

# Marine Protected Areas Product Specification

**Edition 1.2.1 – December 2024**

IHO



International  
Hydrographic  
Organization

Published by the  
International Hydrographic Organization  
4b quai Antoine 1<sup>er</sup>  
Principauté de Monaco  
Tel: (377) 93.10.81.00  
Fax: (377) 93.10.81.40  
[info@ihodata.int](mailto:info@ihodata.int)  
[www.ihodata.int](http://www.ihodata.int)

© Copyright International Hydrographic Organization 2024

This work is copyright. Apart from any use permitted in accordance with the Berne Convention for the Protection of Literary and Artistic Works (1886), and except in the circumstances described below, no part may be translated, reproduced by any process, adapted, communicated or commercially exploited without prior written permission from the International Hydrographic Organization (IHO). Copyright in some of the material in this publication may be owned by another party and permission for the translation and/or reproduction of that material must be obtained from the owner.

This document or partial material from this document may be translated, reproduced or distributed for general information, on no more than a cost recovery basis. Copies may not be sold or distributed for profit or gain without prior written agreement of the IHO and any other copyright holders.

In the event that this document or partial material from this document is reproduced, translated or distributed under the terms described above, the following statements are to be included:

"Material from IHO publication [reference to extract: Title, Edition] is reproduced with the permission of the International Hydrographic Organization (IHO) Secretariat (Permission No ...../...) acting for the International Hydrographic Organization (IHO), which does not accept responsibility for the correctness of the material as reproduced: in case of doubt, the IHO's authentic text shall prevail. The incorporation of material sourced from IHO shall not be construed as constituting an endorsement by IHO of this product."

"This [document/publication] is a translation of IHO [document/publication] [name]. The IHO has not checked this translation and therefore takes no responsibility for its accuracy. In case of doubt the source version of [name] in [language] should be consulted."

The IHO Logo or other identifiers shall not be used in any derived product without prior written permission from the IHO.

## **Contents**

1	Overview.....	1
1.1	Scope.....	1
1.2	References.....	1
1.3	Terms, definitions and abbreviations.....	3
1.3.1	Use of language.....	3
1.3.2	Terms and definitions.....	3
1.3.3	Abbreviated terms.....	5
1.4	General S-102 data product description.....	6
1.5	Product Specification metadata.....	6
1.6	IHO Product Specification Maintenance.....	7
1.6.1	Introduction.....	7
1.6.2	New Edition.....	7
1.6.3	Revision.....	7
1.6.4	Clarification.....	7
1.6.5	Version Numbers.....	7
2	Specification Scope.....	7
3	Data Product Identification.....	8
4	Data Content and Structure.....	8
4.1	Introduction.....	8
4.2	Application Schema.....	9
4.2.1	Application Schema implementation classes.....	11
4.3	Feature Catalogue.....	16
4.3.1	Introduction.....	16
4.3.2	Feature types.....	16
4.3.3	Feature relationship.....	16
4.3.4	Attributes.....	16
4.4	Dataset types.....	16
4.4.1	Introduction.....	16
4.4.2	Regular grid.....	17
4.5	Multiple datasets.....	18
4.6	Dataset rules.....	18
4.7	Geometry.....	18
5	Coordinate Reference Systems (CRS).....	18
5.1	Introduction.....	18
5.2	Horizontal Coordinate Reference System.....	18
5.3	Vertical Coordinate Reference System.....	19
5.4	Temporal reference system.....	19
6	Data Quality.....	19
6.1	Completeness.....	19
6.1.1	Commission.....	19
6.1.2	Omission.....	20
6.2	Logical consistency.....	20
6.2.1	Conceptual consistency.....	20
6.2.2	Domain consistency.....	20
6.2.3	Format consistency.....	20
6.3	Positional accuracy.....	20
6.3.1	Gridded data positional accuracy.....	20
6.3.2	Relative internal positional accuracy.....	20
6.4	Temporal accuracy.....	20
6.5	Thematic accuracy.....	21
6.5.1	Thematic classification correctness.....	21
6.5.2	Non-quantitative attribute accuracy.....	21
6.5.3	Quantitative attribute accuracy.....	21
7	Data Capture and Classification.....	21
7.1	Quality and source metadata.....	21
8	Data Maintenance.....	22
8.1	Maintenance and update frequency.....	22
8.2	Data source.....	22

8.3	Production process.....	22
9	Portrayal.....	22
9.1	Introduction.....	22
9.2	Portrayal Catalogue.....	23
9.2.1	Use of sun-illumination.....	24
10	Data Product Format (Encoding).....	25
10.1	Introduction.....	25
10.2	Product structure.....	26
10.2.1	Root Group.....	28
10.2.2	Feature Codes (Group_F).....	29
10.2.3	BathymetryCoverage and QualityOfBathymetryCoverage Tables (in Group_F).....	30
10.2.4	Root BathymetryCoverage.....	31
10.2.5	Feature Instance group—BathymetryCoverage.nn.....	31
10.2.6	The values group—Group_001.....	34
10.2.7	BathymetryCoverage feature instance group—values dataset.....	34
10.2.8	Root QualityOfBathymetryCoverage.....	35
10.2.9	Instance group QualityOfBathymetryCoverage.01.....	38
10.2.10	Values group for QualityOfBathymetryCoverage.....	38
10.2.11	Values dataset for QualityOfBathymetryCoverage.....	38
10.2.12	Mandatory Naming Conventions.....	38
11	Data Product Delivery.....	38
11.1	Introduction.....	38
11.2	Dataset.....	39
11.2.1	Dataset management.....	39
11.2.2	Dataset size.....	40
11.2.3	Dataset file naming.....	41
11.3	Exchange Set.....	41
11.4	Exchange Catalogue.....	41
11.5	Data integrity and encryption.....	41
11.5.1	Use of compression.....	41
11.5.2	Use of data protection.....	42
11.5.3	Use of digital signatures.....	42
12	Metadata.....	42
12.1	Introduction.....	42
12.2	Exchange Set metadata.....	42
12.3	Language.....	45
12.4	S100_ExchangeCatalogue.....	46
12.4.1	S100_ExchangeCatalogueIdentifier.....	46
12.4.2	S100_CataloguePointOfContact.....	46
12.5	S100_DatasetDiscoveryMetadata.....	46
12.5.1	S100_NavigationPurpose.....	50
12.5.2	S100_DataCoverage.....	50
12.5.3	S100_Purpose.....	51
12.5.4	S100_EncodingFormat.....	51
12.5.5	S100_ProductSpecification.....	52
12.5.6	S100_CompliancyCategory.....	53
12.5.7	S100_ProtectionScheme.....	53
12.6	MD_MaintenanceInformation.....	53
12.7	MD_MaintenanceFrequencyCode.....	53
12.8	S100_CatalogueDiscoveryMetadata.....	54
12.8.1	S100_CatalogueScope.....	54
12.8.2	PT_Locale.....	54
12.9	Certificates and Digital Signatures.....	54
	Annex A Data Classification and Encoding Guide.....	55
A.1	Features.....	55
A.1.1	BathymetryCoverage.....	55
A.1.2	QualityOfBathymetryCoverage.....	55
A.2	Feature Attributes.....	55
A.2.1	BathymetryCoverage.....	55
A.2.2	QualityOfBathymetryCoverage.....	56

## Document History

Changes to this Specification are coordinated by IHO NIPWG. New editions will be made available via the IHO web site. Maintenance of the Specification shall conform to IHO Resolution 2/2007 (as amended).

**Table — Document History**

Version Number	Date	Approved By	Purpose
1.0.0	April 2012	TSMAD	Approved edition of S-102
2.0.0	March 2017	S-102PT	Updated clause 4.0 and 12.0. Populated clause 9.0 and Annex B.

Page intentionally left blank

## 1 Overview

This document has been produced by the IHO Nautical Information Provision Working Group (NIPWG) in response to a requirement to produce a data product that can be used as a Nautical Publication Information Overlay (NPIO) within an Electronic Chart Display and Information Systems (ECDIS). It is based on the IHO S-100 framework specification and the ISO 19100 series of standards. It is a vector product specification that is primarily intended for encoding the extent and nature of Marine Protected Areas, for navigational purposes.

The United Nations Convention on the Law of the Sea (UNCLOS) identifies certain categories of Marine Protected Areas which may require higher standards of environmental protection. Article 194(5) places an obligation on parties to take measures necessary to protect and preserve rare or fragile ecosystems. Part IX of UNCLOS identifies enclosed or semi-enclosed areas, such as a gulf, bay, basin or sea between two or more countries, as places where countries shall endeavor to coordinate the management of environmental protection activities. In respect of Particularly Sensitive Sea Areas (PSSA), Article 211(6) (a) UNCLOS makes provision for a State to submit to the “competent international organization” (IMO for shipping), special mandatory measures concerning the protection from vessel sourced pollution.

UNCLOS thus creates an overall structure for the protection and preservation of the marine environment and places a general obligation on States to implement global conventions addressing particular forms of pollution protection and regional agreements tailored to the requirements of discrete sea areas.

### 1.1 Scope

This document describes an S-100 compliant product specification for a bathymetric surface product. Incorporating aspects of the navigation surface concept [Smith et al. 2002], an S-102 bathymetric surface product is a digital elevation model which represents the seafloor in a regular grid structure. It can be used alone or as an important element/source for future S-100 conformant ECDIS navigation. The product specification is based on the IHO S-100 framework specification and the ISO 19100 series of standards. It comprises the content model (spatial structure and metadata), encoding structure, portrayal and exchange file format for a bathymetric surface product.

### 1.2 References

- [1] S-100 edition 5.2.0: IHO Universal Hydrographic Data Model, International Hydrographic Organization ([https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-100/S-100\\_5.2.0\\_Final\\_Clean.pdf](https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-100/S-100_5.2.0_Final_Clean.pdf)).
- [2] S-44 edition 6.1.0: IHO Standards for Hydrographic Surveys, International Hydrographic Organization ([https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-44/S-44\\_5E.pdf](https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-44/S-44_5E.pdf)).
- [3] S-49 edition 2.1.0: STANDARDIZATION of MARINERS' ROUTEING GUIDES, International Hydrographic Organization ([https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-49/S-49\\_Ed.2.1.0\\_Standardization%20of%20Mariners%20Routeing%20Guides\\_EN.pdf](https://ihodata.ihoplatform.net/uploads/user/pubs/standards/s-49/S-49_Ed.2.1.0_Standardization%20of%20Mariners%20Routeing%20Guides_EN.pdf)).
- [4] S-32 edition 1.0.0: Hydrographic Dictionary—Glossary of ECDIS Related Terms, International Hydrographic Organization ([http://hd.ihodata.ihoplatform.net/en/index.php/Main\\_Page](http://hd.ihodata.ihoplatform.net/en/index.php/Main_Page)).
- [5] ISO 8601:2004: Data elements and interchange formats—Information interchange—Representation of dates and times, International Organization for Standardization (<https://www.iso.org/standard/40874.html>).
- [6] ISO 639-2:1998: Codes for the representation of names of languages—Part 2: Alpha-3 code, International Organization for Standardization (<https://www.iso.org/standard/4767.html>).

