Submission to the

IHO Transfer Standard and Maintenance Sub Committee (TSMAD) for a proposed new auxiliary layer product specification (S.10y) for

Navigationally Significant

Surface Currents

Submitted by the

Canadian Hydrographic Service

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Navigationally Significant Surface Currents
Product Specification S.10y

Forward

This document describes a proposed **Navigationally Significant Surface Current Product Specification** S-10y. Surface currents address the currents of relevance to navigation that appear in the top 0 up to 10 meters of the water column. This is represented as a regular two dimensional grid coverage with values of orientation and intensity (direction and speed of the current) at each grid point. The purpose of this product specification is as an auxiliary aid to navigation.

This surface current product specification is separate from a volumetric current representation that would represents currents in a three dimensional volume. Such a volumetric current representation would be addressed in a separate product 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. Since the content and encoding are separated, different encodings are permitted for the same data for use in different situations.

Navigationally Significant Surface Currents
Product Specification S.10y

Introduction

The understanding of surface currents is an important factor in safety of navigation since currents affect the motion of vessels. This information is auxiliary information that complements the ENC. Surface currents have an important effect on ship management and route planning since currents effect the amount of fuel used and therefore costs involved for a voyage.

In the ocean, surface currents are primarily wind driven or driven by the deeper primary ocean currents. Near the shore or in rivers, bays or estuaries surface currents are driven by the tides and the flow of rivers. In shallower areas the geometry of the adjacent land and the local bathymetry can have a large effect upon the direction and intensity of currents. Real-time knowledge of currents is of great use to the mariner allowing for more efficient and safe navigation (fuel economy, ice movement predictions, etc).

This document is an S-100 compliant product specification for surface current products. Surface currents are represented as a gridded coverage. A value representing the orientation and intensity (direction and speed of the current) at each vertex point in a grid coverage is used to describe the current coverage function. This is illustrated in Figure 1.

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

This document has a similar structure to that used in S.102 - Bathymetric Surface Product Specification. Surface Current data may be used alone or may be combined with 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.

A single surface is represented as a quadrilateral grid coverage structure as defined in S-100 Part 8. Each grid may be standalone or be a tile within a larger set of data. The metadata defining the tiling scheme is inherited through the S100_IGCollection.

[1] Picture used with permission of the St Lawrence Global Observatory.

Optionally, an uncertainty coverage may also be included which describes the uncertainty of each grid vertex value. The uncertainty may be bivariate, including a value of uncertainty for both orientation and direction. The surface may be certified by using a digital signature. This product specification includes a content model and separate encodings.

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. The data structure is defined in a manner independent of the encoding so that multiple encodings may be used for the same data. The Navigationally Significant Surface Current product specification is a template application schema that may be further refined by profiling.

Navigationally Significant Surface Currents
Product Specification S.10y

1. Scope

This document is a product specification for Navigationally Significant 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.[2] Optionally, an uncertainty coverage may also be included which describes the uncertainty of each grid 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.

3. Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions 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/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

[2] 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..

ISO/IEC 19501:2005, Information technology — Open Distributed Processing - Unified Modelling Language Version 1.4.2

4. Terms, and definitions

4.1 Terms, and definitions

Terms and definitions have been taken from the normative references cited in clause 3. Only those which are specific to this document have been included and modified where necessary. Additional terms are defined in this document.

4.1.1 coordinate

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

4.1.2 coordinate reference system

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

4.1.3 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, polygon overlay, or digital elevation matrix.

NOTE In other words, a coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.

4.1.4 coverage geometry

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

4.1.5 direct position

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

4.1.6 domain

well-defined set
[ISO 19103]

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

4.1.7 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.

4.1.8 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.

4.1.9 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.

4.1.10 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

4.1.11 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.

4.1.12 grid point

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

4.1.13 range

<coverage>

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

4.1.14 record

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

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

4.1.15 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.

5. Symbols and abbreviated terms

5.1 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

IEEE Institute of Electrical and Electronic Engineers

IHO International Hydrographic Organization

ISO International Organization for Standardization

PK Public Key

SA Signature Authority

SK Secret Key

UML Universal Modelling Language

5.2 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 "S100" as the prefix optionally followed by the bialpha prefix derived from ISO. For the classes defined in this product specification the prefix is "S10y". [this will be revised to the actual IHO number when that number is assigned]. 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

6. Overview

6.1 Title

S-10y - Surface Current Product Specification.

6.2 Reference date

Proposed draft March 2012 - [date to be revised when document if finalized].

6.3 Responsible party

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

6.4 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 be used in the metadata associated with the set of grid values defining the bathymetry coverage.

6.5 Informal description of the data product

A Navigationally Significant Surface Current Data Product contains the grid data values 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 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 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.

7. Specification scopes

7.1 Scope general

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

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 products that may be used independently or in conjunction with other auxiliary data layers.

7.2 Scope identification

Global

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

7.3 Level

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

006 - series.

7.4 Level name

Surface Current

7.5 Extent

This section describes the spatial and temporal extent of the scope

7.5.1 Extent description

Surface Current data are seamless between datasets and form a continuous coverage.

7.5.2 Geographic extent

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

7.5.3 Temporal extent

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

8. Data product identification

8.1 Title

S10y - Surface Current Data:

8.2 Abstract

The Navigationally Significant Surface Current Data Product consists of a set of grid value matrix values organized to form a quadrilateral grid coverage with associated metadata representing a surface current model for a depth or 0 up to 10 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:

8.3 Purpose

The primary purpose of the Navigationally Significant Surface Current Data 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:

8.4 Topic category

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

012– oceans;

014– inlandWaters

8.5 Spatial representation type

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

002 - grid.

8.6 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 model adopted by the producer (hydrographic office).

8.7 Reference to product specification scope

Global

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

9. Data content and structure

9.1 Description

Navigationally Significant Surface Current data describes the orientation and intensity (direction and speed) of currents in the top 0 up to 10 meters of the water column. This is described as a coverage data set represented as a quadrilateral grid 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.

The overall structure of the Navigationally Significant Surface Current product specification is shown in Figure 2. The same tagged structure used in S.102 for bathymetric data is used, compliant with the HDF5[3] 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.

