

Ice Information Product Specification

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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.

Table 1

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 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

1.2.1 Normative

GML	<i>Geography Markup Language (GML) Encoding Standard (Version 3.2.1)</i>
OpenGIS®	
S-100	<i>IHO Universal Hydrographic Data Model</i> , Edition 5.2.0, June 2024
ISO-19115-1	<i>Geographic information—Metadata—Part 1: Fundamentals—2014/Amd 1: 2018</i>
ISO-19115-3	<i>Geographic information—Metadata—Part 3: XML Schema implementation for fundamental concepts—2016</i>
ISO-19139-1	<i>Geographic information—XML schema implementation—Part 1: Encoding rules—2019</i>

1.2.2 Informative

TBD

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

Coordinate

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

NOTE 1 The numbers must be qualified by units and CRS.

Coordinate Reference System

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

Data Quality

A set of elements describing aspects of quality, including a measure of quality, an evaluation procedure, a quality result, and a scope.

Data Type

Specification of a value domain with operations allowed on values in this domain.

NOTE 2 Data types include primitive predefined types and user-definable types.

NOTE 3 A data type is identified by a term, for example Integer.

Dataset

An identifiable collection of data.

NOTE 4 A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature contained within a larger dataset. A hardcopy map or chart may be considered a dataset.

Datum

Parameter or set of parameters that define the position of the origin, the scale, and the orientation of a **coordinate** system.

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".

This definition may need to be adapted by JCOMM ETSI

NOTE 5 The numbers must be qualified by units and datum.

ECDIS

A navigation information system which with adequate back-up arrangements can be accepted as complying with the up-to-date chart required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended, by displaying selected information from a System Electronic Navigational Chart (System Database) with positional information from navigation sensors to assist the Mariner in route planning and route monitoring, and if required display additional navigation-related information.

Enumeration

A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list.

Feature

Abstraction of real-world phenomena.

NOTE 6 A feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

Feature

Abstraction of real world phenomena.

NOTE 7 A feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

Feature Attribute

Characteristic of a **feature**.

NOTE 8 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.

Feature Catalogue

A catalogue containing definitions and descriptions of the **feature** types, **feature attributes** occurring in one or more sets of geographic data.

Geometric Primitive

Geometric object representing a single, connected, homogeneous element of geometry.

NOTE 9 Geometric primitives are non-decomposed objects that present information about geometric configuration. They include points, curves and surfaces.

Multiplicity

Specification of the number of possible occurrences of a property, or the number of allowable elements that may participate in a given relationship.

EXAMPLES: 1..* (one to many); 1 (exactly one); 0..1 (zero or one)

Point

0-dimensional geometric primitive, representing a position.

NOTE 10 The boundary of a point is the empty set.

Portrayal Catalogue

Collection of defined portrayals for a feature catalogue.

NOTE 11 Content of a portrayal catalogue includes portrayal functions, symbols, and portrayal context.

Vector

Quantity having direction as well as magnitude.

NOTE 12 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:

BSH	Bundesamt für Seeschifffahrt und Hydrographie (Germany)
CRS	Coordinate Reference System
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigational Chart
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
UTF-8	Unicode Transformation Format-8
WMO	World Meteorological Organization
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

A dataset that conforms to this Product Specification may be identified by its discovery metadata as defined in clause 12.

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

S-411 conforms to the General Feature Model (GFM) from S-100 Part 3. The GFM is the conceptual model and the implementation is defined in the Feature Catalogue. The S-411 Application Schema is realised in the Feature Catalogue and the Product Specification only contains specific examples.

Picture below shows very simplified structure of ice data structure

Figure 1 (UML diagram) to be inserted here

image::.../images/figure-ice-data-product-structure.png

General GML (XML) representation:

XML code to be inserted here

4.3 Feature Catalogue

4.3.1 Introduction

The S-411 Feature Catalogue describes the feature types, attributes, attribute values, associations and roles which may be used in an S-411 product.

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.

The S-411 Feature Catalogue is available in an XML document which conforms to the S-100 XML Feature Catalogue Schema and can be downloaded from the IHO website. S-411 Annex A – Data Classification and Encoding Guide, constitutes a human readable interpretation of the Feature Catalogue.

4.3.2 Application Schema implementation classes

4.3.2.1 Implementation classes description

4.3.2.1 UML diagram to be inserted here

I would suggest moving the table to the DCEG (and adapt to the DCEG format)

4.3.3 Feature types

4.3.3.1 IceDataSetType

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

UML diagramm 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.).

4.3.3.2 Geographic

Geographic (geo) feature types form the principal content of the S-411 product and are fully defined by their associated attributes. Details of geographic feature types can be found in Annex A – Data Classification and Encoding Guide, clause 2.1 and Sections 4-22.

4.3.4 Attributes

S-411 defines attributes as either simple or complex.

4.3.4.1 Simple attributes

S-411 uses 3 types of simple attributes; these types are listed in Annex A – Data Classification and Encoding Guide, clause 2.4.2. Descriptions of the simple attributes included in S-101 can be found in Annex A, Sections 27, 28 and 30.