- [7] ISO 19103:2015: Geographic information — Conceptual schema language, International Organization for Standardization (<https://www.iso.org/standard/56734.html>).
- [8] ISO 19111:2007: Geographic information — Spatial referencing by coordinates, International Organization for Standardization (<https://www.iso.org/standard/41126.html>).
- [9] ISO 19115-1:2014/Amd 1:2018: Geographic information — Metadata — Part 1: Fundamentals — Amendment 1, International Organization for Standardization (<https://www.iso.org/standard/73118.html>).
- [10] ISO 19115-2:2009: Geographic information — Metadata — Part 2: Extensions for imagery and gridded data, International Organization for Standardization (<https://www.iso.org/standard/39229.html>).
- [11] ISO/TS 19115-3:2016: Geographic information — Metadata — Part 3: XML schema implementation for fundamental concepts, International Organization for Standardization (<https://www.iso.org/standard/32579.html>).
- [12] ISO 19123:2005: Geographic information — Schema for coverage geometry and functions, International Organization for Standardization (<https://www.iso.org/standard/40121.html>).
- [13] ISO/TS 19129:2009: Geographic information — Imagery, gridded and coverage data framework, International Organization for Standardization (<https://www.iso.org/standard/43041.html>).
- [14] ISO 19131:2007/Amd 1:2011: Geographic information — Data product specifications — Amendment 1: Requirements relating to the inclusion of an application schema and feature catalogue and the treatment of coverages in an application schema., International Organization for Standardization (<https://www.iso.org/standard/51790.html>).
- [15] ISO/IEC 19501:2005: Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2, International Organization for Standardization and International Electrotechnical Commission (<https://www.iso.org/standard/32620.html>).
- [16] ISO 3166-2:2013: Codes for the representation of names of countries and their subdivisions — Part 2: Country subdivision code, International Organization for Standardization (<https://www.iso.org/standard/63546.html>).
- [17] ISO/TS 19130:2010: Geographic information — Imagery sensor models for geopositioning, International Organization for Standardization (<https://www.iso.org/standard/51789.html>).
- [18] ISO/TS 19130-2:2014: Geographic information — Imagery sensor models for geopositioning — Part 2: SAR, InSAR, lidar and sonar, International Organization for Standardization (<https://www.iso.org/standard/56113.html>).
- [19] ISO/TS 19139-1:2019: Geographic information — XML schema implementation — Part 1: Encoding rules, International Organization for Standardization (<https://www.iso.org/standard/67253.html>).
- [20] ISO/IEC 10646-1:2000: Information technology — Universal Multiple-Octet Coded Character Set (UCS)— Part 1: Architecture and Basic Multilingual Plane, International Organization for Standardization and International Electrotechnical Commission (<https://www.iso.org/standard/29819.html>).
- [21] The Navigation Surface: The Navigation Surface: A New Database Approach to Creating Multiple Products from High-Density Surveys, Smith S., Alexander L. and Armstrong A., International Hydrographic Review (<http://scholars.unh.edu/ccom/976>).

- [22] The Open Navigation Surface Project: The Open Navigation Surface Project, Calder B., Byrne S., Brennan R., Case J., Fabre D., Gallagher B., Ladner W., Moggert F. and Patron M., International Hydrographic Review (<https://scholars.unh.edu/ccom/1011>).

## 1.3 Terms, definitions and abbreviations

### 1.3.1 Use of language

Within this document:

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

### 1.3.2 Terms and definitions

#### 1.3.2.1 Accuracy

Closeness of agreement between a test result and the accepted reference values.

NOTE: A test result can be from an observation or measurement.

#### 1.3.2.2 Coordinate

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

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

#### 1.3.2.3 Coordinate Reference System

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

#### 1.3.2.4 Coverage

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

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

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

#### 1.3.2.5 Coverage Geometry

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

#### 1.3.2.6 Direct Position

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

#### 1.3.2.7 Domain

Well-defined set.

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

#### 1.3.2.8 Depth

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

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

#### 1.3.2.9 Feature

Abstraction of real-world phenomena.

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

### **1.3.2.10 Feature Attribute**

Characteristic of a **feature**.

NOTE: A feature attribute type has a name, a data type, and a domain associated to it. A feature attribute instance has an attribute value taken from the value domain of the feature attribute type.

### **1.3.2.11 Function**

Rule that associates each element from a **domain** (source, or domain of the function) to a unique element in another domain (target, co-domain, or **range**).

NOTE: The range is defined by another domain.

### **1.3.2.12 Geometric Object**

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

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

### **1.3.2.13 Grid**

Network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in a systematic way.

NOTE: The curves partition a space into grid cells.

### **1.3.2.14 Grid Point**

Point located at the intersection of two or more curves in a **grid**.

### **1.3.2.15 Lidar**

An optical remote sensing technique that uses a laser pulse to determine distance.

NOTE: Lidar may be used to determine depth in shallow water areas.

### **1.3.2.16 Navigation Surface**

A **coverage** representing the bathymetry and associated uncertainty with the methods by which those objects can be manipulated, combined, and used for a number of tasks, certified for safety of navigation.

### **1.3.2.17 Range <coverage>**

Set of values associated by a **function** with the elements of the **spatiotemporal domain** of a **coverage**.

### **1.3.2.18 Record**

Finite, named collection of related items (objects or values).

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

### **1.3.2.19 Rectified Grid**

**Grid** for which there is a linear relationship between the **grid coordinates** and the **coordinates** of an external **coordinate reference system**.

NOTE: If the coordinate reference system is related to the earth by a datum, the grid is a georectified grid.

### **1.3.2.20 Referenceable Grid**

**Grid** associated with a transformation that can be used to convert **grid coordinate** values to values of coordinates referenced to an **external coordinate reference system**.

### **1.3.2.21 Sonar**

A technique that uses sound propagation through water to determine distance, primarily **depth** measurement.

### **1.3.2.22 Spatiotemporal Domain <coverage>**

**Domain** composed of **geometric objects** described in terms of spatial and/or temporal **coordinates**.

NOTE: The spatiotemporal domain of a continuous coverage consists of a set of direct positions defined in relation to a collection of geometric objects.

#### 1.3.2.23 Surface

Connected 2-dimensional geometric primitive, representing the continuous image of a region of a plane.

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

#### 1.3.2.24 Uncertainty

The interval (about a given value) that will contain the true value of the measurement at a specific confidence level.

NOTE: Errors exist and are the differences between the measured value and the true value. Since the true value is never known it follows that the error itself cannot be known. Uncertainty is a statistical assessment of the likely magnitude of this error. The numbers must be qualified by units.

In this document an S-102 uncertainty is always considered to be 1-dimensional and at the 2-sigma or 95% confidence level.

#### 1.3.2.25 Vector

Quantity having direction as well as magnitude.

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

### 1.3.3 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 Information System
ENC	Electronic Navigational Chart
EPSG	European Petroleum Survey Group
HDF	Hierarchical Data Format
HSSC	IHO Hydrographic Services and Standards Committee (formerly CHRIS)
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IOGP	International association of Oil and Gas Producers (formerly OGP)
ISO	International Organization for Standardization
MRN	Maritime Resource Name
S-100 WG	S-100 Working Group
S-102 PT	S-102 Project Team
TS	Technical Specification
TSMAD	Transfer Standard Maintenance and Application Development Working Group
UML	Universal Modelling Language
URI	Uniform Resource Identifier
XML	eXtensible Markup Language

## 1.4 General S-102 data product description

<b>Title</b>	Marine Protected Area Product Specification.
<b>Abstract</b>	A Marine Protected Area (MPA) is a protected area whose boundaries include an area of the ocean. They include areas of the intertidal or sub-tidal terrain, together with their overlying water and associated flora, fauna, historical and cultural features, which have been reserved by law or other effective means to protect part or all of, the enclosed environment. For example, MPAs may be established to protect fish species, rare habitat area, or entire ecosystems. MPAs can range from, simple declarations to protect a resource, to areas that are extensively regulated. The degree to which environmental regulations affect shipping varies according to whether MPAs are located in territorial waters, exclusive economic zones, or high seas. These limits are regulated by the law of the sea. Most MPAs are located in the territorial waters of coastal states, where enforcement can be ensured. MPAs can also however be established in a state's exclusive economic zone and even within international waters. For example in 1999, Italy, France and Monaco jointly established a cetacean sanctuary in the Ligurian Sea named the Pelagos Sanctuary for Mediterranean Marine Mammals.
<b>Acronym</b>	S-122
<b>Content</b>	Datasets conforming to this specification will contain all relevant MPA information for the area of coverage. Additionally there will be relevant metadata data quality, production authority, data sources and publication date. The DCEG provides guidance on how data product content must be captured. <a href="#">Annex A</a> , in addition to <a href="#">Clause 4.3.1</a> , will provide implementation guidance for developers.
<b>Spatial Extent</b>	<p><b>Description:</b> Global coverage of maritime areas.</p> <p><b>East Bounding Longitude:</b> 180°</p> <p><b>West Bounding Longitude:</b> -180°</p> <p><b>North Bounding Latitude:</b> 90°</p> <p><b>South Bounding Latitude:</b> -90°</p>
<b>Purpose</b>	Describing marine protected area information in the maritime domain for utilization in ECDIS, and to allow the producer to exchange marine protected area information with interested stakeholders.

## 1.5 Product Specification metadata

This information uniquely identifies this Product Specification and provides information about its creation and maintenance. For further information on dataset metadata, see [Section 12](#).

<b>Title</b>	Marine Protected Area Product Specification
<b>S-100 Version</b>	5.2.0
<b>S-122 Version</b>	1.2.1
<b>Date</b>	November 2024
<b>Language</b>	English
<b>Classification</b>	Unclassified
<b>Contact</b>	International Hydrographic Bureau 4 Quai Antoine 1er B.P. 445 MC 98011 MONACO CEDEX Telephone: +377 93 10 81 00 Fax: +377 93 10 81 40 Email: <a href="mailto:info@ioh.int">info@ioh.int</a>

<b>URL</b>	<a href="http://www.ihodata.org">www.ihodata.org</a>
<b>Identifier</b>	S-122
<b>Maintenance</b>	Changes to the Product Specification S-122 are coordinated by the IHO NIPWG, and must be made available via the IHO web site. Maintenance of the Product Specification must conform to IHO Resolution 2/2007, as amended.

## 1.6 IHO Product Specification Maintenance

### 1.6.1 Introduction

Changes to S-122 will be released by the IHO as a New Edition, revision, or clarification.

### 1.6.2 New Edition

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

### 1.6.3 Revision

*Revisions* are defined as substantive semantic changes to S-122. Typically, *revisions* will change S-122 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-122. 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-122.

### 1.6.4 Clarification

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

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

### 1.6.5 Version Numbers

The associated version control numbering to identify changes (n) to S-122 must be as follows:

New Editions denoted as n.0.0

Revisions denoted as n.n.0

Clarifications denoted as n.n.n

## 2 Specification Scope

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

<b>Scope Identification</b>	GeneralScope
-----------------------------	--------------

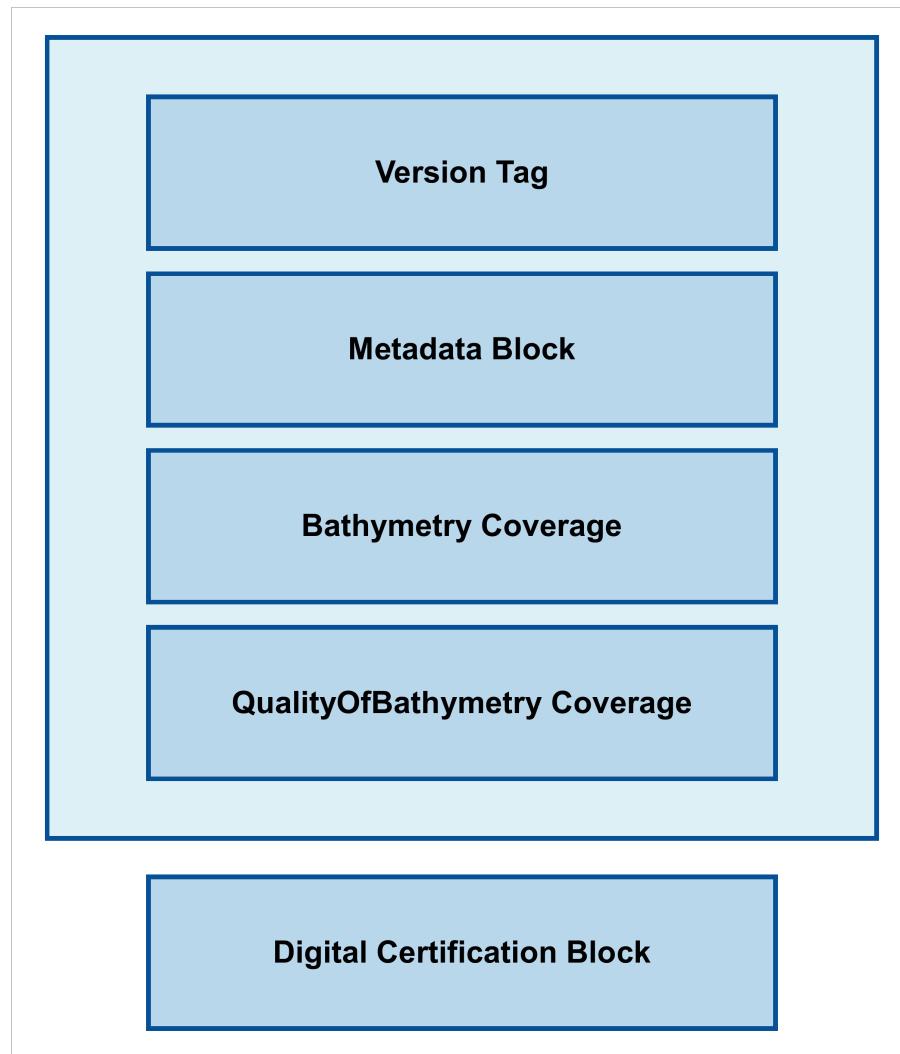
### 3 Data Product Identification

<b>Title</b>	Marine Protected Areas
<b>Alternate Title</b>	None
<b>Abstract</b>	insert abstract here....
<b>Topic Category</b>	Main topics for the product, as according to <a href="#">ISO 19115-1:2014/Amd 1:2018 MD_TopicCategoryCode</a> :
	006—elevation
	014—oceans
	012—inlandWaters
<b>Geographic Description</b>	Areas specific to marine navigation.
<b>Spatial Resolution</b>	...
<b>Purpose</b>	...n.
<b>Language</b>	English (Mandatory), other (Optional)
<b>Classification</b>	Data can 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
<b>Spatial Representation Type</b>	Type of spatial representation for the product, as defined by the <a href="#">ISO 19115-1:2014/Amd 1:2018 MD_SpatialRepresentationTypeCode</a> : 002—grid.
<b>Point of Contact</b>	Producing Agency

