

Ice Information Product Specification

Edition 1.1.0 – December 2024

IHO



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Document History

Changes to this Specification are coordinated by WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM). New editions will be made available via the IHO web site.

Maintenance of the Specification shall conform to IHO Resolution 2/2007 (as amended).

I suggest deleting the previous sentence

Table — Document History

| Version Number | Date | Approved By | Purpose |
|----------------|-----------------|-----------------|---|
| 1.0.0 | 2 February 2014 | Alexander Benke | Initial edition of S-411 |
| 1.1.0 | 15 June 2014 | Jürgen Holfort | Clarifications in the based on ETSI Meeting 2014 and new color for 10/10. |
| 1.2.0 | xx January 2025 | | |

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1 Overview

1.1 Scope

This document has been produced by the BSH as part of JCOMM/ETSI in response to a requirement to produce an ice data product that can be used within Electronic Chart Display and Information Systems.

The Ice Information product specification is based on the IHO S-100 framework specification, Geography Markup Language (GML) Encoding Standard and the ISO 19100 series of standards. It is a vector product specification that is primarily intended for encoding the extent and nature of Sea Ice for navigational purpose.

1.2 References

GML — OpenGIS® Geography Markup Language (GML) Encoding Standard (Version 3.2.1)

IHO S-100 — IHO Universal Hydrographic Data Model, Edition 5.2.0, June 2024

ISO-19115-1 — ISO 19115-1:2014/Amd 1:2018, Geographic information — Metadata — Part 1: Fundamentals — Amendment 1

ISO-19115-2 — ISO 19115-2:2009/Amd 1:2018, Geographic information — Metadata — Part 2: Extensions for imagery and gridded data

ISO-19115-3 — ISO 19115-3:2016, Geographic information — Metadata — Part 3: XML Schema implementation for fundamental concepts

ISO-19139-1 — ISO 19139-1:2019, Geographic information — XML schema implementation — Part 1: Encoding rules

1.3 Terms, definitions and abbreviations

1.3.1 Use of language

Within this document:

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

1.3.2 Terms and definitions

There are no definitions in current version of S-411. Do I delete the ones here after?

1.3.2.1 Accuracy

No reference to Accuracy in S-411 1.1.0.

1.3.2.2 Coordinate

One of a sequence of n numbers designating the position of a point in N-dimensional space.

NOTE The numbers must be qualified by units and CRS.

1.3.2.3 Coordinate Reference System

Coordinate system which is related to the real world by a datum.

1.3.2.4 Coverage

Feature that acts as a function to return values from its range for any direct position within its spatial, temporal, or **spatiotemporal domain**.

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.

EXAMPLE: Examples include a digital image, polygon overlay, or digital elevation matrix

1.3.2.5 Coverage Geometry

Configuration of the **domain** of a **coverage** described in terms of **coordinates**.

1.3.2.6 Direct Position

Position described by a single set of **coordinates** within a **coordinate reference system**.

1.3.2.7 Domain

Well-defined set.

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

1.3.2.8 Depth

The vertical distance from a given water level to the bottom. In this standard, depth refers to the S-32 definition of "Depth Charted".

NOTE The numbers must be qualified by units and datum.

1.3.2.9 Feature

Abstraction of real-world phenomena.

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

1.3.2.10 Feature Attribute

Characteristic of a **feature**.

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.

1.3.2.11 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**).

NOTE The range is defined by another domain.

1.3.2.12 Geometric Object

Spatial object representing a set of **direct positions**.

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.

1.3.2.13 Grid

No reference to Grid in S-411 1.1.0.

1.3.2.14 Grid Point

No reference to Grid Point in S-411 1.1.0.

1.3.2.15 Lidar

No reference to Lidar in S-411 1.1.0.

1.3.2.16 Navigation Surface

No reference to Navigation Surface in S-411 1.1.0.

1.3.2.17 Range <coverage>

No reference to Range in S-411 1.1.0.

1.3.2.18 Record

No reference to Record in S-411 1.1.0.

1.3.2.19 Rectified Grid

No reference to Rectified Grid in S-411 1.1.0.

1.3.2.20 Referenceable Grid

No reference to Referenceable Grid in S-411 1.1.0.

1.3.2.21 Sonar

No reference to Sonar in S-411 1.1.0.

1.3.2.22 Spatiotemporal Domain <coverage>

No reference to Spatiotemporal Domain in S-411 1.1.0.

1.3.2.23 Surface

No reference to Surface in S-411 1.1.0.

1.3.2.24 Uncertainty

No reference to Uncertainty in S-411 1.1.0.

1.3.2.25 Vector

Quantity having direction as well as magnitude.

NOTE A directed line segment represents a vector if the length and direction of the line segment are equal to the magnitude and direction of the vector. The term vector data refers to data that represents the spatial configuration of features as a set of directed line segments.