4.3.4.2 Complex attributes

Complex attributes are aggregations of other attributes that are either simple or complex. The aggregation is defined by means of attribute bindings. Examples of modelling complex attributes can be found in S-100 Part 2a, Appendix 2a-A. Descriptions of the complex attributes included in S-411 can be found in Annex A – Data Classification and Encoding Guide, Section 29.

4.4 Dataset types

4.4.1 Introduction

At the moment there 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 code to be inserted here._#
```

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 code to be inserted here._#
```

Figure 4-3

Line String encoding example:

```
#_gml code to be inserted here._#
```

Figure 4-4

Polygon encoding example:

```
#_gml code to be inserted here._#
```

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 updated. The old one have 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

This clause describes encoding rules for S-100 base ice datasets. For the encoding of ice datasets GML 3.2.1 was used.

10.2 Encoding Rules

10.2.1 Longitude / Latitude

Longitude and latitude must be encoded in decimal degrees, e.g.: 12.567 56.765

Number of decimals is not limited, but it should be as less as possible for minimizing of file size, normally 3 or even 2 digits are enough

10.2.2 Elements and attributes

Names of elements representing ice features or attributes (from IceFDC dictionary see Table 1: Summary of Types) must be encoded with lower case letters

Names of elements representing features or attributes from other dictionaries must be encoded with upper case letters

Character Set is UTF-8

Elements or attributes may be empty, but it should be eliminated for minimizing of file size

10.3 Encoding Examples

Below there are three examples of the encoding of various ice features using different geometric primitives, the encoding of other ice objects can be done in a similar way.

10.3.1 Polygon Feature

GML code to be inserted

10.3.2 LineString Feature

GML code to be inserted

10.3.3 Point Feature

GML code to be inserted

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.

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

test image

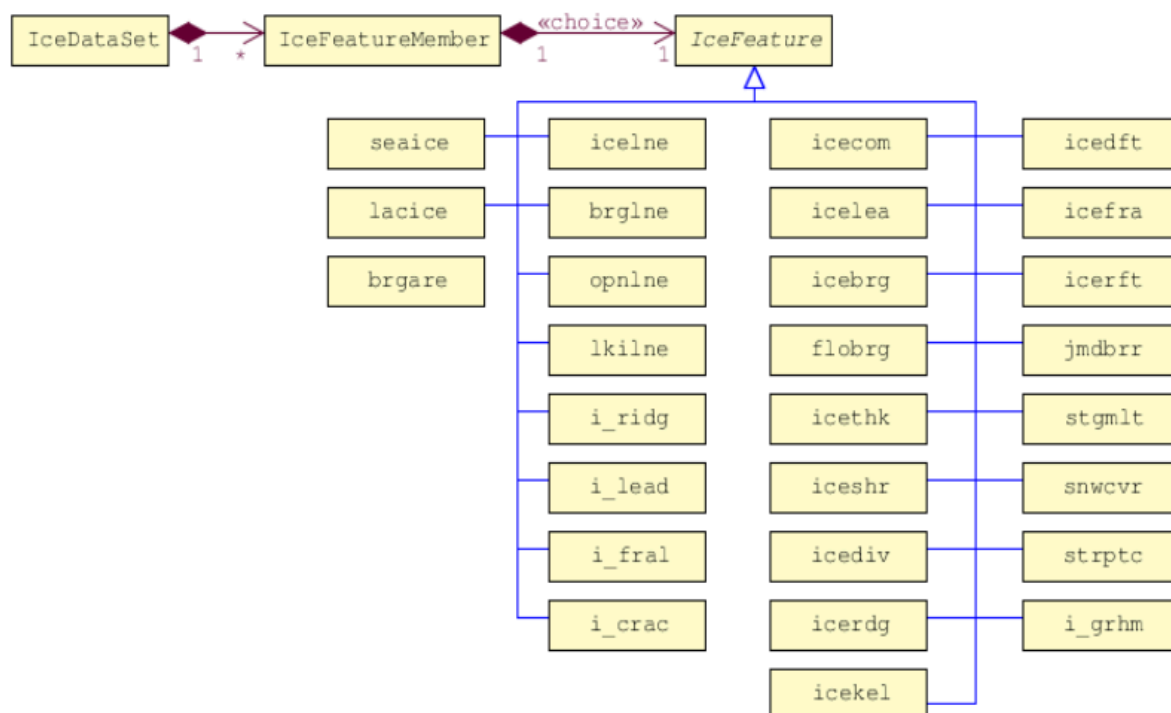


Figure 12-1 — Data Set Structure of S-411

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.

[\[fig-components-and-associated-metadata-for-the-s411-exchange-set\]](#) 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.

[\[fig-relationship-between-exchange-catalogue-discovery-metadata-and-dataset\]](#) 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 [\[fig-s411-exchange-set-class-details\]](#) 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.

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: