

# Ice Information Product Specification

Edition 1.2.0 – January 2025

**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.

**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 Introduction

S-411 is the Ice Information Product Specification, produced by the World Meteorological Organization (WMO)/Intergovernmental Oceanographic Commission Technical Commission for Oceanography and Marine Meteorology (JCOMM) Expert Team on Sea Ice (ETSI).

This document has been produced in response to a requirement to produce a data product that can be used as an Information Overlay within an Electronic Chart Display and Information Systems (ECDIS). It is based on the IHO S-100 framework specification, the ISO 19100 series of standards and Geography Markup Language (GML). It is a vector product specification that is intended for encoding the extent and nature of Sea Ice for navigational purpose in ice covered regions.

## 1.2 Scope

This document describes an S-100 compliant Product Specification for Ice Information, which will form an overlay layer for an S-100 based marine navigation system. It specifies the content, structure, and metadata needed for creating a fully compliant S-411 product and for its portrayal within an S-100 system. This Product Specification includes the content model, the encoding, the Feature Catalogue, Portrayal Catalogue, and metadata.

## 1.3 References

### 1.3.1 Normative

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

S-97 *IHO Guidelines for Creating S-100 Product Specifications*, Edition 1.1.0, June 2020.

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

WMO-No. 574 *Sea-ice Information and Services*, 2024 edition

### 1.3.2 Informative

ISO 19101 *Geographic Information – Reference Model*, 2003

ISO 19103 *Geographic Information – Conceptual Schema Language*, 2005

ISO 19103-2 *Geographic Information – Conceptual Schema Language – Part 2*, 2005

ISO 19109 *Geographic Information – Rules for Application Schema*, 2005

ISO 19110 *Geographic Information – Methodology for Feature Cataloguing*, 2005

ISO 19111 *Geographic Information – Spatial Referencing by Coordinates*, 2007

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

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

ISO 19117 *Geographic Information – Portrayal*, 2012

ISO 19131 *Geographic Information – Data Product Specifications*, 2008

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

## 1.4 Terms, definitions and abbreviations

### 1.4.1 Use of language

Within this document:

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

#### 1.4.2 Terms and definitions

*The definitions hereafter have been copied from other S-1xx PS. The list has to be reviewed by JCOMM-ETSI*

##### **Application Schema**

Conceptual schema for data required by one or more applications.

##### **Attribute**

(1) Named property of an entity.

NOTE Describes a geometrical, thematic, or other characteristic of an entity.

(2) Feature within a classifier that describes a range of values that instances of the classifier may hold.

NOTE An attribute is semantically equivalent to a composition association; however, the intent and usage is normally different.

NOTE “Feature” used in this definition is the UML meaning of the term.

##### **Boundary**

Set that represents the limit of an entity.

NOTE Boundary is most commonly used in the context of geometry, where the set is a collection of points or a collection of objects that represent those points.

##### **Coordinate**

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

NOTE In a **coordinate reference system**, the coordinate numbers are qualified by units.

##### **Coordinate Reference System**

**Coordinate** system which is related to an object by a datum.

##### **Curve**

1-dimensional geometric primitive, representing the continuous image of a line.

NOTE The boundary of a curve is the set of points at either end of the curve. If the curve is a cycle, the two ends are identical, and the curve (if topologically closed) is considered to not have a boundary. The first point is called the start point, and the last is the end point. Connectivity of the curve is guaranteed by the “continuous image of a line” clause. A topological theorem states that a continuous image of a connected set is connected.

##### **Data Quality**

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

*No quality data in the current PS. TBC*

##### **Data Type**

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

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

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

##### **Dataset**

An identifiable collection of data.



**NOTE** A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature 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** 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** 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** 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** 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** 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** The boundary of a point is the empty set.

### Portrayal Catalogue

Collection of defined portrayals for a feature catalogue.

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

### 1.4.3 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

## 1.5 General data product description

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

## 1.6 Product Specification metadata

<b>Title</b>	Ice Information Product Specification
<b>S-100 Version</b>	5.2.0
<b>S-411 Version</b>	1.1.0

<b>Date</b>	15 June 2014
<b>Language</b>	English (optional additional)
<b>Classification</b>	Unclassified
<b>Contact</b>	Jürgen Holfort ( <a href="mailto:ice@bsh.de">ice@bsh.de</a> )
<b>Identifier</b>	JCOMM S-411
<b>Maintenance</b>	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: <a href="mailto:info@iho.int">info@iho.int</a>
<b>URL</b>	<a href="http://www.iho.int">www.iho.int</a>
<b>Identifier</b>	S-411
<b>Maintenance</b>	Changes to the Product Specification S-411 are coordinated by the JCOMM, and must be made available via the IHO web site.

## 1.7 IHO Product Specification Maintenance

### 1.7.1 Introduction

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

### 1.7.2 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.

### 1.7.3 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.

### 1.7.4 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.

### 1.7.5 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.

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

## 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.

The diagram below shows a very simplified summary of the ice data structure.

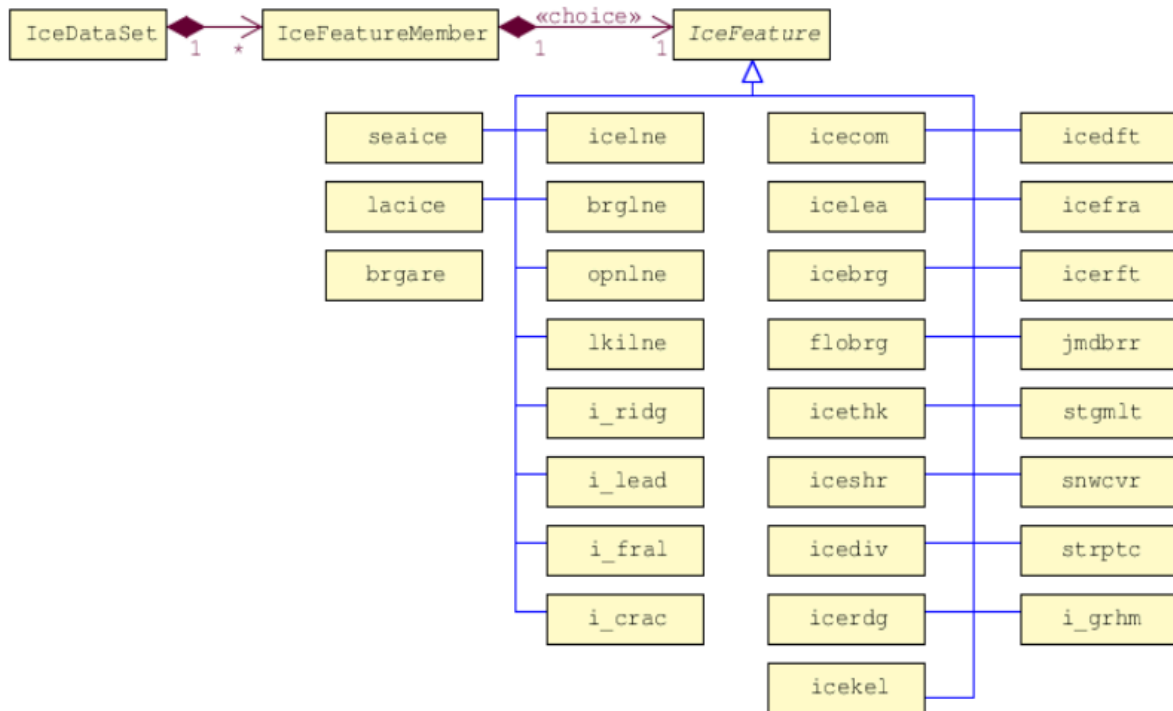


Figure 4-1 — : Ice Data Product Structure

### 4.2.1 S-411 Features

#### 4.2.1.1 Meta Features

S-411 provides a single meta-feature, **DataCoverage**. **DataCoverage** is for describing areas in the dataset that are populated with data. The dataset may include multiple **DataCoverage** features to describe different contiguous (i.e. non-overlapping) areas.

#### 4.2.1.2 Geographic Features

Geographic (geo) feature types form the principal content of the S-411 product and are fully defined by their associated attributes.

