is taken from ISO 19115 and it provides the permissible data values to the optional attribute toipcCategory. Only the codes "oceans" and "inlandWaters" apply from the enumeration.

B.3.2.3 MD_SpatialRepresentationTypeCode

The code list **MD_SpatialRepresentationTypeCode** is taken from ISO 19115 and it provides the permissible data values to the attribute spatialRepresentationType. Only the codes "grid" applies from the code list. The code list does yet not have a value for point set coverage.

B.3.2.4 EX_GeographicExtent semantics

The class **EX_GeographicExtent** is a metadata class from ISO 19115. It is a component of the metaclass EX_Extent. The use of EX_Extent is optional. When used it describes the spatial boundaries of the surface current (and optionally associated uncertainty) coverage(s) within the bounds established by CV_GridEnvelope for the S111_Surface Current coverage. That is the extent of the data may be a portion of the area defined by the grid coverage.

B.3.2.5 EX_GeographicBoundingBox semantics

The class **EX_GeographicBoundingBox** is a metadata class from ISO 19115. It is a subtype of the abstract class EX_GeographicExtent. It defines a bounding box used to indicate the spatial boundaries of the surface current data. It has four attributes

B.3.2.5.1 westBoundLongitude

The attribute **westBoundLongitude** is a coordinate value providing the west bound longitude for the bound.

B.3.2.5.2 eastBoundLongitude

The attribute **eastBoundLongitude** is a coordinate value providing the west bound longitude for the bound.

B.3.2.5.3 southBoundLongitude

The attribute **southBoundLongitude** is a coordinate value providing the south bound longitude for the bound.

B.3.2.5.4 northBoundLongitude

The attribute **northBoundLongitude** is a coordinate value providing the north bound longitude for the bound.

B.3.2.6 CI_Citation semantics

The class **CI_Citation** is a class from ISO 19115. It defines the information required to cite a resource (tile or data set). The attribute CI_Citation:title carries the Data set title. This is a mandatory metadata element as identified in Table B 1. The attribute CI_Citation:date carries the reference date and associated CI_DateTypeCode identifying the type of date. This is a mandatory metadata element as identified in Table B 1. There are 13 attributes of CI_Citation: title, alternateTitle, date, edition, editionDate, identifier, citedResponsibleParty, presentationForm, series, otherCitationDetails, collectiveTitle,

ISBN: and ISSN. The attributes of CI_Citation, other than title and date are optional or do not apply in S111.

B.3.2.6.1 title

The attribute **title** is a character string that is used to carry a title for the data set or tile.

B.3.2.6.2 date

The attribute **date** is used to carry a date for the data set or tile. The date makes use of the class CI_Date which includes both the date and the type of date.

B.3.2.6.3 CI_Date semantics

The class **CI_Date** is a class from ISO 19115, which defines reference date information. It has two attributes a Date basic type, and a CI_Date code to describe the type of date.

B.3.2.6.4 CI_DateTypeCode semantics

The class **CI_DateTypeCode** is a code list from ISO 19115, which defines the type of date. Only the type "creation" applies in S111.

B.3.2.6.5 CI_ResponsibleParty semantics

The class **CI_ResponsibleParty** is a class from ISO 19115, which allows a responsible party to be identified. It has five attributes: individualName, organisationalName, positionName, contactInfo, and role. A profile of this template application scheme, developed by a national hydrographic office or other producer will select which of these attributes are appropriate for the surface current data that they are producing. All of the attributes are optional except the attribute role, which take a code from the code list CI_RoleCode. The optional attributes individualName, organisationalName, and positionName, are character strings. The optional attribute contactInfo is described by the class CI_Contact.