### 4 Data Content and Structure

#### 4.1 Introduction

The Bathymetric Surface Product incorporates aspects of the Navigation Surface concept where in addition to estimation of depth, an optional estimate of the uncertainty associated with the depth can be computed and preserved. [Figure 4-1](#) below shows a high-level overview of the structure of S-102. It shows that the Bathymetric Surface Product consists of a set of data comprising the HDF5 datasets plus a Digital Certification Block. The Digital Certification Block is mandatory so that the user can trace whether the data has been certified. The HDF5 file consists of metadata (spatial, feature and discovery) and collocated coverages consisting of depth values, uncertainty values, and references to metadata records. S-102 uses the S-100 Data Protection Scheme to ensure certification and authentication.

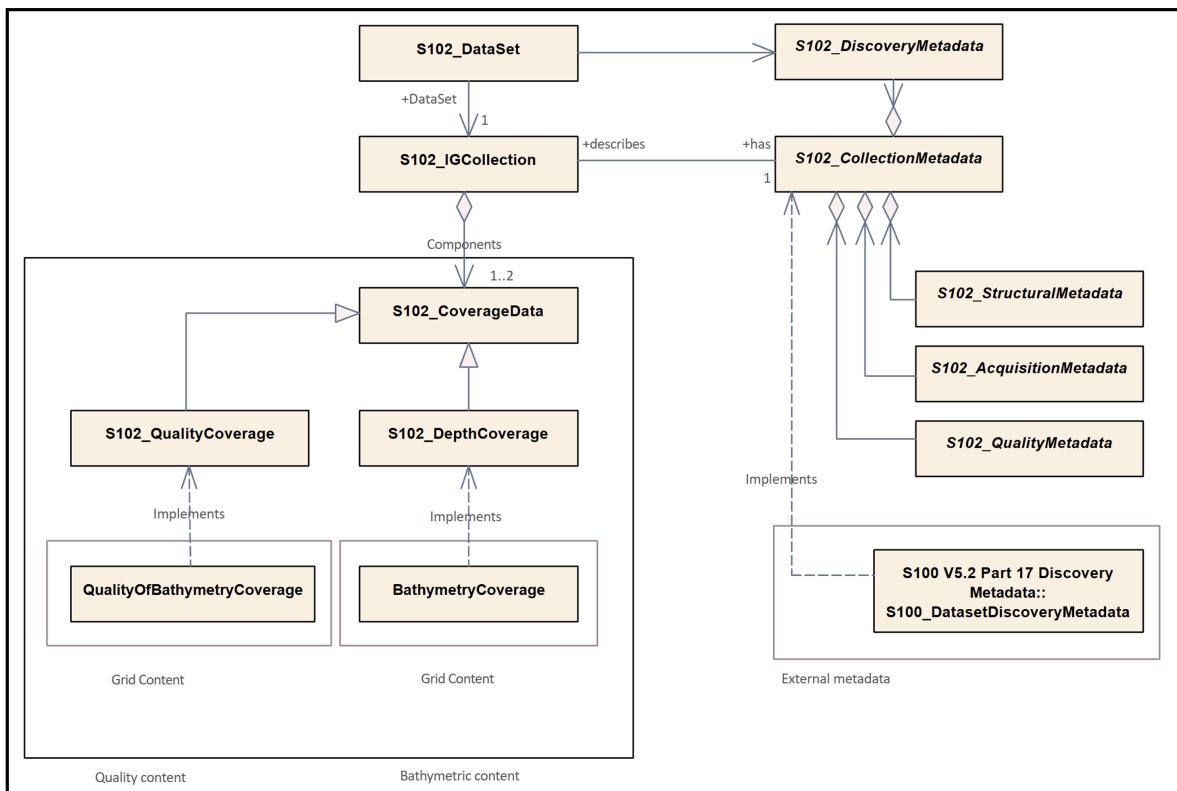


**Figure 4-1 — Overview Structure of S-102**

Thus, the Bathymetric Surface Product is a hybrid of coverages, as defined in [S-100, Part 8](#), and metadata packages as defined in [S-100, Part 4](#). This is described in [Clause 4.2](#).

## 4.2 Application Schema

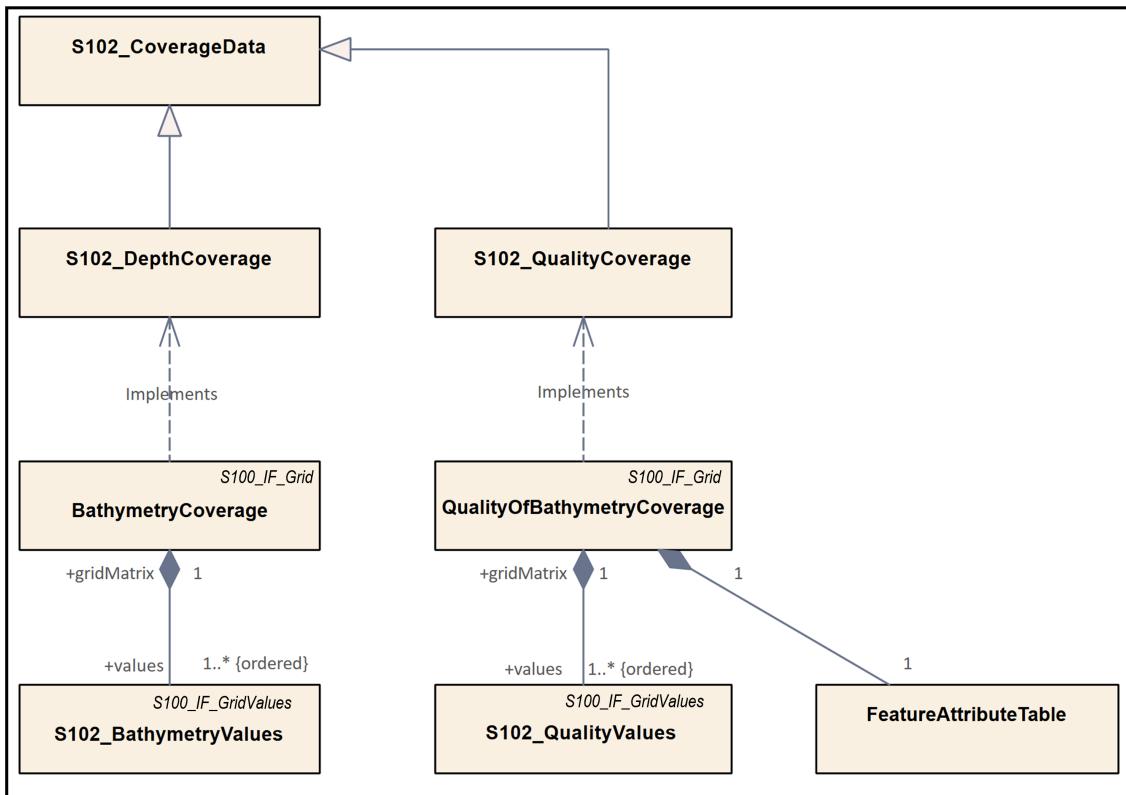
The Application Schema Data Set Structure is shown in [Figure 4-2](#) and [Figure 4-3](#). They show a number of classes specialized for use in S-102 and six sets of implementation classes. An actual data set of S-102 bathymetry data contains only the implementation classes. All of the required attributes from the other classes in the application schema are satisfied by statements within the Product Specification. This approach to producing the Application Schema results in a very simple structure for implementation.



**Figure 4-2 — Data Set Structure of S-102**

The model in [Figure 4-2](#) states that:

- An S-102 data set (**S102\_DataSet**), which is inherited from **S100\_DataSet**, references an S-102 Image and Gridded Data Collection (**S102\_IGCollection**). In S-100 it is possible to have multiple collections but in S-102 only one is needed to hold the bathymetry coverage. The S-102 discovery metadata class (**S102\_DiscoveryMetadata**) describes the metadata entities required for the identification of the entire data set. The required discovery metadata is implemented through the **S100\_DatasetDiscoveryMetadata** class defined in [S-100, Part 17](#).
- An instance of an S-102 Image and Gridded Data Collection (**S102\_IGCollection**) which is a subtype of **S100\_IGCollection**, is described by a set of S-102 Collection Metadata (**S102\_CollectionMetadata**). This relationship is 1 to 1 meaning that there is one set of collection metadata for each instance of **S102\_IGCollection**. There is a large choice of metadata that may be used in an S-100 compliant data product. Only a small amount of this metadata is mandated by [ISO 19115-1:2014/Amd. 1:2018](#) for discovery. This edition of S-102 neither uses ISO metadata files nor extends S-100 generic metadata and therefore **S102\_StructuralMetadata**, **S102\_QualityMetadata**, and **S102\_AcquisitionMetadata** are abstract classes as described in [S-100, Part 8, Clause 8.5.3](#). This edition of S-102 uses the dataset metadata elements defined in [S-100, Part 17](#) and [S-100, Part 10c](#) with restrictions defined in this product specification. The metadata elements defined in [S-100, Part 17](#) are encoded in a discovery block within the exchange catalogue ([S-100, Part 17, Clause 17.4.4](#) to [S-100, Part 17, Clause 17.4.5](#)), and the metadata elements defined in [S-100, Part 10c](#) are encoded as attributes and datasets within the HDF5 file ([S-100, Part 10c, Clause 10c.9.2](#)). The conceptual structure of coverage features in an S-102 dataset is discussed further in [Clause 4.2.1](#).