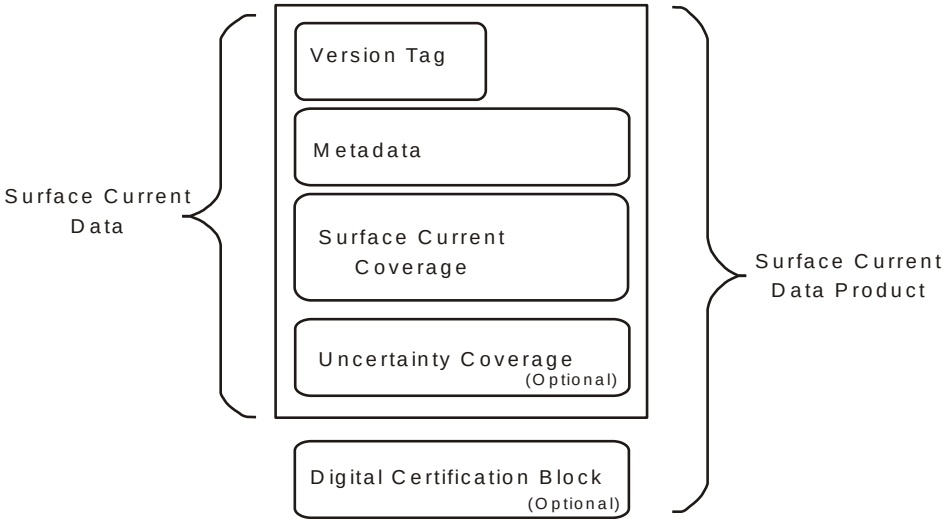

Figure 2 - Overview of Structure of Surface Current Data Product

The Navigationally Significant Surface Current data 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

The application schema for the Navigationally Significant Surface Current Product Specification is a template application schema. A profile can be developed that further

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

refines the application schema. For example, the choice of whether to use a tiling scheme and which tiling scheme to use is left open. The tiling scheme, extent, resolution of the grid 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.

Figure 3 presents the high level of the application schema derived from S.100.

(Note: for the purpose of the model, the number S.10y is assumed. This will be changed to the actual number assigned by IHO when this document is at a more mature state.)

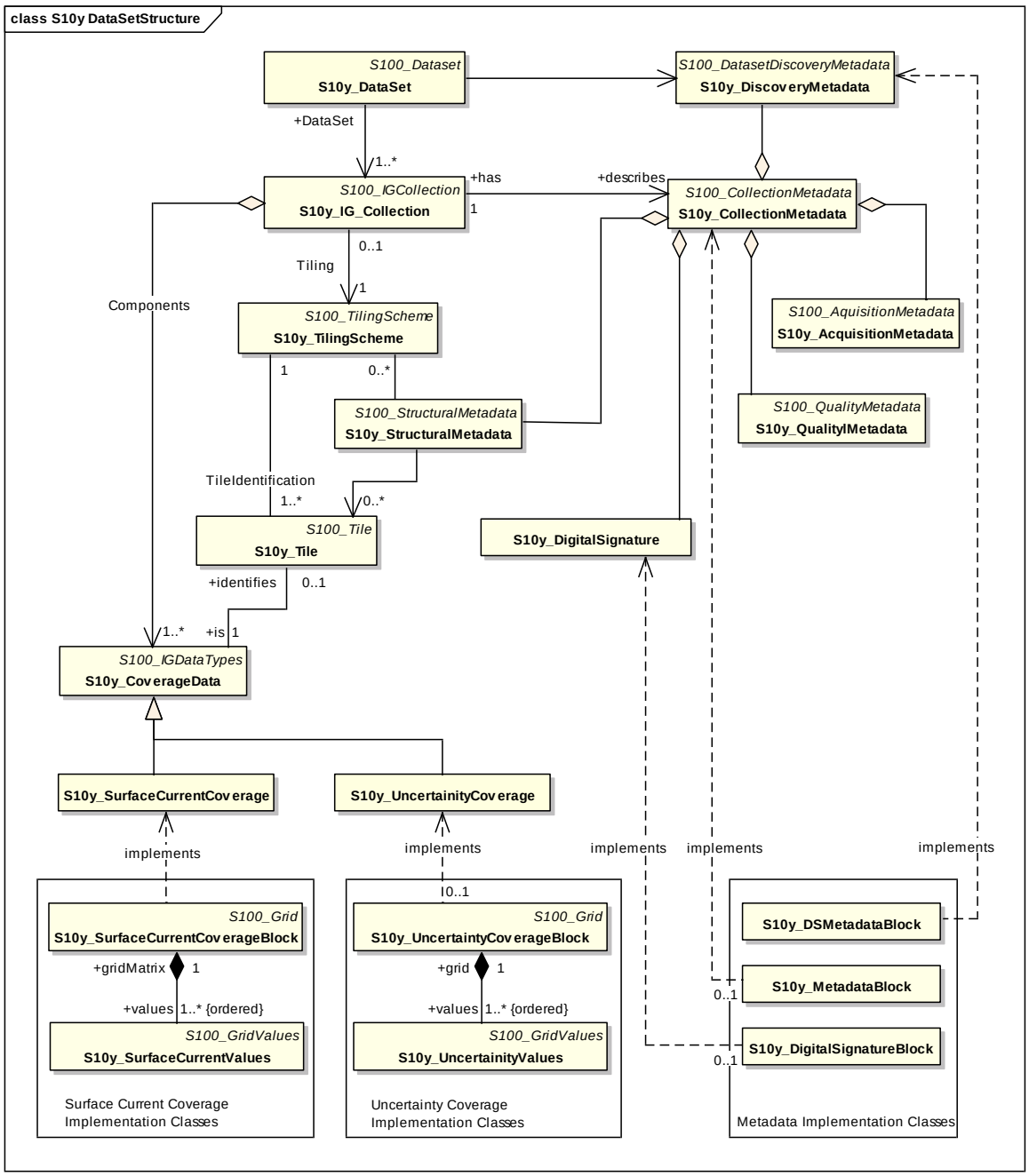

Figure 3 - S10y High Level of the Application Schema

The root class of this model is the **S10y_DataSet**. This class is a subtype of the S100_DataSet class and represents the entire data set. The S10y_DataSet class references the **S10y_DiscoveryMetadata** class to carry the essential metadata that allows for identification and discovery of the data set. The S10y_DataSet class also references the **S10y_IG_Collection** class with a 1 to many multiplicity. This allows for multiple instances of S10y 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 **S10y_StructuralMetadata** and the identification of the tile is contained in **S10y_Tile**.

