S-412

Wind and Weather Warning Product Specification

Edition 1.2.0 – January 2026

IHO

International Hydrographic Organization

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Document History

Changes to this Specification are coordinated by WMO Commission for Weather, Climate, Hydrological, Marine, and related-Environmental Services and Applications (SERCOM), formely (JCOMM). New editions will be made available via the IHO web site.

Table — Document History

Version Number	Date	Approved By	Purpose
0.0.1	13 August 2013	Julia Powell	Initial Draft.
0.0.2	2 December 2013	A. Schultz	Updated draft for review by ETMSS.
0.0.3	3 June 2015	Julia Powell	Updated to latest version of S-100.
0.0.4	25 September 2017	A. Phillips, G. Seroka	Added data product format information, including GML encoding, expanded sections on the feature model, definitions, references and application schema.
0.1.0	10 December 2018	A. Phillips	Updated multiple sections including new scope, DCEG and FC.
0.1.1	30 April 2025	A. Cervone-Richards, D. Spindler, S. Stevenson, S. Williamson	Updated multiple sections including new scope, DCEG and FC.
1.0.1	25 October 2025	IIC Technologies	Initial Population of document skeleton.
1.1.0	9 December 2025	IIC Technologies	Review and alignment of the PS with the Feature Catalogue.
1.2.0	23 January 2026	IIC Technologies	Updated based on WMO review of edition 1.1.0. Metadata and Product delivery sections reviewed based on recent versions of S-127 and S-131 PS.

1 Overview

1.1 Introduction

This document has been produced by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Ocean Prediction Center (OPC) on behalf of the Joint World Meteorological Organization – Intergovernmental Oceanographic Commission (WMO-IOC) Technical Commission for Oceanography and Marine Meteorology (JCOMM), now WMO Commission for Weather, Climate, Hydrological, Marine, and Related Environmental Services and Applications (SERCOM), and the Worldwide Met-Ocean Information and Warning Service (WWMIWS) to define a data product that can be used as a Nautical Publication Information Overlay (NPIO) within electronic charting systems (ECS), including Electronic Chart Display and Information Systems (ECDIS). It has been developed within the framework specification defined by the International Hydrographic Organization (IHO) S-100 Universal Hydrographic Data Model and the International Standards Organization (ISO) 19100 series of standards. This product specification, S-412, is primarily intended for encoding marine weather warnings. These warnings include polygon portrayals of different hazardous weather conditions forecasted during the warning period to enhance situational awareness, route planning, and route monitoring.

1.2 Information

This product specification, S-412, is a vector graphic product specification that is primarily intended for encoding information on meteorological and oceanographic warnings that are used by mariners for route-planning, hazard avoidance, and risk mitigation. S-412 defines meteorological and oceanographic features, attributes and relationships, as well as their mapping to a dataset.

1.3 Scope

This document is maintained by the World Meteorological Organization (WMO) and describes an IHO S-100 compliant product specification for meteorological and oceanographic datasets, which will primarily act as an overlay for S-101 Electronic Navigational Charts on an S-100 based ECS, including ECDIS, in order to provide the maritime community with greater situational awareness. It specifies the content, structure, and metadata needed for creating a fully compliant Marine Weather Warnings dataset that will be compatible with an S-100 capable electronic navigation system. This product specification includes the content model, encoding guides, feature catalogue, portrayal catalogue, metadata, and example datasets.

In addition to acting as an overlay for S-101 Electronic Navigation Charts, this product specification outlines the capacity to interoperate with other S-100 compliant product specifications in accordance with the IHO S-98 Interoperability Specification.

This product specification does not include recommended changes to or requirements for services by National Meteorological and Hydrological Services.

1.4 References

1.4.1 Normative references

GML OpenGIS®	*Geography Markup Language (GML) Encoding Standard* (Version 3.2.1).
NOAA National Weather Service Glossary	*https://forecast.weather.gov/glossary.php*.
National Weather Service Instruction 10-315	*Marine Weather Message*, 2020 Edition.
National Weather Service Instruction 10-303	*Marine and Coastal Services Standards and Guidelines*, 2022 Edition.

National Weather Service Instruction 10-604	*Tropical Cyclone Names and Definitions*, 2021 Edition.
National Weather Service Instruction 10-811	*Enroute Forecasts and Advisories*, 2022 Edition.
National Weather Service Policy Directive 10-6	*Tropical Cyclone Weather Services Program*, 2020 Edition.
S-32	*IHO Hydrographic Dictionary*, 2023 Edition.
S-53	*Joint IHO/IMO/WMO Manual on Maritime Safety Information (MSI)*, January 2016 Edition.
S-98	*Interoperability Specification*, 2022 Edition.
S-100	*IHO Universal Hydrographic Data Model*, 2024 Edition._
S-101	*IHO Electronic Navigation Chart Product Specification*, 2024 Edition._
WMO 8	*Guide to Meteorological Instruments and Methods of Observation*, 2023 Edition.
WMO 182	*International Meteorological Vocabular*, 1992 Edition.
WMO 306	*Manual on Codes*, 2024 Edition.
WMO 386	*Manual on the Global Telecommunication System*, 2020 Edition.
WMO 471	*Guide to Marine Meteorological Services*, 2024 Edition.
WMO 485	*Manual on the Global Data-processing and Forecasting System*, 2023 Edition.
WMO 558	*Manual on Marine Meteorological Services*, 2024 Edition.
WMO 702	*Guide to Wave Analysis and Forecasting*, 2020 Edition.
WMO/TD 850	, 1998 Edition. Global Maritime Distress and Safety System, GMDSS (weather.gov). *IHO Geospatial Information Registry.*
S-97	*IHO Guidelines for Creating S-100 Product Specifications*, Edition 1.1.0, June 2020.
S-100	*IHO Universal Hydrographic Data Model*, Edition 5.2.1, December 2025.

1.4.2 Informative references

IMO A27/Res. 1051	IMO/WMO Worldwide Met-Ocean Information and Warning Service, 2011 Edition.
ISO 8601. 2004	*Data elements and interchange formats – Information interchange – Representation of dates and times*. 2004.
ISO 3166-1. 2020	*Country Codes*. 2020.
ISO 639-2/T. 1998	*Language Codes*. 1998.
ISO/TS 19103. 2024	*Geographic information – Conceptual schema language*. 2024.
ISO/IEC 10646:2020	*Information technology — Universal coded character set (UCS)*
ISO 19111. 2019	*Geographic Information – Spatial referencing by coordinates*. 2019.
ISO 19115. 2003	*Geographic Information – Metadata*. 2003.
ISO 19115-1. 2014	*Geographic information — Metadata — Part 1: Fundamentals*. 2014.
ISO 19115-2.2019	*Geographic Information – Metadata – Part 2: Extension for imagery and gridded data*. 2019.

ISO/TS 19123. 2005	*Geographic information – Schema for coverage geometry and functions*. 2005.
ISO/TS 19123-1. 2023	*Geographic information – Schema for coverage geometry and functions. Part 1: Fundamentals*. 2023.
ISO 19129. 2009	*Geographic information – Imagery, gridded and coverage data framework*. 2009.
ISO 19131. 2022	*Geographic information – Data product specifications*. 2022.
ISO 19136:2007	*Geographic Information – Geographic Markup Language (GML)*. 2007.
ISO 19136-1:2020	*Geographic Information – Geographic Markup Language (GML). Part 1: Fundamentals*. 2020.
ISO/IEC 19501. 2005	*Information technology – Unified Modeling Language (UML) Version 1.4.2*. 2005
ISO 19101:2002	*Geographic information – Reference model*. 2002.
ISO 19101-1:2014	*Geographic information – Reference model. Part 1: Fundamentals*. 2014.
ISO 19103: 2024	*Geographic information – Conceptual schema language*. 2024.
ISO 19105: 2022	*Geographic information – Conformance and testing*. 2022.
ISO 19107:2019	*Geographic information – Spatial schema*. 2019.
ISO 19108:2002	*Geographic information – Temporal schema*. 2002.
ISO 19109:2015	*Geographic information – Rules for application schema*. 2015.
ISO 19110: 2016	*Geographic information – Methodology for feature cataloguing*. 2016.
ISO 19113: 2005	*Geographic information – Quality principles*. 2005
ISO 19116: 2019	*Geographic information – Positioning services*. 2019. ISO 19117:2012: *Geographic information – Portrayal*. 2012.
ISO 19118: 2011	*Geographic information – Encoding*. 2011.
ISO 19128:2005	*Geographic information – Web Map Server interface*. 2005.
19132: 2007	*Geographic information – Location-based services – Reference model*. 2007.
ISO 19133:2005	*Geographic information – Location-based services – Tracking and navigation*. 2005.
ISO 19138:2006	*Geographic information – Data quality measures*. 2006.
ISO 19142:2010	*Geographic information – Web Feature Service*. 2010.
ISO 19144-1:2009	*Geographic information – Classification systems – Part 1: Classification system structure*. 2009.
ISO 19145:2013	*Geographic information – Registry of representations of geographic point location*. 2013.
ISO 19153:2014	*Geographic information – Geospatial Digital Rights Management Reference Model (GeoDRM RM) 1)*. 2014.
ISO 19156:2023	*Geographic information – Observations and measurements*. 2011.
ISO 19157:2023	*Geographic information – Data quality*. 2013.
ISO/TS 19158:2012	*Geographic information – Quality assurance of data supply*. 2010.
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

1.5 Terms, definitions and abbreviations

1.5.1 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.

The S-100 framework is based on the ISO 19100 series of geographic standards. The terms and definitions provided here are used to standardise the relevant nomenclature found within that framework, whenever possible. Additional definitions specific to S-412 are provided in this section as well. Features, attributes and associations that may be realised in an S-412 compliant dataset are defined in Annex A, B and C.

1.5.2 Terms and definitions

Abstract Class An object class which cannot be instantiated, or is designated in an information model as not allowed to be instantiated [ISO 19107].

NOTE subclasses of an abstract class may be either abstract or non-abstract.

Aggregation

Special form of association that specifies a whole-part relationship between the aggregate (whole) and a component part (see composition) [ISO 19103].

Application

Manipulation and processing of data in support of user requirements [ISO 19101-1:2014].

Application Schema

Conceptual schema for data required by one or more applications [ISO 19101].

Association

Semantic relationship between two or more classifiers that specifies connections among their instances [ISO 19101].

NOTE A binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

Attribute

(1) Named property of an entity [ISO/IEC 2382-17:1999].

NOTE Describes a geometrical, topological, 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.

Class

Description of a set of objects that share the same attributes, operations, methods, relationships, and semantics [ISO/TS 19103:2005].

NOTE a class represents a concept within the system being modelled. Depending on the kind of model, the concept may be real-world (for an analysis model), or it may also contain algorithmic and computer implementation concepts (for a design model). A classifier is a generalisation of class that includes other class-like elements, such as data type, actor and component.

Code List

Value domain including a code for a permissible value [ISO 19136].

Coordinate

One of a sequence of *n* numbers designating the position of a **point** in N-dimensional space [ISO 19111].

NOTE In a **coordinate reference system**, the coordinate numbers are qualified by units [ISO 19107, ISO 19111].

Coordinate Reference System

A coordinate system that is related to the real world by a datum [ISO 19111].

NOTE for geodetic and vertical datums, it will be related to the Earth.

Coverage

Feature that acts as a function to return values from its range for any direction position within its spatial, temporal, or spatiotemporal domain [ISO 19123:2005].

Example: Examples include a raster image, polygon overlay, or digital elevation matrix type.

Curve

1-dimensional geometric primitive, representing the continuous image of a line[ISO 19107].

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 Product

A dataset or dataset series that conforms to a data product specification [ISO 19131].

Dataset

Identifiable collection of data [ISO 19115].

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 or feature attribute contained within a larger dataset. A hardcopy map or chart may be considered a dataset.

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 [ISO/TS 19103:2005].

Example: Integer, Real, Boolean, String, Date

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

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

Datum

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

ECDIS

“Electronic Chart Display and Information System”. 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.

Direct Position

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

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 [ISO 19101:2003].

Example: The phenomenon truck may be classified with other similar phenomena into a feature type named automobile.

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** [ISO 19101].

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.

Example: A feature attribute named ‘colour’ may have an attribute value ‘green’ which belongs to the data type ‘text’.

Feature Catalogue

A catalogue containing definitions and descriptions of the **feature** types, **feature attributes** and occurring in one or more sets of geographic data [ISO 19110].

Geometric Object

Spatial object representing a set of direction positions [ISO 19107].

NOTE *A geometric object consists of a geometric primitive, a collection of geometric primitives, or a geometric complex treated as a single entity. A geometric object may be the spatial characteristics of an object such as a feature or a significant part of a feature.*

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.*

Generalisation

Taxonomic relationship between a more general element and a more specific element [ISO 19103].

NOTE The more specific element is fully consistent with the more general element and contains additional information. An instance of the more specific element may be used where the more general element is allowed.

Inheritance

Mechanism by which more specific elements incorporate structure and behavior of more general elements related by behavior [ISO 19103].

Map Projection

Coordinate conversion from an ellipsoidal coordinate system to a plane [ISO 19111].

Maritime Zone

Zones recognized under international law include internal waters, the territorial sea, the contiguous zone, the exclusive economic zone (EEZ), the continental shelf, the high seas, and the Area [NOAA] Maritime Zones and Boundaries | National Oceanic and Atmospheric Administration (noaa.gov).

Metadata Data about data [ISO 19115:2005].

METAREA

METAREA is the acronym for METeorological AREA. It means a geographical sea area established for the purpose of co-ordinating the broadcast of marine meteorological information. The term METAREA followed by a roman numeral may be used to identify a particular sea area. [WMO List of METAREAS].

Multiplicity

Specification of the number of possible occurrences of a property, or the number of allowable elements that may participate in a given relationship [ISO 19103].