**Figure 4-3 — Coverage Structure of S-102**

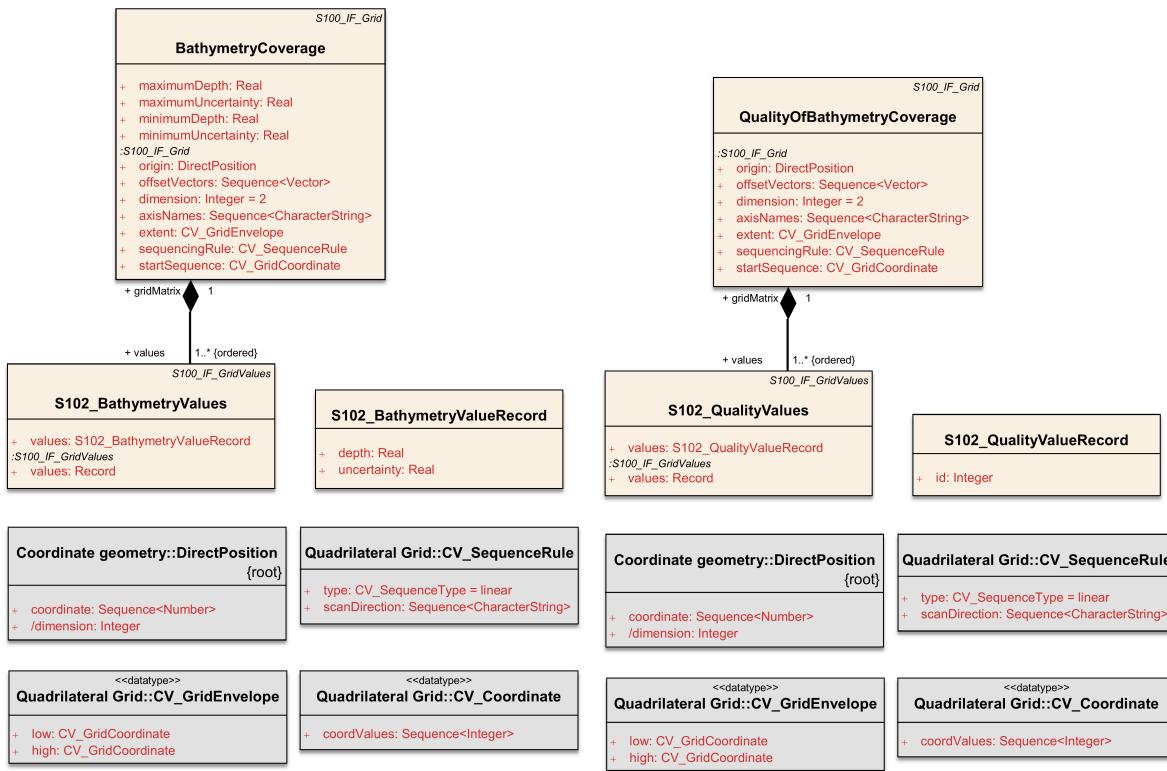
The model in [Figure 4-3](#) depicts the coverage type in this application schema:

- The coverage type for **BathymetryCoverage** is a continuous Regular Grid Coverage called **S102\_DepthCoverage** which inherits from **S100\_IF\_GridCoverage**. Many of the parameters of the coverage are described in the Product Specification.
- The coverage type for **QualityOfBathymetryCoverage** is a continuous Regular Grid Coverage called **S102\_QualityCoverage** which inherits from **S100\_IF\_GridCoverage**. Many of the parameters of the coverage are described in the Product Specification.

#### 4.2.1 Application Schema implementation classes

The implementation classes for the template application schema are shown in [Figure 4-4](#). The attributes are shown for the coverage related classes together with the attribute classes.

In order to simplify the implementation, a number of defaults are assumed for S-102. These defaults simplify implementation and help simplify interaction with the Navigation Surface implementation from the Open Navigation Surface Working Group and other bathymetric gridded types. In the following sub clauses, the default values are emphasized so that they do not need to be encoded when generating an encoding of the implementation classes. However, if specified they must assume the stated values unless other options are stated.



**Figure 4-4 — Implementation Classes of S-102**

#### 4.2.1.1 Implementation classes description

##### 4.2.1.1.1 BathymetryCoverage

###### 4.2.1.1.1.1 BathymetryCoverage semantics

The class **BathymetryCoverage** has the attributes *minimumDepth*, *maximumDepth*, *minimumUncertainty*, and *maximumUncertainty* which bound the depth attribute and the uncertainty attribute from the **S102\_BathymetryValues** record. **BathymetryCoverage** additionally contains the inherited attributes *origin*, *offsetVectors*, *dimension*, *axisName*, *extent*, *sequenceRule*, and *startSequence* from **S100\_IF\_Grid** and **CV\_Grid**.

The origin is a position in a specified coordinate reference system, and a set of offset vectors specify the direction and distance between the grid lines. It also contains the additional geometric characteristics of a rectified grid.

###### 4.2.1.1.1.2 minimumDepth

The attribute *minimumDepth* has the value type *Real* and describes the lower bound of the depth estimate for all the *depth* values in **S102\_BathymetryValues** record. This attribute is required. There is no default.

###### 4.2.1.1.1.3 maximumDepth

The attribute *maximumDepth* has the value type *Real* and describes the upper bound of the depth estimate for all the *depth* values in **S102\_BathymetryValues** record. This attribute is required. There is no default.

###### 4.2.1.1.1.4 minimumUncertainty

The attribute *minimumUncertainty* has the value type *Real* and describes the lower bound of the uncertainty of the depth estimate for all the *depth* values in **S102\_BathymetryValues** record. If all uncertainty values are populated with the fill value (i.e., if no actual uncertainties exist in the data), this attribute shall be populated with the fill value. This attribute is required. There is no default.

#### 4.2.1.1.5 maximumUncertainty

The attribute *maximumUncertainty* has the value type *Real* and describes the upper bound of the uncertainty of the depth estimate for all the *depth* values in **S102\_BathymetryValues** record. If all uncertainty values are populated with the fill value (i.e., if no actual uncertainties exist in the data), this attribute shall be populated with the fill value. This attribute is required. There is no default.

#### 4.2.1.1.6 origin

The attribute *origin* has the value class *DirectPosition* which is a position that shall locate the origin of the rectified grid in the coordinate reference system. This attribute is required. There is no default. In the encoding this is split into properties *gridOriginLatitude* and *gridOriginLongitude*.

#### 4.2.1.1.7 offsetVectors

The attribute *offsetVectors* has the value class *Sequence<Vector>* that shall be a sequence of offset vector elements that determine the grid spacing in each direction. The data type *Vector* is specified in [ISO 19103:2015](#). This attribute is required. There is no default. The HDF5 encoding implements and simplifies *offsetVectors* in the form of two HDF5 attributes: *gridSpacingLatitudinal* and *gridSpacingLongitudinal*.

#### 4.2.1.1.8 dimension

The attribute *dimension* has the value class *Integer* that shall identify the dimensionality of the grid. The value of the grid dimension in this product specification is 2. This value is fixed in this Product Specification.

#### 4.2.1.1.9 axisNames

The attribute *axisNames* has the value class *Sequence<CharacterString>* that shall be used to assign names to the grid axis. The grid axis names shall conform to those of the CRS. For the allowable CRS according to this specification, the axis names shall be “Latitude” and “Longitude” for unprojected data sets or “Northing” and “Easting” in a projected space.

#### 4.2.1.1.10 extent

The attribute *extent* has the value class **CV\_GridEnvelope** that shall contain the extent of the spatial domain of the coverage. It uses the value class **CV\_GridEnvelope** which provides the grid coordinate values for the diametrically opposed corners of the grid. The default is that this value is derived from the bounding box for the data set. The extent of the dataset limits is defined as a rectangle coincident with the outermost cell boundaries of the dataset. In the encoding the property *BoundingBox* is used to hold the extent.

#### 4.2.1.1.11 sequencingRule

The attribute *sequencingRule* has the value class **CV\_SequenceType** that shall describe how the grid points are ordered for association to the elements of the sequence values. The default value is “linear”. No other options are allowed.

#### 4.2.1.1.12 startSequence

The attribute *startSequence* has the value class **CV\_GridCoordinate** that shall identify the grid point to be associated with the first record in the values sequence. The default value is the lower left corner of the grid. No other options are allowed.

### 4.2.1.2 S102\_BathymetryValues

#### 4.2.1.2.1 S102\_BathymetryValues semantics

The class **S102\_BathymetryValues** is related to **BathymetryCoverage** by a composition relationship in which an ordered sequence of *depth* values provide data values for each grid cell. The class **S102\_BathymetryValues** inherits from **S100\_IF\_Grid**.

#### 4.2.1.2.2 values

The attribute *values* has the value type **S102\_BathymetryValueRecord**, which is a sequence of value items that shall assign values to the grid points. There are two attributes in the bathymetry value record in the **S102\_BathymetryValues** class:

- *depth*

- (optional) *uncertainty*

#### 4.2.1.1.3 QualityOfBathymetryCoverage

##### 4.2.1.1.3.1 QualityOfBathymetryCoverage semantics

The class **QualityOfBathymetryCoverage** contains the inherited attributes *origin*, *offsetVectors*, *dimension*, *axisName*, *extent*, *sequenceRule*, and *startSequence* from **S100\_IF\_Grid** and **CV\_Grid**.

The origin is a position in a specified coordinate reference system, and a set of offset vectors specify the direction and distance between the grid lines. It also contains the additional geometric characteristics of a rectified grid.

##### 4.2.1.1.3.2 origin

The attribute *origin* has the value class *DirectPosition* which is a position that shall locate the origin of the rectified grid in the coordinate reference system. This attribute is required. There is no default. In the encoding this is split into properties *gridOriginLatitude* and *gridOriginLongitude*.

##### 4.2.1.1.3.3 offsetVectors

The attribute *offsetVectors* has the value class *Sequence<Vector>* that shall be a sequence of offset vector elements that determine the grid spacing in each direction. The data type *Vector* is specified in [ISO 19103:2015](#). This attribute is required. There is no default. The HDF5 encoding implements and simplifies *offsetVectors* in the form of two HDF5 attributes: *gridSpacingLatitudinal* and *gridSpacingLongitudinal*.

##### 4.2.1.1.3.4 dimension

The attribute *dimension* has the value class *Integer* that shall identify the dimensionality of the grid. The value of the grid dimension in this product specification is 2. This value is fixed in this Product Specification and does not need to be encoded.

##### 4.2.1.1.3.5 axisNames

The attribute *axisNames* has the value class *Sequence<CharacterString>* that shall be used to assign names to the grid axis. The grid axis names shall conform to those of the CRS. For the allowable CRS according to this specification, the axis names shall be “Latitude” and “Longitude” for unprojected data sets or “Northing” and “Easting” in a projected space.

##### 4.2.1.1.3.6 extent

The attribute *extent* has the value class **CV\_GridEnvelope** that shall contain the extent of the spatial domain of the coverage. It uses the value class **CV\_GridEnvelope** which provides the grid coordinate values for the diametrically opposed corners of the grid. The default is that this value is derived from the bounding box for the data set. The extent of the dataset limits is defined as a rectangle coincident with the outermost cell boundaries of the dataset. In the encoding the property *BoundingBox* is used to hold the extent.

##### 4.2.1.1.3.7 sequencingRule

The attribute *sequencingRule* has the value class **CV\_SequenceType** that shall describe how the grid points are ordered for association to the elements of the sequence values. The default value is “linear”. No other options are allowed.

##### 4.2.1.1.3.8 startSequence

The attribute *startSequence* has the value class **CV\_GridCoordinate** that shall identify the grid point to be associated with the first record in the values sequence. The default value is the lower left corner of the grid. No other options are allowed.

#### 4.2.1.1.4 S102\_QualityValues

##### 4.2.1.1.4.1 S102\_QualityValues semantics

The class **S102\_QualityValues** is related to **QualityOfBathymetryCoverage** by a composition relationship in which an ordered sequence of *id* values provide for each cell references to metadata. The class **S102\_QualityValues** inherits from **S100\_IF\_Grid**.

#### 4.2.1.1.4.2 values

The attribute *values* has the value type **S102\_QualityValueRecord** which is a sequence of value items that shall assign values to the grid points. There is one attribute in the quality value record, *id*, in the **S102\_QualityValues** class.

#### 4.2.1.1.5 DirectPosition

##### 4.2.1.1.5.1 DirectPosition semantics

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

##### 4.2.1.1.5.2 coordinate

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

##### 4.2.1.1.5.3 dimension

The attribute *dimension* is a derived attribute that describes the number of coordinate axes.

#### 4.2.1.1.6 CV\_GridEnvelope

##### 4.2.1.1.6.1 CV\_GridEnvelope semantics

The class **CV\_GridEnvelope** provides the grid coordinate values for the diametrically opposed corners of an envelope that bounds a grid. It has two attributes.

##### 4.2.1.1.6.2 low

The attribute *low* shall be the minimum coordinate values for each coordinate axis among all grid cells within the envelope. For this specification the value is the southwesternmost grid point coordinate minus half of the grid spacing for each coordinate axis.

##### 4.2.1.1.6.3 high

The attribute *high* shall be the maximum coordinate values for each coordinate axis among all grid cells within the envelope. For this specification the value is the northeasternmost grid point coordinate plus half of the grid spacing for each coordinate axis.