An instance of the S10y_IG_Collection is described by one instance of the S10y_CollectionMetadata. The S10y_CollectionMetadata class has as components the S10y_DiscoveryMetadata, S10y_AcquisitionMetadata, S10y_QualityMetadata, S10y_StructuralMetadata and the metadata describing the S10y_DigitalSignature information.

The classes S10y_DSMetadataBlock, S10y_MetadataBlock, and S10y_DigitalSignatureBlock are implementation classes that allow the metadata to be grouped for encoding. The S10y_MetadataBlock carries all the metadata that is not otherwise carried in the S10y_DSMetadataBlock, and S10y_DigitalSignatureBlock classes. The discovery metadata as represented by S10y_DSMetadataBlock is required to be implemented in any data set.

An S10y_IG_DataCollection class also optionally makes reference to a tiling scheme (S10y_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 S10y_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-10y 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-10y are required to support the capability to decode and verify the data using the digital signature information.

The S10y_CoverageData class is a component of the S10y_IG_Collection. It carries the actual data values that drive the coverage function. both coverages are quadrilateral grid coverages. There are two subtypes, the S10y_SurfaceCoverage and the S10yUncertainityCoverage. The classes S10y_SurfaceCurrentCoverageBlock, and S10yUncertainityCoverageBlock are implementation classes. The implementation of the S10yUncertainityCoverageBlock is optional. The classes S10y_SurfaceCoverageValues and the S10yUncertainityCoverageValues represent grid value matrices that contain the values that drive the surface current coverage function and the uncertainty coverage function respectively.

9.2 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[4].

[4] 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.

9.3 Coverage Implementation Classes

The details of the implementation classes for the coverage portion of the Surface Current template application schema are shown in Figure 4. The attributes are shown for the coverage related classes together with the attribute classes.

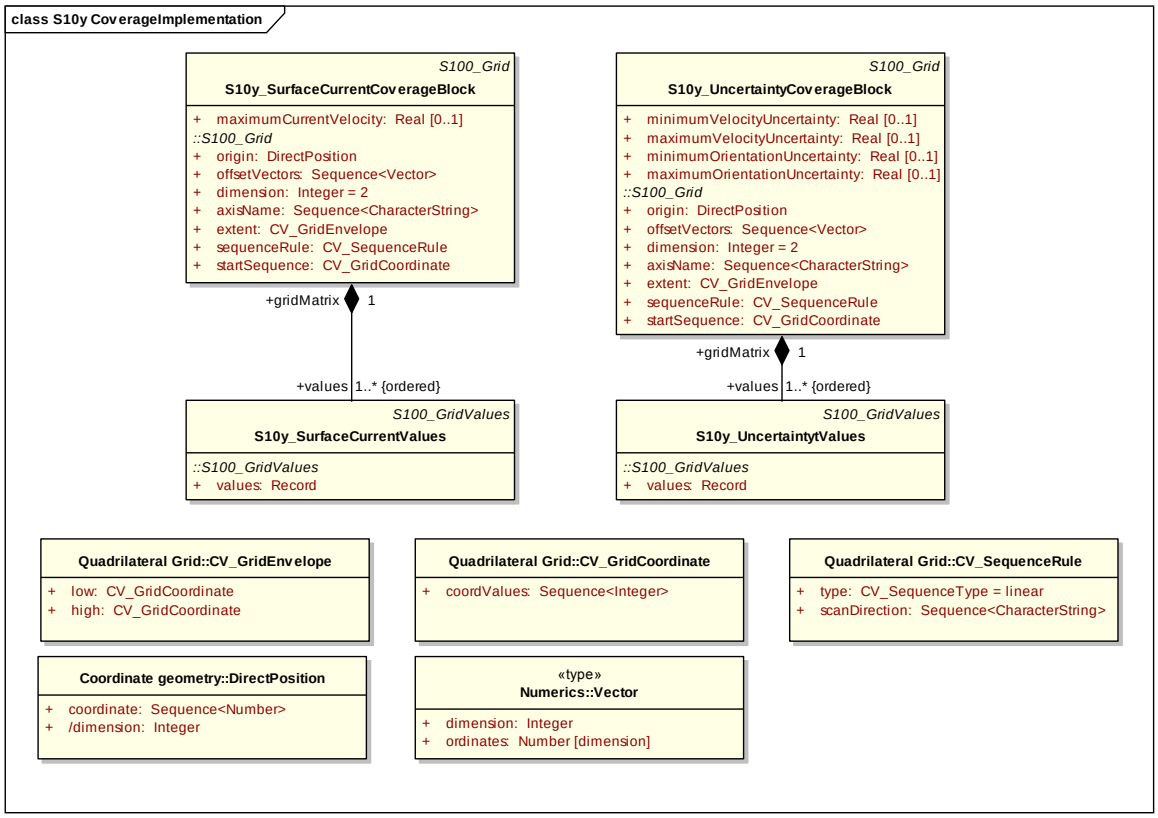

Figure 4 - S10y Coverage Implementation Classes

The primary coverage is the surface current coverage as represented in the class **S10y_SurfaceCurrentCoverageBlock**. 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. 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 **S10y_SurfaceCurrentValues** defines a grid value matrix as a set of records. Each record consists of an orientation and direction for the current value. This is illustrated in Figure 5.

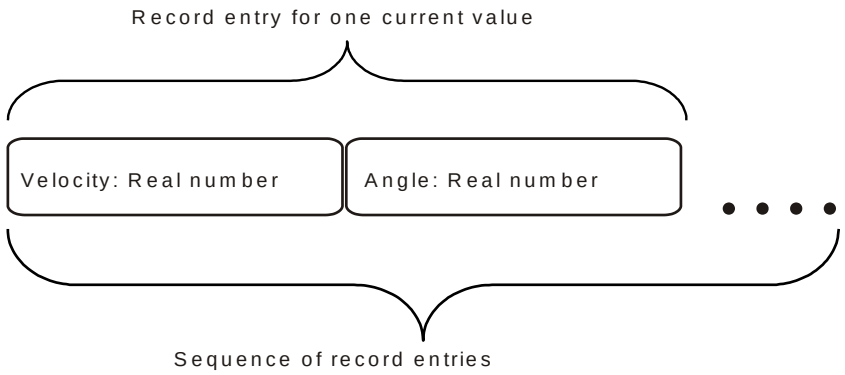

Figure 5 - S10y Surface Current Coverage Record Structure

The secondary coverage is the optional uncertainty coverage as represented in the class S10y_UncertainityCoverageBlock. 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 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 S10y_UncertainityValues 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. This is illustrated in Figure 6.