B.3.2.6.6 CI_Contact semantics

The class **CI_Contact** is a class from ISO 19115, which is used to identify a contact resource. It allows different methods of identifying a contact so all of its attributes are optional. It has five attributes phone, address, onlineResource, hoursOfService, and contactInstructions. The attributes hoursOfService, and contactInstructions are represented as character strings. The attribute phone is described by the class CI_Telephone, the attribute address is described by the class CI_Address, and the attribute onlineResource is described by the class CI_OnlineResource,

B.3.2.6.7 CI_Telephone semantics

The class **CI_Telephone** is a class from ISO 19115, which is used to identify a telephone resource. It has two optional attributes voice, and facsimile. The attributes are represented as character strings and contain phone numbers.

B.3.2.6.8 CI_Address semantics

The class **CI_Address** is a class from ISO 19115, which is used to identify a physical or electronic mailing address. It has six attributes: deliveryPoint, city, administrativeArea, postalCode, country, and electronicMailAddress. Its attributes form an address, either a postal address or an electronic address. All of the attributes are optional since different ones are used together to describe an address.

B.3.2.6.9 CI_OnlineResource semantics

The class **CI_OnlineResource** is a class from ISO 19115, which is used to identify an online resource. It has six attributes: linkage, protocol, applicationProfile, name, description, and function. Its attributes form an address, either a postal address or an electronic address. All of the attributes are optional since different ones are used together to describe an address. The attributes protocol, applicationProfile, name, and description are represented as character strings. The attribute linkage is a URL basic type. The attribute function is described by the code list CI_OnLineFunctionCode.

B.3.2.6.10 CI_OnLineFunctionCode semantics

The class CI_OnLineFunctionCode is a code list from ISO 19115, which is used to identify the type of an on-line resource.

B.3.3 Metadata Block Implementation Class

The Metadata Block implements the **S111_Collection** Metadata class. This class aggregates the S111_StructuralMetadata, the S111_AcquisitionMetadata, the S111_QualityMetadata as well as the S111_DiscoveryMetadata and S111_DigitalSignature classes. The discovery metadata and the optional digital signature are handled as separate metadata implementation blocks, however, since they can be components of the S111_CollectionMetadata class it is possible to repeat any discovery metadata element or use a digital signature on a portion of an IG collection.

B.3.3.1 Structure Metadata component

The Structure metadata is used to describe the structure of an instance of a collection, including any reference to a tiling scheme. Since constraints can be different on separate files (for example they could be derived from different legal sources), or security constraints may be different, the constraint information becomes part of the structure metadata. The other structure metadata is the grid representation and the reference system.

Figure B-9 illustrates the S111 Structural Metadata component together with the support classes taken from the ISO 19115 Geographic information - Metadata standard, referenced by the discovery metadata attributes. Since the S111 Structural metadata component is generated by the inheritance of attributes from a number of ISO 19115 metadata classes, and the S-100 class for tiling this metadata block becomes a simple table.