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

Numerical Model

Computer simulations of the atmosphere and/or ocean that use an analysis of the current weather as a starting point to project the future state and provide the foundation of the weather forecasts. [Adapted from NOAA (https://www.weather.gov/rah/virtualtourforecast)].

Object

Entity with a well-defined boundary and identity that encapsulates state and behavior. Note: State is represented by attributes and relationships, behavior is represented by operations, methods, and state machines. An object is an instance of a class. [S-100].

Point

0-dimensional geometric primitive, representing a position.

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

Portrayal

Presentation of information to humans [ISO 19117].

NOTE within the scope of this International Standard portrayal is restricted to the portrayal of geographic information. [S-100].

Portrayal Catalogue

Collection of defined portrayals for a feature catalogue.

NOTE Content of a portrayal catalogue includes portrayal functions, symbols, and portrayal context [ISO 19117:2012 (E), 4.21].

Portrayal Rule

Specific type of portrayal function expressed in a declarative language.

NOTE A declarative language is rule-based and includes decision and branching statements. [ISO 19117:2012 (E), 4.25].

Range <Coverage>

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

Realization

Relationship between a specification and its implementation [ISO 19103].

Record

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

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

Register

Set of files containing identifiers assigned to items with descriptions of the associated items [ISO 19135].

NOTE Descriptions may consist of many types of information, including names, definitions and codes.

Register Manager

Organization to which management of a register has been delegated by the register owner. [ISO 19135].

NOTE In the case of an IHO Register, the Register Manager performs the functions of the registration authority specified in the IHO Directives.

Register Owner

Organization that establishes a register [S-100].

Registry

Information system on which a register is maintained. [ISO 19135].

Schema Formal description of a model [S-100].

Applied.**Significant Wave Height**

The average trough-to-crest height of the highest one third of the wave heights (sea and swell) occurring in a particular time period [WMO Glossary].

Spatial Reference

Description of position in the real world [S-100].

Start Point

First point of a curve. [ISO 19107].

Submitting Organization

Organization authorized by a register owner to propose changes to the content of a register. [ISO 19135].

Surface (Geometry)

2-dimensional geometric primitive, representing the continuous image of a region of a plane [ISO 19107].

NOTE The boundary of a surface is the set of oriented, closed curves that delineate the limits of the surface.

Symbol

Portrayal primitive such as line styles, patterns, text and point symbol graphics defined in SVG. [S-100].

Type

Stereotype of class that is used to specify a domain of instances (objects) together with the operations applicable to the objects.

NOTE A type may have attributes and associations [S-100].

Unit

Defined quantity in which dimensioned parameters are expressed. [S-100].

Value

Element of a type domain [ISO/TS 19103:2005]. NOTE 1:: A value may be considered a possible state of an object within a class or type (domain).

NOTE 2 A data value is an instance of a data type, a value without identity.

1.5.3 Abbreviated terms

This Product Specification adopts the following convention for presentation purposes:

CRS	Coordinate Reference System
DCEG	Data Classification and Encoding Guide
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System (Non SOLAS)
ENC	Electronic Navigational Chart
EPSG	European Petroleum Survey Group [https://epsg.org/]
ET-MS	Expert Team on Maritime Safety
FCD	Feature Concept Dictionary
GFM	General Feature Model
GI	Geospatial Information
GMDSS	Global Maritime Distress and Safety System
GML	Geography Markup Language
HDF5	Hierarchical Data Format (HDF5 is the fifth release)
ICC	International Color Consortium
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
ISO	International Organization for Standardization
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
METAREA	METeorological AREA
OEM	Original Equipment Manufacturer
S-100WG	S-100 Working Group
SC-MMO	Standing Committee on Marine Meteorological and Oceanographic Services
SERCOM	Commission for Weather, Climate, Hydrological, Marine, and Related Environmental Services and Applications
SOLAS	International Convention for Safety of Life at Sea
SVG	Scalable Vector Graphics
UML	Unified Modelling Language
URI	Uniform Resource Identifier
URL	Universal Resource Locator
UTC	Coordinated Universal Time
UTF-8	Unicode Transformation Format-8
WMO	World Meteorological Organization
WWMIWS	Worldwide Met-Ocean Information and Warning Service

XML	Extensible Mark-up Language
XSD	World Wide Web Consortium XML Schema Definition
XSLT	eXtensible Stylesheet Language Transformations

1.6 General Marine Weather Warnings Data Product Description

Title S-412 Marine Weather Warnings

Abstract This data product describes real-world weather and oceanographic warnings created from authoritative maritime weather analysis and forecast data products. These S-100-compliant weather warnings will be used by mariners for route-planning and hazard mitigation.

Acronym S-412

Content The Product Specification defines all requirements to which Marine Weather Warnings data products must conform. Specifically it defines the data product content in terms of features and attributes within the feature catalogue. The display of polygons is defined by the features and rule sets contained in the portrayal catalogue. The Data Classification and Encoding Guide (DCEG) provide guidance on how data product content must be captured.

Spatial Extent **Description**: Maritime zones and terrestrial locations within proximity of navigable waters.

East Bounding Longitude: 180°
West Bounding Longitude: -180°
North Bounding Latitude: 90°
South Bounding Latitude: -90°

Purpose **Navigation**
The purpose of a Marine Weather Warnings dataset is to enhance the situational awareness and decision-making capacity of a mariner, as well as warn mariners of adverse, hazardous, dangerous, or extreme conditions that may pose a threat to life or property.
An S-412 product can be used as an overlay for electronic navigational charts within shipboard or shore side navigation systems or as a standalone product within an appropriate geographic information system display.

1.7 Data Product Specification metadata

Title	S-412 Marine Weather Warnings Product Specification
S-100 Version	5.2.0
S-412 Version	1.2.0
Date	23 January 2026
Language	English (optional additional)
Classification	Unclassified
Contact	World Meteorological Organization 7bis, avenue de la Paix Case postale 2300 CH -1211 Geneva 2 Switzerland Telephone: +41 (0) 22 730 84 03 Email: publications@wmo.int
URL	www.wmo.int

Identifier S-412

Maintenance Changes to the Product Specification S-412 are coordinated by the SERCOM, formely JCOMM, and must be made available via the IHO web site. When a new version of the product spec is ready for approval it must follow through several bodies of the WMO; including: ET-MS and SC-MMO while keeping WWMIWS aware of changes for METAREAS. Once approved by the WMO, the WMO's Domain Control Body Member will submit the document to IHO for approval into the GI Registry.

URL www.wmo.int

Identifier S-412

1.8 Product Specification Maintenance

1.8.1 Introduction

Changes to this product specification are coordinated by the WMO Commission for Weather, Climate, Hydrological, Marine, and Related Environmental Services and Applications (SERCOM), Standing Committee on Marine Meteorological and Oceanographic Services (SC-MMO), and WorldWide Met-ocean Information and Warning Service (WWMIWS). Changes to the Marine Weather Warnings will be released by the WWMIWS as a new edition, revision, or clarification. Requests for specific changes to this product specification should be coordinated through the most convenient National Meteorological Service or directly to WWMIWS.

1.8.2 New Edition

New Editions of S-412 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-412. All cumulative *revisions* and *clarifications* must be included with the release of approved New Editions.

1.8.3 Revision

Revisions are defined as substantive semantic changes to S-412. Typically, *revisions* will change S-412 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-412. 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-412.

1.8.4 Clarification

Clarifications are non-substantive changes to S-412. 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-412.

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.

1.8.5 Version Numbers

The associated version control numbering to identify changes (n) to S-412 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 outlines the development of data from inception to the end user, through an authoritative weather forecasting agency. Requirements for data and metadata are provided. This document does not include product delivery mechanisms.

Scope Identification	Global
Hierarchical Level	006 — series
Hierarchical Level Name	Marine Weather Warnings 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	Marine Weather Warnings
Abstract	S-412 datasets must be produced in accordance with the rules defined in this S-412 Product Specification. The S-412 Product Specification contains all the information necessary to enable meteorological organisations to produce a consistent overlay, and manufacturers to use that data efficiently in an electronic navigation systems. Compliant datasets of Marine Weather Warnings contain polygons of hazardous meteorological and oceanographic conditions. Datasets are produced by an authoritative weather forecasting agency for a particular geographic region and set of times, and may include accompanying metadata describing the content, variables, applicable times, locations, and structure of the data product. Data used to create the polygons may be derived from observed, mathematically-predicted, or model-driven phenomena.
Topic Category	Climatology, Meteorology, Atmosphere (ISO 19115 Domain Code 004) — Oceans (ISO 19115 Domain Code 014)
Geographic Description	The geographic boundaries of warning polygons are determined by meteorological events for a given time period; however, the warnings are only provided over maritime regions.
Spatial Resolution	The spatial resolution varies by weather forecasting agency and is largely determined by their forecasting and analysis domain and file size of each data file. Producers should note that at the smaller scales, geographic details will have no perceptible visual separation on a graphic display, and are therefore encouraged to determine display scales taking into account the content and intended navigation purpose of the dataset.
Purpose	Navigation in all regions. The Marine Weather Warnings dataset is primarily intended to be used in electronic navigation systems as an overlay to an ENC.
Language	English (Mandatory), other (Optional)
Classification	Data may be classified as one of the following: 1) Unclassified; 2) Restricted; 3) Confidential; 4) Secret; 5) Top Secret; 6) Sensitive but Unclassified; 7) For official Use Only;

8) Protected;
9) Limited Distribution.

Spatial Representation Type	Vector
Point of Contact	Dataset Producing Agency
Use Limitation	Must be used with an ENC. An S-412 dataset is not intended to be used for land-based or aviation weather forecasting purposes.

4 Data Content and Structure

4.1 Introduction

This section describes the application schema, which is described in Unified Modelling Language (UML):

- Feature Catalogue;
- Dataset types;
- Geometry.

The Marine Weather Warnings Overlay is a feature-based vector product that contains meteorological and oceanographic datasets. The content information is described in terms of a General Feature Model and a Feature Catalogue.

4.2 Application Schema

S-412 conforms to the General Feature Model (GFM) outlined in S-100 Part 3 and is realised in Figure 1. The GFM is the conceptual model for feature and information types.

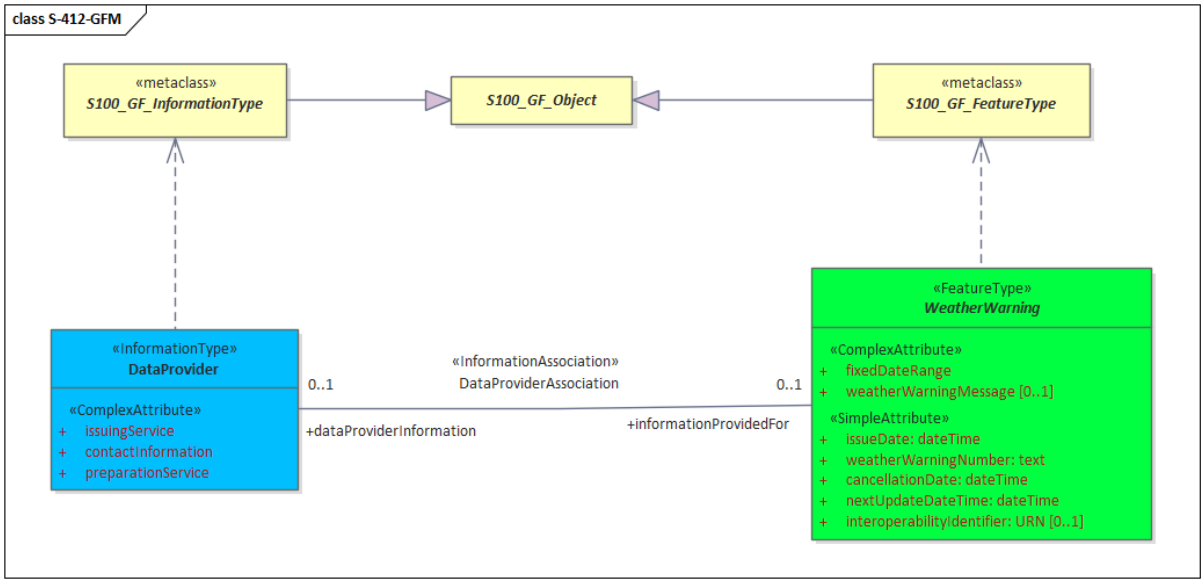

Figure 4-1 — S-412 General Feature Model

The complete application schema is expressed in UML and is provided in Annex A.

The data model consists of:

- five feature types which are derived from the **WeatherWarning** abstract type:
  - **SignificantWaveHeightWarning**;
  - **IceAccretionWarning**;
  - **WindWarning**;

  - **RestrictedVisibilityWarning**;
  - **ThunderstormWarning**;

and,

- one information type:
  - **DataProvider**.

These feature types are derived from the S-100_GF_FeatureType metaclass. Feature and information Ttype descriptions can be found in Annex A.

This section describes the Application Schema as expressed in the UML diagrams included. This document contains an overview of the S-412 application schema. The S-412 Application Schema types are then realised in the Feature Catalogue. The Feature Catalogue can be found in the WMO Domain of the IHO Registry, and provides a full specification of all types including feature and information types, their attributes, allowed values, and the relationships between types in the data product.

The following conventions are used in the UML diagrams depicting the application schema:

- Standard UML conventions for classes, associations, inheritance, roles, and multiplicities apply. These conventions are described in Part 1 of S-100.
- Italic font for a class name indicates an Abstract Class.
- Abstract Feature Classes are depicted with a blue background.
- Ordinary (non-abstract) feature classes are depicted with a green background.
- Information type classes are depicted with a grey background. There are no abstract information type classes in S-412.
- Association Classes are depicted with a white background. There are no association classes in S-412+
- Complex attributes are depicted with a salmon background.
- Enumeration lists are depicted with a brown background. The numeric code corresponding to each listed value is shown to its right following an ‘=’ sign.
- No significance is attached to the colour of associations. (Complex diagrams may use different colours to distinguish associations that cross one another.).
- Where the association role or name is not explicitly shown, the default rules for the roles and names apply:
  - The role name is ‘the<CLASSNAME>’ where <CLASSNAME> is the name of the class to which that association end is linked.
  - The association name is ‘<CLASSNAME1>_<CLASSNAME2>’ where <CLASSNAME1> is the source and <CLASSNAME2> the target. In the case of a feature/information association, the feature is the source. For feature/feature or information/information associations without explicit names, the source/target are indicated by an arrowhead.
- Subclasses inherit the attributes and associations of their superclasses at all levels, unless such inheritance is explicitly overridden in the subclass.