The following figure shows all the major ice features and a simplified view of their attributes in the S-411 Application Schema

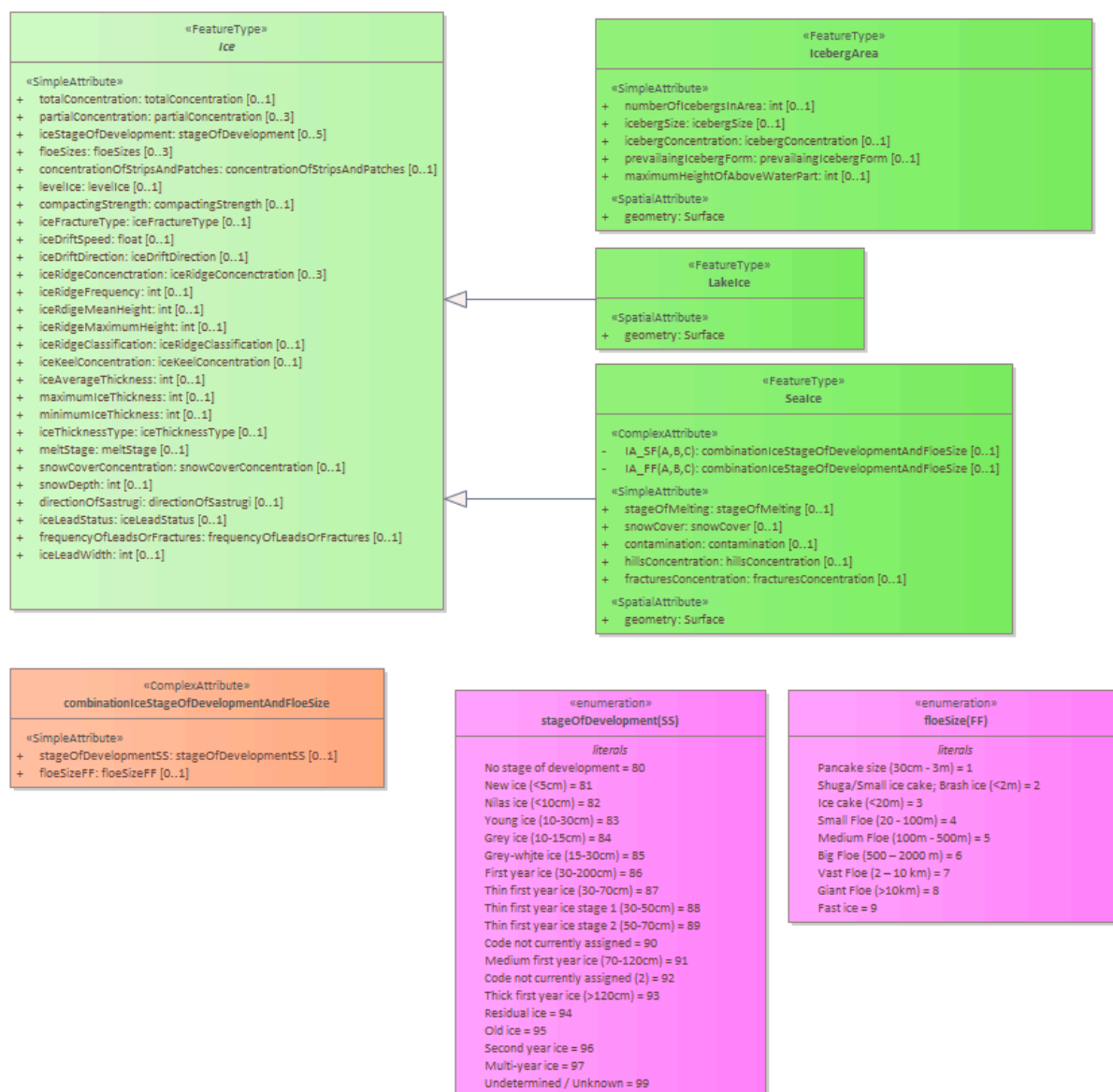


Figure 4-2 — All Ice Features

Limit and Line curve features and their attributes are shown in the following diagram

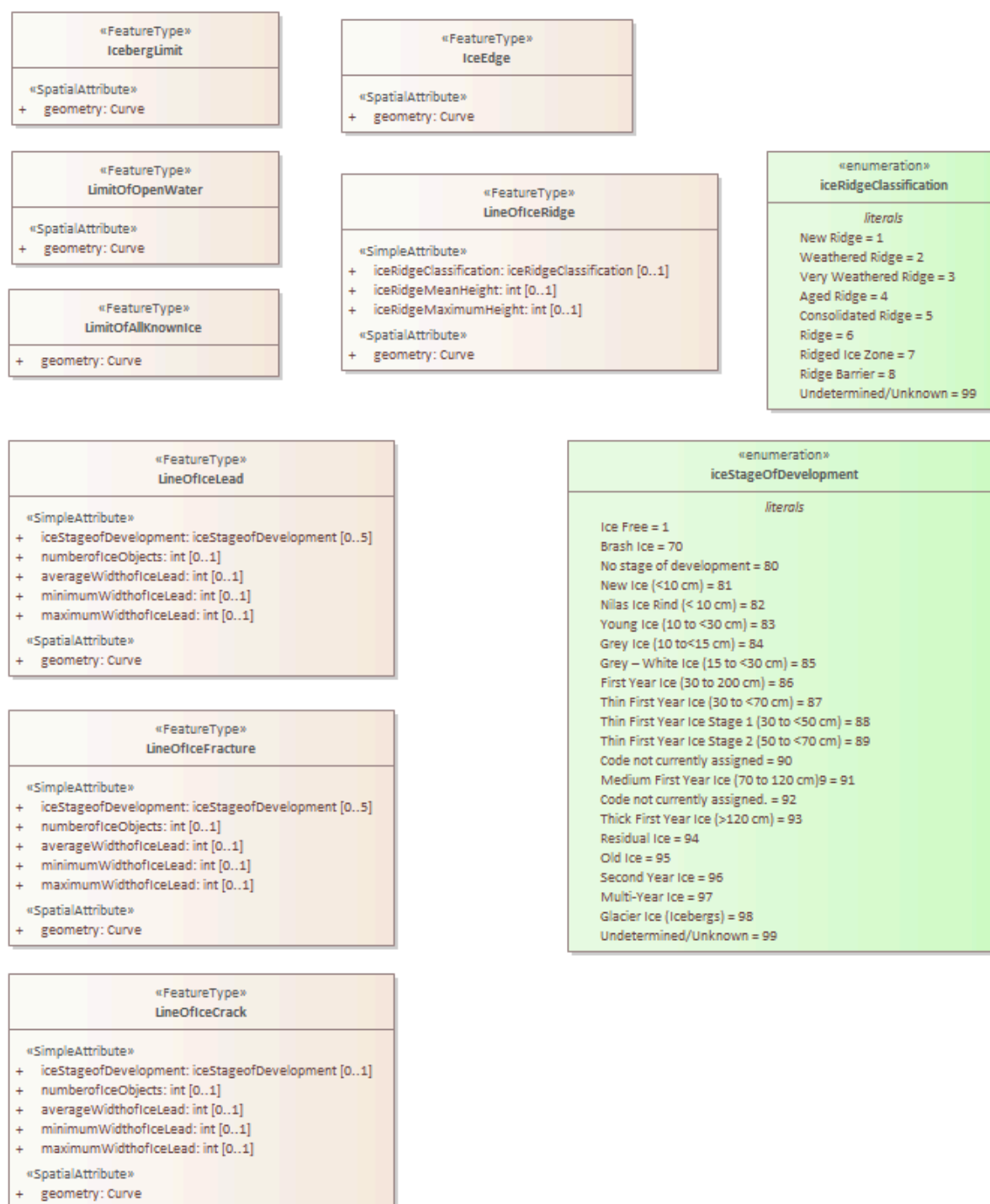


Figure 4-3 — All Curve Features

Full details of all geographic feature types can be found in Annex A – Data Classification and Encoding Guide, clause 2.1 and Sections 4-22.