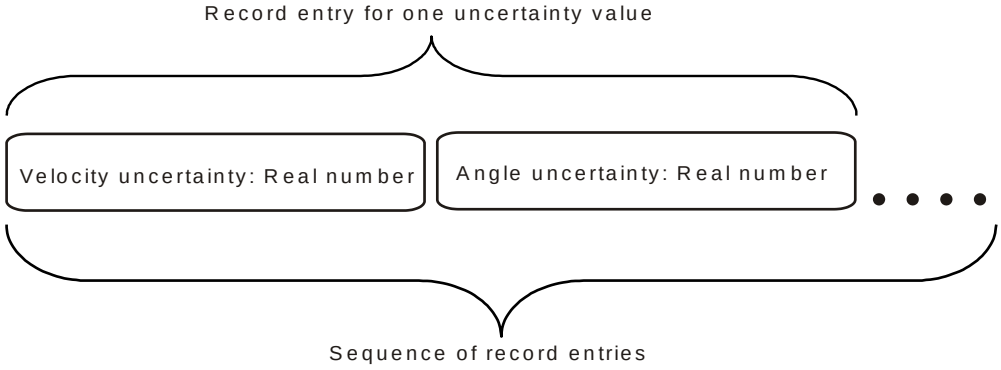

Figure 6 - S10y Uncertainty Coverage Record Structure

9.3.1 S10y_SurfaceCurrentCoverageBlock semantics

The class **S10y_SurfaceCurrentCoverageBlock** 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 S10y_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.

9.3.1.1 *maximumCurrentVelocity*

The attribute *maximumCurrentVelocity* has the value type Real and describes the upper bound of the current velocity for all the velocity values in S10y_SurfaceCurrentValues record. This attribute is optional. There is no default.

9.3.1.2 *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

9.3.1.3 *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.

9.3.1.4 *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

9.3.1.5 *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 be "Latitude" and "Longitude" for unprojected data sets or "Northing" and "Easting" in a projected space.

9.3.1.6 *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.

9.3.1.7 *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.

9.3.1.8 *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.

9.3.2 S10y_SurfaceCurrentValues semantics

The class **S10y_SurfaceCurrentValues** is related to S10y_ S10y_SurfaceCurrentCoverageBlock by a composition relationship in which an ordered sequence of values provide data for each grid cell. The class S10y_SurfaceCurrentValues inherits from S100_GridValues.

9.3.2.1 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 S10y_SurfaceCurrentValues class which provides the current velocity and orientation for the grid cell.

9.3.3 S10y_UncertaintyCoverageBlock semantics

The class **S10y_UncertaintyCoverageBlock** has the optional attributes *minimumVelocityUncertainty, maximumVelocityUncertainty, minimumOrientationUncertainty* and *maximumOrientationUncertainty*. These values bound the velocity and orientation attributes from the uncertainty current coverage value attribute record from **S10y_UncertaintyCurrentValues** grid value matrix. 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.

The optional Uncertainty Coverage provides additional information to assist in the interpretation of the Surface Current Coverage. The two coverages do not need to be the same density of grid cells to allow the two coverage functions to be conflated; however, the coverage functions shall cover the same extent.

9.3.3.1 *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 S10y_UncertaintyValues record. This attribute is optional. There is no default.

9.3.3.2 *maximumVelocityUncertainty*

The attribute *maximumVelocityUncertainty* has the value type Real and describes the upper bound of the current velocity for all the velocity values in S10y_SurfaceCurrentValues record. This attribute is conditional on the existence of a value for the *minimumVelocityUncertainty* attribute. There is no default.

9.3.3.3 *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 S10y_UncertaintyValues record. This attribute is optional. There is no default.

9.3.3.4 *maximumOrientationUncertainty*

The attribute *maximumOrientationUncertainty* has the value type Real and describes the upper bound of the current orientation for all the orientation values in S10y_SurfaceCurrentValues record. This attribute is conditional on the existence of a value for the *minimumOrientationUncertainty* attribute. There is no default.

9.3.3.5 *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.

9.3.3.6 *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.

9.3.3.7 *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

9.3.3.8 *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 be "Latitude" and "Longitude" for unprojected data sets or "Northing" and "Easting" in a projected space.

9.3.3.9 *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. The extent of the Uncertainty Coverage shall correspond to the extent of the Surface Current Coverage.

9.3.3.10 *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.

9.3.3.11 *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.

9.3.4 S10y_UncertaintyValues semantics

The class **S10y_UncertaintyValues** is related to S10y_ S10y_UncertaintyCoverageBlock by a composition relationship in which an ordered sequence of values provide data for each grid cell. The class S10y_UncertaintyValues inherits from S100_GridValues.

9.3.4.1 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 S10y_UncertaintyValues class which provides the velocity uncertainty and orientation uncertainty for the grid cell.

9.3.4.2 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.

9.3.4.2.1 low

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

9.3.4.2.2 high

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

9.3.5 CV_GridCoordinate semantics

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

9.3.5.1 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 be the same as that of the elements of axisNames. The value of a single

coordinate shall be the number of offsets from the origin of the grid in the direction of a specific axis.

9.3.6 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.

9.3.6.1 type

The attribute *type* identifies the type of sequencing method that shall be used. A code list of scan types is provided in S-100 Part 8. Only the value "linear" shall be used in S-10y, which describes scanning row by row by column.

9.3.6.2 scanDirection

The attribute *scanDirection* has the value class Sequence<CharacterString> a list of axis names that indicates the order in which grid points shall be mapped to position within the sequence of records of feature attribute values. The scan direction for all layers in S-102 is "Longitude" and "Latitude" or west to east, then south to north.