#### 4.2.1.1.7 CV\_GridCoordinate

##### 4.2.1.1.7.1 CV\_GridCoordinate semantics

The class **CV\_GridCoordinate** is a data type for holding the grid coordinates of a **CV\_GridPoint**.

##### 4.2.1.1.7.2 coordValues

The attribute *coordValues* has the value class *Sequence<Integer>* that shall hold one integer value for each dimension of the grid. The ordering of these coordinate values shall be the same as that of the elements of *axisNames*. The value of a single coordinate shall be the number of offsets from the origin of the grid in the direction of a specific axis.

#### 4.2.1.1.8 CV\_SequenceRule

##### 4.2.1.1.8.1 CV\_SequenceRule semantics

The class **CV\_SequenceRule** contains information for mapping grid coordinates to a position within the sequence of records of feature attribute values. It has two attributes.

##### 4.2.1.1.8.2 type

The attribute *type* shall identify the type of sequencing method that shall be used. A code list of scan types is provided in [S-100, Part 10c](#). Only the value “linear” shall be used in S-102, which describes scanning row by row by column.

##### 4.2.1.1.8.3 scanDirection

The attribute *scanDirection* has the value class *Sequence<CharacterString>*: a list of axis names that indicates the order in which grid points shall be mapped to position within the sequence of records of feature attribute values.

## 4.3 Feature Catalogue

### 4.3.1 Introduction

The S-102 Feature Catalogue describes the feature types, attributes and attribute values which may be used in the product.

The S-102 Feature Catalogue is available in an XML document which conforms to the S-100 XML Feature Catalogue Schema and can be downloaded from the IHO Geospatial Information Registry.

### 4.3.2 Feature types

S-102 is a coverage feature product. **BathymetryCoverage** implements **S102\_DepthCoverage** and includes **S102\_BathymetryValues**. **QualityOfBathymetryCoverage** implements **S102\_QualityCoverage** and includes **S102\_QualityValues**.

#### 4.3.2.1 Geographic

Geographic (geo) feature types form the principle content of the dataset and are fully defined by their associated attributes. In S-102, **BathymetryCoverage** has been registered as a geographic feature type.

#### 4.3.2.2 Meta

Meta feature types are allowed in the dataset and are fully defined by their associated attributes. In S-102, **QualityOfBathymetryCoverage** has been registered as a meta feature type.

### 4.3.3 Feature relationship

S-102 does not use any feature relationships.

### 4.3.4 Attributes

#### 4.3.4.1 Simple attributes

In S-102, *depth* and *uncertainty* have been registered as simple attributes, type `<real>`; and *ID* has been registered as a simple attribute, type `<integer>`. Simple attributes are defined in [S-100, Part 5, Clause 5–4.2.3.3](#).

#### 4.3.4.2 Complex attributes

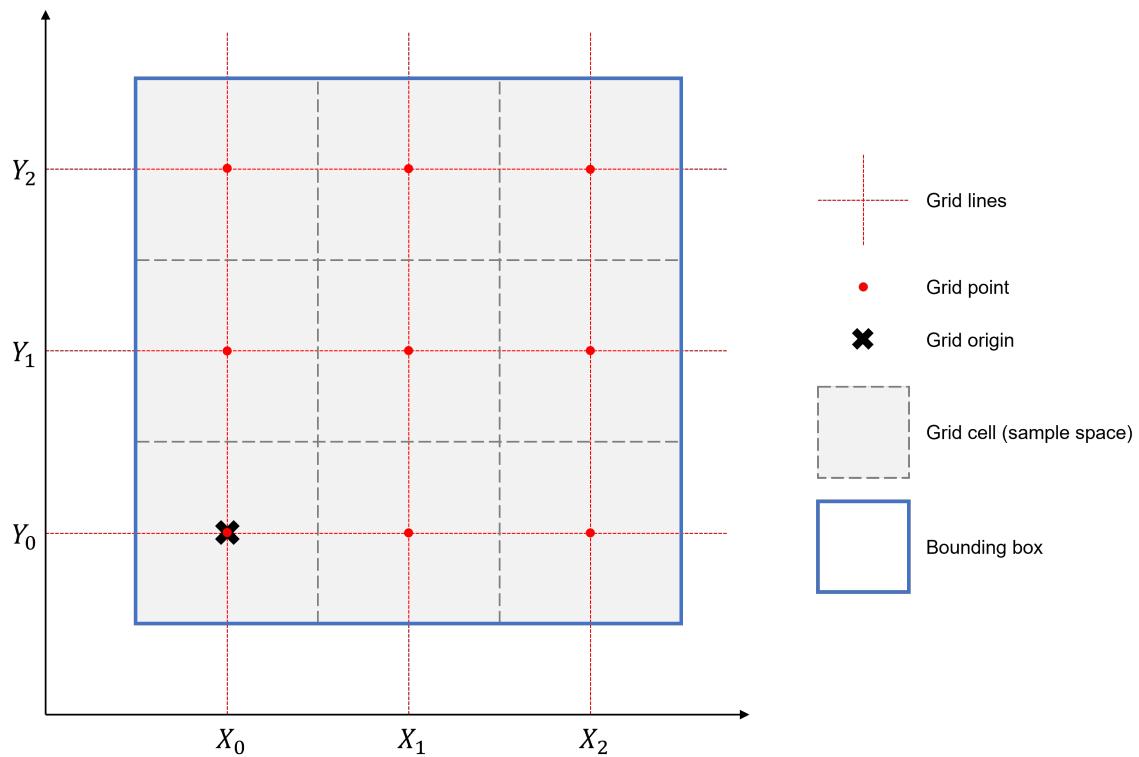
In S-102 there are currently no complex attributes defined.

## 4.4 Dataset types

### 4.4.1 Introduction

Bathymetric Surface datasets are represented as regular grids. The general structure for a regular grid is defined in [S-100, Part 8](#). Each sample in a grid represents the value in the grid cell area.

The georeferencing for an S-102 Bathymetric Surface product shall be grid point based, referenced from the southwesternmost grid point. The reference position (grid origin) included in the metadata, precisely the attributes *gridOriginLatitude* and *gridOriginLongitude*, shall be given in the coordinates used for the grid and shall contain sufficient digits of precision to locate the grid with accuracy no worse than a decimetre on the surface of the ellipsoid of rotation of the chosen horizontal datum.



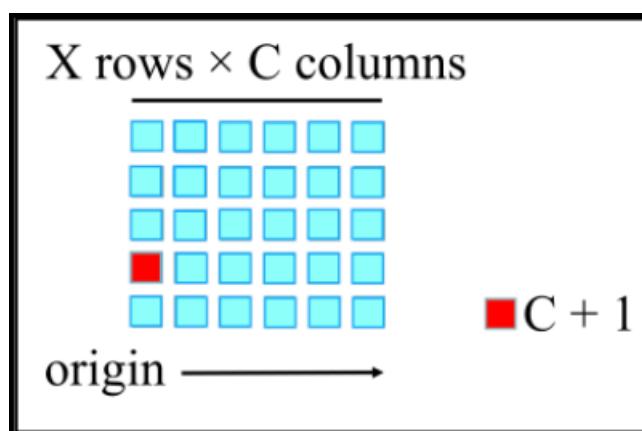
**Figure 4-5 — S-102 grid structure. Grid origin is the lower left grid point. Grid cells are centered around grid points. Bounding box is coincident with the outermost grid cell boundaries.**

#### 4.4.2 Regular grid

##### 4.4.2.1 S-102 coverages

The **BathymetryCoverage** contains *depth* and, optionally, *uncertainty*. The general structure of each is defined in [S-100, Part 8](#) as a georectified grid. Similarly, the **QualityOfBathymetryCoverage** contains *id*.

The grid properties of origin and spacing are defined by attributes in the **BathymetryCoverage.nn** and **QualityOfBathymetryCoverage.01** Feature Instance Groups. Each grid is a two-dimensional matrix organized in row major order and starting from the southwesternmost grid point. Thus, for each grid, the first sample is the point at the southwest corner of the grid with location specified by the georeferencing parameters, the second is one grid resolution unit to the east of that position and at the same northing or latitude, and the third is two grid resolution units to the east and at the same northing or latitude. For  $C$  columns in the grid, the  $(C + 1)^{\text{th}}$  sample in the grid is located one grid resolution unit to the north but on the same easting or longitude as the first sample in the grid.



**Figure 4-6 — S-102 Grid point location**

For **BathymetryCoverage.nn**, *depth* and optional *uncertainty*, are stored in the same grid as members of a data compound. The units of the depth values are in metres. The vertical distance is given

water level to the bottom. Drying heights (drying soundings) are indicated by a negative depth value. For **QualityOfBathymetryCoverage.01**, only *id* is stored in the grid.

The unknown state for depth is defined to be 1,000,000.0 (1.0e6).

The uncertainty values are expressed as positive quantities at each grid cell. As detailed in [Table 10-8](#) and [Table 10-9](#) the uncertainty grid supports multiple definitions of vertical uncertainty. A recipient of an S-102 file can refer to the uncertainty definition in the Metadata to gain an understanding of how the uncertainty was computed.

The undetermined state for uncertainty is defined to be 1,000,000.0 (1.0e6).

The *id* values in **QualityOfBathymetryCoverage.01** are expressed as unsigned 32-bit integer at each grid cell. Each value corresponds to the identifier for a metadata record in a **featureAttributeTable Clause 10.2.8**.

The fill value for *id* is defined to be 0.

#### 4.4.2.2 Extensions

In S-102 there are currently no extensions defined.

### 4.5 Multiple datasets

In order to facilitate the efficient processing of S-102 data, the geographic coverage of a given **maximum display Scale** may be split into multiple datasets.

### 4.6 Dataset rules

Each S-102 dataset must only have a single extent as it is a coverage feature.

There should be no overlapping data of the same maximum display scale, except at the agreed adjoining limits. Where it is difficult to achieve a perfect join, a buffer to be agreed upon by the producing agencies may be used.

### 4.7 Geometry

S-102 regular gridded coverages are an implementation of S100\_IF\_GridCoverage [S-100, Part 8, Clause 8.7](#).

## 5 Coordinate Reference Systems (CRS)

### 5.1 Introduction

The Coordinate Reference System information contained in [Table 5-1](#) is defined in the manner specified in [S-100, Part 6](#). The vertical datum is specified separately using other root group attributes.

### 5.2 Horizontal Coordinate Reference System

**Table 5-1 — S-102 Coordinate Reference Systems (EPSG Codes)**

EPSG Code	Coordinate Reference System
4326	WGS84
32601—32660	WGS 84 / UTM Zone 1N to Zone 60N
32701—32760	WGS 84 / UTM Zone 1S to Zone 60S

5041	WGS 84 / UPS North (E,N)
5042	WGS 84 / UPS South (E,N)
The full reference to EPSG can be found at <a href="https://epsg.org">https://epsg.org</a> .	

<b>Horizontal Coordinate Reference System</b>	EPSG (see <a href="#">Table 5-1</a> )
<b>Projection</b>	NONE/UTM/UPS
<b>Temporal reference system</b>	Gregorian Calendar
<b>Coordinate Reference System registry</b>	<a href="#">EPSG Geodetic Parameter Dataset</a>
<b>Date type (according to <a href="#">ISO 19115-1:2014/Amd 1:2018</a>)</b>	002 — publication
<b>Responsible party</b>	International Association of Oil & Gas Producers (IOGP)
<b>URL</b>	<a href="https://www.iogp.org/">https://www.iogp.org/</a>

### 5.3 Vertical Coordinate Reference System

Although in this product there are no direct vertical coordinates the values of the depth attributes are indirectly such coordinates. Therefore, it is important to specify the vertical CRS to which these values conform. The vertical CRS is an earth gravity-based, one-axis coordinate system. The Orientation of the axis is defined by the vertical coordinate system attribute (*vertical/CS*) in the root group (see [Table 10-2](#)).

The vertical datum must be taken from the code-list specified by the IHO Geospatial Information (GI) Registry for the attribute named *Vertical Datum*. It will be defined in the root group as an HDF5 attribute (see [Table 10-2](#)).

### 5.4 Temporal reference system

The temporal reference system is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with [ISO 8601:2004, Clause 5.4.4](#). A date-time variable will have the following 16-character format: *yyyymmddThhmmssZ*.