## 4.2.2 Attributes

S-411 defines attributes as either simple or complex.

### 4.2.2.1 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.

#### **4.2.2.2 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.

*description of use of complex attributes in S-411*

### **4.3 Feature Catalogue**

#### **4.3.1 Introduction**

*Text in italics below has been added based on the S-101 PS. TBC by JCOMM-ETSI.*

*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

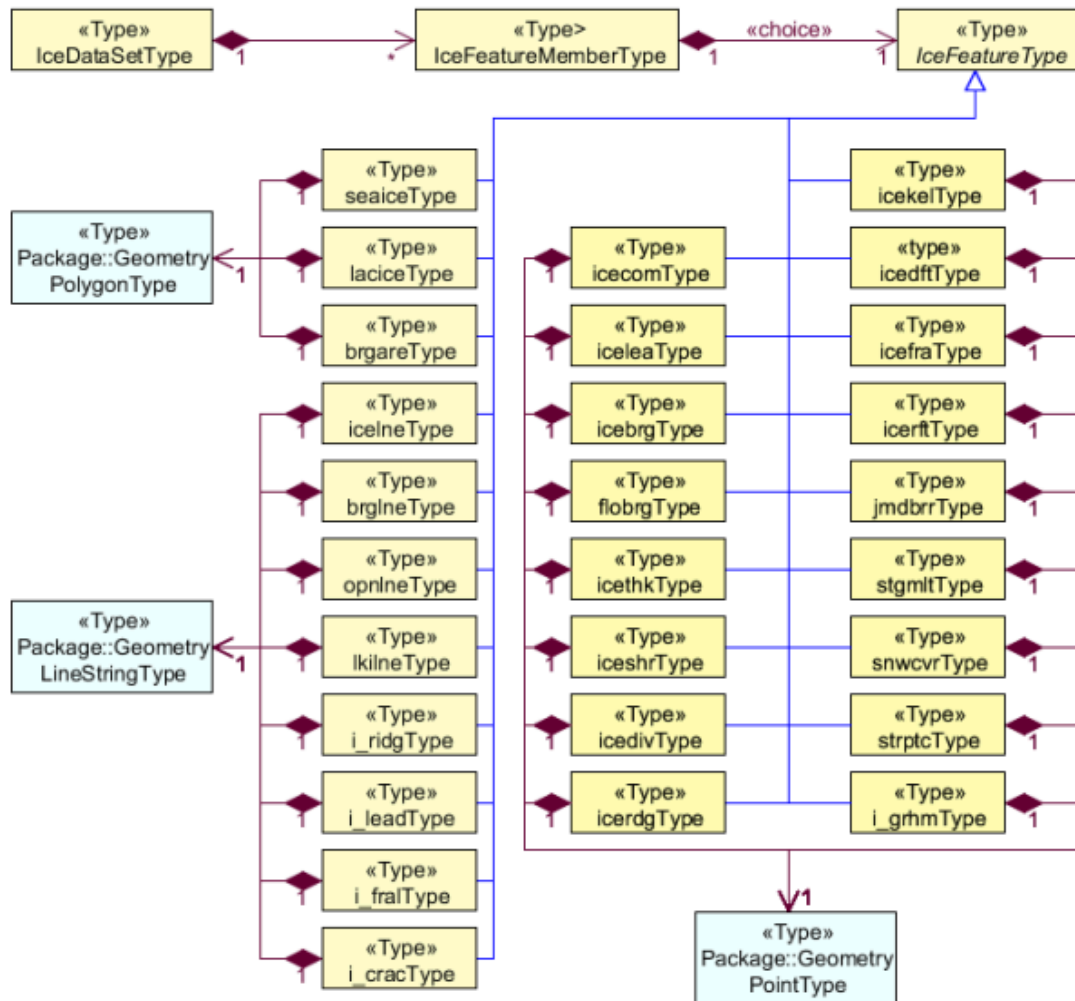


Figure 4-4 — : Ice Application Schema Types

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

Table 4-1

Role Name	Name	Description	Mult.	Data Type
Class	IceDataSet	Set of ice data	-	IceDataSetType
Association	IceFeatureMember	Contains ice feature members	1..*	IceFeatureMemberType

#### 4.3.2.2 IceDataSet / Types

##### 4.3.2.2.1 IceDataSetType

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

Placeholder

Figure 4-5 — : Ice Data Set Type

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

#### **4.3.2.3 seaiceType (Sea Ice)**

### Placeholder

**Figure 4-6 — : Sea Ice Type Sea Ice**

#### **4.3.2.4 laciceType (Lake Ice)**

### Placeholder

**Figure 4-7 — : Lake Ice Type Lake Ice**

#### **4.3.2.5 brgareType (Iceberg Area)**

### Placeholder

**Figure 4-8 — : Brgare Type Iceberg Area**

#### **4.3.2.6 icelneType (Ice Edge)**

### Placeholder

**Figure 4-9 — : Icelne Type Ice Edge**

#### **4.3.2.7 brglne Type (Iceberg Limit)**

### Placeholder

**Figure 4-10 — : Brglne Type Iceberg Limit**

#### **4.3.2.8 opnlne Type (Limit of Open Water)**

### Placeholder

**Figure 4-11 — : Opnlne Type Limit Of Open Water**

#### **4.3.2.9 lkilne Type (Limit of All Known Ice)**

### Placeholder

**Figure 4-12 — : Opnlne Type Limit of All Known Ice**

#### **4.3.2.10 i\_ridg Type (Line of Ice Ridge)**

### Placeholder

**Figure 4-13 — : i\_ridg Type Line Of Ice Ridge**

**4.3.2.11 i\_lead Type (Line of Ice Lead)**

## Placeholder

Figure 4-14 — : i\_lead Type Line Of Ice Lead

**4.3.2.12 i\_fral Type (Line of Ice Fracture)**

## Placeholder

Figure 4-15 — : i\_fral Type Line Of Ice Fracture

**4.3.2.13 i\_crac Type (Line of Ice Crack)**

## Placeholder

Figure 4-16 — : i\_crac Type Line Of Ice Crack

**4.3.2.14 icecom Type (Ice Compacting)**

## Placeholder

Figure 4-17 — : icecom Type Ice Compacting

**4.3.2.15 icelea Type (Ice Lead)**

## Placeholder

Figure 4-18 — : icelea Type Ice Lead

**4.3.2.16 icebrg Type (Iceberg)**

## Placeholder

Figure 4-19 — : icebrg Type Iceberg

**4.3.2.17 flobrg Type (Floeberg)**

## Placeholder

Figure 4-20 — : flobrg Type Floeberg

**4.3.2.18 icethk Type (Ice Thickness)**

## Placeholder

Figure 4-21 — : icethk Type Ice Thickness

#### 4.3.2.19 iceshr Type (Ice Shear)

## Placeholder

Figure 4-22 — : iceshr Type Ice Shear

#### 4.3.2.20 icediv Type (Ice Divergence)

## Placeholder

Figure 4-23 — : icediv Type Ice Divergence

#### 4.3.2.21 icerdg Type (Ice Ridge/Hummock)

[[fig-icerdg-type-ice-ridge/hummock]] . : **icerdg Type Ice Ridge/Hummock** image::.../images/figure-icerdg-type-ice-ridge.png[UML diagram depicting the icerdg Type]