1.3.3 Abbreviations

This Product Specification adopts the following convention for presentation purposes:

CRS Coordinate Reference System

ECDIS Electronic Chart Display and Information System

EPSG European Petroleum Survey Group

ETSI Expert Team on Sea Ice

GML Geography Markup Language

IHO International Hydrographic Organization

ISO International Organization for Standardization

JCOMM Joint Technical Commission for Oceanography and Marine Meteorology

XML eXtensible Markup Language

1.4 General data product description

| | |
|-----------------------|--|
| Title | Ice Information Product Specification. |
| Abstract | Ice Information for ship navigation |
| Acronym | S-411 |
| Content | Ice features as vector data |
| Spatial Extent | East Bounding Longitude: 180° West Bounding Longitude: -180° North Bounding Latitude: 90° South Bounding Latitude: -90° |
| Purpose | Navigation in ice covered regions |

1.5 Product Specification metadata

| | |
|-----------------------|---|
| Title | Ice Information Product Specification |
| S-100 Version | 1.0.0 |
| S-411 Version | 1.1.0 |
| Date | 15 June 2014 |
| Language | English (optional additional) |
| Classification | Unclassified |
| Contact | Jürgen Holfort (ice@bsh.de) |
| Identifier | JCOMM S-411 |
| Maintenance | Changes to this product specification are coordinated by ETSI. International Hydrographic Organization 4 Quai Antoine 1er B.P. 445 MC 98011 MONACO CEDEX Telephone: +377 93 10 81 00 Fax: +377 93 10 81 40 Email: info@iho.int |
| URL | www.iho.int |
| Identifier | S-411 |
| Maintenance | Changes to the Product Specification S-411 are coordinated by the JCOMM, and must be made available via the IHO web site. |

1.6 IHO Product Specification Maintenance

1.6.1 Introduction

Changes to S-411 will be released by the IHO as a New Edition, revision, or clarification.

1.6.2 New Edition

New Editions of S-411 introduce significant changes. *New Editions* enable new concepts, such as the ability to support new functions or applications, or the introduction of new constructs or data types. *New Editions* are likely to have a significant impact on either existing users or future users of S-122. All cumulative *revisions* and *clarifications* must be included with the release of approved New Editions.

1.6.3 Revision

Revisions are defined as substantive semantic changes to S-411. Typically, *revisions* will change S-411 to correct factual errors; introduce necessary changes that have become evident as a result of practical experience or changing circumstances. A *revision* must not be classified as a clarification. Revisions could have an impact on either existing users or future users of S-411. All cumulative *clarifications* must be included with the release of approved *revisions*.

Changes in a revision are minor and ensure backward compatibility with the previous versions within the same Edition. Newer revisions, for example, introduce new features and attributes. Within the same Edition, a dataset of one version could always be processed with a later version of the Feature and Portrayal Catalogues.

In most cases a new feature or portrayal catalogue will result in a *revision* of S-411.

1.6.4 Clarification

Clarifications are non-substantive changes to S-122. Typically, *clarifications*: remove ambiguity; correct grammatical and spelling errors; amend or update cross references; insert improved graphics in spelling, punctuation and grammar. A *clarification* must not cause any substantive semantic change to S-411.

Changes in a *clarification* are minor and ensure backward compatibility with the previous versions within the same Edition. Within the same Edition, a dataset of one clarification version could always be processed with a later version of the Feature and Portrayal Catalogues, and a Portrayal Catalogue can always rely on earlier versions of the Feature Catalogue.

1.6.5 Version Numbers

The associated version control numbering to identify changes (n) to S-411 must be as follows:

New Editions denoted as n.0.0

Revisions denoted as n.n.0

Clarifications denoted as n.n.n

2 Specification Scope

This product specification defines only one general scope which applies to all its sections.

Scope Identification JCOMM S-411 dataset

Hierarchical Level MD_ScopeCode -005

Hierarchical Level Name Dataset

Extent

EX_GeographicExtent -Global coverage of maritime areas.

EX_TemporalExtent -Not defined for this product specification.

EX_VerticalExtent -Not defined for this product specification.

3 Data Product Identification

| | |
|------------------------------------|---|
| Title | Ice Information |
| Abstract | Ice Information for navigation in ice covered regions |
| Topic Category | Transportation, climatology, meteorology, atmosphere |
| Geographic Description | Ice covered regions |
| Spatial Resolution | — |
| Purpose | Navigation in ice covered regions |
| Language | English (Mandatory), other (Optional) |
| Classification | Unclassified |
| Spatial Representation Type | Vector |
| Point of Contact | Producing Agency |
| Use Limitation | — |

4 Data Content and Structure

4.1 Introduction

The application schema of ice information product contains 28 feature types with their attributes, enumerations etc. It is based on the ice objects catalogue (Version 5.1) and can also be found in the ICE domain of the IHO Registry. Because of this it is not possible to describe full schema in suitable form in this specification. The full schema can be found as XML Schema File in Annex B – Data Product format (encoding).

4.2 Application Schema

Picture below shows very simplified structure of ice data structure

Figure 1 (UML diagram) to be inserted here

General GML (XML) representation:

XML code to be inserted here

4.2.1 Application Schema implementation classes

4.2.1.1 Implementation classes description

4.3 Feature Catalogue

4.3.1 Introduction

The feature Catalogue for Ice Information contains only geographic features. The ice features which can be used in ECDIS are fully presented in the ICE domain of the IHO Registry.

4.3.2 Feature types

IceDataSetType is a type of root Element of an ice information data set.

4.3.2.2.1 UML diagram to be inserted here

Ice Data Set contains an unlimited number of Ice Feature Members, each Ice Feature Member contains one Ice Feature (seaice, lacice, iceberg, etc.).

4.3.2.1 Geographic

4.3.2.2 Meta

4.3.3 Feature relationship

4.3.4 Attributes

4.3.4.1 Simple attributes

4.3.4.2 Complex attributes

4.4 Dataset types

4.4.1 Introduction

At the moment is only one type of dataset supported. This is GML(XML) encoded ice feature collections

4.5 Geometry

Ice Information datasets use S-100 Level 3a geometry which supports 0-, 1-, and 2-dimensional objects (points, line strings, and polygons).