## 6 Data Quality

Data quality allows users and user systems to assess fitness for use of the provided data. Data quality measures and the associated evaluation are reported as metadata of a data product. This metadata improves interoperability with other data products and provides usage by user groups that the data product was not originally intended for. The secondary users can make assessments of the data product usefulness in their application based on the reported data quality measures.

### 6.1 Completeness

#### 6.1.1 Commission

Commission is applicable for S-102. Data Producers must verify that no excess items have been included in the dataset. Such excess items include duplicate items, which must be removed.

If no excess items are present, the dataset PASSES this test.

### 6.1.2 Omission

Omission is applicable for S-102. Data Producers must verify that no items that should have been included in the dataset have been omitted.

If no necessary items have been omitted, the dataset PASSES this test.

## 6.2 Logical consistency

### 6.2.1 Conceptual consistency

Conceptual Consistency is applicable for S-102 and follows the guidelines from [S-100, Part 1](#).

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

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

### 6.2.2 Domain consistency

Domain consistency is applicable for S-102 and follows the guidelines from [S-100, Part 5](#).

Data Producers must verify that the dataset conforms to the S-102 Feature Catalogue and to [Annex A](#).

If the dataset conforms to the S-102 Feature Catalogue and to [Annex A](#), the dataset PASSES this test.

### 6.2.3 Format consistency

Format Consistency is applicable for S-102 and follows the guidelines from [S-100, Part 10c](#).

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

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

## 6.3 Positional accuracy

### 6.3.1 Gridded data positional accuracy

Gridded positional accuracy is defined by the precision of the positional reference used to specify its location within its spatial projection. These positional references are contained within the spatial metadata of the S-102 grid. It is assumed that any horizontal errors are assimilated into the vertical uncertainty. The vertical values are calculated for each grid point using the processes and procedures used by each hydrographic office during the creation of the S-102 grid. Appropriate selection of both the origin reference point and spatial resolution are important and are another factor in gridded positional accuracy.

### 6.3.2 Relative internal positional accuracy

The internal positional accuracy is defined as the precision of the location of each grid point within the S-102 grid. The position of each grid point within the grid is referenced by a row and column combination. The metadata for S-102 defines a gridded resolution along both the X and Y axis of the grid. This absolute position of a grid point within the spatial projection of the grid is calculated using the row/column and the X/Y resolution. In this case, the accuracy is controlled by the precision used in defining these resolutions.

## 6.4 Temporal accuracy

Temporal accuracy, consistency, and validity of bathymetric grids are confined to elements of the vertical control processes. These aspects are addressed during the formulation and application of vertical control processes applied by the various hydrographic offices. Details of these processes will be included in the Lineage portion of the metadata defined in [Section 12](#) of this Product Specification.

## 6.5 Thematic accuracy

### 6.5.1 Thematic classification correctness

For S-102 bathymetric grids there are two classifications of data values, which are land and water. There are two considerations for assessing classification correctness when using the grid. The first is that values given in the depth layer of the S-102 grid are based on the associated hydrographic office's chosen vertical datum. Should another value in relation to a different vertical datum be required, a series of correctors would need to be applied. Secondly, when considering the data values, the value stored in the uncertainty for a given grid point must be considered. This uncertainty value represents the magnitude of possible deviation in either direction from the data value and must be applied when assessing the classification correctness. The new value generated when applied may cause a change in the classification.

### 6.5.2 Non-quantitative attribute accuracy

Thematic accuracy of S-102 bathymetric data is wholly quantitative.

### 6.5.3 Quantitative attribute accuracy

As defined in [S-100, Part 4c](#) the data quality for the depth coverage is also defined as a co-located optional coverage, which is the uncertainty. This value particularly refers to the vertical uncertainty at each grid point. The uncertainty coverage supports multiple definitions of vertical uncertainty.

See [Table 10-9](#).

## 7 Data Capture and Classification

The DCEG describes how data describing the real world should be captured using the types defined in the S-102 Feature Catalogue. The DCEG is located at [Annex A](#).

A number of sounding techniques are used to capture bathymetric data. It is permitted, but not required, to include data acquisition information in the metadata of an S-102 Bathymetric Surface product. The metadata class S102\_AcquisitionMetadata has been defined, but the information elements to populate this metadata class should be identified in a national profile of S-102.

### 7.1 Quality and source metadata

Quality and source metadata in S-102 are intended to enable and support future navigation software to appropriately auto-generate and attribute cartographic features such as custom depth contours and soundings from S-102 products, all while minimally impacting the overall file size of the product.

Quality and source metadata are encoded in a feature attribute table compliant with both HDF5 and S-100. This feature attribute table will provide valuable information about the bathymetry on a grid cellwise basis compared to traditional vector-based metadata files, simplifying the interpretation and implementation by navigation software systems.

The fields of the feature attribute table are defined elsewhere in this Product Specification ([Table 10-7](#)).

Quality and source metadata in S-102 are based on S-101 quality attributes, with significant augmentations and omissions described below. The quality and source metadata support a threefold purpose:

- 1) Support S-101-defined attribution of auto-generated vector depth areas, depth contours, and soundings created directly from the S-102 dataset.
  - a) The attribute *featureSizeVar* is meant to augment *featureSize* which corresponds to S-101 size of features detected. As noted in S-101, size of features detected is intended to be described as the smallest size in cubic metres the survey was capable of detecting. Depending on various survey parameters, this definition might require different depth ranges to have different values. For example, a survey vessel working at a fixed height off the seafloor (such as an autonomous underwater survey vessel) could maintain a fixed feature detection size capability over a wide range of depths. Conversely, a surface vessel working over that same range of depths may have a feature detection capability that varies with depth. The latter situation could foreseeably

cause the detection capability to be ambiguous and potentially misrepresented. For this reason, *featureSizeVar* is defined as the ratio (expressed as a percentage) of minimum detectable feature size to water depth. When both *featureSize* and *featureSizeVar* are present, the whichever value implies a larger feature size should be considered valid. The expectation is that *featureSizeVar* will be set to zero if the feature size does not scale with depth. As with *featureSize*, *featureSizeVar* should be ignored if *significantFeatures* is False.

- b) Note that depth range maximum and minimum in S-101 are omitted. The assumption is that if this information is required, then the corresponding grid cells in the elevation layer can be queried for a minimum and maximum depth for each table row.
- 2) Provide necessary uncertainty information as an input into critical underkeel clearance precision navigation systems.
  - 3) Prevent the automated selection of soundings from interpolated grid cells, while still providing the continuous data required for depth contour creation. This purpose is accomplished by the *bathyCoverage* Boolean attribute field. This field enables the flagging of grid cells populated by interpolation (when that interpolation occurs across gaps in bathymetric observations greater than the S-102 grid spatial resolution). This functionality is especially useful in side-scan surveys which are characterized by gaps in bathymetric observations with full coverage side-scan imagery. In this case, interpolated gaps between bathymetry coverage would show *fullSeafloorCoverageAchieved* = True and *bathyCoverage* = False. However, if *fullSeafloorCoverageAchieved* = False, *bathyCoverage* must also equal False (e.g., gaps between single beam echosounder data without correlating side scan sonar coverage). Thus, this facility will provide navigation software systems with the required information necessary to preferably select soundings from direct bathymetric observations.

Quality and source metadata are encoded as records within a *featureAttributeTable* dataset, which is itself within the *QualityOfBathymetryCoverage* container group ([Table 10-7](#)).

## 8 Data Maintenance

### 8.1 Maintenance and update frequency

Datasets are maintained by replacement on a dataset basis. That is, the entire data product and the associated metadata are replaced as a unit. This is unlike vector data that may be updated incrementally. Also, each replacement data set must have its own digital signature.

### 8.2 Data source

Data producers must use applicable sources to maintain and update data and provide a brief description of the sources that were used to produce the dataset.

### 8.3 Production process

Data Producers should follow their established production processes for maintaining and updating datasets.

## 9 Portrayal

### 9.1 Introduction

S-102 portrayal is intended to contribute to the safe operation of an S-100 based marine navigation system by:

- Ensuring display of bathymetric surfaces, standards of colours, and their assignment to depths;
- Ensuring the display is clear and unambiguous;
- Establishing an accepted pattern for presentation that becomes familiar to mariners and so can be recognized instantly without confusion; and

- Utilizing the S-100 portrayal model to ensure interoperability.

To ensure that presentation remains intuitive, the following principles must be followed when changes are made to the S-102 Portrayal Catalogue:

- S-102 must maintain equivalence in terms of alerts and indications functionality in ECDIS;
- The S-102 Portrayal Catalogue should be modified by extension. Portrayal rules should be retained for items that have been superseded in the current version of S-102. This retention ensures that S-102 data produced to previous versions can be displayed using the latest Portrayal Catalogue.

S-102 portrayal is covered by the portrayal model as defined in S-100. This model reflects how the Portrayal Catalogue is defined for use in marine navigation systems.

S-102 uses the portrayal processes defined in [S-100, Part 9](#) and [S-100, Part 9a](#). Items included in the S-102 Portrayal Catalogue must be registered in the IHO Geospatial Information (GI) Registry.

## 9.2 Portrayal Catalogue

Citation information for the S-102 Portrayal Catalogue is provided in [Table 9-1](#) below.

**Table 9-1 — S-102 Portrayal Catalogue Citation Information**

No.	ISO class or attribute	Type	Value
	CI_Citation	Class	
1	title	Character String	S-102 Portrayal Catalogue
2	date	CI_Date (class)	
2.1	date	DateTime	2024-06-11T00:00:00
2.2	dateType	CI_DateTypeCode (ISO codelist)	publication
3	edition	CharacterString	3.0.0
4	editionDate	DateTime	2024-06-11T00:00:00
5	citedResponsibleParty	CI_responsibility (class)	
5.1	role	CI_RoleCode (ISO codelist)	publisher
5.2	party	CI_Organisation (class)	
5.2.1	name	CharacterString	International Hydrographic Organization
6	otherCitationDetails	CharacterString	Found under: GI Registers Product Specifications Bathymetric Surface
7	onlineResource	CI_OnlineResource (class)	
7.1	linkage	CharacterString (URL)	<a href="https://registry.ihodata.int/">https://registry.ihodata.int/</a>
7.2	name	CharacterString	S-102 Portrayal Catalogue

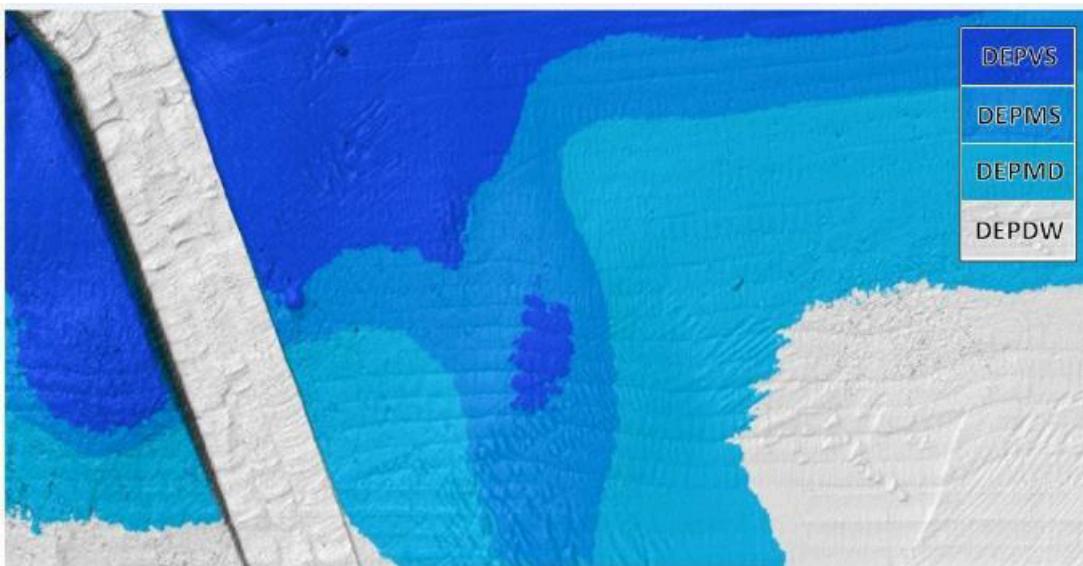
No.	ISO class or attribute	Type	Value
7.3	description	CharacterString	XML Portrayal Catalogue accompanied by related files for colour profiles, rules, etc.