#### 4.3.2.22 icekel Type (Ice Keel/Bummock)

## Placeholder

Figure 4-24 — : icerdg Type Ice Keel/Bummock

#### 4.3.2.23 icedft Type (Ice Drift)

## Placeholder

Figure 4-25 — : icedft Type Ice Drift

#### 4.3.2.24 icefra Type (Ice Fracture)

## Placeholder

Figure 4-26 — : icefra Type Ice Fracture

#### 4.3.2.25 icerft Type (Ice Rafting)

## Placeholder

Figure 4-27 — : icerft Type Ice Rafting

#### 4.3.2.26 jmdbrr Type (Jammed Brash Barrier)

## Placeholder

Figure 4-28 — : jmdbrr Type Jammed Brash Barrier

**4.3.2.27 stgmt Type (Stage of Melt)**

## Placeholder

**Figure 4-29 — : stgmt Type Stage of Melt****4.3.2.28 snwcvr Type (Snow Cover)**

## Placeholder

**Figure 4-30 — : snwcvr Type Snow Cover****4.3.2.29 strptc Type (Strips and Patches)**

## Placeholder

**Figure 4-31 — : strptc Type Strips and Patches****4.3.2.30 i\_grhm Type (Grounded Hummock)**

## Placeholder

**Figure 4-32 — : i\_grhm Type Grounded Hummock****4.3.3 Feature Types Summary****1) Summary of Types****Table 4-2**

<b>Register Dictionary</b>	<b>Index</b>	<b>Alpha code</b>	<b>Name</b>
IceFCD	Feature	SEAICE	Sea Ice
IceFCD	Feature	LACICE	Lake Ice
IceFCD	Feature	BRGARE	Iceberg Area
IceFCD	Feature	ICELNE	Ice Edge
IceFCD	Feature	BRGLNE	Iceberg Limit
IceFCD	Feature	OPNLNE	Limit of Open Water
IceFCD	Feature	LKILNE	Limit of All Known Ice
IceFCD	Feature	I_RIDG	Line of Ice Ridge
IceFCD	Feature	I_LEAD	Line of Ice Lead
IceFCD	Feature	I_FRAL	Line of Ice Fracture
IceFCD	Feature	I_CRAC	Line of Ice Crack
IceFCD	Feature	ICECOM	Ice Compacting
IceFCD	Feature	ICELEA	Ice Lead
IceFCD	Feature	ICEBRG	Iceberg

Register Dictionary	Index	Alpha code	Name
IceFCD	Feature	FLOBRG	Floeberg
IceFCD	Feature	ICETHK	Ice Thickness
IceFCD	Feature	ICESHR	Ice Shear
IceFCD	Feature	ICEDIV	Ice Divergence
IceFCD	Feature	ICERDG	Ice Ridge/Hummock
IceFCD	Feature	ICEKEL	Ice Keel/Bummock
IceFCD	Feature	ICEDFT	Ice Drift
IceFCD	Feature	ICEFRA	Ice Fracture
IceFCD	Feature	ICERFT	Ice Rafting
IceFCD	Feature	JMDBRR	Jammed Brash Barrier
IceFCD	Feature	STGMLT	Stage of Melt
IceFCD	Feature	SNWCVR	Snow Cover
IceFCD	Feature	STRPTC	Strips and Patches
IceFCD	Feature	I_GRHM	Grounded Hummock
IceFCD	Attribute	ICEACT	Total Concentration
IceFCD	Attribute	ICEAPC	Partial Concentration
IceFCD	Attribute	ICESOD	Ice Stage of Development
IceFCD	Attribute	ICELSO	Lake Ice Stage of Development
IceFCD	Attribute	ICEFLZ	Floe Sizes
IceFCD	Attribute	ICEMLT	Melt Stage
IceFCD	Attribute	ICESPC	Concentration of Strips and Patches
IceFCD	Attribute	ICEBNM	Number of Icebergs in Area
IceFCD	Attribute	ICELVL	Level Ice
IceFCD	Attribute	ICECST	Compacting Strength
IceFCD	Attribute	ICEFTY	Ice Fracture Type
IceFCD	Attribute	ICELST	Ice Lead Status
IceFCD	Attribute	ICELFQ	Frequency of Leads or Fractures
IceFCD	Attribute	ICELOR	Orientation of Leads or Fractures
IceFCD	Attribute	ICELWD	Ice Lead (or Fracture or Crack) Width
IceFCD	Attribute	ICELOC	Ice Location Information
IceFCD	Attribute	ICEBSZ	Iceberg Size
IceFCD	Attribute	ICEDDR	Ice Drift Direction
IceFCD	Attribute	ICEDSP	Ice Drift Speed

Register Dictionary	Index	Alpha code	Name
IceFCD	Attribute	ICETCK	Ice Average Thickness
IceFCD	Attribute	ICEMAX	Maximum Ice Thickness
IceFCD	Attribute	ICEMIN	Minimum Ice Thickness
IceFCD	Attribute	ICETTY	Ice Thickness Type
IceFCD	Attribute	ICESCT	Snow Depth
IceFCD	Attribute	ICESCN	Snow Cover Concentration
IceFCD	Attribute	ICEDOS	Direction Of Sastrugi
IceFCD	Attribute	ICERCN	Ice Ridge Concentration
IceFCD	Attribute	ICERDV	Ice Ridge Classification
IceFCD	Attribute	ICERMH	Ice Ridge Mean Height
IceFCD	Attribute	ICERFQ	Ice Ridge Frequency
IceFCD	Attribute	ICERXH	Ice Ridge Maximum Height
IceFCD	Attribute	ICEKCN	Ice Keel Concentration
IceFCD	Attribute	ICEKFQ	Ice Keel Frequency
IceFCD	Attribute	ICEKMD	Ice Keel Mean Depth
IceFCD	Attribute	ICEKXD	Ice Keel Maximum Depth
IceFCD	Attribute	ICEFCN	Ice Rafting Concentration
IceFCD	Attribute	IA_SFA	Ice Stage of Development and Floe Size for the 1st p.c.
IceFCD	Attribute	IA_SFB	Ice Stage of Development and Floe Size for the 2nd p.c.
IceFCD	Attribute	IA_SFC	Ice Stage of Development and Floe Size for the 3rd p.c.
IceFCD	Attribute	IA_FFA	Ice Breccia for the 1st partial concentration
IceFCD	Attribute	ICEFCN	Ice Breccia for the 2nd partial concentration
IceFCD	Attribute	IA_FFC	Ice Breccia for the 3rd partial concentration
IceFCD	Attribute	IA_SNG	Snow concentration
IceFCD	Attribute	IA_MLT	Stage of melting
IceFCD	Attribute	IA_PLG	Contamination
IceFCD	Attribute	IA_HLG	Hills concentration
IceFCD	Attribute	IA_DUG	Fractures concentration
IceFCD	Attribute	IA_BCN	Icebergs concentration
IceFCD	Attribute	IA_BFM	Prevailing iceberg form
IceFCD	Attribute	IA_BUH	Max. height of the above-water part (iceberg / grounded hummock)
IceFCD	Attribute	IA_OBN	Number of ice objects
IceFCD	Attribute	IA_DXW	Max. width of ice lead (or fracture or crack)

Register Dictionary	Index	Alpha code	Name
IceFCD	Attribute	IA_DMW	Min. width of ice lead (or fracture or crack)
IceFCD	Attribute	ICEBRS	Brash Ice

## 5 Coordinate Reference Systems (CRS)

### 5.1 Introduction

For exchange of ice data WGS84 (EPSG:4326) must be used  
*consider use of projected and/or UTM data*

### 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 <a href="https://epsg.org">https://epsg.org</a> .	

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

### 5.3 Vertical Coordinate Reference System

In this product there are no direct vertical coordinates which require the use of a vertical coordinate reference system.