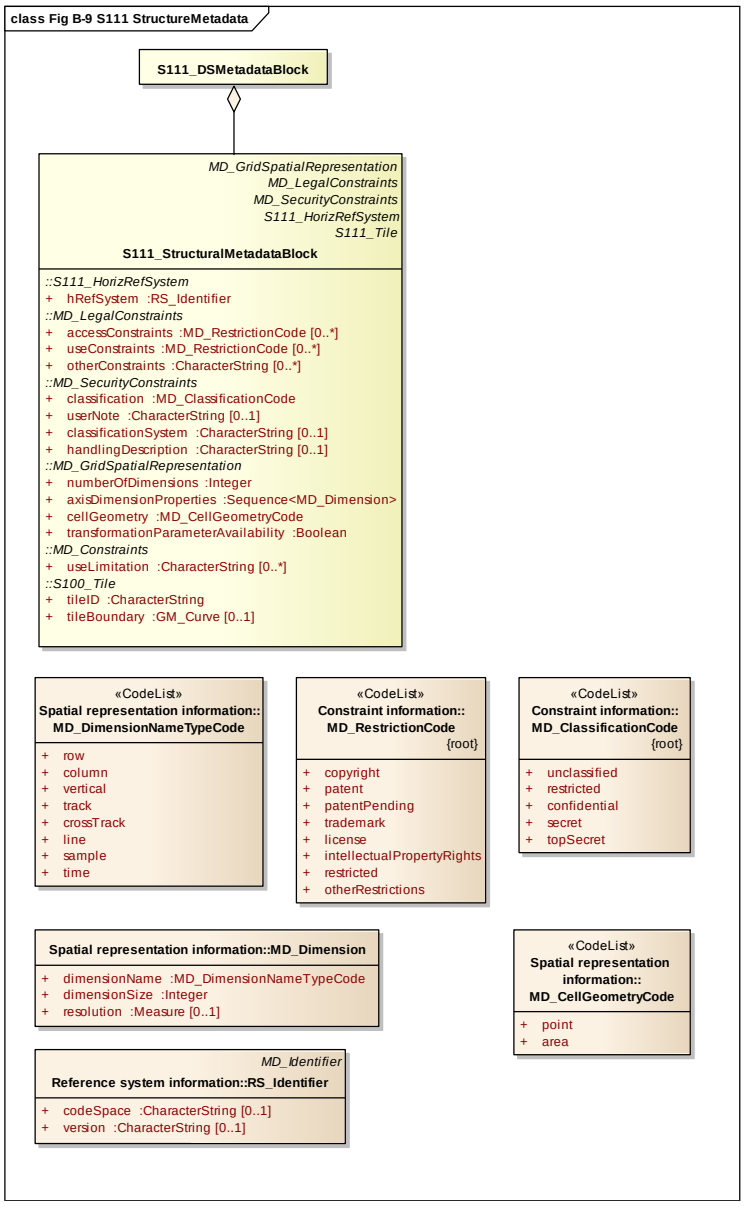

Figure B-9 - S111 Structural Metadata

Table B-3 provides a description of each attribute of the S111_StructureMetadataBlock class attributes.

~~Table B-3 – Structural Metadata Block description~~

B.3.3.2 MD_SupportCode

The code list **MD_SupportCode** is taken from ISO 19115 and it provides the permissible data values to the attribute heirachyLevel. Only the two codes "dataset" and "tile" are used from the code list.

Table B-3 - Structural Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S111_StructuralMetadataBlock	Container class for structural metadata	-	-	
attribute	*unitsOfVelocity*	units of measure for velocity attribute of surface current coverage	0-1	UomVelocity	default "~~Km/h~~knots"
attribute	*unitsOfAngle*	units of measure for angle attribute of surface current coverage	0-1	UomAngle	default "decimal degrees"
attribute	*UnitsOfUncertainityForVelocity*	measure of uncertainty for velocity	0-1	CharacterString	required if the Uncertainty component of the combined coverage exists, because there is no default
attribute	*UnitsOfUncertainityForAngle*	measure of uncertainty for angle	0-1	CharacterString	required if the Uncertainty coverage exists, because there is no default
attribute	numberOfDimensions	number of independent spatialtemporal axes	1	Integer	default = 2 No other value is allowed.
attribute	axisDimensionProperties	information about spatial-temporal axis properties	1	MD_Dimension	MD_Dimension <<DataType>> dimensionName and dimensionSize
attribute	cellGeometry	identification of grid data as point or cell	1	MD_CellGeometryCode	MD_CellGeometryCode default = point No other value is allowed.
attribute	transformationParameterAvailability	indication of whether or not parameters for transformation between image coordinates and geographic or map coordinates exist (are available)	1	Boolean	1 = yes 0 = no Mandatory and must be 1.
attribute	vRefSystem	name of vertical reference system	1	RS_Identifier	reference system vertical information, can also be defined explicitly by use of the parameters in