The S-102 Portrayal Catalogue contains the mechanisms for the system to portray information found in S-102 bathymetric surfaces. The S-102 Portrayal Catalogue contains the following types of mechanisms and structures:

- Set of portrayal rules;
- Set of colour profiles.

The Portrayal Catalogue model is defined in [S-100, Part 9, Clause 9–13](#). The S-102 Portrayal Catalogue is available in an XML document, which conforms to the S-100 XML Portrayal Catalogue Schema. The structure for the Portrayal Catalogue is described in [S-100, Part 9, Clause 9–13.2](#).

[Figure 9-1](#) is included to illustrate informative depth zone colouring as adapted from S-52. More comprehensive portrayal details can be found in the S-102 Portrayal Catalogue, which is available in the IHO GI Registry (as detailed in [Table 9-1](#)).



**Figure 9-1 — S-52, Edition 6.1(1) Depth Zone Colouring for Day**

### 9.2.1 Use of sun-illumination

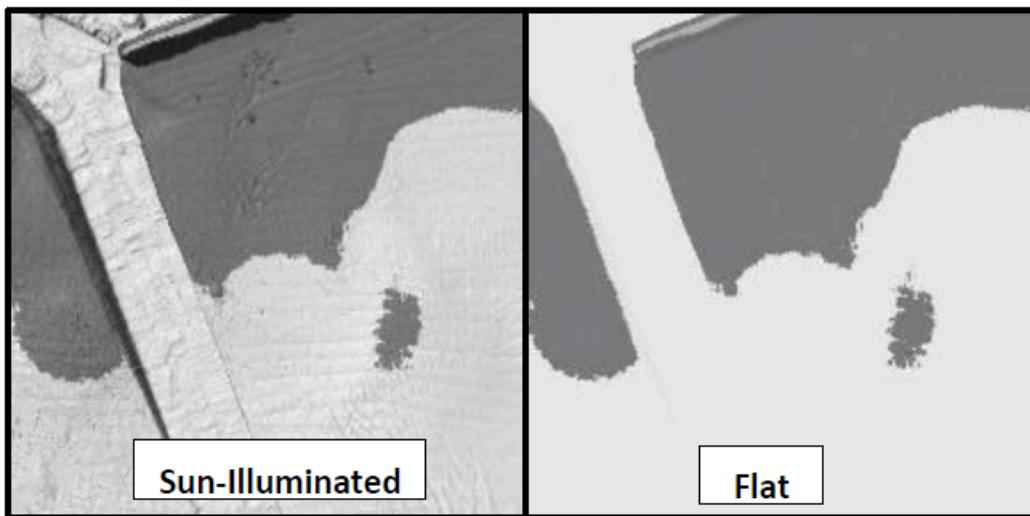
S-102 data can be visualized as a sun-illuminated or static (flat) dataset. The depiction of sun-illumination requires the entry of a sun azimuth and corresponding elevation. [Figure 9-2](#) shows the difference between a sun-illuminated and static (flat) surface.

NOTE: Although sun-illumination provides marked benefit to the user, it is not currently supported by S-100. As such, it is advisable for ECDIS manufacturers to implement the facility of sun-illumination in order to make such a benefit available.

Informative values for sun azimuth angle and elevation have been provided in [Table 9-2](#) below.

**Table 9-2 — Sun Azimuth and Elevation Values**

Attribute	Value in Degrees	
	Sun-Illuminated	Flat Surface
Sun Azimuth Angle	135 Degrees	0.0 Degrees
Sun Elevation	45 Degrees	0.0 Degrees



**Figure 9-2 — Sun-illuminated and Static (Flat) Shading**

## 10 Data Product Format (Encoding)

### 10.1 Introduction

The S-102 data set must be encoded using the Hierarchical Data Format standard, Version 5 (HDF5).

<b>Format Name</b>	HDF5
<b>Version</b>	1.8.8
<b>Character Set</b>	UTF-8
<b>Specification</b>	<a href="https://www.hdfgroup.org/">https://www.hdfgroup.org/</a>

The key idea behind the S-102 product structure is that each coverage is a feature. Each of these features is co-located with the others. Therefore, they share the same spatial metadata, and each is required to correctly interpret the others.

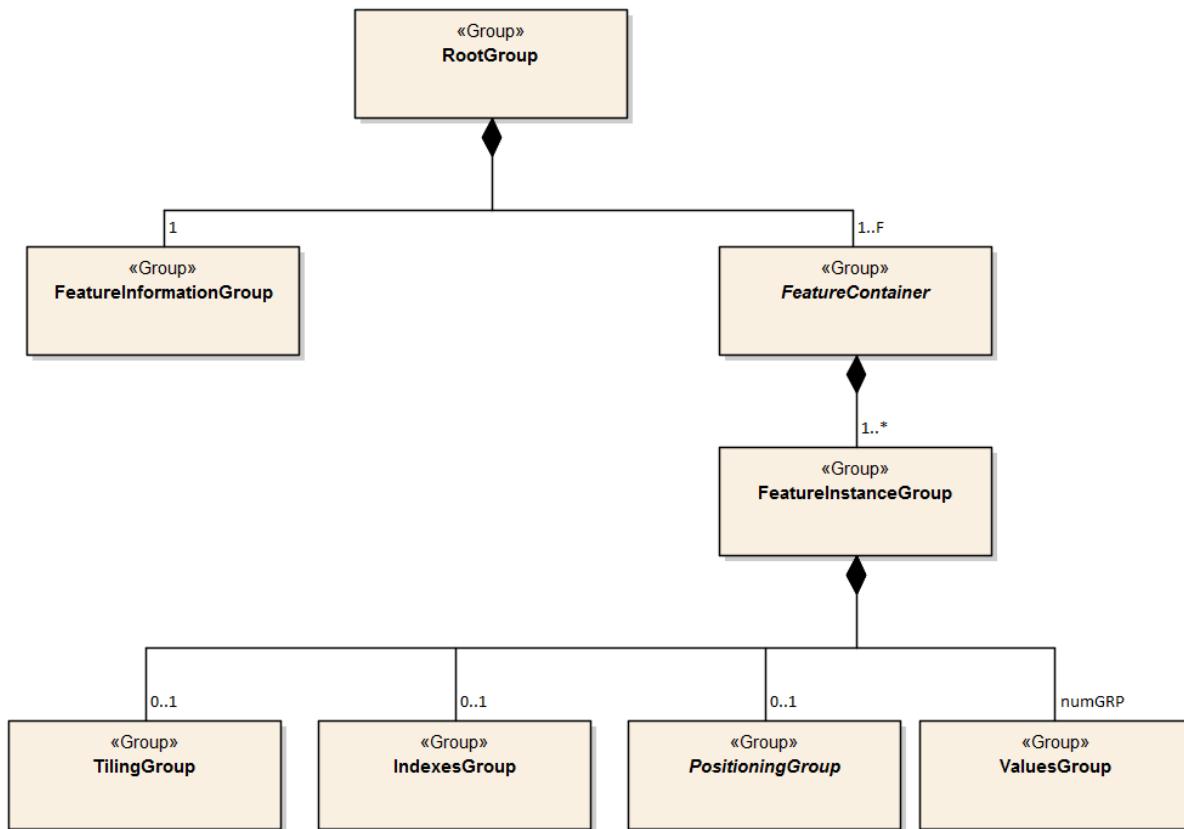
For the use of HDF5, the following key concepts ([S-100, Part 10c, Clause 5.1](#)) are important:

<i>File</i>	a contiguous string of bytes in a computer store (memory, disk, etc.), and the bytes represent zero or more objects of the model;
<i>Group</i>	a collection of objects (including groups);
<i>Dataset</i>	a multidimensional array of data elements with attributes and other metadata;
<i>Dataspace</i>	a description of the dimensions of a multidimensional array;
<i>Datatype</i>	a description of a specific class of data element including its storage layout as a pattern of bits; (Enumerations are encoded with unsigned 8-bit or unsigned 16-bit indices, depending on the number of transported values.)
<i>Attribute</i>	a named data value associated with a group, dataset, or named datatype and stored as a scalar;
<i>Property</i>	a collection of parameters (some permanent and some transient) controlling options in the library.

In addition, datasets may be a compound (a single record consisting of an array of simple value types) and have multiple dimensions.

## 10.2 Product structure

The structure of the data product follows the form given in [S-100, Part 10c](#)—HDF5 Data Model and File Format. The general structure, which was designed for several S-100 products is given in [Figure 10-1](#).



**Figure 10-1 — Outline of the generic data file structure**

[Figure 10-1](#) shows the four levels defined within the HDF encoding as defined in [S-100, Part 10c](#). Below is a further definition of these levels.

**Level 1** At the top level lies the Root Group, and it contains the Root Metadata and two subsidiary groups.  
1 The Root Metadata applies to all S-100 type products.

**Level 2** The next Level contains the Feature Information Group and the Feature Container Group. The Feature Information Group contains the feature **BathymetryCoverage**, the feature attribute codes and the optional feature **QualityOfBathymetryCoverage**. The Feature Container Group contains the Feature Metadata and one or more Feature Instance Groups.

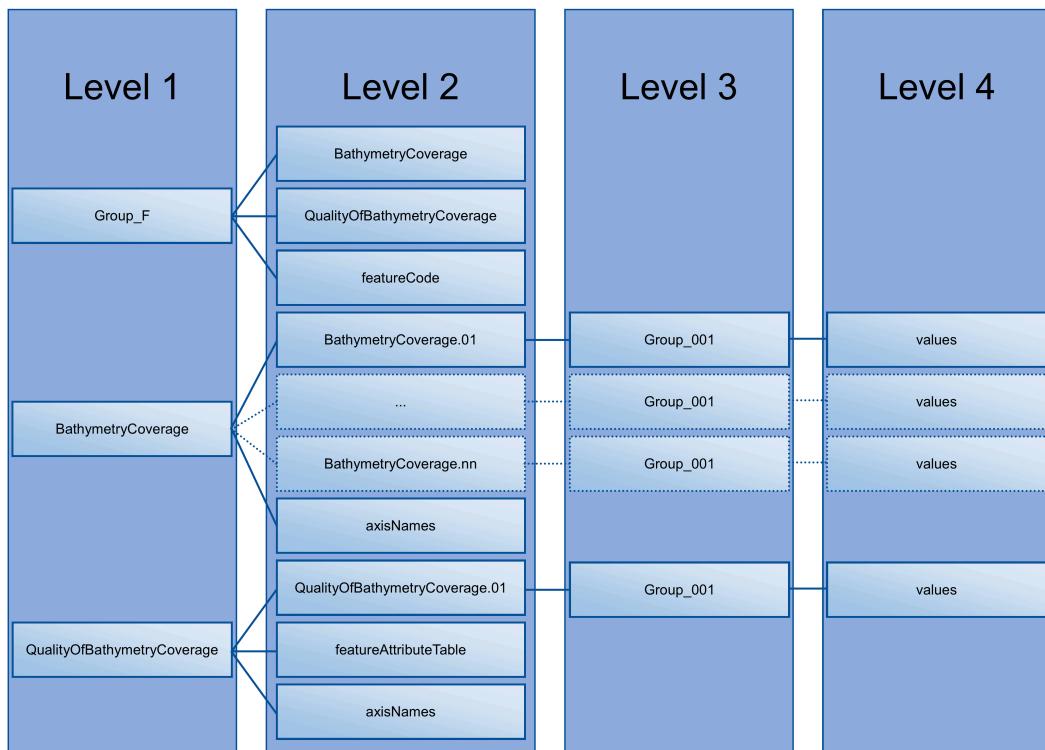
**Level 3** This level contains one or more Feature Instance groups. A **BathymetryCoverage** feature instance is a bathymetric gridded data set for a single region and at a single vertical datum. A **QualityOfBathymetryCoverage** feature instance is a corresponding dataset for the same single region and for all applicable vertical datums.

**Level 4** This level contains the actual data for each feature. In S-102 **BathymetryCoverage** and **QualityOfBathymetryCoverage** each use the **ValuesGroup** to define the content. The other groups at this level are not used.