Types for simple attributes are listed on the right hand side in the UML diagrams, e.g **issueDate** has the S-100 type **dateTime**. In order to simplfy the appearance of the diagrams, no types are stated for complex attributes or enumerations.

4.3 Feature Catalogue

4.3.1 Introduction

The S-412 Feature Catalogue describes real-world meteorological and oceanographic concepts in one or more sets of geographic data as feature types, information types, attributes, attribute values, associations and roles. These are bound together in the .XML Feature Catalogue.

Definitions of each feature type, information type, attribute, including enumerated value definitions, and Associations are also provided in the Data Classification and Encoding Guide (Annex A) and represent concepts that may be encoded in an S-412 dataset. These definitions are drawn from the Feature Concept Dictionary managed by the IHO in the IHO Geospatial Information Registry .

4.3.2 Feature Types

Feature types are the basic level of classification in the Feature Catalogue, and are used in S-412 to represent warnings of atmospheric and oceanographic phenomena.

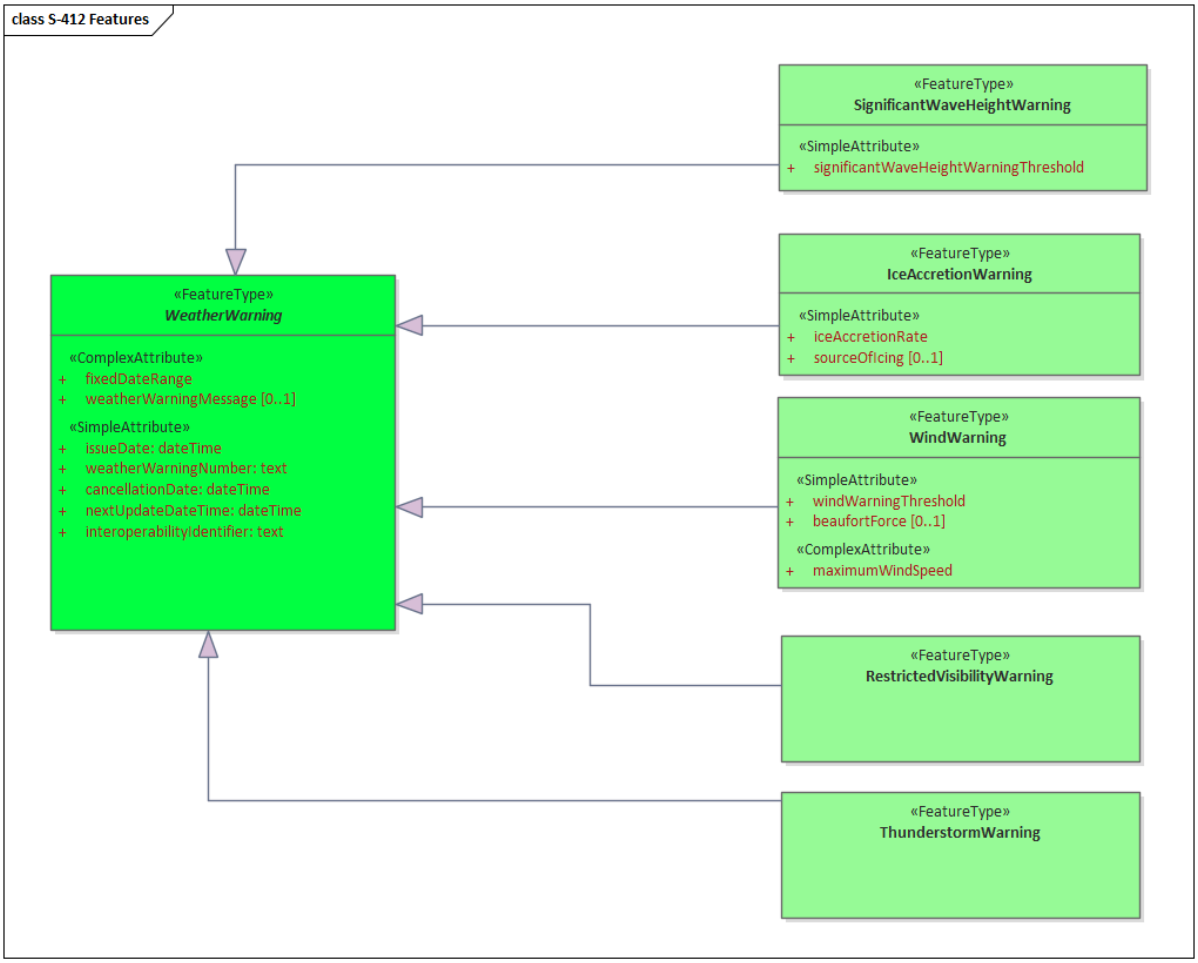

Figure 4-2 — S-412 features

As can be seen in the diagram, a single abstract feature **WeatherWarning** is used as a template from which the concrete features of S-412 are derived.

4.3.2.1 Meta features

S-412 does not make use of any meta feature.

4.3.2.2 Geographic Features

Geographic (geo) feature types form the principal content in S-412 and are defined by their associated attributes and information types.

As an example, the realisation of a Wind Warning concept is provided by the UML diagram below. The diagram shows the Wind Warning feature's inheritance from the abstract Weather Warning feature and its connection to various complex and simple attributes. For more information regarding the relationships between WindWarning and its attributes, please refer to the DCEG. The portrayal of a WindWarning is described in the Portrayal Catalogue. For each Marine Weather Warning polygon, the colour is determined by the attribute value of windWarningThreshold. The optional beaufortForce attribute is used to indicate more specific wind speed bins that the feature represents, based on the international Beaufort Wind Scale. The dateTimeRange attribute provides the start and end times that are valid for the Wind Warning. The weatherWarningNumber attribute provides an identification number to track warnings issued with each new dataset. The optional weatherWarningMessage attribute provides a short message with added context or information about a Weather Warning.

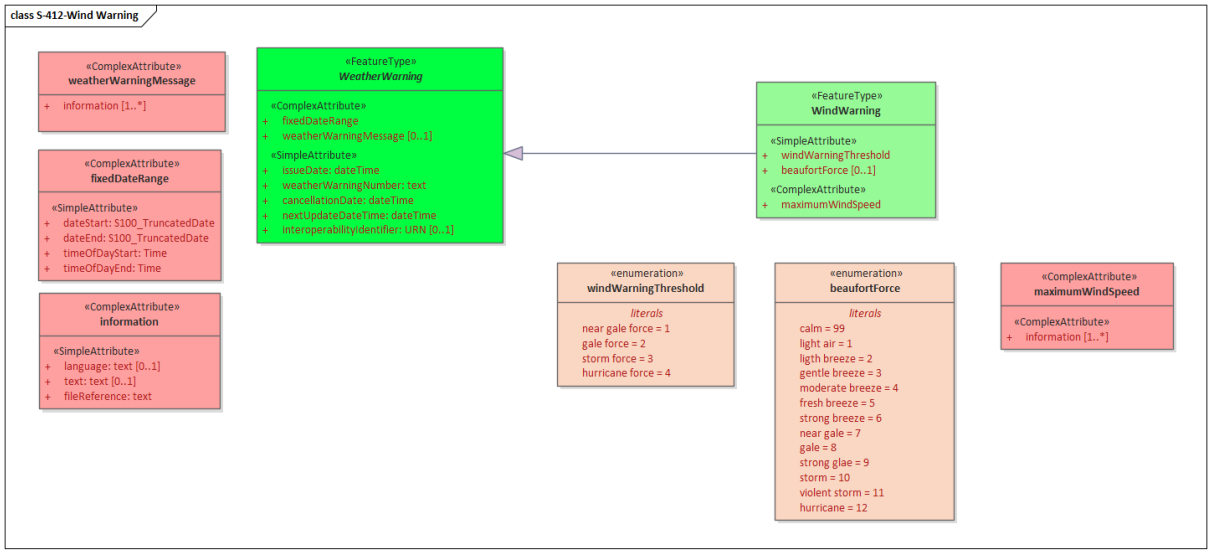

Figure 4-3 — Wind Warning feature

4.3.3 Information types

Information types define identifiable pieces of information in a dataset that can be shared between other features or information types. Information types have attributes but have no relationship to any geometry; Information types may also reference other information types if defined in the Feature Catalogue.

Figure 3 shows the realisation of the single Information Type used in S-412: **DataProvider**.

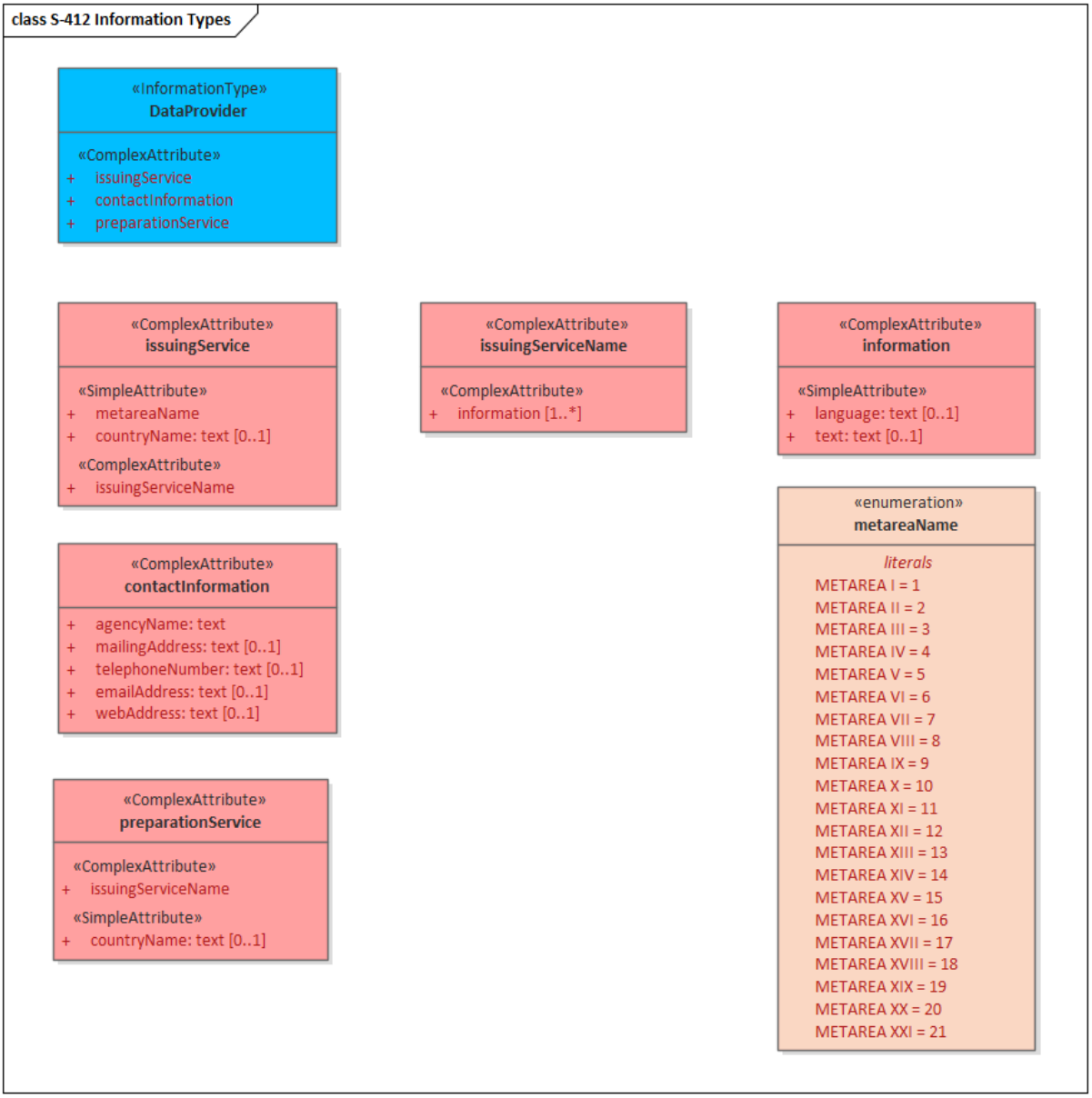

Figure 4-4 — Data Provider information type

4.3.4 Feature Relationship

A feature relationship links one or more instances of one feature type with one or more instances of the same or a different feature type. There are three common types of feature relationships: association, aggregation, and composition. S-412 does not make use of any feature relationships.

Associations are described in more detail in Clause 4.3.6.

4.3.5 Attributes

Attributes define the characteristics of a feature or information type. Attribute types can be either complex or simple. Simple attributes carry the value itself, and complex attributes are aggregations of other simple and/or complex attributes that create a hierarchical data structure to describe a feature. An attribute instance belongs to one and only one Feature or information type.

4.3.5.1 Simple Attributes

The following table lists the types of simple attributes used in S-412.

Table 4-1

Type	Definition
enumeration	List of predetermined values that can be expanded and contracted.
text	A sequence of characters.
dateTime	Character encoding shall follow the format for date and time as specified in ISO 8601. Example: 19850412T101530.

Simple attributes for the Wind Warning feature type are shown in Figure 4-3 and the DataProvider information type in Figure 4-4. Each S-100 attribute type is listed next to their camel case encoding value. Enumerated attributes are referenced by their defined data type and values are listed.