Figure 3 to be inserted here.

There are three types of geometry: Point, Line String and Polygon. Multi-geometries will be not supported. The standard geometries of GML where redefined for S-411. The reason for this is to reduce file sizes. It is only possible to use "posList" with blanks separated coordinate values, like:

```
<gml:posList>-73.991 40.736 -73.991 40.736</gml:posList>
```

Figure 4-1

For standard GML it would be also possible to use following (DO NOT USE THIS):

```
<gml:posList>
<pos>-73.991 40.736</pos>
<pos>-73.991 40.736</pos>
</gml:posList>
```

Figure 4-2

Which means much more chars in the file and growing of file size.

All multi-geometries must be splitted into single geometries. Encoding for geometry is GML:

Point encoding example:

```
<gml:Point
<gml:pos>147.291 -42.851</gml:pos>
</gml:Point>
```

Figure 4-3

Line String encoding example:

```
<gml:LineString>
<gml:posList>-73.991 40.736 -73.991 40.736</gml:posList>
</gml:LineString>
```

Figure 4-4

Polygon encoding example:

```
<gml:Polygon>
<gml:exterior>
<gml:LinearRing>
<gml:posList>
22.546 62.391 25.033 62.404 24.995 60.182 22.483
60.169 22.546 62.391
</gml:posList>
</gml:LinearRing>
</gml:exterior>
<gml:interior>
<gml:LinearRing>
<gml:posList>
23.227 61.811 23.467 61.306 24.023 61.621 24.035
61.621 23.227 61.811
</gml:posList>
</gml:LinearRing>
</gml:interior>
</gml:Polygon>
```

Figure 4-5

5 Coordinate Reference Systems (CRS)

5.1 Introduction

For exchange of ice data WGS84 (EPSG: 4326) must be used

5.2 Horizontal Coordinate Reference System

Table 5-1 — S-4111 Coordinate Reference Systems (EPSG Codes)

| EPSG Code | Coordinate Reference System |
|--|-----------------------------|
| 4326 | WGS84 |
| The full reference to EPSG can be found at https://epsg.org . | |

| | |
|---|--|
| Horizontal Coordinate Reference System | EPSG: 4326 |
| Projection | NONE (tbc) |
| Temporal reference system | Gregorian Calendar (tbc) |
| Coordinate Reference System registry | EPSG Geodetic Parameter Dataset |
| Date type (according to [iso-19115-1]) | 002 — publication (tbc) |
| Responsible party | Technical Commission for Oceanography and Marine Meteorology (JCOMM) |
| URL | https://wmo.int/ |

5.3 Vertical Coordinate Reference System

Although in this product there are no direct vertical coordinates the values of the depth attributes are indirectly such coordinates. Therefore, it is important to specify the vertical CRS to which these values conform. The vertical CRS is an earth gravity-based, one-axis coordinate system. The Orientation of the axis is defined by the vertical coordinate system attribute (*verticalCS*) in the root group (see [\[tab-root-group-attributes\]](#)).

The vertical datum must be taken from the code-list specified by the IHO Geospatial Information (GI) Registry for the attribute named *Vertical Datum*. It will be defined in the root group as an HDF5 attribute (see [\[tab-root-group-attributes\]](#)).

5.4 Temporal reference system

The temporal reference system is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with [clause=5.4.4](#). A date-time variable will have the following 16-character format: *yyyymmddThhmmssZ*.

6 Data Quality

As ice charts are done for different purposes (from weekly overview to tactical charts and further to model forecasts) data quality can differ. Differences can also be found between ice charts of the same region and same nominal date resulting from different issuing agencies or also from different forecasts models. Further information can be found in the WMO publication 574.

6.1 Completeness

6.1.1 Commission

6.1.2 Omission

6.2 Logical consistency

6.2.1 Conceptual consistency

Conceptual Consistency is applicable for S-411 and follows the guidelines from [part=1](#).

Data Producers must verify that the dataset conforms to the S-100 General Feature Model.

If the dataset conforms to the S-100 General Feature Model, the dataset PASSES this test.

6.2.2 Domain consistency

Domain consistency is applicable for S-411 and follows the guidelines from [part=5](#).

Data Producers must verify that the dataset conforms to the S-411 Feature Catalogue and to [Annex A](#).

If the dataset conforms to the S-411 Feature Catalogue and to [Annex A](#), the dataset PASSES this test.

6.2.3 Format consistency

Format Consistency is applicable for S-411 and follows the guidelines from [part=10c](#).

Data Producers must verify that the dataset conforms to [Section 10](#) of this Product Specification.

If the dataset conforms to [Section 10](#), the dataset PASSES this test.

6.3 Positional accuracy

6.4 Temporal accuracy

6.5 Thematic accuracy

6.5.1 Thematic classification correctness

6.5.2 Non-quantitative attribute accuracy

6.5.3 Quantitative attribute accuracy

7 Data Capture and Classification

The data will be captured normally from satellite data. The extraction and classification will be done by ice analysts. In some areas of the world (e.g. the Baltic Sea) in addition also some direct shore and ship based observations and textual ice reports from ice authorities will be used. Further information can be found in the WMO publication 574 in Appendix A.