### 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 [\[annex-data-classification-and-encoding-guide\]](#).

If the dataset conforms to the S-411 Feature Catalogue and to [\[annex-data-classification-and-encoding-guide\]](#), 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

# Placeholder

**Figure 9-1 — : Portrayal Rules**

`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)

Object Class	Acronym						
Sea Ice	seaice						?
Lake Ice	lacice						?
Iceberg Area	icebrg						

**Figure 9-2 — : Ice Navigational Display Mode**

## 9.2.1.2 IceScientificIceactDisplayMode


















iceact	description	rgb	color
1	Ice Free	000 100 255	
2	Open Water (< 1/10 ice)	150 200 255	
3	Bergy Water	150 200 255	
10	1/10 ice	140 255 160	
12	1/10 to 2/10 ice	140 255 160	
13	1/10 to 3/10 ice	140 255 160	
20	2/10 ice	140 255 160	
23	2/10 to 3/10 ice	140 255 160	
24	2/10 to 4/10 ice	140 255 160	
30	3/10 ice	140 255 160	
34	3/10 to 4/10 ice	140 255 160	
35	3/10 to 5/10 ice	255 255 000	
40	4/10 ice	255 255 000	
45	4/10 to 5/10 ice	255 255 000	
46	4/10 to 6/10 ice	255 255 000	
50	5/10 ice	255 255 000	
56	5/10 to 6/10 ice	255 255 000	
57	5/10 to 7/10 ice	255 255 000	
60	6/10 ice	255 255 000	
67	6/10 to 7/10 ice	255 255 000	
68	6/10 to 8/10 ice	255 125 007	
70	7/10 ice	255 125 007	
78	7/10 to 8/10 ice	255 125 007	
79	7/10 to 9/10 ice	255 125 007	
80	8/10 ice	255 125 007	
81	8/10 to 10/10 ice	255 000 000	
89	8/10 to 9/10 ice	255 125 007	
90	9/10 ice	255 000 000	
91	9/10 to 10/10 or 9+/10 ice	255 000 000	
92	10/10 ice	145 000 000	
99	Undetermined/Unknown	SymbolFill	

Figure 9-3 — : Ice Scientific Iceact Display Mode

### 9.2.1.3 IceNavigationalDisplayMode


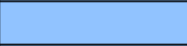

















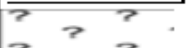
icesod	desc	rgb	color
1	Ice Free	150 200 255	
70	Brash Ice	150 200 255	
80	No stage of development	150 200 255	
81	New Ice (<10 cm)	240 210 250	
82	Nilas Ice Rind (<10 cm)	255 100 255	
83	Young Ice (10 to <30 cm)	170 040 240	
84	Grey Ice (10 to <15 cm)	135 060 215	
85	Grey – White Ice (15 to <30 cm)	220 080 235	
86	First Year Ice (30 to 200 cm)	255 255 000	
87	Thin First Year Ice (30 to <70 cm)	155 210 000	
88	Thin First Year Ice Stage 1 (30 to <50 cm)	215 250 130	
89	Thin First Year Ice Stage 2 (50 to <70 cm)	175 250 000	
91	Medium First Year Ice (70 to 120 cm)	000 200 020	
93	Thick First Year Ice (>120 cm)	000 120 000	
94	Residual Ice	000 120 000	
95	Old Ice	180 100 050	
96	Second Year Ice	255 120 010	
97	Multi-Year Ice	200 000 000	
98	Glacier Ice (Icebergs)	SymbolFill	
99	Undetermined/Unknown	SymbolFill	

Figure 9-4 — : Ice Scientific Icesod Display Mode

### 9.2.2 Line Features









Object Class	Acronym	
Ice Edge	iceIne	
Iceberg Limit	brglne	
Limit of Open Water	opnlne	
Limit of All Known Ice	lkilne	
Line of Ice Ridge	i_ridg	
Line of Ice Lead	i_lead	
Line of Ice Fracture	i_fral	
Line of Ice Crack	i_crac	

Figure 9-5 — : Line Feautures Portrayal

### 9.2.3 Point Features

Feature Class	Acronym	Symbol
Ice Compacting	icecom	↔
Ice Lead	icelea	≡
Floeberg	flobrg	▲
Ice Shear	iceshr	↔
Ice Divergence	icediv	↔
Ice Ridge / Hummock	icerdg	▲▲
Ice Keel / Bummock	icekol	▼▼
Ice Fracture	icefra	↗
Ice Rafting	icerft	≡
Jammed Brash Barrier	jmdbrr	▼▼
Stage of Melt	stgmll	∪
Snow Cover	snwcvr	∪
Strips and Patches	slrptc	∞
Grounded Hummock	i_grhm	▲▲
Iceberg	icebrg	
	icebrg 01 (Growler)	△
	icebrg 02 (Bergy Bit)	△
	icebrg 03 (Small Iceberg)	△
	icebrg 04 (Medium Iceberg)	△
	icebrg 05 (Large Iceberg)	△
	icebrg 06 (Very large Iceberg)	△
	icebrg 07 (Ice Island Fragment)	◻
	icebrg 08 (Ice Island)	◻
	icebrg 09 (Radar Target)	⊗
	icebrg 99 (Unknown)	△
Ice Drift	icedft	
	icedft 01 (No Ice Motion)	✕
	icedft 02 (NE)	↗
	icedft 03 (E)	→
	icedft 04 (SE)	↘
	icedft 05 (S)	↓
	icedft 06 (SW)	↙
	icedft 07 (W)	←
	icedft 08 (NW)	↖
	icedft 09 (N)	↑
	icedft 10 (Variable)	✕
	icedft 99 (Unkonwn)	✕

Figure 9-6 — : Point Features Portrayal

### 9.2.4 Draw order

The highest number will be drawn on the top.

Table 9-1

No	Name	Acronym
1	Sea Ice	seacie

No	Name	Acronym
1	Lake Ice	lacice
2	Iceberg Area	seacie
1	Sea Ice	icebrg
3	Ice Edge	icelne
4	Iceberg Limit	brglne
5	Limit of Open Water	opnlne
6	Limit of All Known Ice	lkilne
7	Line of Ice Ridge	i_ridg
8	Line of Ice Lead	i_lead
9	Line of Ice Fracture	i_fral
10	Line of Ice Crack	i_crac
11	Ice Compacting	icecom
12	Ice Lead	icelea
13	Iceberg	icebrg
14	Floeberg	flobrg
15	Ice Thickness	icethk
16	Ice Shear	iceshr
17	Ice Divergence	icediv
18	Ice Ridge / Hummock	icerdg
19	Ice Keel / Bummock	icekel
20	Ice Drift	icedft
21	Ice Fracture	icefra
22	Ice Rafting	icerft
23	Jammed Brash Barrier	jmdbrr
24	Stage of Melt	stgmlt
25	Snow Cover	snwcvr
26	Strips and Patches	strptc
27	Grounded Hummock	i_grhm

## 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

```
<ice:IceFeatureMember>
  <ice:brgare gml:id="brgare.1">
    <ice:icebnm/>
    <ice:icebsz/>
    <ice:ia_bcn/>
    <ice:ia_bfm/>
    <ice:ia_buh/>
    <gml:Polygon srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
      <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>
  </ice:brgare>
</ice:IceFeatureMember>
```

Figure 10-1

### 10.3.2 LineString Feature

```
<ice:IceFeatureMember>
  <ice:i_fral gml:id="i_fral.1">
    <ice:icesod>83</ice:icesod>
    <ice:ia_obn>50</ice:ia_obn>
    <ice:icedvw>30</ice:icedvw>
    <ice:ia_dmw>25</ice:ia_dmw>
    <ice:ia_dxw>35</ice:ia_dxw>
```



```

        <gml:LineString srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
          <gml:posList>-73.991 40.736 -73.991 40.736</gml:posList>
        </gml:LineString>
      </ice:i_fral>
    </ice:IceFeatureMember>

```

**Figure 10-2**

### 10.3.3 Point Feature

```

<ice:IceFeatureMember>
  <ice:icecom gml:id="icecom.1">
    <ice:icecst/>
    <gml:Point srsDimension="2" srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
      <gml:pos>147.291 -42.851</gml:pos>
    </gml:Point>
  </ice:icecom>
</ice:IceFeatureMember>

```

**Figure 10-3**

## 11 Data Product Delivery

### 11.1 Format Specification

At the moment there is only one type of dataset supported. This is GML encoded ice feature collections according to S-100 Part 10b.

### 11.2 Introduction

Ice Information Product will be delivered as Exchange Set, containing dataset itself, metadata, etc. It is also possible that several datasets are available for an area. The decision which one to use is the responsibility of the navigator on the vessel.

*question, can datasets overlap?*

### 11.3 Exchange Set

The exchange set for the Ice Information Product has following structure:

## Placeholder

**Figure 11-1 — : Exchange set Structure**

#### 11.3.1 Exchange Set Naming

Name of Exchange Set has following structure:

S411\_ProducerCode\_DatasetNameWithoutEnding

Example: S411\_BSH\_ek1-20130305-17

An exchange Set can be a simple data folder, but it is recommended to zip this folder for minimizing file size. In this case name of Exchange Set looks like:

S411\_ProducerCode\_DatasetNameWithoundEnding.zip

Example: S411\_BSH\_ek1-20130305-17.zip

or if .tar.gz compressing algorithm is in use:

S411\_ProducerCode\_DatasetNameWithoutEnding.tar.gz

Example: S411\_BSH\_ek1-20130305-17.tar.gz

## 11.4 Dataset

### 11.4.1 Dataset Naming

The data producer are free to choose file name for data set. The ending or postfix must be “\*.gml”.