Enumerated attributes defined for S-412, represented in UML are shown in Figure 4-5. The complete list of all attributes and their properties approved for use in S-412 are also provided in the DCEG (Annex A).

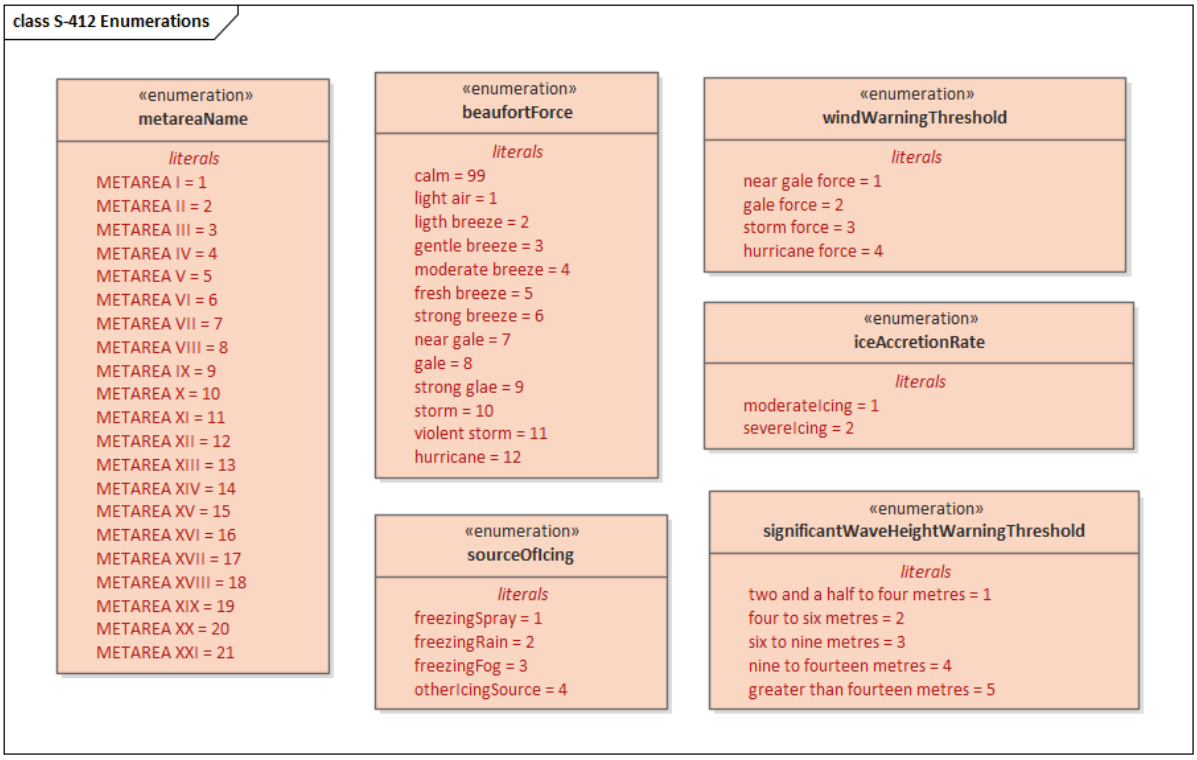

Figure 4-5 — S-412 Enumerated Attributes

4.3.5.2 Code Lists

Within S-100, codelist types may be used for open enumerations whose membership cannot be known at the level of the product specification, for reuse of information model fragments, or for more efficient catalogue management.

Codelist types are not utilised in this version of S-412.

4.3.5.3 Complex Attributes

Complex attributes are aggregations of other attributes that are either simple or complex. The aggregation is defined by means of attribute bindings. The diagram below shows the complex attributes defined in S-412. By way of example, **fixedDateRange** is utilised by the Wind Warning feature type shown in Figure 4-3. This attribute is an aggregation of 2 simple Time attributes and 2 simple S100_TruncatedDate attributes. In the diagram, attributes with no type defined are either enumerations or complex attributes.

For the full list of complex attributes approved for use in an S-412 dataset, refer to the DCEG (Annex A).

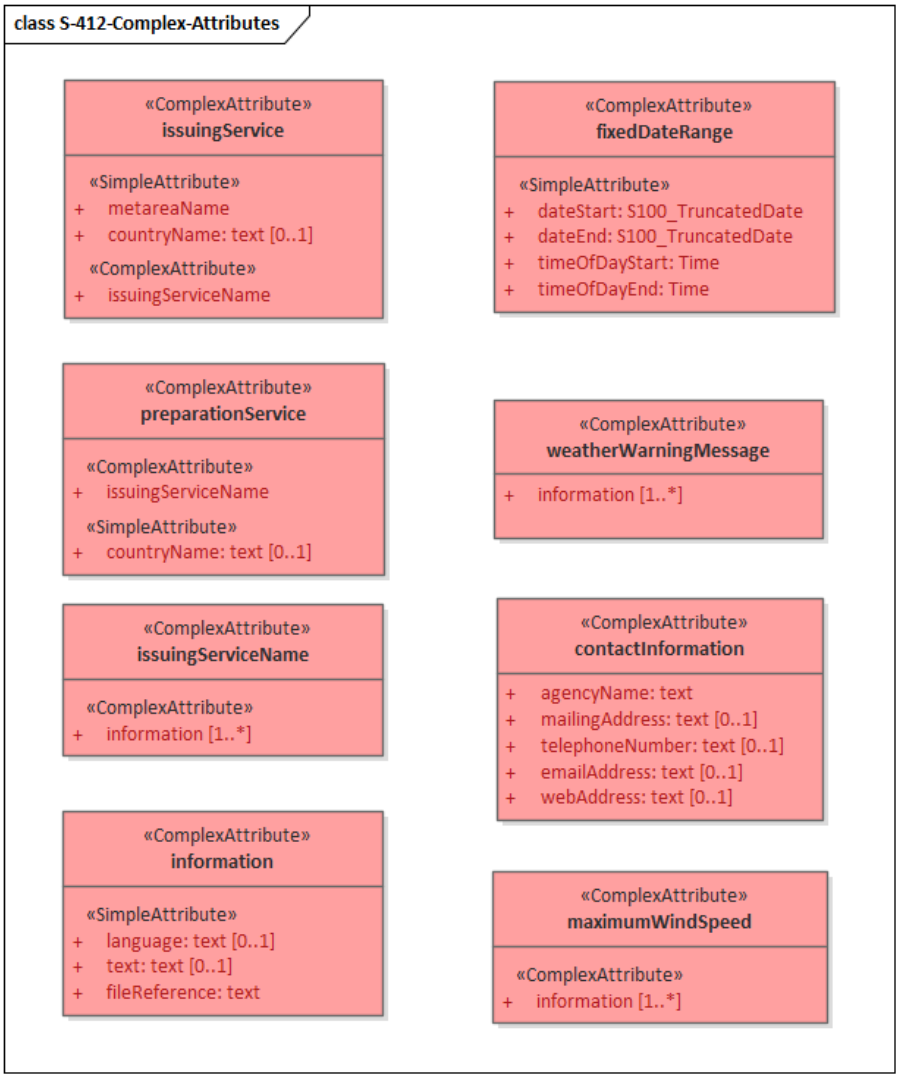

Figure 4-6 — S-412 Complex Attributes

4.3.6 Associations

Associations are used to describe a relationship between instances of one feature or information type with instances of the same or a different feature or information type. Unless otherwise noted, associations are bi-directional in S-412. If an association is unidirectional, source and target roles are defined.

The diagram below shows an example of the association between the WeatherWarning feature type and the DataProvider information type called DataProviderAssociation. The real world relationship between these concepts is that a weather warning has additional information about the service(s) issuing the warning.

The diagram shows the real world relationship between a weather warning and its supplemental information for where it came from. A complete list of associations and roles used in S-412 can be found in the DCEG (Annex A).

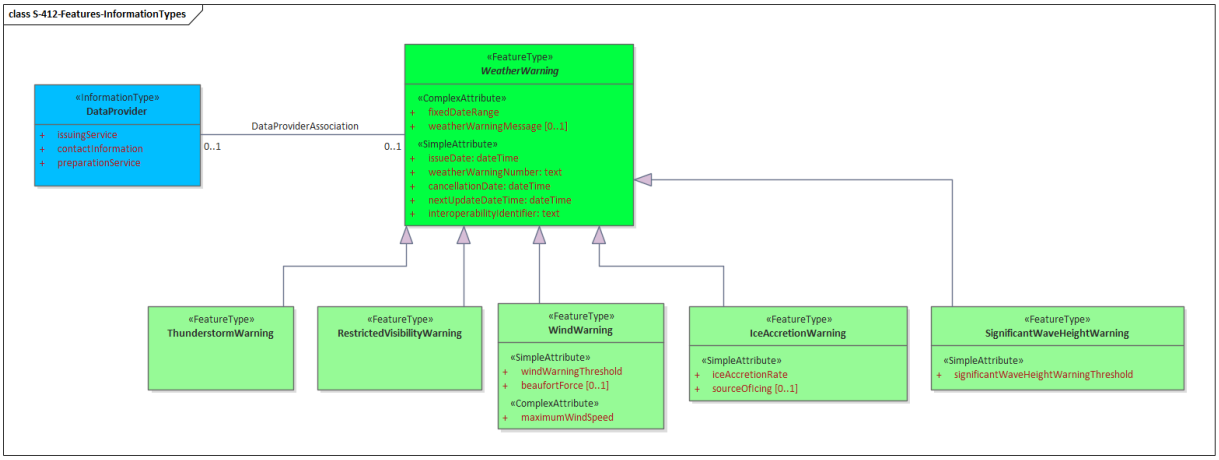

Figure 4-7 — S-412 Data Provider association

4.3.6.1 Camel Case Rules

All names in S-412 are unique in order to distinguish one from another. Further, camel case rules are applied in order to distinguish encoding values. Each class, package, type-specification and association name are concatenated and start with an uppercase letter with each subsequent word starting with a capital letter. Attribute and association role names are concatenated and start with a lower-case letter; subsequent words start with a capital letter.

Example: The Wind Warning feature type is encoded as WindWarning. The Fixed Date Range complex attribute type is encoded as fixedDateRange.

4.3.7 Multiplicity Rules

In UML, all attributes are mandatory by default. Multiplicity rules are used for attributes and association role names to provide a way of describing optional and conditional attributes. In these rules, the first number represents the minimum number of instances that may exist; the second number represents the maximum number of instances that may exist. For example, 0..* means many, optional, zero or more; 1..* means at least one. So, in the UML diagrams unless an attribute (complex or simple) has a specific multiplicity shown it can be assumed to be mandatory.

4.3.8 Inheritance

A hierarchical structure among S-412 feature types and information types exists in order to group similar concepts by definition, use cases or attribute sets. The base level of the hierarchy is commonly called the super-type and represents a generic concept. More specific concepts are the next level in the hierarchy and these are called sub-types. All sub-types inherit the properties of the super-type within the same hierarchical structure unless otherwise specified. Within S-412, inheritance creates flexibility for a data producer to utilise the appropriate feature based on their user's needs.

In the WindWarning feature shown in Figure 4-3, WindWarning inherits all attributes and associations from the WeatherWarning abstract feature type.

4.3.9 Spatial Quality

Spatial quality attributes are commonly carried by S-100 based product specifications in an information class called Spatial Quality and describe the positional quality of an object. Because S-412 datasets are assumed to be composed of the highest quality position data available at the time of issuance, Spatial Quality is not utilised in S-412 Product Specification.

4.3.10 Temporal Quality

There is a direct relationship between temporal quality and spatial quality with S-412 datasets. Because S-412 datasets are assumed to be composed of the highest quality position data available at the time of issuance, it is necessary to ensure the temporal quality of the dataset. Temporal quality ensures spatial quality.

Various time attributes are carried by various features to ensure the end user is aware of when the dataset is published as well as when the data is valid. Together, these attributes in the data ensure the user is aware of the temporal quality of the data.

4.4 Dataset Types

4.4.1 Introduction

A dataset is a grouping of features, attributes, geometry, and metadata which comprises a specific geographic coverage. Only one type of S-412 dataset is supported: 1) GML encoding for surface geometric primitive feature collections.

4.4.2 Time

S-412 datasets can represent real-world phenomena in the present or future. Because of the unique nature of atmospheric and oceanographic concepts and their geographical changes in time, a variety of time attributes are included in S-412 to ensure instances of features are attributed correctly through time. Features or information types outside of the temporal range of a dataset shall not be included in a dataset. Time shall always be provided in Coordinated Universal Time (UTC).

The dateTimeRange is a complex attribute consisting of simple attributes, dateTimeStart and dateTimeEnd, to allow certain features to define a specific temporal range. The dateTimeRange attribute is mandatory for each feature. This attribute provides data producers the flexibility to manage the temporal resolution of their datasets at the feature level and to concatenate data files in a manner which best suits their workflow and customer's needs. In order for features to be portrayed, the user's system must clearly indicate the dateTimeRange of a feature or a group of features if the values are the same. Instances of this attribute may be used for data validation and to ensure temporal quality.

Three other simple dateTime attributes (issuedDateTime, nextUpdateDateTime, and cancellationDate) are mandatory for each WeatherWarning and inherited into the sub-feature types. The issuedDateTime attribute provides a timestamp for when the WeatherWarning has been issued. The nextUpdateDateTime attribute provides the time information for the next expected WeatherWarning to be issued. The cancellationDate {is used to mark when a WeatherWarning is set to expire, or be cancelled}.

Every time attribute is associated with the abstract WeatherWarning feature type. These attributes are then inherited by all sub-types of WeatherWarning (windWarning, significantWaveHeightWarning, iceAccretionWarning, restrictedVisibilityWarning, and thunderstormWarning). This is shown in Figure 4-8.