8 Data Maintenance

8.1 Maintenance and Update Frequency

Ice information datasets should be maintained if a new dataset of region and provider is available. There is no updating mechanism necessary, because the datasets itself will not be updated. The old one has to be replaced with new one.

9 Portrayal

9.1 Rules

Diagramm to be inserted.

main.xml includes all the rules for single feature types. It manages the selection of the right rule, depending on current feature type in dataset and parameters in iceDisplayParameters.xml

iceDisplayParameters.xml contains parameters important for display of ice features:

String iceclass

Boolean encoverlay

String Display Mode

Depending on the iceclass parameter the right seaice or lacice rule can be selected. The default is *_class_III.xml

The encoverlay parameter helps to calculate the priority for display of single ice feature types. If encoverlay is true, the priority will be calculated, depending on priority of land area feature in ENC. The area objects of ice features should be displayed under the land area polygons, because they are usually drawn over the land.

9.2 Symbols

9.2.1 Polygon Features

9.2.1.1 IceNavigationalDisplayMode (Traffic Light Principle, depends on Ice Class)

Figure to be inserted here.

9.2.1.2 IceScientificIceactDisplayMode

Figure to be inserted here.

9.2.1.3 IceNavigationalDisplayMode

Figure to be inserted here.

9.2.2 Line Features

Figure to be inserted here.

9.2.3 Point Features

Figure to be inserted here.

9.2.4 Draw order

Table to be inserted here.

10 Data Product Format (Encoding)

10.1 Introduction

The S-411 data set must be encoded using the Geographical Markup Language (GML).

10.2 Product structure

11 Data Product Delivery

11.1 Introduction

This clause describes how S-411 data will be delivered from the charting authority to the mariner.

Units of Delivery Exchange Set

Transfer Size See [Clause 11.2.2](#).

Medium Name Digital Data Delivery

Other Delivery Information Each dataset must be contained in a physically separate, uniquely identified file on the transfer medium.

Each exchange set has a single exchange catalogue which contains the discovery metadata for each dataset.

An exchange set is encapsulated into a form suitable for transmission by a mapping called an encoding. An encoding translates each of the elements of the exchange set into a logical form suitable for writing to media and for transmission online. An encoding may also define other elements in addition to the exchange set contents (This is media identification, data extents etc. ...) and may define commercial constructs such as encryption and compression methods.

If the data is transformed in S-411 it must not be changed.

This Product Specification defines the encoding which must be used as a default for transmission of data between parties.

The encoding encapsulates exchange set elements as follows:

Mandatory Elements

- S-411 datasets — HDF encoding
- Exchange Catalogue — the XML encoded representation of exchange set catalogue features [discovery metadata].

Optional Elements

- S-411 Feature Catalogue — If it is necessary to deliver the latest Feature Catalogue to the end user it may be done using the S-411 exchange set mechanism for datasets
- S-411 Portrayal Catalogue — If it is necessary to deliver the latest Portrayal Catalogue to the end user it may be done using the S-411 exchange set mechanism for datasets.

11.2 Dataset

11.2.1 Dataset management

11.2.2 Dataset size

11.2.3 Dataset file naming

Dataset naming must follow a standard pattern to give implementers greater predictability of incoming datasets (see [part=17,clause=4.3](#)). S-411 dataset naming conventions must follow these rules.

411YYYY0000000000000000. 411 GML the first 3 characters identify the dataset as an S-411 dataset (mandatory).

- YYYY the fourth to seventh characters identify the producer code according to the Producer Code Register.
- ØØØØ the eighth to the maximum nineteenth characters are optional and may be used in any way by the producer to provide the unique file name. The following characters are allowed in the dataset name: A to Z, 0 to 9 and the special character _ (underscore).
- GML denotes an HDF5 file.

11.3 Exchange Set

The structure of an S-411 Exchange Set must be according to the structure described below, which is based on [part=17,clause=4.2](#).

- 1) An S-411 Exchange Set must contain an Exchange Set Catalogue, CATALOG.XML, its digital signature CATALOG.SIGN, and may contain any number of S-411 conformant dataset files, support files, and Catalogue files.
- 2) All content must be placed inside a top root folder named S100_ROOT. This is the only top level root folder in an Exchange Set containing only S-100 products.
- 3) The S100_ROOT folder must contain a subfolder named S-411. This subfolder holds content specific to the S-411 Product Specification.
- 4) The S-411 subfolder must contain subfolders for the component dataset files (DATASET_FILES) and Catalogues (CATALOGUES) as required.
- 5) The required Exchange Set Catalogue XML document instance must be named CATALOG.XML and placed in the S100_ROOT folder, together with its digital signature (CATALOG.SIGN) file. All other digital signatures are included within their corresponding resource metadata records in the CATALOG.XML.

11.4 Exchange Catalogue

The Exchange Catalogue acts as the table of contents for the Exchange Set. The Catalogue file of the Exchange Set must be named CATALOG.XML. No other file in the Exchange Set may be named CATALOG.XML. The contents of the Exchange Catalogue are described in [Section 12](#).

11.5 Data integrity and encryption

[part=15](#) defines the algorithms for compressing, encrypting and digitally signing datasets based on the S-100 Data Model. The individual Product Specifications provide details about which of the elements are being used and on which files in the dataset.

11.5.1 Use of compression

The data producer decides if compression will be used on the S-411 product files (HDF5). It is expected that a hydrographic office will make a policy decision and that all the S-411 datasets from the producer will be either compressed or uncompressed.