Example: ek1-20130305-17.gml

## 11.5 Support Files

### 11.5.1 Support File Naming

There are no restrictions for support file naming. But it is important to describe the files in the exchange catalogue file.

#### 11.5.1.1 ISO Metadata File

The metadata for Dataset based on ISO 19139/19115, is also official S-100 Metadata with mandatory file identifier. ( See Chapter 10).

#### 11.5.1.2 Portrayal, Symbology

The portrayal (display instructions) should be a part of system, installed on board. But as option display instructions could be a part of exchange set, that means the display instruction xml file and svg symbols can be delivered within the exchange set as support files.

#### 11.5.1.3 SVG Graphics

#### 11.5.1.4 Readme

## 11.6 Exchange Catalogue

### 11.6.1 Exchange Catalogue Naming

Name of Exchange Catalogue is CATALOG.ICE

*The clauses in italic below come from S-102 PS. JCOMM ETSI to confirm what has to be retained/deleted/adapted*

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.

=== Dataset

==== Dataset management

==== Dataset size

==== 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.

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

=== 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.

=== 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 [\[sec-metadata\]](#).

=== 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.

==== 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.

==== 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.

==== 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.

== Metadata

=== Introduction There are two kinds of metadata to prepare:

- ISO 19139 Metadata  
This kind of metadata implementation can be read by broad range of software.
- S100 Metadata  
The S100 metadata are for describing the structure of Exchange Catalogue

==== ISO 19139 Metadata

For the description of ice data following metadata are necessary:

## Placeholder

**Figure 11-2 — Meta Data Structure of S-411**

**Table 11-1**

Element Name	Description	Namespace
MD_Metadata	root element	gmd
fileIdentifier	Id for dataset	gmd
language	Product language	gmd
characterSet	Used character set	gmd
contact	Contact data	gmd
dateStamp	date of publishing	gmd
identificationInfo	Specific info about product	gmd

```
<?xml version="1.0" encoding="UTF-8"?>
<gmd:MD_Metadata xmlns:gmd="http://www.isotc211.org/2005/gmd"
  xmlns:gco="http://www.isotc211.org/2005/gco"
  xmlns:gml="http://www.opengis.net/gml/3.2">
  <gmd:fileIdentifier> ... </gmd:fileIdentifier>
  <gmd:language> ... </gmd:language>
  <gmd:characterSet> ... </gmd:characterSet>
  <gmd:contact> ... </gmd:contact>
  <gmd:dateStamp> ... </gmd:dateStamp>
  <gmd:identificationInfo> ... </gmd:identificationInfo>
</gmd:MD_Metadata>
```

**Figure 11-3**

===== fileIdentifier

**Table 11-2**

Element Name	Description	Namespace
fileIdentifier	Id for dataset	gmd

Element Name	Description	Namespace
CharacterString	String contained id value	gmd

===== language

**Table 11-3**

Element Name	Description	Namespace
language	Language of dataset	gmd
LanguageCode	Code for language	gmd

```
<gmd:language>
  <gmd:LanguageCode
    codeList="http://www.isotc211.org/2005/resources/Codelist/ML_
gmxCodeLists.xml#LanguageCode"
    codeListValue="eng">English
  </gmd:LanguageCode>
</gmd:language>
```

**Figure 11-4**

===== characterSet

**Table 11-4**

Element Name	Description	Namespace
characterSet	characterSet of dataset	gmd
MD_CharacterSetCode	Code for characterSet	gmd

LanguageCode element contains two attributes:

- codeList Link to the list containing the codes for languages
- codeListValue value from the list defining the used language

```
<gmd:characterSet>
  <gmd:MD_CharacterSetCode
    codeList="http://www.isotc211.org/2005/resources/Codelist/ML_
gmxCodeLists.xml#MD_CharacterSetCode"
    codeListValue="utf8">UTF 8
  </gmd:MD_CharacterSetCode>
</gmd:characterSet>
```

**Figure 11-5**

===== contact

**Table 11-5**

Element Name	Description	Namespace
contact	Contact for questions to dataset	gmd
CI_ResponsibleParty	ISO Element for contact data	gmd
individualName	Name of responsible person	gmd
CharacterString	individualName value (text)	gco
organisationName	Name of responsible organisation	gmd

Element Name	Description	Namespace
CharacterString	organisationName value (text)	gco
contactInfo	Contact information	gmd
CI_Contact	ISO Element for contact information	gmd
phone	phone	gmd
CI_Telephone		gmd
voice		gmd
CharacterString	Voice telephone value (text)	gco
facsimile		gmd
CharacterString	Fax number value (text)	gco
address		gmd
deliveryPoint		gmd
CharacterString	Postal Address (street, house number)	gco
city		gmd
CharacterString	City name value (text)	gco
administrativeArea		gmd
CharacterString	Administrative Area name value (text)	gco
postalCode		gmd
CharacterString		gco
electronicMailAddress		gmd
CharacterString	Email value (text)	gco
role		gmd
CI_RoleCode		gmd

CI\_RoleCode element contains two attributes:

- codeList: link to the list containing the codes for roles
- codeListValue: value from the list defining the used roles

```

<gmd:contact>
  <gmd:CI_ResponsibleParty>
    <gmd:individualName>
      <gco:CharacterString>Jürgen Holfort</gco:CharacterString>
    </gmd:individualName>
    <gmd:organisationName>
      <gco:CharacterString>FMHA Germany (BSH)</gco:CharacterString>
    </gmd:organisationName>
    <gmd:contactInfo>
      <gmd:CI_Contact>
        <gmd:phone>
          <gmd:CI_Telephone>
            <gmd:voice>
              <gco:CharacterString>+49 (0) 381 4563-782</gco:
CharacterString>
            </gmd:voice>
          <gmd:facsimile>

```

```

        <gco:CharacterString>+49 (0) 381 4563-949</gco:
CharacterString>
        </gmd:facsimile>
        </gmd:CI_Telephone>
    </gmd:phone>
    <gmd:address>
        <gmd:CI_Address>
            <gmd:deliveryPoint>
                <gco:CharacterString>Neptunallee 5</gco:
CharacterString>
            </gmd:deliveryPoint>
            <gmd:administrativeArea>
                <gco:CharacterString>Rostock</gco:CharacterString>
            </gmd:administrativeArea>
            <gmd:postalCode>
                <gco:CharacterString>18057</gco:CharacterString>
            </gmd:postalCode>
            <gmd:electronicMailAddress>
                <gco:CharacterString>ice@bsh.de</gco:
CharacterString>
            </gmd:electronicMailAddress>
        </gmd:CI_Address>
    </gmd:address>
</gmd:CI_Contact>
</gmd:contactInfo>
<gmd:role>
    <gmd:CI_RoleCode
        codeList="http://www.isotc211.org/2005/resources/Codelist/
gmxCodeLists.xml#CI_RoleCode" codeListValue="originator">originator</gmd:CI_
RoleCode>
    </gmd:role>
</gmd:CI_ResponsibleParty>
</gmd:contact>

```

**Figure 11-6**

===== dateStamp

**Table 11-6**

Element Name	Description	Namespace
dataStamp	Date Stamp	gmd
Date	Formatted String (yyyy-MM-dd)	gco

The dateStamp should be used for the publication date (just day using gco:date or including the time using gco:datetime). The date and time where the ice chart is considered valid should be given in identificationinfo (see 10.1.1.6). Classic operational ice charts should have a time stamp within the temporal extent given in identificationinfo, a dateStamp preceding the temporal extent denotes a prognosis chart, a dateStamp that is more recent then the temporal extent denotes an historic reanalysis or a climatological chart.

```

<gmd:dateStamp>
    <gco>Date>2013-02-25</gco>Date>
</gmd:dateStamp>