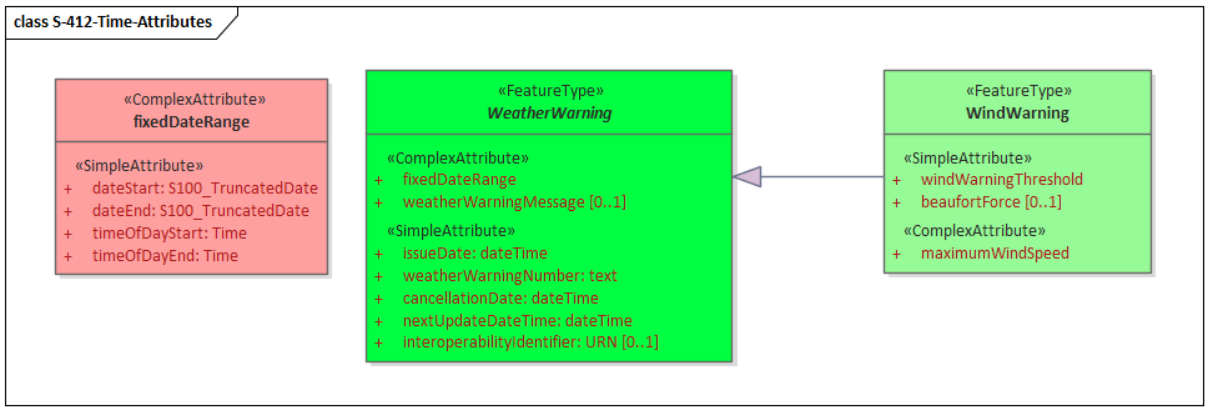

Figure 4-8 — S-412 weatherWarning Time Attributes

4.4.3 Multiple datasets

In order to facilitate the efficient processing and exchange of S-412 data, S-412 data files will be split by the time and date in which the file's data is valid.

4.5 Geometry

4.5.1 S-100 Level 3a Geometry

Weather warning features are encoded as vector entities which conform to S-100 geometry configuration level 3a (see S-100 Part 7, clause 7-4.3).

The underlying geometry of an S-412 dataset is constrained to level 3a which supports 0, 1 and 2 geometric dimensional objects (points, curves and surfaces) as defined by S-100 Part 7 – Spatial Schema. This product specification uses only one type of geometry: S100:Surface with gml PolygonPatch.

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 Figure 4-9
- 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 tangentially (i.e. at one point). See Figure 9.
- 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 Figure 9.

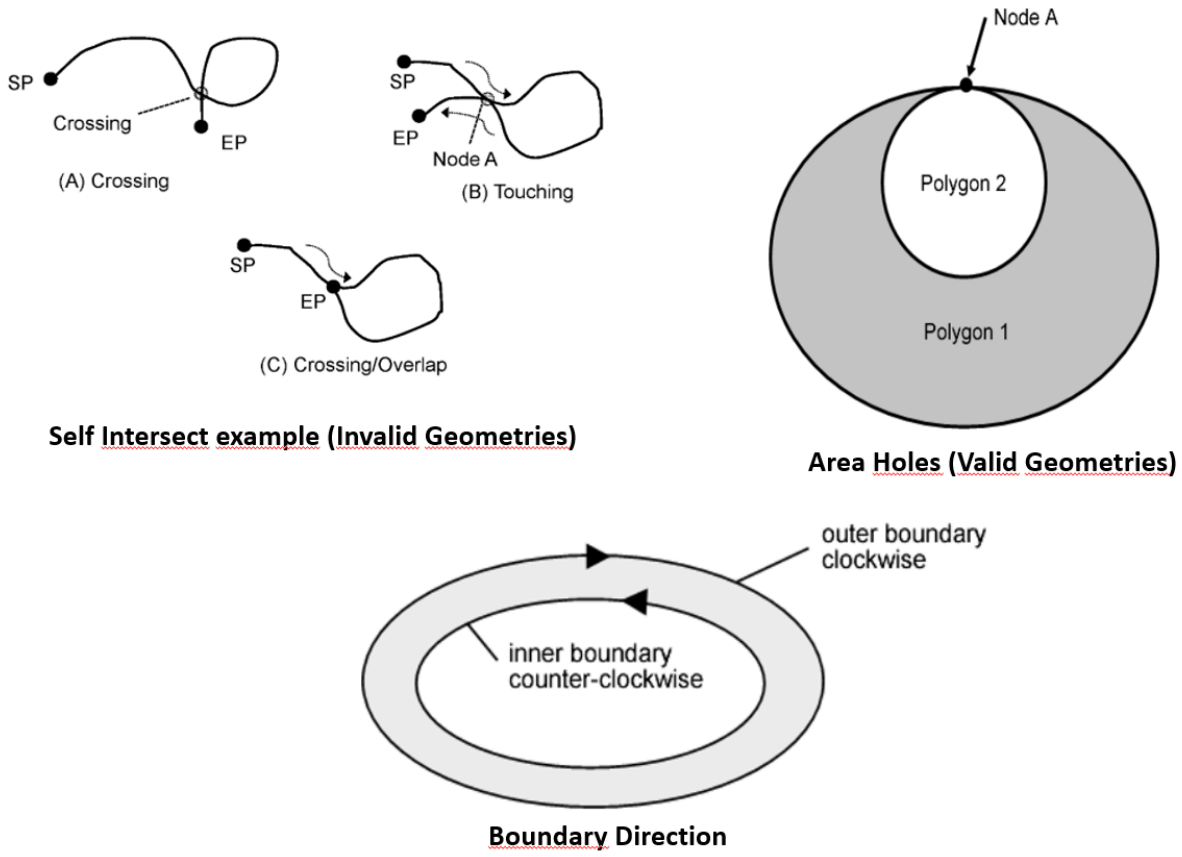

Figure 4-9 — Level3a Geometric Rules

S-412 further constraints Level 3a with the following:

- Coincident linear geometry must be avoided when there is a dependency between features.
- Curve interpolation may be utilised to represent a variety of curve types. Curve interpolation may also be utilised for inner and outer boundaries for polygons.
- Curves, including interpolations, and areas should avoid crossing the 180° longitude.

Examples illustrating the variety of ways geometry may be represented in an S-412 GML data file are provided in Annex C.

Table 4-2

== Coordinate Reference Systems (CRS) === Introduction When describing geographic information, it is common practice to separate the horizontal and vertical part of a position. This leads to 2D Coordinate Reference Systems for the horizontal positions and 1D Coordinate Reference Systems for the vertical positions. === Horizontal Coordinate Reference System The horizontal coordinate reference system used for this product specification must be the World Geodetic System 1984 (WGS84) — (EPSG:4326) which is defined by the European Petroleum Survey Group (EPSG) code 4326. The longitude is stored as a negative number to represent a position west of the prime Meridian. Latitude is stored as a negative number to represent a position south of the Equator. **Horizontal Coordinate Reference System**:: EPSG:4326 (WGS84) **Projection**: : NONE **Temporal reference system**:: Gregorian Calendar **Coordinate Reference System registry**:: EPSG Geodetic Parameter Dataset **Date type (according to [iso-19115-1])**:: 002 — publication **Responsible party**:: International Association of Oil and Gas Producers (IOGP) **URL**:: http://www.iogp.org/ === Vertical Coordinate Reference System This product specification does not apply to meteorological or oceanographic features at multiple vertical levels. All Weather Warning polygons are developed as overlays within ECS and thus are valid at the vertical datum defined by the ENC. *In this product there are no direct vertical coordinates which require the use of a vertical coordinate reference system.* === Temporal reference system The Marine Weather Warnings Product Specification applies to meteorological features valid at specific times. The temporal reference system used is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with ISO 19108:2002 Temporal Schema clause 5.4.4. Times must be in UTC and follow the following 15-character format: yyyymmddThhmmss. == Data Quality Datasets conforming to S-412 should always be created with the best available source information. Weather service providers recognized by the WMO shall be the distributor of datasets for each respective METAREA. All Marine Weather Warning information should be complete and in compliance with this Product Specification. The quality of the information can be verified with the text provided in the GMDSS. Marine Weather Warning information is assumed to be of high quality and guaranteed by the processes employed by data providers. Quality of S-412 products depends on the combined quality of many inputs including observed, mathematically-predicted, or model-driven weather data. S-412 products must be validated with the S-412 specific validation checks prior to release by the data producer. The data producer must review the check results and address any issues to ensure sufficient quality of the data products. The checks are a mixture of data format validation, conformance to standards, completeness and logical consistency. These validation checks are listed in Annex B. === Standard consistency Standard Consistency is the degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical). A series of logical consistency checks for S-412 can be found in Annex B — Validation Checks. It consists of four data quality elements: * Conceptual consistency: adherence to rules of the conceptual schema; * Domain consistency: adherence of values to the value domains; * Format consistency: degree to which data is stored in accordance with the physical structure of the dataset; * Topological consistency: correctness of the explicitly encoded topological characteristics of a dataset. === Positional accuracy The forecasting process is a combination of using observation data (vessel, buoy, or station reports, remotely sensed data from scatterometers, altimeters, satellite imagery, etc) alongside various weather and wave computer model datasets. These models rely on atmospheric and oceanographic physics and mathematics to predict future conditions. A forecaster uses observations and model data to analyse and predict the conditions for a geographic area. The positional accuracy of features will vary depending on the forecaster's confidence in the correlation of these models and the conditions reported in observations. The quality of each model will depend on the quality, timeliness, and spatial coverage of the input data (observations), as well as the mathematical and physical techniques of the model. These can be found in model technical reports. === Temporal Accuracy The S-412 datasets consist of predicted and forecasted data. Because such, data quality will be highly dependent on the timestamp of each feature and the dataset development process (forecast confidence). Traditionally, mariners have used meteorological and oceanographic products to ascertain conditions for a specific time. This can include conditions at times in the future, which may be updated as time approaches this future time. Within S-412, various time attributes exist for a forecasting agency to replicate these expectations. These attributes are for when a feature is issued, when a mariner can expect the data to be updated next, when the data is valid and the application of a time range if needed. The utilisation of these attributes will be dependent on a weather forecasting agency's policies and will directly affect the timeliness of a dataset. == Data Capture and Classification S-412 datasets may be derived from data that has been analysed by a forecaster or numerical weather prediction model output. The data is then translated into text and/or graphical format, reorganised, converted into the compliant format, and/or otherwise processed in order to be made into a usable data format. === Data Sources Data sources can vary across METAREAs, however, primarily comes from three sources: observations, meteorological and oceanographic forecast models, or derived products from weather models with input from a trained forecaster. Data must be produced and quality controlled by

a national authority. === Production Process Nearly all meteorological and oceanographic information from a forecasting agency will need to be reformatted to meet the standards of this Product Specification. This means: * Populating the appropriate dataset metadata, and * Reorganising the data in accordance with the GML and DCEG requirements of this standard. ==== Meteorological and Oceanographic Data Marine weather warning data must be reformatted to be compliant with this standard. S-412 warning polygons primarily contain a list of coordinate points and time attributes. Coordinate points for a warning polygon should be in decimal degrees. More information about coordinate systems is discussed in section 10.2. Additionally, time, if provided in local time, must be converted to UTC. Descriptions of the nature of warning polygons use the following units of measurement: * Latitudes and Longitudes are given in decimal degrees, with up to 7 decimal numbers. == Data Maintenance This clause describes the maintenance process for datasets, source, production process and how feature and portrayal catalogues are to be managed within an S-100 ECDIS. === Dataset Maintenance and Update Frequency Atmospheric and oceanographic conditions can change rapidly and constant revision or updating of warning datasets is essential. Datasets may be available at scheduled times or available for immediate dissemination and promulgation. Forecast data are often updated multiple times per day according to the internal policies and practices of issuing offices and the WMO. New issues of S-412 data should contain the latest information, and replace the previously issued dataset. Marine Weather Warning datasets should be maintained if a new dataset of region and provider is available. There is no updating mechanism used, with datasets being re-issued as appropriate. Future editions may use the updating mechanism for GML datasets contained in S-100, Part 10b. === Feature and Portrayal Catalogue Management Each new version of the Marine Weather Warnings Product Specification will include a cumulative feature and portrayal catalogue. This provides charting systems with a single set of catalogues to verify datasets against. Refer to the Feature Catalogue and Portrayal Catalogue. New versions of the feature and portrayal catalogues will follow a similar approval process as the main product specification documentation. This process is described in Section 1 Product Specification Maintenance. The latest versions of these catalogues should be included in a package with the main product specification document when submitted for approval and will be available in the IHO GI Registry. === GML Encoding Management All S-412 datasets are in Geography Markup Language (GML) format. Any updates or changes to features and attributes will be reflected in the GML Schema File (.XSD), which is used for validating the GML files. Refer to Annex C (GML Data Product Format (encoding)). == Portrayal === Introduction S-412 portrayal is intended to contribute to the safe operation of an S-100 based system by: * Ensuring base and supplementary levels of display for S-412 data; standards of symbols, colours and their standardised assignment to features; scale limitations of data presentation; * Ensuring the display is clear and unambiguous; * Establishing an accepted pattern presentation that becomes familiar to mariners and so can be recognized instantly without confusion; * Utilising the S-100 portrayal model to ensure interoperability. S-412 portrayal is covered by the portrayal model as defined in S-100. This model reflects how the Portrayal Catalogue is defined for use in systems. The Portrayal Catalogue defines symbology and the portrayal rules for each feature attribute combination contained in the Feature Catalogue. S-412 uses the portrayal process defined in S-100 Part 9A. Items included in an S-412 Portrayal Catalogue must be registered in the IHO Geospatial Information (GI) Registry. < < Statement about the types of data allowed in GML format (points, lines, polygons) > > === Polygon Features < < Under development – will include information about polygon features with examples of their portrayal, to include initiating portrayal rules, day/night/dusk colour palettes, orientation > > NOTE:: Polygon portrayals may be included in surface portrayals. In Annex E, the GML encoding for surface features shows a warning polygon example. So may not need a separate section for polygon portrayals. ==== Temporal Rules < < Temporal rules > > ==== Transparency Rules < < Transparency rules > > ==== Interoperability < < Interoperability statements > > ==== Portrayal Catalogue < < Under development – once completed, XML will be provided > > The portrayal catalogue contains the mechanisms for the system to portray information found in S-412 datasets. The portrayal catalogue contains the following types of mechanisms and structures: * Product Input Schema * Set of portrayal rules * Set of drawing instructions * Set of symbols, line styles and colours The portrayal catalogue model is defined in S-100 Part 9. The S-412 Portrayal catalogue is provided in Annex G and will be available in an XML document which conforms to the S-100 XML Portrayal catalogue Schema. It is structured as follows: Root —— (contains the catalogue named “portrayal_catalogue.xml”) Pixmaps (contains XML files describing pixmaps) ColorProfiles (contains XML files with colour profiles and CSS2 style sheets) Symbols (contains SVG files with symbols) LineStyles (contains XML files with line styles) AreaFills (contains XML files area fills) Fonts (contains TrueType font files) Rules (contains XSLT files with templates) ==== Lua vs XSLT Portrayal < < Under development > > == Data Product Format (encoding) === Introduction This clause specifies the encoding for Marine Weather Warning datasets. The principal encoding is the Open Geospatial Consortium (OGC), Geography Markup Language (GML) format as profiled by the S-100 GML schema in Part 10b of S-100. The XML Schema for the S-412 GML application schema is available at the GI Registry (http://registry.iho.int). Feature instances must validate against the schema and conform to all other requirements specified in this data product specification including all constraints not captured in the XML Schema document. === Encoding of Latitude and Longitude Values of latitude and longitude can be accurate up to 7 decimal places. Coordinate values should be coded as decimal numbers with 7 or fewer digits after the decimal. The normative encoding is in degrees, with an accuracy of 10-7 degrees; that is, up to 7 digits after the decimal point. === Text Attribute Values Character strings must be encoded using the character