It is recommended to compress all the dataset files, for example HDF5 files. The ZIP compression method defined in [part=15,clause=5.2](#) must be applied to the product files.

11.5.2 Use of data protection

It is recommended to encrypt all the dataset files, for example HDF5. The encryption method defined in [part=15](#) must be applied.

11.5.3 Use of digital signatures

Digital signatures shall be used on all files included in a S-411 compliant Exchange Set to meet the requirements of IMO resolution MSC.428(98) to reduce cyber security risks among users, especially when used in navigations systems at sea. The recommended signature method is defined in [part=15](#).

The digital signature information is encoded in the corresponding discovery block in the exchange catalogue for each file included in the Exchange Set.

12 Metadata

12.1 Introduction

The Metadata elements used in the Bathymetric Surface product are derived from S-100 and from [\[iso-19115-1\]](#) and [\[iso-19115-2\]](#). Optionally additional metadata may be derived from [\[iso-ts-19130\]](#) and [\[iso-ts-19130-2\]](#) especially metadata relating to the sonar equipment which may have been used to acquire the bathymetric data.

Metadata used for the discovery, identification, and use of S-411 datasets in S-100-based navigations systems (specifically, an S-100-capable ECDIS) is encoded in the exchange catalogue. This metadata conforms to S-100 Part 17, with product-specific restrictions added.

12.2 Exchange Set metadata

For information exchange, there are several categories of metadata required: metadata about the overall Exchange Catalogue, metadata about each of the datasets contained in the Catalogue.

[Figure 12-1](#) depicts the relationships of exchange set elements (datasets and feature/portrayal catalogues) and exchange set metadata. This figure is derived from [part=17,figure=2](#) with relationships not applicable to S-411 omitted.

[Figure 12-2](#) depicts the structure of the exchange catalogue and its component discovery metadata blocks. The structure is the same as in [part=17](#).

More detailed information about the various classes is shown in [Figure 12-3](#) with further description in [Table 12-1](#) to [Clause 12.8.2](#). In the cases in which classes are used without modification, refer to [part=17](#) for their descriptions.

The discovery metadata classes have numerous attributes which enable important information about the datasets to be examined without the need to process the data (e.g., decryption, decompression, loading). Other Catalogues can be included in the Exchange Set in support of the datasets such as Feature and Portrayal.

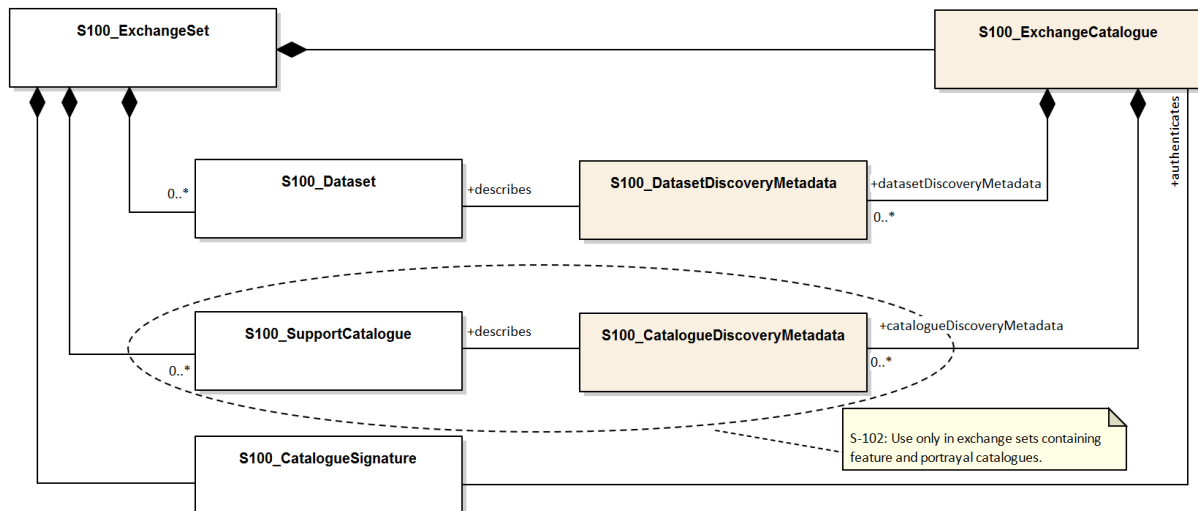


Figure 12-1 — Components and associated metadata for the S-411 exchange set ([part=17,figure=2](#) with items not used by S-411 omitted)

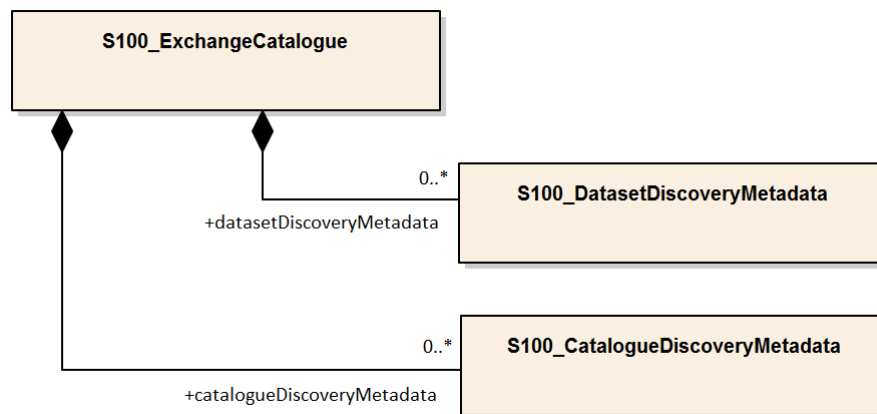


Figure 12-2 — Relationship between exchange catalogue, discovery metadata, and dataset ([part=17,figure=6](#) with items not used by S-411 omitted)



The following clauses define the mandatory and optional metadata needed for S-411. In some cases, the metadata may be repeated in a national language. If this is the case it is noted in the Remarks column.