```

**Figure 11-7**

===== identificationInfo

Table 11-7

Element Name	Description	Namespace
identificationInfo		gmd
MD_DataIdentification		
citation		
CI_Citation		
title		
CharacterString		gco
date		
CI_Date		
date		gco
dateType		
CI_DateTypeCode		
abstract		
CharacterString		gco
language		
LanguageCode		
characterSet		
MD_CharacterSetCode		
topicCategory		
MD_TopicCategoryCode		
extent		
EX_Extent		
geographicElement		
EX_GeographicBoundingBox		
westBoundLongitude		
Decimal		gco
eastBoundLongitude		
Decimal		gco
southBoundLatitude		
Decimal		gco
northBoundLatitude		gmd
Decimal		gco
temporalElement		gmd
EX_TemporalExtent		gmd



Element Name	Description	Namespace
extent		gmd
TimePeriod		gml
beginPosition		gml
endPosition		gml

```

<gmd:identificationInfo>
  <gmd:MD_DataIdentification>
    <gmd:citation>
      <gmd:CI_Citation>
        <gmd:title>
          <gco:CharacterString>IceArea25022013.shp</gco:CharacterString>
        </gmd:title>
        <gmd:date>
          <gmd:CI_Date>
            <gmd:date>
              <gco:Date>2013-02-25</gco:Date>
            </gmd:date>
            <gmd:dateType>
              <gmd:CI_DateTypeCode>
codeList="http://www.isotc211.org/2005/resources/CodeList/ML_gmxCodeLists.
xml#CI_DateTypeCode" codeListValue="creation">creation</gmd:CI_DateTypeCode>
              </gmd:dateType>
            </gmd:CI_Date>
          </gmd:date>
        </gmd:CI_Citation>
      </gmd:citation>
      <gmd:abstract>
        <gco:CharacterString>Ice Chart for Baltic sea</gco:CharacterString>
      </gmd:abstract>
      <gmd:language>
        <gmd:LanguageCode>
codeList="http://www.isotc211.org/2005/resources/CodeList/ML_gmxCodeLists.
xml#LanguageCode" codeListValue="eng">English</gmd:LanguageCode>
        </gmd:language>
      <gmd:characterSet>
        <gmd:MD_CharacterSetCode>
codeList="http://www.isotc211.org/2005/resources/CodeList/ML_gmxCodeLists.
xml#MD_CharacterSetCode"
codeListValue="utf8">UTF 8</gmd:MD_CharacterSetCode>
        </gmd:characterSet>
      <gmd:topicCategory>
        <gmd:MD_TopicCategoryCode>geoscientificInformation</gmd:MD_
TopicCategoryCode>
      </gmd:topicCategory>
      <gmd:extent>
        <gmd:EX_Extent>
          <gmd:geographicElement>
            <gmd:EX_GeographicBoundingBox>
              <gmd:westBoundLongitude>
                <gco:Decimal>8.963</gco:Decimal>
              </gmd:westBoundLongitude>
              <gmd:eastBoundLongitude>
                <gco:Decimal>30.353</gco:Decimal>
              </gmd:eastBoundLongitude>
              <gmd:southBoundLatitude>
                <gco:Decimal>53.613</gco:Decimal>
              </gmd:southBoundLatitude>
              <gmd:northBoundLatitude>
                <gco:Decimal>65.0</gco:Decimal>
            </gmd:geographicElement>
          </gmd:EX_Extent>
        </gmd:extent>
      </gmd:EX_Extent>
    </gmd:CI_Citation>
  </gmd:MD_DataIdentification>
</gmd:identificationInfo>

```

```

        </gmd:northBoundLatitude>
    </gmd:EX_GeographicBoundingBox>
</gmd:geographicElement>
<gmd:temporalElement>
    <gmd:EX_TemporalExtent>
        <gmd:extent>
            <gml:TimePeriod gml:id="ek1-20130225-16">
                <gml:beginPosition>2013-02-25</gml:beginPosition>
                <gml:endPosition>2013-02-27</gml:endPosition>
            </gml:TimePeriod>
        </gmd:extent>
    </gmd:EX_TemporalExtent>
</gmd:temporalElement>
</gmd:EX_Extent>
</gmd:extent>
</gmd:MD_DataIdentification>
</gmd:identificationInfo>

```

**Figure 11-8**

### === Language

The language used in metadata must be English. Other languages are optional and only as addition to the English version.

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.

=== 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 11-8](#) to [\[sec-pt-locale\]](#). 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.

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.

### === 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.

==== S100\_ExchangeCatalogueIdentifier S-411 uses S100\_ExchangeCatalogueIdentifier without modification.

==== S100\_CataloguePointOfContact S-411 uses S100\_CataloguePointOfContact without modification.

=== S100\_DatasetDiscoveryMetadata Dataset discovery metadata in S-411 restricts certain attributes and roles as described in [Table 11-8](#). Optional S-100 attributes which are mandatory in S-411 are indicated in the Remarks column.

**Table 11-8 — S100\_DatasetDiscoveryMetadata parameters**

Role name	Name	Description	Mult	Type	Remarks
Class	S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the Exchange Catalogue	-	-	<b>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.</b>
Attribute	fileName	Dataset file name	1	URI	See <a href="#">part=1,clause=4.6</a> <b>Format: file:/S-411/DATASET_FILES/&lt;dsname&gt;</b> <b>Dataset file name &lt;dsname&gt; must be according to format defined in <a href="#">[subsec-dataset-file-naming]</a>.</b>
Attribute	datasetID	Dataset ID expressed as a Maritime Resource Name	0..1	URN	The URN must be an MRN. <b>See <a href="#">part=3,clause=10</a></b>
Attribute	editionNumber	The edition number of the dataset	<b>1</b>	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. <b>Mandatory in S-411</b>
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 <b>May be required if multiple instances of a product are issued on the same day.</b>

Role name	Name	Description	Mult	Type	Remarks
Attribute	boundingBox	The extent of the dataset limits	1	EX_GeographicBoundingBox	<b>Mandatory in S-411</b> 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	<a href="#">Table 11-12</a>
Attribute	producingAgency	Agency responsible for producing the data	1	CI_Responsibility>CI_Organisation	See <a href="#">part=17,table=17-3</a>
Attribute	producerCode	The official IHO Producer Code from S-62	1	CharacterString	<b>Mandatory in S-411</b>
Attribute	encodingFormat	The encoding format of the dataset	1	S100_EncodingFormat	<b>The only allowed value is GML</b> <a href="#">Table 11-11</a>
Attribute	dataCoverage	Provides information about data coverages within the dataset	1..*	S100_DataCoverage	<b>Mandatory in S-411</b> <a href="#">Table 11-9</a>
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 or CI_Responsibility>CI_Organisation	Only if metadataPointOfContact differs from producingAgency
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 <a href="#">part=17,table=S100_DatasetDiscoveryMetadata</a> <b>Mandatory when purpose = cancellation</b>

Role name	Name	Description	Mult	Type	Remarks
Attribute	dataReplacement	Dataset name	0..*	CharacterString	A dataset may be replaced by 1 or more datasets. <b>Dataset name must be according to format defined in <a href="#">[subsec-dataset-file-naming]</a>.</b> <b>For example, 411DE00KD54.GML</b> See note following <a href="#">part=17,table=S100_DatasetDiscoveryMetadata</a> <b>Mandatory when replacedData = true</b>
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. <b>Mandatory in S-411</b>

==== S100\_NavigationPurpose S-411 uses S100\_NavigationPurpose without modification.

==== S100\_DataCoverage S-411 uses S100\_DataCoverage without modification, but with additional remarks and changes to the multiplicity.

**Table 11-9 — 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.
Attribute	boundingPolygon	A polygon which defines the actual data limit	1	EX_BoundingPolygon	<a href="#">Clause 11.6.1, Note</a>
Attribute	temporalExtent	Specification of the temporal extent of the coverage	0	S100_TemporalExtent	<b>The <i>temporalExtent</i> is not used in S-411.</b>
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	

Role name	Name	Description	Mult	Type	Remarks
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 $\geq 4$ coordinate positions expressed individually or as a list (posList). The GML polygon shall have a valid GML identifier.					