9.3.7 DirectPosition semantics

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

9.3.7.1 coordinate

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

9.3.7.2 dimension

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

9.3.8 Vector semantics

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

9.3.8.1 dimension

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

9.4 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 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-10y. Reference is made to clause 8 where appropriate. Because S-10y makes use of a grid coverage some of the metadata elements that ISO 19115 identifies as optional are required in this product specification. Also some of the metadata elements are implicit in the product specification.

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

Dataset title (M) S10y_DS_DiscoveryMetadata > citation > CI_Citation.title S-10y - Surface Current Data from: (MD_Metadata > MD_DataIdentification.citation > CI_Citation.title) See clause 8.1
Metadata date stamp (M) S10y_DS_DiscoveryMetadata > dateStamp from: (MD_Metadata.dateStamp)
Metadata point of contact (M) S10y_DS_DiscoveryMetadata > contact from: (MD_Metadata.contact > CI_ResponsibleParty)
Abstract describing the dataset (M) S102_DS_DiscoveryMetadata > abstract from: (MD_Metadata > MD_DataIdentification.abstract) See clause 8.2
Dataset topic category (M) S10y_DS_DiscoveryMetadata > topicCategory: MD_TopicCategoryCode 012– oceans; 014– inlandWaters from: (MD_Metadata > MD_DataIdentification.topicCategory) See clause 8.4

Spatial representation type (O) S10y_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. See clause 8.5
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. See clause 8.6
Dataset reference date (M) S10y_DS_DiscoveryMetadata > citation > CI_Citation.date from: (MD_Metadata > MD_DataIdentification.citation > CI_Citation.date)
Dataset responsible party (O) S10y_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) S10y_DS_DiscoveryMetadata > extent > EX_Extent from: (MD_Metadata > MD_DataIdentification.extent > EX_Extent > EX_GeographicExtent > EX_GeographicBoundingBox or EX_GeographicDescription)
Reference system (O) S10y_StructureMetadataBlock > hRefSystem from: (MD_Metadata > MD_ReferenceSystem)
Lineage (C) S10y_QualityMetadataBlock > S10y_LI_Source and S10y_QualityMetadataBlock > S10y_LI_ProcessStep from: (MD_Metadata > DQ_DataQuality.lineage > LI_Lineage)
Dataset language (M) S10y_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-10y product specification reference to ISO 19115 as a normative reference
Metadata standard name (O) (MD_Metadata.metadataStandardName) Implicit in S-10y product specification reference to ISO 19115 as a normative reference
Metadata standard version (O) (MD_Metadata.metadataStandardVersion) Implicit in S-10y 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)

9.4.1 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[5].

There is discovery data for the whole data set at the S10y_DataSet level and at the S10y_IG_Collection level for individual tiles for those data sets that are composed of several tiles.

The S10y_DiscoveryMetadataBlock has two subtypes S10y_DS_DiscoveryMetadata and S10y_Tile_DiscoveryMetadata. This is shown in Figure 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 S10y_DS_DiscoveryMetadata and S10y_Tile_DiscoveryMetadata inherit their attributes from these S-10y 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 can also be included.

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

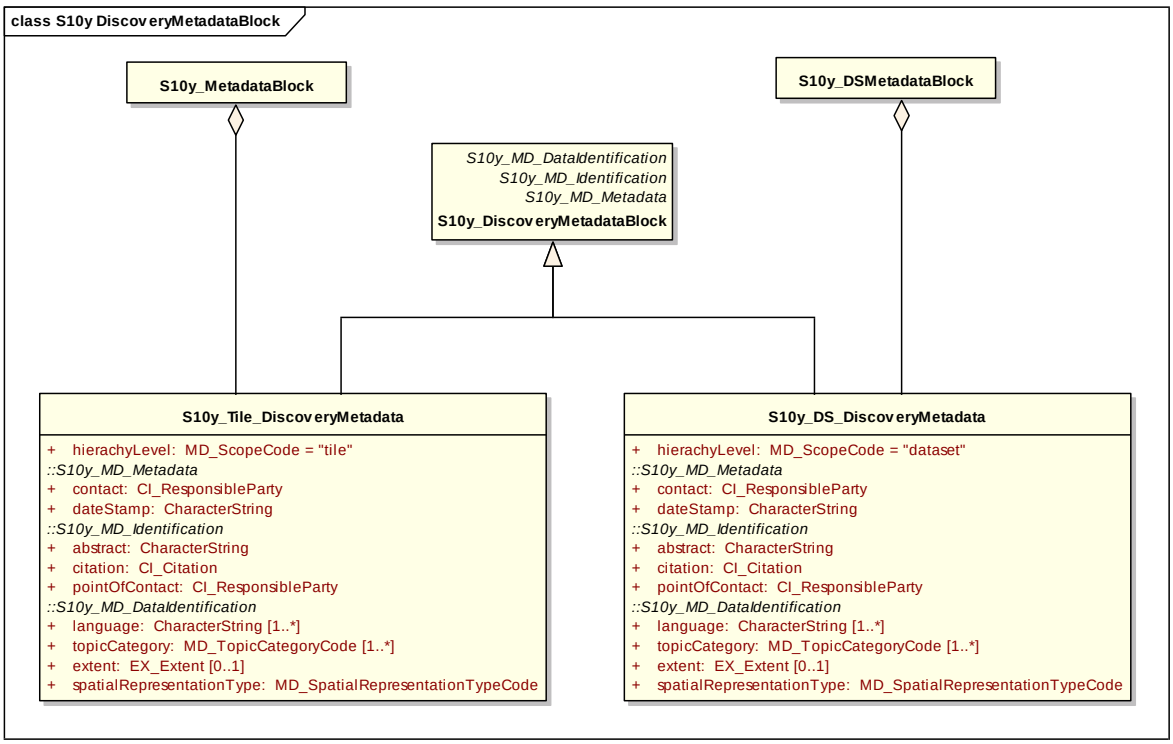

Figure 7 - S10y Discovery Metadata Block

Table 2 provides a description of each attribute of the S10y_DiscoveryMetadataBlock class attributes.