Role Name	Name	Description	Cardin-ality	Type	Remarks
					19111
attribute	hRefSystem	name of horizontal reference system	1	RS_Identifier	default = WGS84. reference system horizontal information, can also be defined explicitly by use of the parameters in 19111 or by the HORDAT attribute values
attribute	accessConstraints	Access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the dataset.	0-*	MD_RestrictionCode	
attribute	useConstraints	Constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the dataset	0-*	MD_RestrictionCode	
attribute	otherConstraints	Other restrictions and legal prerequisites for accessing and using the dataset	0-*	CharacterString	
attribute	classification	Name of the handling restrictions on the dataset	1	MD_ClassificationCode	
attribute	userNote	Additional information about the classification	0-1	CharacterString	
attribute	classificationSystem	Name of the classification system	0-1	CharacterString	
attribute	handlingDescription	Additional information about the restrictions on handling the dataset	0-1	CharacterString	
attribute	tileID	tile identifier	1	CharacterString	
attribute	tileBoundary	tile boundary	0-1	GM_Curve	When not provided is assumed to be the extent of the collection as defined by EX_Extent
Class	MD_Dimension	Axis properties	-	-	
attribute	dimensionName	name of axis	1	MD_DimensionTypeCode	Defaults are "row" and "column" Not other value is allowed.
attribute	dimensionSize	number of elements along the axis	1	Integer	

Role Name	Name	Description	Cardin-ality	Type	Remarks
attribute	resolution	degree of detail in the grid dataset	0-1	Measure	value= number

B.3.4 **S111_StructuralMetadata semantics**

The class **S111_StructuralMetadata** is a container class for structural metadata. It has four attributes related to the two coverages: unitsOfVelocity, unitsOfAngle, UnitsOfUncertainityForVelocity and UnitsOfUncertainityForAngle and has 13 attributes inherited from the ISO 19115 MD metadata classes MD_GridSpatialRepresentation, MD_LegalConstraints, MD_SecurityConstraints, MD_Constraints, and the S-100 class S100_Tile and an S111 implementation of the ISO 19115 MD_ReferenceSystem. The description of the grid is done through the attributes inherited from MD_GridSpatialRepresentation. These attributes are: numberOfDimensions, axisDimensionProperties, cellGeometry, and transformationParameterAvailable. The attribute numberOfDimensions takes on the type basic Integer. The attribute axisDimensionProperties is a sequence of MD_Dimension class instances. The attribute cellGeometry takes on code MD_CellGeometryCode. The attribute transformationParameterAvailable takes on the type basic Boolean.

The attributes unitsOfVelocity, unitsOfAngle, UnitsOfUncertainityForVelocity and UnitsOfUncertainityForAngle are optional and describe the coverages. If the attributes unitsOfVelocity, or unitsOfAngle, are not included then their defaults "~~Km/h~~knots" and "decimal degrees oriented in a positive mathematical sense from the X (easting) axis" apply. The attributes UnitsOfUncertainityForVelocity and UnitsOfUncertainityForAngle are optional only because the uncertainity coverage is optional. They are required if the uncertainity coverage is provided because there is no default.

The description of legal constraints is done through the attributes inherited from MD_LegalConstraints. These attributes are: accessConstraints, useConstraints, and otherConstraints. The optional attribute accessConstraints takes on a code from MD_RestrictionCode. The optional attribute useConstraints also takes on a code from MD_RestrictionCode. The attribute otherConstraints is a character string.

The description of security constraints is done through the attributes inherited from MD_SecurityConstraints. These attributes are: classification, userNote, classificationSystem, and handlingDescription. The attribute classification takes on a code from MD_ClassificationCode. Note that a classification code is mandatory. It is necessary to state that a data set is unclassified if there is no classification. However a profile of this template application scheme may assign a default value to the classification code such as unclassified. The optional attribute classificationSystem is a character string. The optional attribute handlingDescription is a character string.

The description of general constraints is done through the attributes inherited from MD_Constraints. This optional attributes is: useLimitations which is a character string.

The description of the horizontal reference system is done through an S-111 implementation of the ISO 19115 RS_Identifier class. There is one attribute inherited which is RS_Identifier.

The structural metadata relating to the tiling system is done through two attributes inherited from S-100_Tile. These attributes are: tileID and optionally tileBoundary. The attribute tileID is a character string. The attribute tileBoundary takes on the type GM_Curve, from the ISO 19107 Spatial Schema standard.