==== S100\_Purpose S-411 uses S100\_Purpose without modification, but with a restriction on the allowed values.

**Table 11-10 — S100\_Purpose**

Role name	Name	Description	Code	Remarks
Enumeration	S100_Purpose	The purpose of the dataset	-	<b>The S-100 values <i>update</i>, <i>reissue</i>, and <i>delta</i> are not used in S-411.</b>
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.

==== 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 11-11 — S100\_EncodingFormat parameters**

Role name	Name	Description	Code	Remarks
Enumeration	S100_EncodingFormat	The encoding format	-	<b>The only value allowed in S-411 is “GML”.</b>
Value	HDF5	The HDF5 data format as defined in <a href="#">part=10c</a>	3	-

==== S100\_ProductSpecification S-411 uses S100\_ProductSpecification without modification, but with additional remarks and changes to the multiplicity.

Table 11-12 — 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. <b>For S-411, this name is “Bathymetric Surface” (as of 25 June 2024).</b>
Attribute	version	The version number of the Product Specification	1	CharacterString	TR 2/2007 specifies versioning of Product Specifications <b>Example: 3.0.0 for S-411 Edition 3.0.0</b>
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)	<b>For S-411, this identifier is “S-411” (without quotes).</b>
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. <b>The corresponding idx-number of the IHO Registry for S-411 is numbered 199.</b>
Attribute	complianceCategory	The level of compliance of the Product Specification to S-100	0..1	S100_ComplianceCategory	See <a href="#">part=4a,clause=4a-5.5</a> and <a href="#">[subsec-s100-compliance-category]</a> below.

==== 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 11-13 — S100\_ComplianceCategory**

Role Name	Name	Description	Code	Remarks
Enumeration	S100_ComplianceCategory	-	-	<b>S-411 should use <i>category3</i> or <i>category4</i>, subject to the guidance provided in <a href="#">[subsec-s100-compliance-category]</a>.</b>
Value	category3	IHO S-100 compliant with standard encoding	3	<b>Qualifies as <i>category2</i>; plus “The Product Specification uses only an encoding method defined in <a href="#">part=10;and!part=4a,clause=5.5.3</a>”</b>
Value	category4	IHO S-100 and IMO harmonized display compliant	4	<b>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. <a href="#">part=4a,clause=5.5.4</a></b>

==== S100\_ProtectionScheme S-411 uses S100\_ProtectionScheme without modification.

=== MD\_MaintenanceInformation S-411 uses MD\_MaintenanceInformation without modification.

=== MD\_MaintenanceFrequencyCode S-411 uses MD\_MaintenanceFrequencyCode without modification.

=== S100\_CatalogueDiscoveryMetadata S-411 uses S100\_CatalogueDiscoveryMetadata without modification.

==== S100\_CatalogueScope S-411 uses S100\_CatalogueScope without modification.

==== 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.

=== 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.”

== Datasets

=== Introduction

=== Dataset Rules

In order to facilitate the efficient processing of S-411 data the geographic coverage of a given maximum display scale may be split into multiple datasets.

The discovery metadata of a dataset must list all the Data Coverage features contained within that dataset and their assigned scale attributions.

Datasets must not cross the 180° meridian; this includes both the Data Coverage features and the bounding box for the dataset.

All base datasets (new dataset, new edition) must contain at least one Data Coverage feature.

#### === Data Coverage rules

- The data boundary of the base dataset is defined by the extent of the Data Coverage features and must be contained within the bounding box.
- The Data Coverage features within a dataset must not overlap, however Data Coverage features from different datasets may overlap if they have differing maximum display scales.
- Datasets may overlap, however there must be no overlapping Data Coverage features of the same maximum display scale, except at the agreed adjoining national data limits, where, if it is difficult to achieve a perfect join, a 5 metre overlapping buffer zone may be used; and for this situation, there must be no gaps in data.
- When a dataset has multiple Data Coverage features, then the minimum display scale must be the same for all Data Coverage features within the dataset. The maximum display scale for multiple Data Coverage features within a dataset may be different.
- When a dataset has multiple Data Coverage features then the maximum display scale of the dataset must be equal to the largest maximum display scale of the Data Coverage features.
- The maximum display scale is considered to be the equivalent of the compilation scale of the data.

== Display Scale Range A scale range of a dataset is used to indicate a range of scales between which a producer considers the data is intended for use. The smallest scale is defined by the minimum display scale and the largest scale by the maximum display scale. These scales must be set at one of the scales specified elsewhere in this product specification.

When the system's viewing scale is smaller than the value indicated by minimum display scale, features within the Data Coverage feature are not displayed, except where the System Database does not contain a dataset covering the area at a smaller scale, in which case the dataset will be displayed at all smaller scales. When the viewing scale is larger than the value indicated by maximum display scale, an overscale indication must be shown.

#### == Geometry

##### === S-411 Geometry

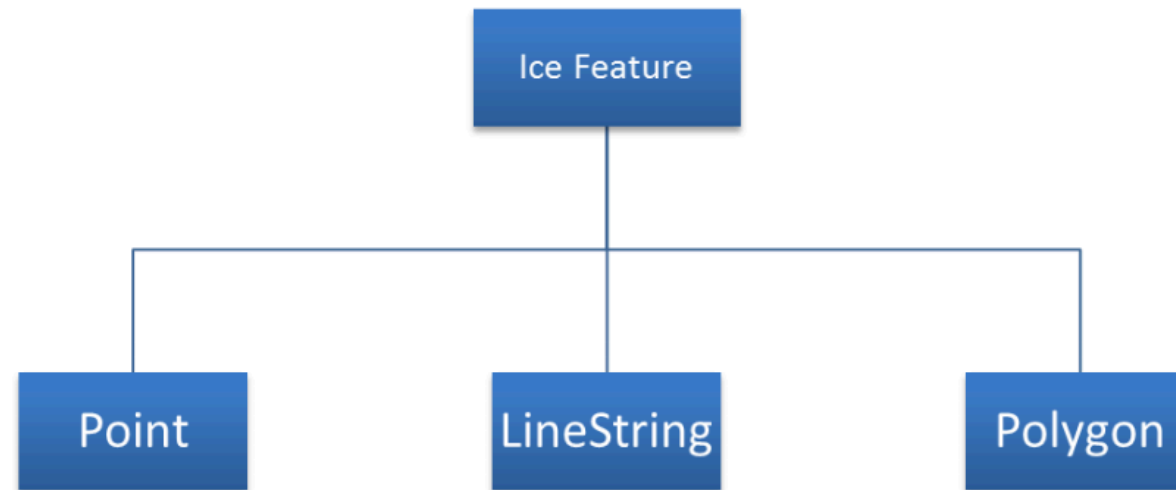
S-411 Ice Information features are encoded as vector entities which conform to S-100 geometry configuration level 3a (S-100 clause 7-4.3). Level 3a is described by the following constraints:

- Each curve must reference a start and end point (they may be the same).
- Curves must not self intersect. See S-100 Figure 7-5.
- Areas are represented by a closed loop of curves beginning and ending at a common point.

- In the case of areas with holes, all internal boundaries must be completely contained within the external boundary and the internal boundaries must not intersect each other or the external boundary. Internal boundaries may touch other internal boundaries or the external boundary tangentially (that is at one point) as shown in S-100 Figure 7-6.
- The outer boundary of a surface must be in a clockwise direction (surface to the right of the curve) and the curve orientation positive. The inner boundary of a surface must be in a counter-clockwise direction (surface to the right of the curve) and the curve orientation negative. See S-100 Figure 7-7.

S-411 further constrains Level 3a with the following:

- Linear geometry is defined by curves which are made of curve segments. Each curve segment contains the geographic coordinates as control points and defines an interpolation method between them. Coordinate density can have a significant impact on file size and system performance. A rule of thumb is to limit the coordinate density to 0.3 mm at maximum permitted display scale.
- For a scale-less product, the producer should keep in mind the expected scale range for typical use and the density of coordinates needed to suit the needs of the product.



**Figure 11-9 — Geometric Primitives Ice Information Product [REDRAW THIS DIAGRAM]**