Table 2 - Discovery Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S10y_DiscoveryMetadataBlock	Container class for discovery metadata	-	-	
Class	S10y_DS_DiscoveryMetadata	Container class for discovery metadata related to an entire data set	-	-	
Class	S10y_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 S10y_DS_DiscoveryMetadata or "tile" for S10y_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	

Role Name	Name	Description	Cardin-ality	Type	Remarks
attribute	citation	citation data for the resource(s)	1	CI_Citation	CI_Citation <<DataType>> Required items are Citation.title, & 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;

9.4.1.1 S10y_DiscoveryMetadataBlock semantics

The class **S10y_DiscoveryMetadataBlock** is a container class for discovery metadata. It has two subtypes, **S10y_Tile_DiscoveryMetadata** and **S10y_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 2.

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

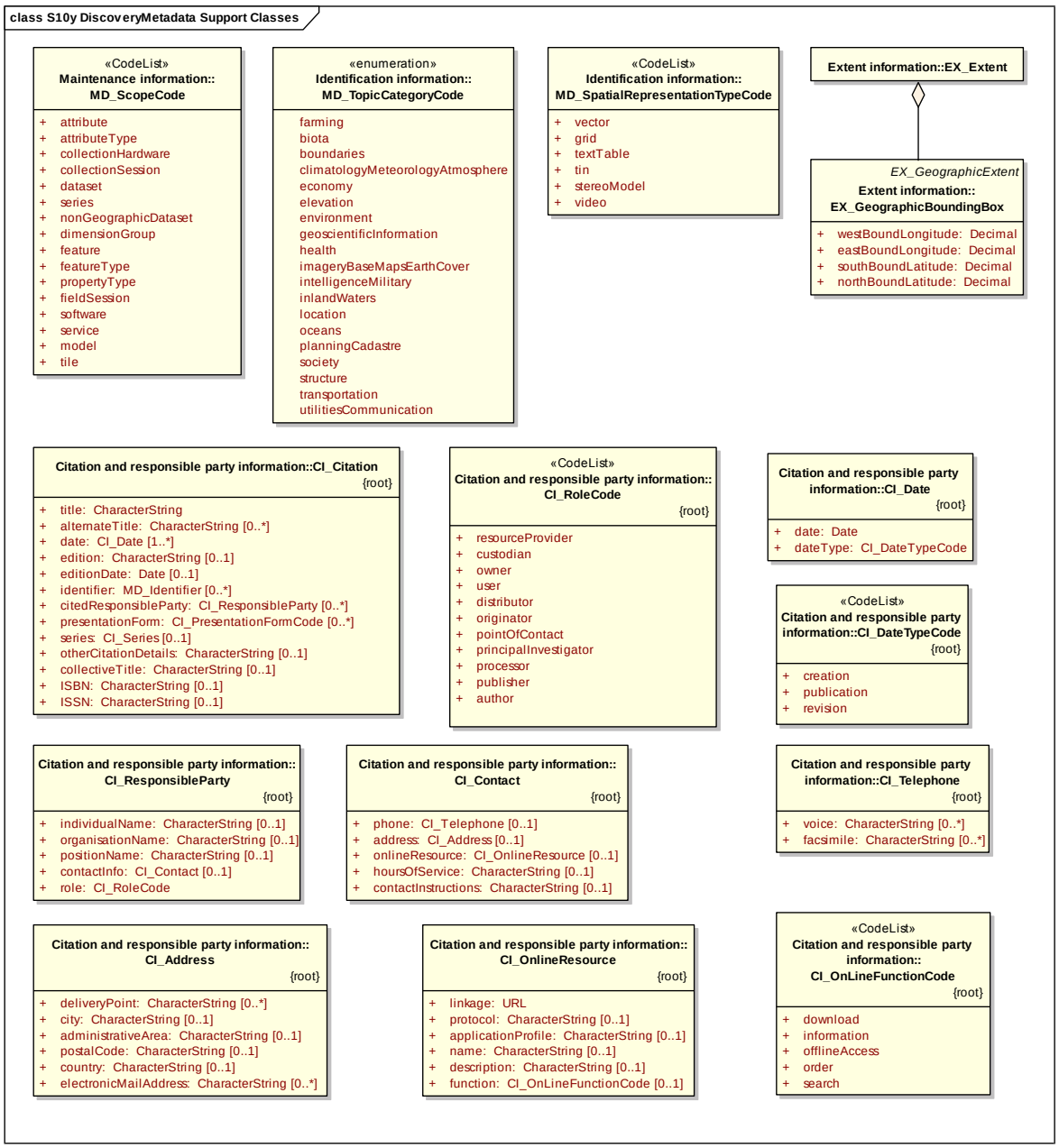

Figure 8 - Discovery Metadata Support Classes

9.4.1.2 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..

9.4.1.3 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.

9.4.1.4 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.

9.4.1.5 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 S10y_Surface Current coverage. That is the extent of the data may be a portion of the area defined by the grid coverage.

9.4.1.6 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

9.4.1.6.1 westBoundLongitude

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

9.4.1.6.2 eastBoundLongitude

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

9.4.1.6.3 southBoundLongitude

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

9.4.1.6.4 northBoundLongitude

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

9.4.1.7 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 1 and clause 8.1. 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 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 S10y.

9.4.1.7.1 title

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

9.4.1.7.2 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.

9.4.1.8 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.

9.4.1.9 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 S10y.

9.4.1.10 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**.

9.4.1.11 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**,

9.4.1.12 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.

9.4.1.13 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.

9.4.1.14 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**.

9.4.1.15 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.

9.4.2 Metadata Block Implementation Class

The Metadata Block implements the S10y_Collection Metadata class. This class aggregates the S10y_StructuralMetadata, the S10y_AcquisitionMetadata, the S10yQualityMetadata as well as the S10y_DiscoveryMetadata and S10y_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 S10y_CollectionMetadata class it is possible to repeat any discovery metadata element or use a digital signature on a portion of an IG collection.

9.4.2.1 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 9 illustrates the S10y 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 S10y 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.