B.3.4.1 unitsOfVelocity

The optional attribute **unitsOfVelocity** describes units of measure for the velocity attribute of surface current coverage and has the default "~~Km/h~~knots".

B.3.4.2 unitsOfAngle

The optional attribute **unitsOfAngle** describes units of measure for the angle attribute of surface current coverage and has the default "decimal degrees".

B.3.4.3 unitsOfUncertaintyForVelocity

The conditional attribute **unitsOfUncertaintyForVelocity** describes measure of uncertainty for velocity and is required if the Uncertainty coverage component of the combined coverage exists, because there is no default.

B.3.4.4 unitsOfUncertaintyForAngle

The conditional attribute **unitsOfUncertaintyForVelocity** describes units of measure of uncertainty for angle and is required if the Uncertainty coverage component of the combined coverage exists, because there is no default.

B.3.4.5 MD_Dimension semantics

The class **MD_Dimension** is a class from ISO 19115, which is used to identify the name, size and optionally resolution of a dimension. The attributes are dimensionName, dimensionSize, and resolution. The attribute dimensionName takes on a value from MD_NameTypeCode. The attribute dimensionSize, is represented by the basic type Integer. The optional attribute resolution takes on the type Measure form ISO 19103 units of measure.

B.3.4.6 MD_DimensionNameTypeCode semantics

The class **MD_DimensionNameTypeCode** is a code list from ISO 19115, which is used to identify the type of a dimension.

B.3.4.7 MD_CellGeometryCode semantics

The class **MD_CellGeometryCode** is a code list from ISO 19115, which is used to identify whether a cell represents a point or an area.

B.3.4.8 MD_RestrictionCode semantics

The class **MD_RestrictionCode** is a code list from ISO 19115, which is used to identify the type of a restriction.

B.3.4.9 MD_ClassificationCode semantics

The class **MD_ClassificationCode** is a code list from ISO 19115, which is used to identify a security classification.

B.3.4.10 RS_Identifier semantics

The class **RS_Identifier** is a class from ISO 19115, which is used to identify reference system information. The attributes are codeSpace, and version both of which are represented as character strings.

B.3.5 Quality Metadata component

The Quality metadata optionally describes the quality of the surface coverage data. Quality may be described in two ways. The first is a documentation of the steps used to produce the data. This is done by recording the lineage of the data. This is done by using the ISO 19115 metadata element DQ_Quaity. The attribute scope allows for a description of the type of the quality description and its extent if the quality is different for different parts of the data set. The quality may be described either for the whole data set, using the MD_ScopeCode "dataset" It is also possible to use the quality metadata to describe aspects of the collection or software processing of the data. The stage of processing that has been applied to the data is part of the quality description of the data.The actual lineage information is described using the attribute description of the class S111_LI_Source as a textual description, with a citation of the person or organization assessing the quality.

The second method of optionally describing quality is using the supplementary uncertainty coverage as described under S111_UncertaintyCoverageBlock. In this case the S111_QualityMetadataBlock would carry the indication of which particular attribute, such as the velocity and/or orientation of the current measure in the S111_QualityMetadataBlock scope attribute using the using the "attribute" and "attributeType" MD_ScopeCode.

The elements of the Quality Metadata component are described in Figure B-10. This shows the S111_QualityMetadataBlock and S111_LI_Source classes.