The XML schemas for S-411 exchange catalogues will be available from the IHO Geospatial Information (GI) Registry and/or the S-100 GitHub site (<https://github.com/IHO-S100WG>).

The S-411 exchange catalogue uses the S-100 exchange catalogue schemas which are available from the S-100 schema server at <https://schemas.s100dev.net> (downloadable archives are also available on the site for offline use). Implementation of the S-411-specific constraints described in following clauses below is left to developer decision as it can be done in various ways depending on implementation frameworks and the requirements of production or application software.

12.3 Language

The exchange language must be English.

Character strings must be encoded using the character set defined in [\[iso-10646-1\]](#), in Unicode Transformation Format-8 (UTF-8). A BOM (byte order mark) must not be used.

12.4 S100_ExchangeCatalogue

Each Exchange Set has a single S100_ExchangeCatalogue which contains meta information for the data in the Exchange Set.

S-411 uses S100_ExchangeCatalogue without modification.

12.4.1 S100_ExchangeCatalogueIdentifier

S-411 uses S100_ExchangeCatalogueIdentifier without modification.

12.4.2 S100_CataloguePointOfContact

S-411 uses S100_CataloguePointOfContact without modification.

12.5 S100_DatasetDiscoveryMetadata

Dataset discovery metadata in S-411 restricts certain attributes and roles as described in [Table 12-1](#). Optional S-100 attributes which are mandatory in S-411 are indicated in the Remarks column.

Table 12-1 — S100_DatasetDiscoveryMetadata parameters

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|-------------------------------|--|------|---------|--|
| Class | S100_DatasetDiscoveryMetadata | Metadata about the individual datasets in the Exchange Catalogue | - | - | The optional S-100 attributes <i>updateNumber</i> , <i>updateApplicationDate</i> , <i>referenceID</i> , and <i>temporalExtent</i> are not used in S-411. References to support file discovery metadata are not permitted because S-411 does not use support files. |
| Attribute | fileName | Dataset file name | 1 | URI | See part=1,clause=4.6 Format: file:/S-411/DATASET_FILES/<dsname> Dataset file name <dsname> must be according to format defined in Clause 11.2.3 . |
| Attribute | datasetID | Dataset ID expressed as a Maritime Resource Name | 0..1 | URN | The URN must be an MRN. See part=3,clause=10 |
| Attribute | editionNumber | The edition number of the dataset | 1 | Integer | When a data set is initially created, the Edition number 1 is assigned to it. The Edition number is increased by 1 at each new Edition. Edition number remains the same for a re-issue. |

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|------------------------|---|------|-----------------------------------|--|
| | | | | | Mandatory in S-411 |
| Attribute | issueDate | Date on which the data was made available by the Data Producer | 1 | Date | - |
| Attribute | issueTime | Time of day at which the data was made available by the Data Producer | 0..1 | Time | The S-100 datatype Time May be required if multiple instances of a product are issued on the same day. |
| Attribute | boundingBox | The extent of the dataset limits | 1 | EX_GeographicBoundingBox | Mandatory in S-411 Defined as a rectangle coincident with the outermost cell boundaries of the dataset. |
| Attribute | productSpecification | The Product Specification used to create this dataset | 1 | S100_ProductSpecification | Table 12-5 |
| Attribute | producingAgency | Agency responsible for producing the data | 1 | CI_Responsibility>CI_Organisation | See part=17,table=17-3 |
| Attribute | producerCode | The official IHO Producer Code from S-62 | 1 | CharacterString | Mandatory in S-411 |
| Attribute | encodingFormat | The encoding format of the dataset | 1 | S100_EncodingFormat | The only allowed value is GML Table 12-4 |
| Attribute | dataCoverage | Provides information about data coverages within the dataset | 1..* | S100_DataCoverage | Mandatory in S-411 Table 12-2 |
| Attribute | comment | Any additional information | 0..1 | CharacterString | - |
| Attribute | defaultLocale | Default language and character set used in the dataset | 0..1 | PT_Locale | In absence of defaultLocale, the language is English, and the character set is UTF-8. |
| Attribute | otherLocale | Other languages and character sets used in the dataset | 0..* | PT_Locale | |
| Attribute | metadataPointOfContact | Point of contact for metadata | 0..1 | CI_Responsibility>CI_Individual | Only if metadataPointOfContact differs from producingAgency |

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|-------------------|---|------|---|---|
| | | | | or CI_Responsibility>CI_ Organisation | |
| Attribute | metadataDateStamp | Date stamp for metadata | 0..1 | Date | May or may not be the issue date |
| Attribute | replacedData | Indicates if a cancelled dataset is replaced by another data file(s) | 0..1 | Boolean | See note following part=17,table=S100_DatasetDiscoveryMetadata Mandatory when purpose = cancellation |
| Attribute | dataReplacement | Dataset name | 0..* | CharacterString | A dataset may be replaced by 1 or more datasets. Dataset name must be according to format defined in Clause 11.2.3. For example, 411DE00KD54.GML See note following part=17,table=S100_DatasetDiscoveryMetadata Mandatory when replacedData = true |
| Attribute | navigationPurpose | Classification of intended navigation purpose (for Catalogue indexing purposes) | 1..3 | S100_NavigationPurpose | If Product Specification is intended for creation of navigational products, this attribute should be mandatory. Mandatory in S-411 |

12.5.1 S100_NavigationPurpose

S-411 uses S100_NavigationPurpose without modification.