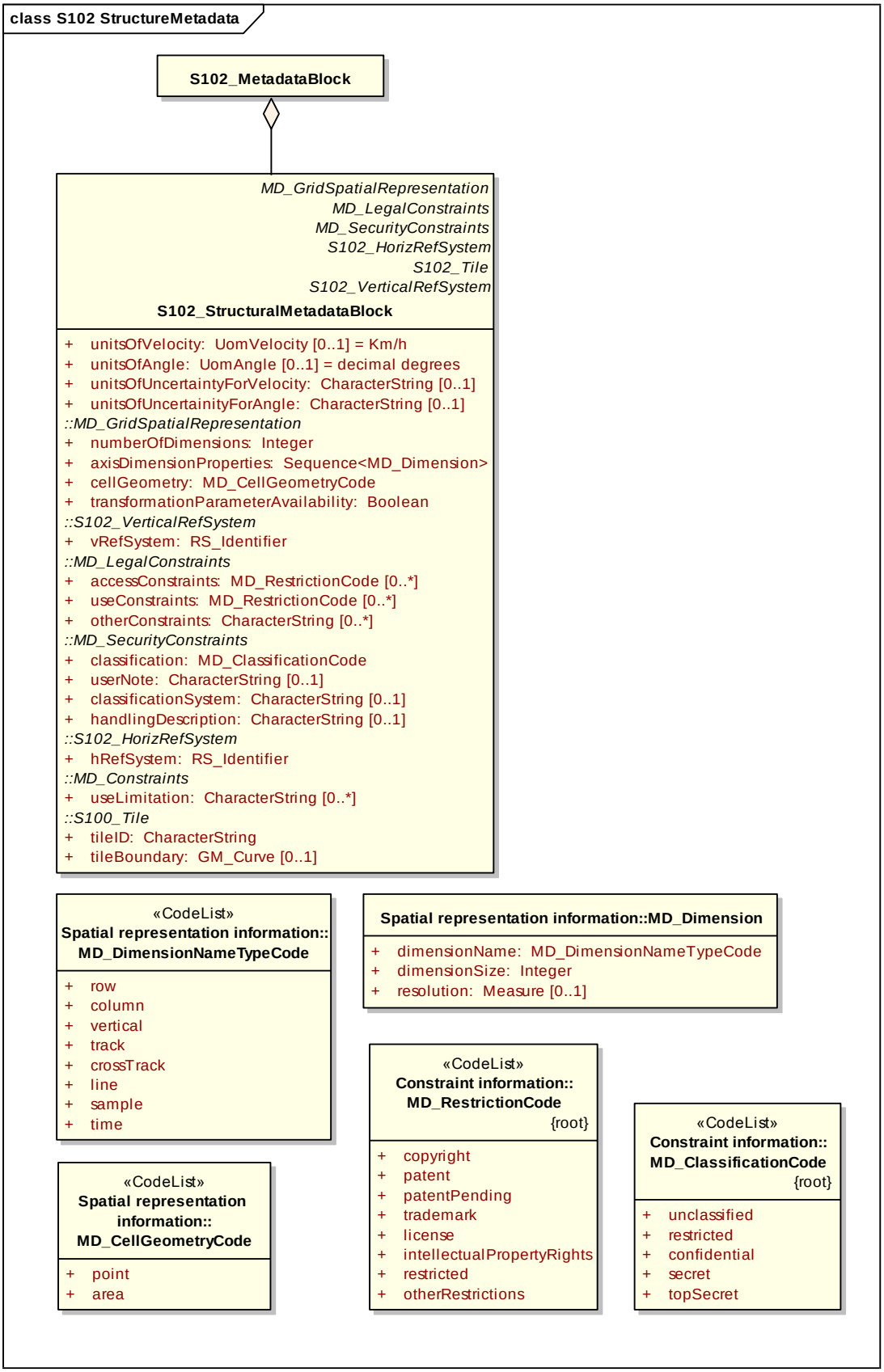

Figure 9 - Structural Metadata

Table 3 provides a description of each attribute of the S102_StructureMetadataBlock class attributes.

Table 3 - Structural Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S10y_StructuralMetadataBlock	Container class for structural metadata	-	-	
attribute	*unitsOfVelocity*	units of measure for velocity attribute of surface current coverage	0-1	UomVelocity	default "Km/h"
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 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 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.

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

9.4.2.1.1 S10y_StructuralMetadata semantics

The class **S10y_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 S100 class S100_Tile and an S10y 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" 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 S10y 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.

9.4.2.1.1.1 unitsOfVelocity

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

9.4.2.1.1.2 unitsOfAngle

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

9.4.2.1.1.3 unitsOfUncertaintyForVelocity

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

9.4.2.1.1.4 unitsOfUncertaintyForAngle

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

9.4.2.1.2 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.

9.4.2.1.3 MD_DimensionNameTypeCode semantics

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

9.4.2.1.4 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.

9.4.2.1.5 MD_RestrictionCode semantics

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

9.4.2.1.6 MD_ClassificationCode semantics

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

9.4.2.1.7 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.

9.4.2.2 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 actual lineage information is described using the attribute *description* of the class S10y_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 S10y_UncertaintyCoverageBlock. In this case the S10y_QualityMetadataBlock would carry the indication of which particular attribute, such as the velocity and/or orientation of the current measure in the S10y_QualityMetadataBlock *scope* attribute using the using the "attribute" and "attributeType" MD_ScopeCode.

The elements of the Quality Metadata component are described in Figure 10. This shows the S10y_QualityMetadataBlock and S10y_LI_Source classes.