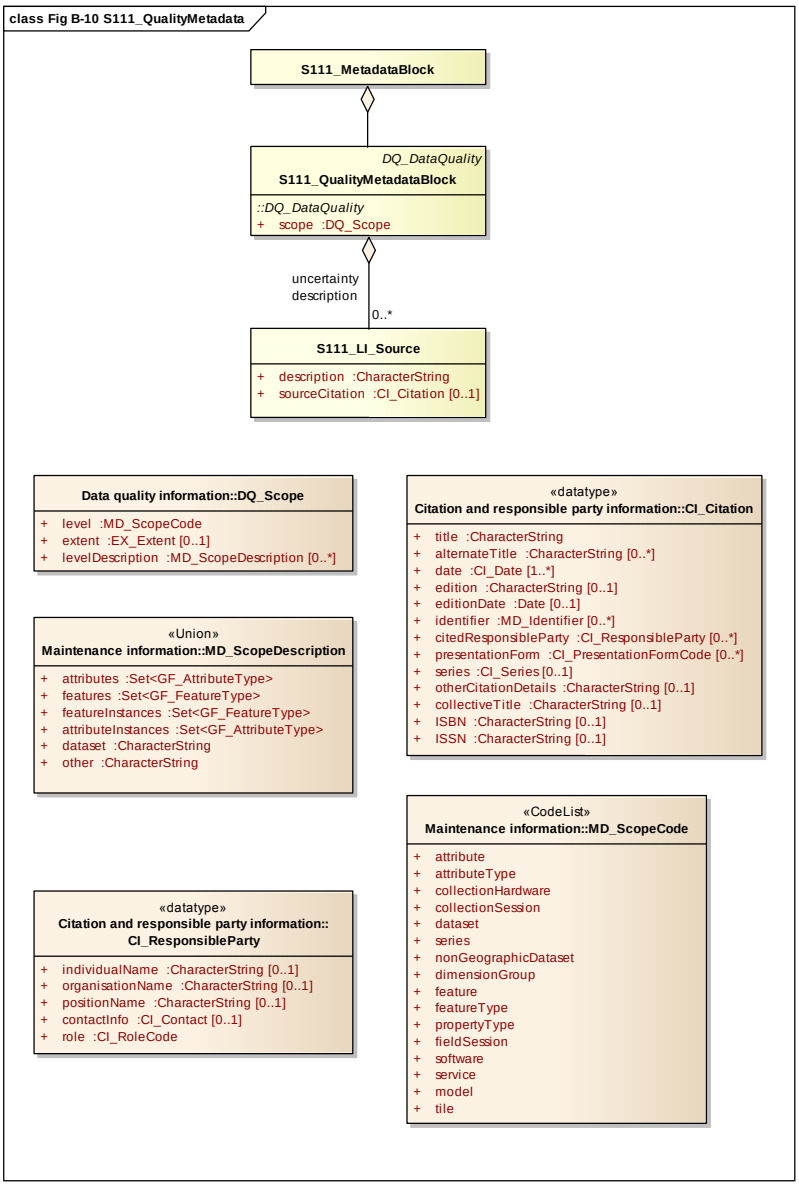

Figure B-10 - S-111 Quality Metadata Component

Table B-4 provides a description of each attribute of the S111_QualityMetadataBlock class attributes.

Table B-4 - Quality Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S111_QualityMetadataBlock	Container class for quality metadata	-	-	
attribute	scope	extent of characteristic(s) of the data for which quality information is reported	1	DQ_Scope	
Class	S111_LI_Source	information about the source data used in creating the data specified by the scope	-	-	
attribute	description	detailed description of the level of the source data	1	CharacterString	
attribute	sourceCitation	recommended reference to be used for the source data	0..1	CI_Citation	
Class	DQ_Scope	Container class for quality metadata	-	-	
attribute	level	hierarchical level of the data specified by the scope	0-*	MD_ScopeCode <<CodeList>>	"dataset" or "tile" or a specific "attribute" or "attributeType" such as current velocity and/or orientation.
attribute	extent	information about the horizontal, vertical and temporal extent of the data specified by the scope	0-*	EX_Extent <<DataType>>	Used only if the extent of the data is different from the EX_Extent given for the collection / tile
attribute	levelDescription	detailed description about the level of the data specified by the scope	1	MD_ScopeDescription <<Union>>	If there is an uncertainty coverage, this attribute provides the capability for a full description of the coverage.

B.3.6 **S111_QualityMetadataBlock semantics**

The class **S111_QualityMetadataBlock** is a container class for quality metadata. It has one attribute scope inherited from the ISO 19115 DQ_Quality.