set defined in ISO 10646:2020, in Unicode Transformation Format-8 (UTF-8). A BOM (byte order mark) must not be used. === Temporal Attribute Encoding Times must be in UTC and follow the following 16-character format: *yyyymmddThhmmssZ.* === Mandatory Attribute Values There are five reasons why attribute values may be considered mandatory:
● They determine whether a feature is to be displayed;
● Certain features make no logical sense without specific attributes;
● Some attributes are necessary to determine portrayal elements;
● Certain attributes are used to verify data quality;
● Some attributes are required for safety of navigation. All mandatory attributes are identified in the Feature catalogue and summarised in the Data Classification and Encoding Guides provided in Annex A. === Missing or Unknown Attribute Values Missing or unknown values are not permitted in S-412. Mandatory attributes must contain meaningful data. === Encoding Datasets Across 180° Longitude Datasets must not cross the 180° meridian of longitude; this includes the bounding box for the dataset. === Message Filtering Along Routes < < Statement regarding systems ability to filter information along a route by date, time, and conditions > > == Data Product Delivery Data which conforms to this Product Specification must be delivered by means of an Exchange Set. === Exchange set components S-412 uses the same exchange set components and metadata as S-100. Table 4-2 depicts the exchange set components (datasets and feature/portrayal catalogues) and exchange set metadata. This figure is derived from Figure 17-2 in S-100 Edition 5.2.0. Note also that the link between S100_Dataset and S100_CatalogueMetadata is implicit by means of the S-412 version to which the feature catalogue, portrayal catalogue, and dataset conform, which must have the same edition and revision components. .Components and associated metadata for the S-412 exchange set (S-100 Figure 17-2) image::../images/S-412-ExchangeSet.png[] The rules governing the presence and roles of the exchange set components depicted in Table 4-2 are given below. . Every exchange set must contain an Exchange Catalogue, represented by **S100_ExchangeCatalogue** in Table 4-2. . Dataset discovery metadata (**S100_DatasetDiscoveryMetadata**) must be provided in the exchange catalogue for each S-412 dataset in the exchange set. . Catalogue metadata (**S100_CatalogueDiscoveryMetadata**) must be provided in the exchange catalogue for any feature and portrayal catalogues included in the exchange set. . S-412 allows exchange sets to include the following types of support files: .. Plain text support files referenced by datasets (**S100_SupportFile**). .. Language packs (**S100_SupportFile**). . Plain text support files referenced in a dataset must be included in the exchange set. . The inclusion of language packs in exchange sets is optional. . Language packs are described in S-100 Part 18 and provide translations of feature catalogues. . A signature file for the exchange catalogue must also be included in the exchange set (**S100_CatalogueSignature**). The tangible representations of the structure classes in Table 4-2 within actual exchange sets are the digital files or folders containing the exchange set, dataset(s), catalogue(s), and support files. The tangible representations of their roles as depicted in Table 4-2 are the inclusion of the respective components within the exchange set. Documentation tables for the structure classes are not provided since the exchange set structure is described in this clause. The metadata classes in Table 4-2 are represented by XML files or XML blocks and are documented in Table 4-4. Each Exchange Set consists of one or more S-412 datasets and a single Exchange Catalogue XML file containing metadata. It may also include one or more support files (or no support files). The Exchange Set structure is the same as that described in S-100 Clause 17-4.2. == Encapsulation Each dataset must be contained in a physically separate, uniquely identified file on the transfer medium. An Exchange Set is encapsulated into a form suitable for transmission as packages (such as ZIP archives or files organised within a file system folder/directory structure), containing both the exchange catalogue and one or more data products (of possibly different S-100 types), with each product covering a specific geographic region and specific period of time. The contents of an Exchange Set are : * Mandatory elements **Exchange Catalogue — the XML encoded description of the content of the Exchange Set (discovery metadata). * Optional elements** S-412 datasets — Since it is possible for an exchange set to contain only a feature or portrayal catalogue, or only a support file which is being updated or delivered as a new file, datasets are an optional component of S-412 exchange sets. **Supplementary files — These are contained within the Exchange Set as files. If the exchange set contains a dataset, the support files referenced in the dataset must be included.** S-412 Feature Catalogue — If it is necessary to deliver the latest Feature Catalogue to the end user it may be done using the S-412 Exchange Set mechanism for datasets. ** S-412 Portrayal Catalogue — If it is necessary to deliver the latest Portrayal Catalogue to the end user it may be done using the S-412 Exchange Set mechanism for datasets. === Dataset ==== Types of Datasets EDITOR: Revisit cancellation depending on PT decision. Table 4-2 lists the types of datasets which may be produced and contained within an exchange set. The corresponding value of the dataset discovery metadata “purpose” field and the format are also described. .Types of datasets [cols=”88,311,108,80”]

h| Dataset Type h| Explanation h| Encoding Format h| “purpose” field

| New dataset | Data for an area different (in coverage and/or extent) from existing datasets. | Table 4-4 | *newDataset*

| Re-issue | Includes all the updates applied to the original dataset up to the date of the reissue. A Re-issue is intended to avoid unnecessary loading of the Base cell and all applicable updates individually for new users of the dataset, and therefore does not contain any new information additional to that previously distributed by updates. A reissue dataset can be issued at any time. | As for new dataset | *reissue*

| New Edition of a dataset | A re-issue plus new information which has not been previously distributed by Updates. Each New Edition of a dataset must have the same name as the dataset that it replaces and should have the same spatial extents. The edition number in the dataset discovery metadata must increment up by one from the previous edition. | As for new dataset | *newEdition*

| Cancellation | Used to cancel a dataset. The dataset is cancelled and is deleted from the system.

A cancellation dataset must be a pro-forma dataset containing only header information (no instances of spatial objects, information types, or feature types). | As for new dataset, but containing only header information. | *cancellation*

Table 4-3

==== 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-412 dataset naming conventions must follow these rules and no further restrictions are made in this product specification. The dataset file metadata that accompanies the file will inform the user of the name and purpose of the file (Table 4-2). S-412 dataset files for new, reissue, new editions, and cancellation datasets are named according to the specifications given below: **412YYYYØØØØØØØØØØØØ.GML**:: 412::: the first 3 characters identify the dataset as an S-412 dataset (mandatory);
YYYY::: the fourth to seventh characters identify the producer code according to the Producer Code Register;
ØØØØØØØØØØØ::: 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 a GML file (according to part=10b). ==== New Editions, re-issues, and cancellations This section defines the sequencing of S-412 datasets for New Editions and re-issues. **S-412 does not support update datasets. Edition number**:: When a dataset is initially created (Base dataset), the Edition number 1 is assigned to it. The Edition number is increased by 1 at each New Edition. **Update number**:: Update number is always 0 for S-412 datasets. **Issue date**:: Date up to which the Data Producer has incorporated all applicable changes. The issue date must be greater than the previous issue date of the dataset. In order to cancel a dataset, the Edition number must be set to 0. Where a dataset is cancelled and its name is reused at a later date, the issue date must be greater than the issue date of the cancelled dataset. When the dataset is cancelled it must be removed from the system. ==== Exchange set structure The structure of an S-412 exchange set must be according to the structure described below, which is based on S-100 Clause 17-4.2. The S-412 exchange set structure is depicted in Table 4-3. . 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. . The S100_ROOT folder must contain a subfolder for S-412 which holds content specific to S-412. . An S-412 exchange set must contain an exchange set catalogue, CATALOG.XML, its digital signature CATALOG.SIGN and may contain any number of S-412 conformant dataset files and catalogue files. . The S-412 subfolder must contain subfolders for the component dataset files (DATASET_FILES), support files (SUPPORT_ FILES), and catalogues (CATALOGUES) as required: .. The DATASET_FILES subfolder is required if and only if the exchange set contains an S-412 dataset. .. The CATALOGUES subfolder is required if and only if the exchange set contains a feature, interoperability, or portrayal catalogue. .. The SUPPORT_FILES folder is required if and only if the exchange set contains at least one S-412 support file. . The DATASET_ FILES folder must contain a subfolder named according to the producer code. . Individual data files must be placed under the producer subfolder, either directly in the producer folder, or within a lower-level subfolder hierarchy. Individual data files may be optionally placed in their own subfolders or grouped with other data files. . An exchange set may carry feature and portrayal catalogues in different versions, which should also be grouped together in the CATALOGUES folder. . If a portrayal catalogue is included in the exchange set, it may be packaged as either a ZIP archive containing all portrayal catalogue files, or a filesystem structure of folders and files. The structure of portrayal catalogues is described in S-100 Part 9 Clause 9-13.2. . Except for the signature of the exchange catalogue file (CATALOG.XML), which is in the CATALOG.SIGN file, all digital signatures are included within their corresponding resource metadata records in CATALOG.XML. . Dataset and catalogue file and/or folder names should be such as to avoid inadvertent overwriting of files. . Digital signatures for exchange sets conforming to Edition 1.2.0 of S-412 may be dummy values (values that conform to the format requirements but are not actual signatures). Proper digital signatures will be mandatory when S-412 reaches Readiness Level 3 (cf. S-97 1.1.0 Clause A-5). .Typical Exchange Set structure image::../images/412_ExchgSet.png[] === Support files Dataset support files offer supplementary information that can be included in an S-412 Exchange Set. **S-412 only supports plain text files (TXT format).** * Plain text files must contain only general text as defined by this standard (text consisting only of printable characters

and without HTML, XML, or other markup). The extension must be TXT. * Files must use the UTF-8 character set encoding. * XML files are allowed only for language packs and dictionaries such as the languages list included in the S-100 schema distributiona .Support file formats and extensions [cols="3"]

[a] The languages list, other dictionaries, language packs, and portrayal catalogue files are expected to be distributed separately in special exchange sets and should not be included in ordinary S-412 exchange sets.

h| File Types h| Extensions h| Comment

| **Text** | TXT | Plain-text files (UTF-8 encoding)

Table 4-4

==== Support File Naming All support files must have unique file identifiers. The support file metadata that accompanies the file will inform the user of the name and purpose of the file (that is new, replacement and deletion). In this encoding the support files are named according to the specifications given below: 412CCCCØØØØØØØØØØ.EEE The main part forms an identifier where: * 412 — the first 3 characters identify the support file as applicable to an S-412 dataset (mandatory). * CCCC — the fourth to seventh characters identify the producer code according to the Producer Code Register; * ØØØØØØØØØØ — the eighth and following characters are optional and can be used in any way by the Producer to provide the unique support file name. The following characters are allowed in the support file name: A to Z, 0 to 9 and the special character _ (underscore). * .EEE — support file extension. (TXT only for S-412). * The maximum length of the file name (including the extension and preceding ".") is 64 characters. === Support file management When a support file is created or a subsequent version is issued it must carry its own issue date and be supported with a digital signature which authenticates it against the Producer's public key included in the Exchange Set metadata. The type of support file is indicated in the "purpose" field of the discovery metadata. Three types: new, replacement and deletion are defined. Support files carrying the "deletion" flag must be removed from the system. When a feature pointing to a text file is deleted or updated so that it no longer references the file, the system software must check to see whether any other feature references the same file, before that file is deleted. Each support file required must be included only once in the Exchange Set. Support files must be stored in a separate folder within the Exchange Set, refer to Table 4-3 — Typical Exchange Set structure. Re-use of a support file name after a deletion period is possible only if the support file edition number is higher than the previous edition number before deletion. Only the latest edition of a support file can be used. As soon as a New Edition is created and installed, the older version is retired and can no longer be used by any feature. If a support file is associated with multiple features in one or several datasets, a New Edition of the file will immediately be used by all associated features. **Text files**: For plain-text files (TXT), since users may see additional portions of the file as well as the specific section referenced, a new TXT file must be created if there are objects that still need the old information. The file content must be reviewed and updated to ensure that there is no possibility of reader confusion. In deciding between options, producers should consider the expected lifetime of support files and the effects on update frequency for both datasets and support files, especially in connection with removal of obsolete information from the system as a whole as well as the removal of obsolete sections within support files. === 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 S-412 Exchange Catalogue are described in Table 4-4. === Dataset Loading and Unloading S-412 datasets are typically intended to be overlays to S-101 ENC and displayed with S-101 ENC data in the background. Systems that support the display of S-412 datasets should provide the user with simple functions to turn the display of S-412 datasets on and off. Optionally, S-412 datasets can be viewed as overlays to a combination of S-101 ENC and S-102 (Bathymetric Surface) datasets, with S-413 (Weather and Wave Conditions), S-414 (Weather and Waves Observations) datasets incorporated where applicable. The same requirements to allow the user to easily toggle the S-412 dataset on/off persist. When a new edition of a dataset is received, the system must replace the previous edition with the new edition of the dataset. == = Dataset size S-412 datasets must not exceed 10MB. === Data integrity and encryption Signatures are required for datasets and exchange sets intended for use on ECDIS, as described in S-100 Parts 15 and 17. Datasets may be encrypted or unencrypted as determined by producer policy. == Metadata === Introduction For information exchange, there are several categories of metadata required: * metadata about the overall exchange set and catalogue; * discovery metadata about each of the datasets contained in the catalogue; and * discovery metadata about the support files that make up the package. The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, for example, decrypt, decompress, load, etc. Discovery metadata for each dataset is given in an XML block within the exchange set catalogue file, and can be accessed without opening the GML dataset file. Discovery metadata is described in Table 4-4. Since S-412 does not add product-specific metadata attributes, the S-100 metadata classes and schema are used in S-412