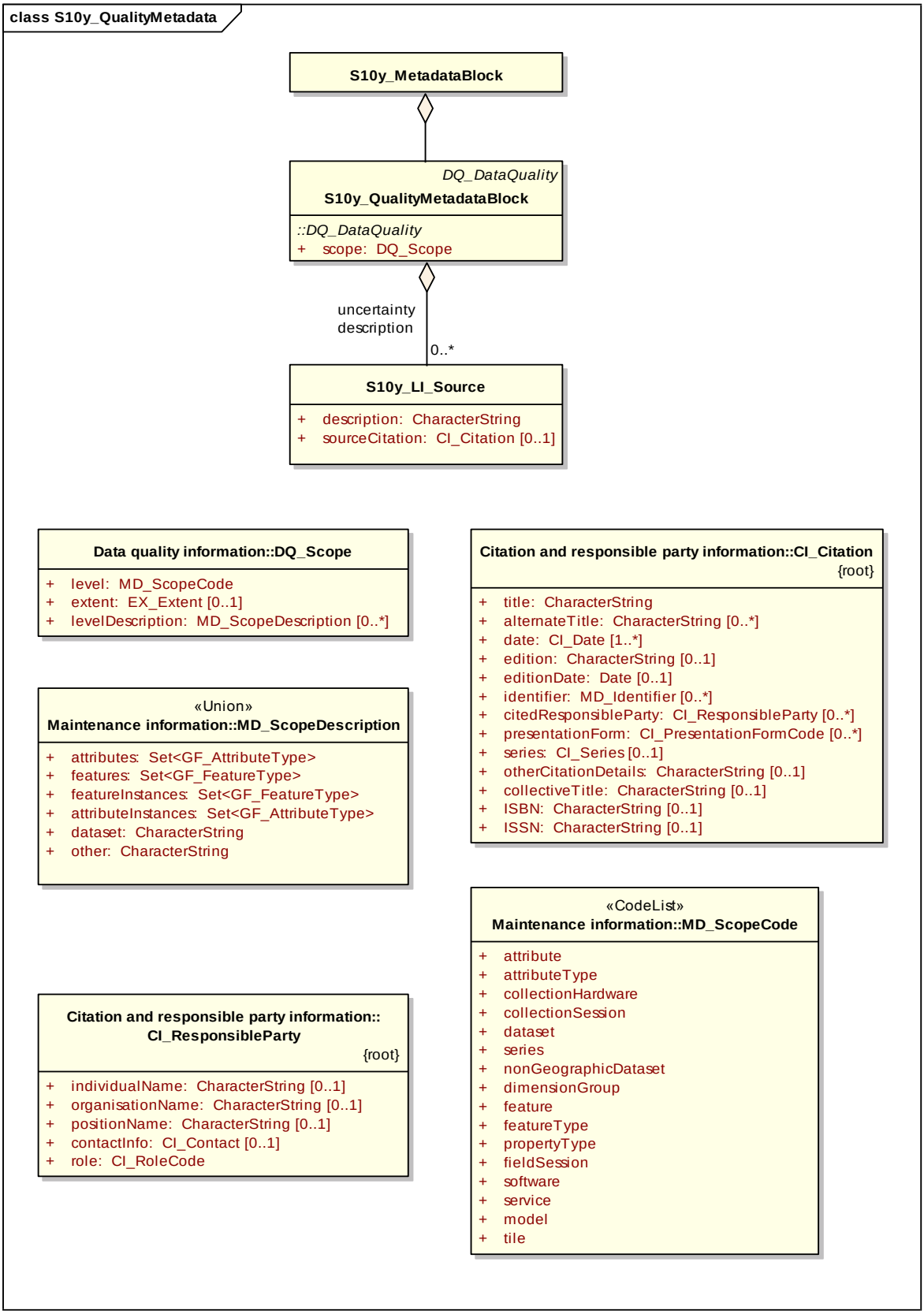

Figure 10 - Quality Metadata Component

Table 4 provides a description of each attribute of the S102_QualityMetadataBlock class attributes.

Table 4 - Quality Metadata Block description

Role Name	Name	Description	Cardin-ality	Type	Remarks
Class	S102_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	S102_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.

9.4.2.2.1 S10y_QualityMetadataBlock semantics

The class **S10y_QualityMetadataBlock** is a container class for quality metadata. It has one attribute *scope* inherited from the ISO 19115 DQ_Quality.

9.4.2.2.1.1 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.

9.4.2.2.2 S10y_LI_Source semantics

The class **S10y_LI_Source** is a class which implements the ISO 19115 class LI_Source. It has two attributes *description* and optionally *sourceCitation*.

9.4.2.2.2.1 description

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

9.4.2.2.2.2 sourceCitation

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

9.4.2.2.3 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.

9.4.2.2.4 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 S10y. Particular attributes such as velocity and orientation can be identified in an uncertainity coverage, or the whole data set may be identified.

9.4.2.2.5 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 S10y.

9.4.2.3 Acquisition Metadata component

Acquisition metadata is optional in S10y. 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.

9.4.2.4 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.

9.4.3 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.10y is based on that used in S.102 for bathymetry data. The main difference is that in S.10y, 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 S10y_DigitalSignatureBlock is an implementation class corresponding to the class S10y_DigitalSignature. It is a component of the S10y_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.

9.5 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 current coverage and the uncertainty coverage. These two entries compose the feature catalogue.

9.6 Data Maintenance

A coverage is a type of feature so a Surface Current Product specification does contain features. There are two coverages defined which are the current coverage and the uncertainty coverage. These two entries compose the feature catalogue.

9.6.1 Data Maintenance description

S-102 data sets are maintained by replacement on a tile or dataset basis. That is, the entire data product or tile within a data set including its coverages (elevation/depth, uncertainty, and tracking list point set coverage) and the associated metadata are replaced as a unit. This is unlike S-101 vector data that may be updated incrementally. However, coverage data must be considered as a unit at least at the tile level. This is because processing is done on the entire tile to produce the data product. Any replacement tile will include its own tracking list (when a tracking list is used) to deliberately bias the information for safety of navigation. Also each replacement tile or data set must have its own digital signature.

9.6.2 Reference to product specification scopes

Global.

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

10. Encoding

10.1 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.

10.2 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. 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 11.

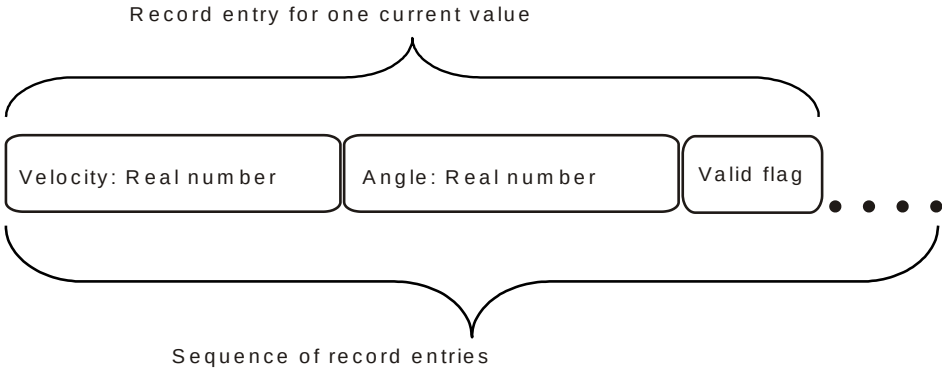

Figure 11 - Encoding Null Values in the Data Record

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.