B.3.6.1 scope

The attribute **scope** is used to carry a description of the extent of characteristic(s) of the data for which quality information is reported. The date makes use of the class DQ_Scope which includes the type, extent and description.

B.3.7 **S111_LI_Source semantics**

The class **S111_LI_Source** is a class which implements the ISO 19115 class LI_Source. It has two attributes description and optionally sourceCitation.

B.3.7.1 description

The attribute **description** is a character string that is used to carry a detailed description of the level of the source data.

B.3.7.2 sourceCitation

The attribute **sourceCitation** is used to carry a reference to be used for the source data description.

B.3.7.3 DQ_Scope semantics

The class **DQ_Scope** is a class from ISO 19115 class which describes quality metadata. It has three attributes: level, extent and levelDescription. The attribute level describes the level to which the quality metadata applies. It is either identifies that the quality applies to a "dataset" or "tile" or a specific "attribute" or "attributeType" such as current velocity and/or orientation. The optional attribute extent describes the extent to which the quality description applies if it is different that the from the EX_Extent given for the entire collection / tile. The optional attribute levelDescription provides a detailed description about the level of the data specified by the scope. If there is an uncertainty coverage, this attribute provides the capability for a full description of the coverage.

B.3.7.4 MD_ScopeDescription semantics

The class **MD_ScopeDescription** is a class from ISO 19115 which allows for the description of the metadata scope. It has six attributes: attributes features, featureInstances, attributeInstances, dataset, and other. The attributes: attributes, dataset, and other are applicable to S-111. Particular attributes such as velocity and orientation can be identified in an uncertainty coverage, or the whole data set may be identified.

B.3.7.5 MD_ScopeCode semantics

The class **MD_ScopeCode** is a code list from ISO 19115 which provides a list types of quality information. The codes "attribute", "attributeType", "dataset" and "tile" are applicable to S-111.

B.3.8 **Acquisition Metadata component**

Acquisition metadata is optional in S111. A producer or national hydrographic office may add acquisition metadata to a Surface Current Product Specification profile that they are developing nationally. The classes derive from ISO 19115, 19115-2, and 19130.

B.3.9 **Tiling Scheme**

A Tiling scheme decomposes an area of interest into smaller more manageable chunks of data each of which is a separate coverage with associated metadata. A Tiling scheme is a

second higher level discrete grid coverage where the tiles are the value items of the discrete coverage. As such a tiling scheme requires a complete description as a coverage.

The tiling scheme does not have to be described with the data set, but it is necessary that the data set be able to index into the tiling scheme, and that the tiling scheme be well documented and able to be referenced. The tiling scheme derives from S-100 and is not described in this template product specification. A profile of this specification could include an explicit tiling scheme or it could reference a common tiling scheme for a data series of several types of data that build upon a base set of data such as an ENC.

B.3.10 Digital Signature Block Implementation Class

The Digital Signature Block provides a method of ensuring that the data in a Surface Current data set is actually the data issued by a hydrographic office or other authority. came from an appropriate authority, and also that there were no inadvertent data errors introduced in the transmission. The Digital Signature Block mechanism used in S-111 is based on that used in S-102 for bathymetry data. The main difference is that in S-111, for Surface Currents, the Digital Signature Block is optional. The Digital Signature Block provides an assurance that the data set is suitable as an aid to safe navigation.

The S111_DigitalSignatureBlock is an implementation class corresponding to the class S111_DigitalSignature. It is a component of the S111_CollectionMetadata.

The basic entity of the DSS is the Digital Signature (DS), a multi-byte sequence of digits computed from the contents of the S-10y Data Set (i.e. the contents of the encoded data file) and knowledge of the secret key (SK), belonging to the person or entity signing the data product, known as the Signature Authority (SA). The SK is known only to the SA, and as the name suggests should be kept confidential since knowledge of the SK would allow anyone to certify the data product as if they were the SA. The DS value can be shown to be probabilistically unique for the contents of the data set and the SK in the sense that, with vanishingly small probability, no two data sets would generate the same DS with a particular SK, and no two SKs would generate the same DS with the same content.