exchange sets without extension. The constraints S-412 imposes on generic S-100 metadata are included in Table 4-4, generally as remarks describing the extra conditions and restrictions imposed by S-412 (such as making an optional attribute mandatory). This clause defines the mandatory and optional metadata needed for S-412. In some cases (if provided by the producer or exchange set packager) the metadata may be repeated in a language other than English. See S-100 Part 17 Clauses 17-4.6 — 17-4.8 for guidance on encoding of metadata in languages other than English. === Discovery metadata An outline of the overall concept of an S-412 exchange set for the interchange of geospatial data and its relevant metadata is explained in Table 4-2. Table 4-4 depicts the structure of the exchange catalogue and its component discovery metadata blocks. . Relationship between exchange catalogue, discovery metadata, and dataset (from S-100 5.2.0 Figure 17-6). image::../images/figure-27.png[] The detailed structure of the S-412 exchange catalogue is depicted in Table 4-4. This figure is derived from Figure 17-7 in S-100 Edition 5.2.0, with the following restriction: * Elements that are optional in the generic S-100 catalogue model but not used in S-412 are not shown; for example, the ISO 8211 and HDF5 formats in **S100_EncodingFormat**. .Details of exchange set catalogue classes. (Derived from S-100 Figure 17-7.) image::../images/fig-exchange-catalogue-classes.png[] The following clauses define the mandatory and optional metadata needed for S-412. In some cases the metadata may be repeated in a national language. If this is the case it is noted in the Remarks column. In the following clauses, wherever S-412 makes an optional S-100 metadata attribute mandatory (that is, restricts multiplicity from 0.. to 1..), the restricted multiplicity is shown in place of the multiplicity given in S-100 Part 17. When this is done, the Remarks column contains a note about the restriction. Further, enumerations in the figure and the following clauses show only the values allowed in S-412 Exchange Catalogues. These differences from the S-100 generic metadata are in red bold font. [%landscape] <<< ==== S100_ExchangeCatalogue The Catalogue file is defined in XML Schema language. The Exchange Catalogue inherits the dataset discovery metadata and support file discovery metadata from S-100 with additional S-412-specific restrictions. [cols="a,a,a,a,a,a", options="unnumbered"]

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_ExchangeCatalogue | An exchange catalogue contains the discovery metadata about the exchange datasets and support files | — | - | **The optional S-100 attributes *identifier*, *contact*, and *productSpecification* are mandatory in S-412.**

| Attribute | identifier | Uniquely identifies this exchange catalogue | **1** | S100_ExchangeCatalogueIdentifier | **Mandatory in S-412.** | Attribute | contact | Details about the issuer of this exchange catalogue | **1** | S100_CataloguePointOfContact | **Mandatory in S-412.** | Attribute | productSpecification | Details about the product specifications used for the datasets contained in the exchange catalogue | **1** | S100_ProductSpecification | **Mandatory in S-412**. | Attribute | defaultLocale | Default language and character set used for all metadata records in this Exchange Catalogue | 0..1 | PT_Locale | Default is English and UTF-8 | Attribute | otherLocale | Other languages and character sets used for the localized metadata records in this Exchange Catalogue | 0..* | PT_Locale | Required if any localized entries are present in the Exchange Catalogue

| Attribute | exchangeCatalogueDescription | Description of what the exchange catalogue contains | 0..1 | CharacterString |

| Attribute | exchangeCatalogueComment | Any additional Information | 0..1 | CharacterString |

| Attribute | certificates | Signed public key certificates referred to by digital signatures in the Exchange Set | 0..* | S100_SE_CertificateContainer | Content defined in S-100 Part 15. All certificates used, except the SA root certificate (installed separately by the implementing system) shall be included

| Attribute | dataServerIdentifier | Identifies the data server for the permit | 0..1 | CharacterString |

| Role | datasetDiscoveryMetadata | Exchange Catalogues may include or reference discovery metadata for the datasets in the Exchange Set | 0..* | Aggregation S100_DatasetDiscoveryMetadata |

| Role | catalogueDiscoveryMetadata | Metadata for Catalogue | 0..* | Aggregation S100_CatalogueDiscoveryMetadata | Metadata for the Feature, Portrayal and Interoperability Catalogues, if any

| Role | supportFileDiscoveryMetadata | Exchange Catalogues may include or reference discovery metadata for the support files in the Exchange Set | 0..* | Aggregation S100_SupportFileDiscoveryMetadata |

Table 4-5

```
===== S100_ExchangeCatalogueIdentifier [cols="6",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_ExchangeCatalogueIdentifier | An Exchange Catalogue contains the discovery metadata about the exchange datasets and support files |—|—| - | Attribute | identifier | Uniquely identifies this Exchange Catalogue | 1 | CharacterString | E.g., US00412_<LOCODE>_20200101 | Attribute | dateTime | Creation date and time of the Exchange Catalogue, including time zone | 1 | DateTime | Format: yyyy-mm-ddThh:mm:ssZ

Table 4-6

```
===== S100_CataloguePointOfContact [cols="6",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_CataloguePointOfContact | Contact details of the issuer of this Exchange Catalogue |—|—| - | Attribute | organization | The organization distributing this Exchange Catalogue | 1 | CharacterString | This could be an individual producer, value added reseller, etc | Attribute | phone | The edition number of this Exchange Catalogue | 0..1 | CI_Telephone | | Attribute | address | The address of the organization | 0..1 | CI_Address |

Table 4-7

```
==== S100_DatasetDiscoveryMetadata [cols="a,a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_DatasetDiscoveryMetadata | Metadata about the individual datasets in the exchange catalogue |—| - | **The optional S-100 attributes *datasetID*, *editionNumber*, *updateNumber* and *boundingBox* are mandatory in S-412.**

The optional S-100 attribute *temporalExtent* is not used.

| Attribute | fileName | Dataset file name | 1 | URI | See S-100 Part 1, clause 1-4.6 | Attribute | description | Short description giving the area or location covered by the dataset | 0..1 | CharacterString | E.g. a harbour or port name, between two named locations etc. | Attribute | datasetID | Dataset ID expressed as a Marine Resource Name | **1** | URN | The URN must be an MRN. **Restricted to mandatory in S-412** | Attribute | compressionFlag | Indicates if the resource is compressed | 1 | Boolean | *true* indicates a compressed dataset resource
false indicates an uncompressed dataset resource | Attribute | dataProtection | Indicates if the data is encrypted | 1 | Boolean | *true* indicates an encrypted dataset resource
false indicates an unencrypted dataset resources | Attribute | protectionScheme | Specification of method used for data protection | 0..1 | S100_ProtectionScheme | In S-100 Edition 5.2.0 the only allowed value is “S100p15”.

| Attribute | digitalSignatureReference | Specifies the algorithm used to compute digitalSignatureValue | 1 | S100_DigitalSignatureReference (see S-100 Part 15) |

| Attribute | digitalSignatureValue | Value derived from the digital signature | 1..* | S100_DigitalSignatureValue (see S-100 Part 15) | The value resulting from application of *digitalSignatureReference*. Implemented as the digital signature format specified in Part 15. There must be at least one signature on the file as included in the exchange set.

| Attribute | copyright | Indicates if the dataset is copyrighted | 1 | Boolean | *true* indicates the resource is copyrighted
false Indicates the resource is not copyrighted | Attribute | classification | Indicates the security classification of the dataset | 0..1 | MD_SecurityConstraints> MD_ClassificationCode (codelist) | . unclassified . restricted . confidential . secret . top secret . sensitive but unclassified . for official use only . protected . limited distribution

| Attribute | purpose | The purpose for which the dataset has been issued | 0..1 | S100_Purpose |

| Attribute | notForNavigation | Indicates the dataset is not intended to be used for navigation | 1 | Boolean | *true* indicates the dataset is not intended to be used for navigation
false indicates the dataset is intended to be used for navigation | Attribute | specificUsage | The use for which the dataset is intended | 1 | MD_USAGE>specificUsage (character string) | Information about specific usage(s) for which the dataset is intended. The string value “general” may be encoded if there is no specific usage. | Attribute | editionNumber | The edition number of the dataset | **1** | CharacterString | **Mandatory in S-412.** | Attribute | updateNumber | Update number assigned to the dataset and increased by one for each subsequent update | **1** | Integer | **S-412 does not support updates. updateNumber is always 0** | Attribute | updateApplicationDate | This date is only used for the base cell files (that is new data set, re-issue and new edition), not update cell files. All updates dated on or before this date must have been applied by the producer | 0..1 | Date | This date is only used for the base dataset files (that is new dataset, re-issue and new edition), not update dataset files. All updates dated on or before this date must have been applied by the producer | Attribute | referenceID | Reference back to the datasetID | 0..1 | URN | Update metadata refers to the datasetIDof the dataset metadata. This is used ifand only if the dataset is an updateThe URN must be an MRN

| 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 | Mandatory when the interval between datasets is shorter than 1 day, such as 6-hourly forecasts. | Attribute | boundingBox | The extent of the dataset limits | **1** | EX_GeographicBoundingBox | **Mandatory in S-412.**

| Attribute | productSpecification | The product specification used to create this dataset | 1 | S100_ProductSpecification |

| Attribute | producingAgency | Agency responsible for producing the data | 1 | CI_ResponsibleParty>CI_Organisation | See S-100 Table 17-3

| Attribute | producerCode | The official IHO Producer Code from S-62 | 0..1 | CharacterString |

| Attribute | encodingFormat | The encoding format of the dataset | 1 | S100_EncodingFormat | **Must be GML** | Attribute | dataCoverage | Area covered by the dataset | **1**..* | S100_DataCoverage | **Mandatory in S-412.**

| Attribute | comment | Any additional information | 0..1 | CharacterString |

| Attribute | defaultLocale | Default language and character set used in the exchange catalogue | 1 | PT_Locale |

| Attribute | otherLocale | Other languages and character sets used in the exchange catalogue | 0..* | PT_Locale |

| Attribute | metadataFileIdentifier | Identifier for metadata file | 1 | CharacterString | For example, for ISO 19115-3 metadata file | Attribute | metadataPointOfContact | Point of contact for metadata | 0..1 | CI_Responsibility > CI_Individual or CI_Responsibility > CI_Organisation | Only if metadataPointOfContact isdifferent from producingAgency.

See S-100 Tables 17-2 and 17-3. | Attribute | metadataDateStamp | Date stamp for metadata | 0..1 | Date | May or may not be the issue date of the dataset.

| Attribute | replacedData | If a data file is cancelled is it replaced by another data file | 0..1 | Boolean |

| Attribute | dataReplacement | Cell name | 0..* | CharacterString | A dataset may be replaced by 1 or more datasets | Attribute | navigationPurpose | Classification of intended navigation purpose (for Catalogue indexing purposes) | 0..3 | S100_NavigationPurpose | Mandatory when *notForNavigation = false*. | Role | resourceMaintenance | Information about the frequency of resource updates, and the scope of those updates | 0..1 | MD_MaintenanceInformation | S-100 restricts the multiplicity to 0..1and adds specific restrictions on the ISO 19115 structure and content. Seeclause **MD_MaintenanceInformation**in S-100 Part 17.

Format: PnYnMnDTnHnMnS (XML built-in type for ISO 8601 duration). See S-100 clause 17-4.9 for encoding guidance.

Table 4-8

```
===== S100_NavigationPurpose [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_NavigationPurpose | The purpose of the dataset | — | | Value | port | For port and near shore operations | 1 | - | Value | transit | For coast and planning purposes | 2 | - | Value | overview | For ocean crossing and planning purposes | 3 | -

Table 4-9

```
===== S100_DataCoverage [cols="a,a,a,a,a",options="unnumbered"]
```

h| Name h| Description h| Multiplicity h| Type h| Remarks

| S100_DataCoverage | A spatial extent where data is provided; and the display scale information for the provided data | — | - | **The optional S-100 attributes *temporalExtent* and *approximateGridResolution* are not used in S-412.** | boundingPolygon | A polygon which defines the actual data limit | 1 | EX_BoundingPolygon | | optimumDisplayScale | The scale with which the data is optimally displayed | 0..1 | Integer | Example: A scale of 1:25000 is encoded as 25000 | maximumDisplayScale | The maximum scale with which the data is displayed | 0..1 | Integer | Must be one of the following values:

1000
2000
3000
4000
8000
12000
22000
45000
90000
180000
350000
700000
1500000
3500000
10000000

| minimumDisplayScale | The minimum scale with which the data is displayed | 0..1 | Integer | Must be one of the following values:

2000
3000
4000
8000
12000
22000
45000
90000
180000
350000
700000
1500000
3500000
10000000

Table 4-10

```
===== S100_Purpose [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_Purpose | The purpose of the dataset | — | **The value *delta* is not used.** | 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 | update | Dataset update | 3 | Changing some information in an existing dataset | Value | reissue | Dataset that has been re-issued | 4 | Includes all the updates applied to the original dataset up to the date of the re-issue. A re-issue does not contain any new information additional to that previously issued 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

Table 4-11

```
===== S100_EncodingFormat [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_EncodingFormat | The encoding format | - | **Values listed in S-100 Part 17 but not mentioned in this table are not allowed** | Value | GML | The GML data format as defined in S-100 Part 10b | |

Table 4-12

```
===== S100_ProductSpecification [cols="a,a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_ProductSpecification | The Product Specification contains the information needed to build the specified product | — | - | **The attribute *compliancyCategory* is made mandatory.**

| Attribute | name | The name of the Product Specification used to create the datasets | 0..1 | CharacterString | Marine Weather Warnings Overlay | Attribute | version | The version number of the Product Specification | 0..1 | CharacterString | 1.0.0 | Attribute | date | The version date of the Product Specification | 0..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) | "S-412" (without quotes) | Attribute | number | The number (registry index) used to lookup the product in the Product Specification Register | 1 | Integer | From the Product Specification Register in the IHO Geospatial Information (GI) Registry | Attribute | compliancyCategory | The level of compliance of the Product Specification to S-100 | **1** | S100_CompliancyCategory a| Needed for S-98 interoperability.

Table 4-13

```
===== S100_CompliancyCategory [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_CompliancyCategory | | — | **S-412 uses only *category4*** | Value | category4 | IHO S-100 and IMO harmonized display compliant | |

Table 4-14

```
===== S100_ProtectionScheme [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_ProtectionScheme | Data protection schemes | — | - | Value | S100p15 | IHO S-100 Part 15 | — | See S-100 Part 15

Table 4-15

```
==== S100_SupportFileDiscoveryMetadata [cols="a,a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult. h| Type h| Remarks

| Class | S100_SupportFileDiscoveryMetadata | Metadata about the individual support files in the Exchange Catalogue |—|—| **Only TXT_UTF-8 format is allowed for S-412 support files.** | Attribute | fileName | Name of the support file | 1 | URI | See S-100 Part 1, clause 1-4.6 | Attribute | revisionStatus | The purpose for which the support file has been issued | 1 | S100_SupportFileRevisionStatus | For example new, replacement, etc | Attribute | editionNumber | The Edition number of the support file | 1 | Integer | | Attribute | issueDate | Date on which the data was made available by the Data Producer | 0..1 | Date | Date on which the support file was made available by its producer. | Attribute | supportFileSpecification | The specification used to create this file | 0..1 | S100_SupportFileSpecification | May be omitted for language packs. | Attribute | dataType | The format of the support file | 1 | S100_SupportFileFormat | | Attribute | otherDataTypeDescription | Support file format other than those listed | 0..1 | CharacterString | | Attribute | comment | Optional comment | 0..1 | CharacterString | | Attribute | compressionFlag | Indicates if the resource is compressed | 1 | Boolean | *true* indicates a compressed resource
false indicates an uncompressed resource | Attribute | digitalSignatureReference | Specifies the algorithm used to compute digitalSignatureValue | 1 | S100_DigitalSignatureReference(see Part 15) |

| Attribute | digitalSignatureValue | Value derived from the digital signature | 1..* | S100_DigitalSignatureValue(see Part 15) | The value resulting from application of digitalSignatureReference. Implemented as the digital signature format specified in S-100 Part 15. There must be at least one signature on the file as included in the exchange set.

| Attribute | defaultLocale | Default language and character set used in the support file | 0..1 | PT_Locale | In absence of defaultLocale the language is English in UTF-8A support file is expected to use only one as locale. Additional support files can be created for other locales. | Attribute | supportedResource | Identifier of the resource supported by this support file | 0..* | CharacterString | Conventions for identifiers are detailed in S-100 Part 15. S-100 allows file URI, digital signature or cryptographic hash checksums to be used. | Attribute | resourcePurpose | The purpose of the supporting resource | 0..1 | S100_ResourcePurpose | Identifies how the supporting resource is used

Table 4-16

```
===== S100_SupportFileFormat [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_SupportFileFormat | The format used for the support file | - | **Only TXT_UTF-8 is allowed for S-412.** | Value | TXT_UTF-8 | UTF-8 text excluding control codes | 1 | Text

Table 4-17

```
===== S100_SupportFileRevisionStatus [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_SupportFileRevisionStatus | The reason for inclusion of the support file in this exchange set |—| - | Value | new | A file which is new | 1 | Signifies a new file | Value | replacement | A file which replaces an existing file | 2 | Signifies a replacement for a file of the same name | Value | deletion | Deletes an existing file | 3 | Signifies deletion of a file of that name

Table 4-18

```
===== S100_SupportFileSpecification [cols="a,a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_SupportFileSpecification | The standard or specification to which a support file conforms |—|—| - | Attribute | name | The name of the specification used to create the support file | 1 | CharacterString | | Attribute | version | The version number of the specification | 0..1 | CharacterString | | Attribute | date | The version date of the specification | 0..1 | Date |

Table 4-19

```
===== S100_ResourcePurpose [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_ResourcePurpose | Defines the purpose of the supporting resource |—| The values ISOMetadata and GMLSchema are not permitted | Value | supportFile | A support file | 1 | | Value | languagePack | A Language pack | 3 | | Value | other | A type of resource not otherwise described | 100 |

Table 4-20

```
==== S100_CatalogueDiscoveryMetadata This is an optional element that allows for the delivery of S-412 Feature and Portrayal Catalogues within the Exchange Set. [cols="a,a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | S100_CatalogueDiscoveryMetadata | Class for S-100 Catalogue metadata |—|—| - | Attribute | fileName | The name for the Catalogue | 1 | URI | See S-100 Part1, clause 1-4.6 | Attribute | purpose | The purpose for which the Catalogue has been issued | 0..1 | S100_Purpose(codelist) | The values must be one of the following:
2 new edition
5 cancellationDefault is new edition | Attribute | editionNumber | The Edition number of the Catalogue | 1 | Integer | Initially set to 1 for a given productSpecification.numberIncreased by 1 for each subsequent newEditionUniquely identifies the version of the Catalogue

| Attribute | scope | Subject domain of the Catalogue | 1 | S100_CatalogueScope | | Attribute | versionNumber | The version identifier of the Catalogue | 1 | CharacterString | Human readable version identifier | Attribute | issueDate | The issue date of the Catalogue | 1 | Date | | Attribute | productSpecification | The Product Specification used to create this file | 1 | S100_ProductSpecification | | Attribute | digitalSignatureReference | Specifies the algorithm used to compute digitalSignatureValue | 1 | S100_DigitalSignatureReference(see S-100 Part 15) |

| Attribute | digitalSignatureValue | Value derived from the digital signature | 1..* | S100_DigitalSignatureValue(see S-100 Part 15) | The value resulting from application of *digitalSignatureReference* Implemented as the digital signature format specified in Part 15. There must be at least one signature on the file as included in the exchange set.

| Attribute | compressionFlag | Indicates if the resource is compressed | 1 | Boolean | *true* indicates a compressed resource
false indicates an uncompressed resource | Attribute | defaultLocale | Default language and character set used in the Catalogue | 0..1 | PT_Locale | In absence of *defaultLocale* the language is English in UTF-8 | Attribute | otherLocale | Other languages and character sets used in the Catalogue | 0..* | PT_Locale |

Table 4-21

```
===== S100_CatalogueScope [cols="a,a,a,a,a",options="unnumbered"]
```

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | S100_CatalogueScope | The scope of the Catalogue |—| Interoperability Catalogues are not implemented | Value | featureCatalogue | S-100 Feature Catalogue | 1 | | Value | portrayalCatalogue | S-100 Portrayal Catalogue | 2 |

Table 4-22

==== Miscellaneous metadata types ===== MD_MaintenanceInformation [cols="a,a,a,a,a,a",options="unnumbered"]

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | MD_MaintenanceInformation | Information about the scope and frequency of updating | — | - a| S-100 restricts the ISO 19115-class to:

- prohibit maintenanceScope, maintenanceNote, and contact attributes;
- define restrictions on maintenanceAndUpdateFrequency, maintenanceDate, and userDefinedMaintenanceFrequency attributes

| Attribute | maintenanceAndUpdateFrequency | Frequency with which changes and additions are made to the resource after the initial resource is completed | 0..1 | MD_MaintenanceFrequencyCode (codelist) | Must be populated if userDefinedMaintenanceFrequency is not present, otherwise optional. See Table MD_MaintenanceFrequencyCode in this Part for values allowed in S-100 metadata | Attribute | maintenanceDate | Date information associated with maintenance of the resource | 0..1 | CI_Date | Exactly one of maintenanceDate and userDefinedMaintenanceFrequency must be populatedAllowed value for dateType: nextUpdate | Attribute | userDefinedMaintenanceFrequency | Maintenance period other than those defined | 0..1 | TM_PeriodDuration | Exactly one of maintenanceDate and userDefinedMaintenanceFrequency must be populatedOnly positive durations allowed

Table 4-23

===== MD_MaintenanceFrequencyCode S-100 uses a subset of the values allowed in [ISO_19115_1]. [cols="a,a,a,a,a",options="unnumbered"]

h| Role Name h| Name h| Description h| Code h| Remarks

| Enumeration | MD_MaintenanceFrequencyCode | Frequency with which modifications and deletions are made to the data after it is first produced | - | S-100 is restricted to only the following values from the [ISO_19115_1] codelist. The conditions for the use of a particular value are described in its Remarks | Value | asNeeded | Resource is updated as deemed necessary | 1 | Use only for datasets which normally use a regular interval for update or supersession, but will have the next update issued at an interval different from the usualAllowed if and only if userDefinedMaintenanceFrequency is not populated | Value | irregular | Resource is updated in intervals that are uneven in duration | 2 | Use only for datasets which do not use a regular schedule for update or supersessionAllowed if and only if userDefinedMaintenanceFrequency is not populated

Table 4-24

===== PT_Locale [cols="a,a,a,a,a,a",options="unnumbered"]

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | PT_Locale | description of a locale | — | — | From [ISO_19115_1] | Value | language | designation of the locale language | 1 | LanguageCode | ISO 639-2 3-letter language codes. | Value | country | designation of the specific country of the locale language | 0..1 | CountryCode | ISO 3166-2 2-letter country codes | Value | characterEncoding | designation of the character set to be used to encode the textual value of the locale | 1 | MD_CharacterSetCode | UTF-8 is used in S-100

Table 4-25

The class PT_Locale is defined in [ISO_19115_1]. LanguageCode, CountryCode, and MD_CharacterSetCode are ISO codelists which are defined in a resource file in the S-100 5.2.0 schemas distribution. ===== EX_GeographicBoundingBox From [ISO_19115_1]. [cols="a,a,a,a,a,a",options="unnumbered"]

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | EX_GeographicBoundingBox | geographic position of the dataset |—| - | Defined in [ISO_19115_1]: geographic position of the resource

| Attribute | westBoundLongitude | western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east) | 1 | Real | Arc degrees | Attribute | eastBoundLongitude | eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east) | 1 | Real | Arc degrees | Attribute | southBoundLatitude | southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north) | 1 | Real | Arc degrees | Attribute | northBoundLatitude | northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north) | 1 | Real | Arc degrees

Table 4-26

===== EX_BoundingPolygon From [ISO_19115_1]. [cols=”a,a,a,a,a,a”,options=”unnumbered”]

h| Role Name h| Name h| Description h| Mult h| Type h| Remarks

| Class | EX_BoundingPolygon | boundary enclosing the dataset, expressed as the closed set of (x,y) coordinates of the polygon (last point replicates first point) |—| - | Defined in [ISO_19115_1]: enclosing geometric object which locates the resource, expressed as a set of (x,y) coordinate(s)

| Attribute | polygon | sets of points defining the bounding polygon | 1 | GM_Object | Must be a GM_Polygon(See S-100 Part 7, ISO 19107, ISO 19136)

Table 4-27

==== Types for digital signatures The types relating to digital signatures: * S100_SE_CertificateContainer * S100_SE_DigitalSignatureReference * S100_SE_DigitalSignatureValue * S100_SE_SignatureOnData * S100_SE_SignatureOnSignature * DataStatus are defined in S-100 Part 15 and are used in S-412 without modification. === Language The exchange language must be English. Other languages may be used as a supplementary option. National geographic names can be left in their original national language using the complex attribute **feature name**. 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. == Dataset Encoding WMO to consider if this section should be removed: * Dataset Coverage and Display Scale Range rules may not apply if Data Coverage feature is not used in S-412. * Geometry is already detailled in section 4. === Introduction A dataset is a grouping of features, attributes, geometry and metadata which comprises a specific coverage. === Dataset Rules In order to facilitate the efficient processing of S-412 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. === Data Coverage rules * All base datasets (new dataset, new edition) must contain at least one **Data Coverage** feature. * 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. == Geometry === S-412 Geometry S-412 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. == List of annexes These Annexes are separate files and can be found either in the S-411 Product Specification distribution package or at the locations indicated. Annex A:: Data Classification and Encoding Guide. Separate document. IHO Geospatial Information Registry, https://registry.iho.int Annex B:: Encoding Format. GML schema, Schematron rule files, and schema documentation. S-100 schema server, https://schemas.s100dev.net **TBC** Annex C:: Feature catalogue. XML file. IHO Geospatial Information Registry, https://registry.iho.int Annex D:: Validation Checks. Separate document. IHO Geospatial Information Registry, https://registry.iho.int **TBC** Annex E:: Portrayal Catalogue. Zip archive of portrayal catalogue. IHO Geospatial Information Registry, https://registry.iho.int

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