12.5.2 S100_DataCoverage

S-411 uses S100_DataCoverage without modification, but with additional remarks and changes to the multiplicity.

Table 12-2 — S100_DataCoverage parameters

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|-------------------|--|------|------|--|
| Class | S100_DataCoverage | A spatial extent where data is provided along with the display scale information for the provided data | - | - | This field is used by user systems as part of the data loading and unloading algorithms, and it is strongly encouraged that Product Specifications mandate the use of one or more of the displayScale provided as part of S100_DataCoverage. |

| Role name | Name | Description | Mult | Type | Remarks |
|--|---------------------|--|------|---------------------|--|
| Attribute | boundingPolygon | A polygon which defines the actual data limit | 1 | EX_BoundingPolygon | Clause 12.5.2, Note |
| Attribute | temporalExtent | Specification of the temporal extent of the coverage | 0 | S100_TemporalExtent | The <i>temporalExtent</i> is not used in S-411. |
| Attribute | optimumDisplayScale | The scale at which the data is optimally displayed | 0..1 | Integer | Example: A scale of 1:25000 is encoded as 25000 |
| Attribute | maximumDisplayScale | The maximum scale at which the data is displayed | 0..1 | Integer | |
| Attribute | minimumDisplayScale | The minimum scale at which the data is displayed | 0..1 | Integer | |
| NOTE <i>boundingPolygon</i> is restricted to a single GML Polygon with one exterior and 0 or more interiors expressed as Linear Rings using SRS EPSG:4326. The exterior and optional interiors shall be composed of a closed sequence of ≥ 4 coordinate positions expressed individually or as a list (posList). The GML polygon shall have a valid GML identifier. | | | | | |

12.5.3 S100_Purpose

S-411 uses S100_Purpose without modification, but with a restriction on the allowed values.

Table 12-3 — S100_Purpose

| Role name | Name | Description | Code | Remarks |
|-------------|--------------|--|------|--|
| Enumeration | S100_Purpose | The purpose of the dataset | - | The S-100 values <i>update</i>, <i>reissue</i>, and <i>delta</i> are not used in S-411. |
| Value | newDataset | Brand new dataset | 1 | No data has previously been produced for this area. |
| Value | newEdition | New edition of the dataset or Catalogue | 2 | Includes new information which has not been previously distributed by updates. |
| Value | cancellation | Dataset or Catalogue that has been cancelled | 5 | Indicates the dataset or Catalogue should no longer be used and can be deleted. |

12.5.4 S100_EncodingFormat

S-411 uses S100_EncodingFormat with a restriction on the allowed values to permit only the S-100 GML format for S-411 datasets.

Table 12-4 — S100_EncodingFormat parameters

| Role name | Name | Description | Code | Remarks |
|-------------|---------------------|---|------|--|
| Enumeration | S100_EncodingFormat | The encoding format | - | The only value allowed in S-411 is “GML”. |
| Value | HDF5 | The HDF5 data format as defined in part=10c | 3 | - |

12.5.5 S100_ProductSpecification

S-411 uses S100_ProductSpecification without modification, but with additional remarks and changes to the multiplicity.

Table 12-5 — S100_ProductSpecification parameters

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|---------------------------|--|------|--|---|
| Class | S100_ProductSpecification | The Product Specification contains the information needed to build the specified product. | - | - | - |
| Attribute | name | The name of the Product Specification used to create the datasets | 1 | CharacterString | The name in the GI Registry should be used for this field. For S-411, this name is “Bathymetric Surface” (as of 25 June 2024). |
| Attribute | version | The version number of the Product Specification | 1 | CharacterString | TR 2/2007 specifies versioning of Product Specifications Example: 3.0.0 for S-411 Edition 3.0.0 |
| Attribute | date | The version date of the Product Specification | 1 | Date | - |
| Attribute | productIdentifier | Machine readable unique identifier of a product type | 1 | CharacterString (Restricted to Product ID values from the IHO Product Specification Register in the IHO Geospatial Information (GI) Registry) | For S-411, this identifier is “S-411” (without quotes). |
| Attribute | number | The number used to lookup the product in the Product Specification Register of the IHO GI registry | 1 | Integer | For IHO Product Specifications, these numbers should be taken from the IHO Product Specification Register in the IHO GI Registry. The corresponding Idx-number of the IHO Registry for S-411 is numbered 199. |

| Role name | Name | Description | Mult | Type | Remarks |
|-----------|--------------------|---|------|-------------------------|--|
| Attribute | complianceCategory | The level of compliance of the Product Specification to S-100 | 0..1 | S100_ComplianceCategory | See part=4a,clause=4a-5.5 and Clause 12.5.6 below. |