Corresponding to the SK, there is a public key (PK) that can be distributed freely. There is no way to compute the DS using the PK. However, given a data set and a DS purported to have been constructed with the SK, it is simple to verify whether the data set content has changed, or if another SK was used to construct the certification. This technique is called "public key encryption" and is widely used in many communications systems.

Appendix C - **Feature Catalogue**

(Normative)

C 1. Feature catalogue

C .1.1. Name

Surface Current Coverage Feature Catalogue

C .1.2. Scope

Since coverages are a type of feature, this feature catalogue contains ~~one~~ two element~~s~~, the Surface Current coverage feature~~.~~ and the optional uncertainity .coverage feature.

C .1.3. Version number

1.0

C .1.4. Version Date

2014-03-31

C .1.5. Producer

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

See clause 5.6

C .1.6. Language

This feature catalogue is available in:

eng – English

C .1.7. Feature Catalogue Entries

~~One~~ Two ~~entry~~ entries exist~~s~~ for the Surface Current Feature Catalogue corresponding to the surface current coverage and the uncertainty coverage.

IHO Definition: **CURRENT (Water Current):** a set of value items required to define a coverage data set representing the orientation and intensity (direction and speed) of the current, (S-111 clause 5.3.1).

S-111 Geo Feature: ~~Navigationally Significant~~ Surface Currents
Primitives: S-100_Grid and S-100_PointCoverage

S-111 Attribute	Allowable Encoding Value	Type	Multiplicity
Intensity (Velocity)		C	1,1
Intensity Value		(S) RE	1,1
Intensity Units	1: Metres per second 2: Kilometres per hour 3: Miles per hour 4: Nautical miles per hour (knots)	(S) EN	1,1
~~Intensity Uncertainty~~		~~C~~	~~0,1~~
~~Intensity Uncertainty Value~~		~~(S) RE~~	~~0,1~~
~~Intensity Uncertainty Units~~	~~1: Metres per second~~ ~~2: Kilometres per hour~~ ~~3: Miles per hour~~ ~~4: Nautical miles per hour (knots)~~	~~(S) EN~~	~~0,1~~
Orientation		C	1,1
Azimuth Degrees		(S) RE	1,1
~~Orientation Uncertainty~~		~~C~~	~~0,1~~
~~Azimuth Degrees~~		~~(S) RE~~	~~0,1~~
Type		C	1,1
Composition	1: Tidal 2: Total	(S)EN	1,1
Character	1: Prediction (Tide only) 2: Observation 3: Forecast (Tide plus meteorological and other forcing)	(S)EN	1,1
Source		C	1,1
Country		TE	1,1
Agency (or Entity)		TE	1,1
Sub-clause heading(s)			

IHO Definition: **CURRENT (Water Current) Uncertainity:** a set of value items required to define a coverage data set representing the uncertainty for orientation and intensity (direction and speed) of the current, (S-111 clause 5.3.1).

S-111 Geo Feature: Surface Currents
Primitives: S-100_Grid and S-100_PointCoverage

S-111 Attribute	Allowable Encoding Value	Type	Multiplicity
Intensity (Velocity) Uncertainty		C	1,1
Intensity Uncertainty Value		(S) RE	1,1
Intensity Uncertainty Units	1: Metres per second 2: Kilometres per hour 3: Miles per hour 4: Nautical miles per hour (knots)	(S) EN	1,1
Orientation Uncertainty		C	1,1

Azimuth Uncertainty in Degrees		(S) RE	1,1
Type		C	1,1
Composition	1: Tidal 2: Total	(S)EN	1,1
Character	1: Prediction (Tide only) 2: Observation 3: Forecast (Tide plus meteorological and other forcing)	(S)EN	1,1
Source		C	1,1
Country		TE	1,1
Agency (or Entity)		TE	1,1
Sub-clause heading(s)			