12.5.6 S100_ComplianceCategory

S-411 exchange sets conforming to this edition of S-411 and using a CRS from the EPSG registry may be encoded as category 3 or 4 when the *complianceCategory* metadata attribute is populated. Because S-98 interoperability assumes *category4* datasets, *category4* may be used for test purposes, though the absence of test datasets and of a published IHO interoperability catalogue mean this edition of S-411 does not yet qualify for *category4*. **Given the uncertainty about interoperability testing requirements and availability of test datasets, the S-100 WG chair and S-411 PT chair should be consulted for up-to-date guidance.**

Table 12-6 — S100_ComplianceCategory

| Role Name | Name | Description | Code | Remarks |
|-------------|-------------------------|--|------|---|
| Enumeration | S100_ComplianceCategory | - | - | S-411 should use <i>category3</i> or <i>category4</i> , subject to the guidance provided in Clause 12.5.6 . |
| Value | category3 | IHO S-100 compliant with standard encoding | 3 | Qualifies as <i>category2</i> ; plus “The Product Specification uses only an encoding method defined in part=10;and!part=4a,clause=5.5.3 ” |
| Value | category4 | IHO S-100 and IMO harmonized display compliant | 4 | Qualifies as <i>category3</i> ; plus additional requirements, including a portrayal catalogue, cybersecurity (digital signatures and encryption), test material, use of a CRS from the EPSG Registry, and compliance with the IHO S-98 interoperability catalogue. part=4a,clause=5.5.4 |

12.5.7 S100_ProtectionScheme

S-411 uses S100_ProtectionScheme without modification.

12.6 MD_MaintenanceInformation

S-411 uses MD_MaintenanceInformation without modification.

12.7 MD_MaintenanceFrequencyCode

S-411 uses MD_MaintenanceFrequencyCode without modification.

12.8 S100_CatalogueDiscoveryMetadata

S-411 uses S100_CatalogueDiscoveryMetadata without modification.

12.8.1 S100_CatalogueScope

S-411 uses S100_CatalogueScope without modification.

12.8.2 PT_Locale

S-411 uses PT_Locale without modification. The class PT_Locale is defined in [\[iso-19115-1\]](#). LanguageCode, CountryCode, and MD_CharacterSetCode are ISO codelists which are defined in a codelists file which is part of the S-100 Edition 5.2.0 schema distribution.

12.9 Certificates and Digital Signatures

The classes S100_SE_CertificateContainerType ([part=15,clause=8.11.1](#)), S100_SE_DigitalSignatureReference ([part=15,clause=8.11.7](#)), and S100_SE_DigitalSignature are defined in [part=15](#) and implemented in the S-100 generic schemas.

In accordance with [part=15](#), only the ECDSA algorithm is allowed from the S100_SE_DigitalSignatureReference enumeration.

S-411 uses S100_SE_DigitalSignature without modification. As stated in [part=15,clause=15-8.11.3](#):

“The class S100_SE_DigitalSignature is realized as one of either S100_SE_SignatureOnData (a digital signature of a particular identified resource) or an additional digital signature defined using the class S100_SE_AdditionalSignature, each of which is either a S100_SE_SignatureOnData or S100_SE_SignatureOnSignature element as described in [part=15,clause=8.8](#). [part=17](#) metadata thus allows for multiple digital signatures, a single mandatory S100_SE_SignatureOnData and any number of additional signatures, either of the data or other signatures.”

Annex A

Data Classification and Encoding Guide

A.1 Features

A.1.1 BathymetryCoverage

Table A-1 — BathymetryCoverage feature parameters

| Term: Bathymetry Coverage | | | |
|---|---|---------------------|--------------|
| IHO Definition: A set of value items required to define a dataset representing a depth calculation and its associated uncertainty. | | | |
| Primitive: S100_IF_GridCoverage | | | |
| Attribute | Allowable Encoding Value | Type | Multiplicity |
| depth | Must be in decimal metres with resolution not to exceed 0.01 metres | real (32-bit Float) | 1 |
| uncertainty | Must be in decimal metres with resolution not to exceed 0.01 metres | real (32-bit Float) | 0..1 |

A.1.2 QualityOfBathymetryCoverage

Table A-2 — QualityOfBathymetryCoverage feature parameters

| Term: Quality Of Bathymetry Coverage. | | | |
|--|--|-------------------------|--------------|
| IHO Definition: A set of references to value records that provide localised information about depth, uncertainties, and bathymetry coverage metadata. | | | |
| Primitive: S100_IF_GridCoverage | | | |
| Attribute | Constraint | Type | Multiplicity |
| iD | Each record must have a unique identifier. | unsigned 32-bit Integer | 1 |

A.2 Feature Attributes

A.2.1 BathymetryCoverage

Table A-3 — BathymetryCoverage feature attribute parameters

| |
|--|
| IHO Definition: depth . The vertical distance from a given water level to the bottom [[iho-s32]] . |
| Unit: metres |
| Resolution: 0.01 |
| Remarks: <ul style="list-style-type: none"> Drying heights (drying depths) are indicated by a negative value. |
| IHO Definition: uncertainty . Estimate characterising the range of values within which the true value of a measurement is expected to lie as defined within a particular confidence level. It is expressed as a positive value. |
| Unit: metres |
| Resolution: 0.01 |
| Remarks: |

- Represents a +/- value defining the possible range of associated depth.
- Expressed as a positive number.

A.2.2 QualityOfBathymetryCoverage

Table A-4 — QualityOfBathymetryCoverage feature attribute parameters

| |
|---|
| IHO Definition: ID . Meta data record identifier for QualityOfBathymetryCoverage |
| Unit: |
| Resolution: |
| Remarks: |