In [Table 10-1](#) below, levels refer to HDF5 structuring (see [Figure 10-1](#)). Naming in each box below the header line is as follows: Generic name; S-100 or S-102 name, or nothing if none; and (HDF5 type) group, attribute or attribute list, or dataset. [Figure 10-2](#) depicts the same structure using a graphical representation.

**Table 10-1 — Overview of S-102 Data Product**

LEVEL 1 CONTENT	LEVEL 2 CONTENT	LEVEL 3 CONTENT	LEVEL 4 CONTENT
General Metadata (metadata) ( <i>h5_attribute</i> )			
Feature Codes Group_F ( <i>h5_group</i> )	Feature Name BathymetryCoverage ( <i>h5_dataset</i> )		
	QualityOfBathymetryCoverage ( <i>h5_dataset</i> )		
	Feature Codes featureCode ( <i>h5_dataset</i> )		
Feature Type BathymetryCoverage ( <i>h5_group</i> )	Type Metadata (metadata) ( <i>h5_attribute</i> )		
	Feature Instance BathymetryCoverage.01 ... BathymetryCoverage.nn ( <i>h5_group</i> )	Instance Metadata (metadata) ( <i>h5_attribute</i> )	
		First data group Group_001 ( <i>h5_group</i> )	Group Metadata (metadata) ( <i>h5_attribute</i> )
	X and Y Axis Names axisNames ( <i>h5_dataset</i> )		Bathymetric Data Array values ( <i>h5_dataset</i> )
Feature Type QualityOfBathymetryCoverage ( <i>h5_group</i> )	Metadata ( <i>h5_attribute</i> ) (same as BathymetryCoverage)		
	QualityOfBathymetryCoverage.01 ( <i>h5_group</i> )	Group_001 ( <i>h5_group</i> )	Group Metadata (metadata) ( <i>h5_attribute</i> )
	X and Y Axis Names axisNames ( <i>h5_dataset</i> )		Quality of Bathymetry Data Array values ( <i>h5_dataset</i> )
	Feature Attribute Table ( <i>h5_dataset</i> )		



**Figure 10-2 — Hierarchy of S-102 Data Product**

The following sections explain entries in [Table 10-1](#) in greater detail.

### 10.2.1 Root Group

The root group is required by HDF5. The S-100 HDF5 format ([S-100, Part 10c](#)) attaches metadata attributes applicable to the whole dataset to this group. S-102 uses all the S-100 attributes except *geographicIdentifier* and *metaFeatures*. The attributes used in S-102 are listed in [Table 10-2](#), with specific requirements, if any, added in the Remarks column.

**Table 10-2 — Root group attributes**

No	Name	Camel Case	Mult	Data Type	Remarks
1	Product specification number and version	productSpecification	1	String	<a href="#">S-100, Part 10c, Table 6</a> Example: INT.IHO.S-102.3.0.0
2	Time of data product issue	issueTime	0..1	String (Time format)	<a href="#">S-100, Part 1, Table 2</a> <a href="#">S-100, Part 10c, Table 1</a>
3	Issue date	issueDate	1	String (Date format)	<a href="#">S-100, Part 1, Table 2</a> <a href="#">S-100, Part 10c, Table 1</a>
4	Horizontal CRS	horizontalCRS	1	Integer 32-bit	The identifier (EPSG code) of the horizontal CRS as defined in <a href="#">Clause 5.2</a> (see <a href="#">Clause 10.2.1, Note 2</a> ).
5	Epoch of realization	epoch	0..1	String	
6a	Bounding box	westBoundLongitude	1	Float 32-bit	The values are in decimal degrees. If a projected CRS is used for the dataset, these values refer to those of
6b		eastBoundLongitude	1	Float	

No	Name	Camel Case	Mult	Data Type	Remarks
	6c 6d			32-bit	the baseCRS underlying the projected CRS (see <a href="#">Clause 10.2.1, Note 3</a> ).  The root bounding box needs to encompass all data, including fill values. The outermost cell boundaries of the grid cells and the bounding box / domain extent polygon of each feature instance group form the basis for the root bounding box.
6c		southBoundLatitude	1	Float 32-bit	
6d		northBoundLatitude	1	Float 32-bit	
7	Metadata	metadata	0..1	String	Name of metadata file MD_file base name>.XML (or .xml) ISO metadata (per <a href="#">S-100, Part 10c, Clause 12 &amp; S-100, Part 8</a> ).
8	Vertical coordinate system	verticalCS	1	Integer 32-bit	Mandatory in S-102. EPSG code;  The only allowed value is: *6498 (Depth—metres—orientation down)
9	Vertical coordinate base	verticalCoordinateBase	1	Enumeration	Mandatory in S-102. The only allowed value is 2: <i>verticalDatum</i> (see <a href="#">S-100, Part 10c, Table 22</a> ).
10	Vertical datum reference	verticalDatumReference	1	Enumeration	Mandatory in S-102. The only allowed value is 1: s100VerticalDatum (see <a href="#">S-100, Part 10c, Table 23</a> ).
11	Vertical datum	verticalDatum	1	Integer unsigned 16-bit	Numeric code from IHO GI Registry <i>Vertical Datum</i> attribute 1 – 30 & 44  see <a href="#">Clause 10.2.1, Note 4</a>
<p>NOTE 1: The <i>productIdentifier</i> ("S-102") and <i>version</i> fields (X.X.X) of S100_ProductSpecification must be used.</p> <p>NOTE 2: The value <i>horizontalCRS</i> specifies the horizontal Coordinate Reference System. At the time of writing, S-100 does not yet provide a mechanism for this value's definition within HDF5 encoding (such as an enumeration of horizontal CRSS). Consequently, this configuration causes a deviation from S-100. The horizontal datum is implicitly defined by this CRS because each horizontal CRS consists of a coordinate system and a datum. S-102 does not use "user defined" CRS as mentioned in <a href="#">S-100, Part 10c, Table 6</a>.</p> <p>NOTE 3: The baseCRS is the geodetic CRS on which the projected CRS is based. In particular, the datum of the base CRS is also used for the derived CRS (see <a href="#">S-100, Part 6, Table 6</a>).</p> <p>NOTE 4: This is the default vertical datum. If and only if a <b>BathymetryCoverage</b> feature instance group does not specify a vertical datum, this (Root Group) vertical datum shall apply.</p>					

## 10.2.2 Feature Codes (Group\_F)

No attributes.

This group specifies the S-100 features to which the data applies, and consists of three components:

**featureCode** — a 1-dimensional dataset with the featureCode(s) of the S-100 feature(s) contained in the data product. For S-102, the dataset has only two elements—the string “**BathymetryCoverage**” and “**QualityOfBathymetryCoverage**” (without quotes). The entries in this dataset give the names of the other two components of Group\_F.

**BathymetryCoverage** — A 1-dimensional dataset that contains the standard definition of the bathymetry coverage feature class in terms of its attributes and their types, units of measure, etc. The datatype of its elements is the compound type described in [S-100, Part 10c, Table 8](#).

**QualityOfBathymetryCoverage**—A 1-dimensional dataset of the same datatype as the **BathymetryCoverage** dataset described above. This **QualityOfBathymetryCoverage** dataset contains the definition of the reference to metadata records. The reference is a single integer which identifies a metadata record in *featureAttributeTable* (described in [S-100, Part 10c, Clause 9.6.2](#) and [Clause 10.2.8](#)).

### 10.2.3 BathymetryCoverage and QualityOfBathymetryCoverage Tables (in Group\_F)

BathymetryCoverage and QualityOfBathymetryCoverage are arrays of compound type elements, whose components are the 8 components specified in [Table 10-3](#).

**Table 10-3 — Sample contents of the BathymetryCoverage and QualityOfBathymetryCoverage arrays**

Name	Explanation	BathymetryCoverage	QualityOfBathymetryCoverage	
		S-100 Attribute 1	S-100 Attribute 2	S-100 Attribute 1
code	Camel Case code of attribute as in Feature Catalogue	depth	uncertainty	iD
name	Long name as in Feature Catalogue	depth	uncertainty	ID
uom.name	Units (uom.name from S-100 Feature Catalogue)	metres	metres	(empty)
fillValue	Fill value (integer or float, string representation, for missing values)	1000000	1000000	0
datatype	HDF5 datatype, as returned by H5Tget_class() function	H5T_FLOAT	H5T_FLOAT	H5T_INTEGER
lower	Lower bound on value of attribute	-14	0	1
upper	Upper bound on value of attribute	11050	(empty)	(empty)
closure	Open or Closed data interval. See S100_IntervalType in <a href="#">S-100, Part 1</a> .	closedInterval	geSemilInterval	geSemilInterval

NOTE: The *uncertainty* attribute of BathymetryCoverage may be omitted under certain conditions. See [Clause 10.2.7](#).

According to [S-100, Part 10c, Clause 9.5](#), “All the numeric values in the feature description dataset are string representations of numeric values; for example, “-9999.0” not the float value -9999.0.”

While the sample contents are shown in the two attributes columns, these are actually rows in the BathymetryCoverage table. They are also each a single HDF5 compound type and represent a single HDF5 element in the table.

All cells shall be HDF5 variable length strings. The minimum and maximum values are stored in lower and upper columns. Variable length strings allow future proofing the format in the event editing is allowed or correcting these values is required.

#### 10.2.4 Root BathymetryCoverage

**Table 10-4 — Attributes of BathymetryCoverage feature container group**

No	Name	Camel Case	Mult	Data Type	Remarks
1	Data organization index	dataCodingFormat	1	Enumeration	Value: 2
2	Dimension	dimension	1	Integer unsigned 8-bit	Value: 2
3	Common point rule	commonPointRule	1	Enumeration	Value: 2 (low) see <a href="#">S-100, Part 8, Table 11</a> .
4	Horizontal position uncertainty	horizontalPositionUncertainty	1	Float 32-bit	Value: -1.0 (if unknown or not available)
5	Vertical position uncertainty	verticalUncertainty	1	Float 32-bit	Value: -1.0 (if unknown or not available)
6	Number of feature instances	numInstances	1	Integer unsigned 8-bit	This is the total number of Feature Instance Groups within the Feature Container Group. The minimum is 1. see <a href="#">Clause 10.2.4, Note</a>
7a	Sequencing rule	sequencingRule.type	1	Enumeration	Value: 1 (linear) see <a href="#">S-100, Part 8, Table 12</a> .
7b		sequencingRule.scanDirection	1	String	Value: <axisNames entry> (comma-separated). For example, “latitude,longitude”. Reverse scan direction along an axis is indicated by prefixing a ‘-’ sign to the axis name. See <a href="#">Clause 4.2.1.1.8.3</a>
8	Interpolation type	interpolationType	1	Enumeration	Value: 1 (nearestneighbor). See <a href="#">S-100, Part 8, Table 13</a>
9	Offset of data point in cell	dataOffsetCode	1	Enumeration	Value: 5 barycenter (centroid) of cell. See <a href="#">S-100, Part 10c, Table 10</a>

NOTE: The number depends on the number of different vertical datums in the Feature Container Group.

#### 10.2.5 Feature Instance group—BathymetryCoverage.nn

The BathymetryCoverage Feature Container Group can contain one or more Feature Instance Groups. The naming of the Feature Instance Groups follows the notation specified by the S-100. For generalization, the numbering is indicated with “.nn”.

Each feature instance group implements a unique vertical datum. All feature instance groups must share the same spatial location and extent. For each feature instance group, only the grid cells falling within the area of validity for that feature instance group’s vertical datum should be populated with (real) data. Within that feature instance group, all other grid cells should be populated with the fill value. Therefore, it is expected that:

- The only grid cells that should be populated in more than one feature instance group are those that fall along a vertical datum boundary.
- Where multiple population occurs, the ECDIS should choose the set of values resulting in the most conservative description to the mariner. (I.e., it should choose the shoalest adjusted depth.)

As derived from [S-100, Part 10c, Clause 9.7](#) and [S-100, Part 10c, Table 12, Table 10-5](#) and [Table 10-6](#) describe the structure and attributes, respectively, of the **BathymetryCoverage** feature instance group.

**Table 10-5 — Structure of BathymetryCoverage feature instance group**

Group	HDF5 Category	Name	Mult	Data Type	Remarks / Data Space
/BathymetryCoverage/ BathymetryCoverage.01	attributes	(see Remarks)	1	(see Remarks)	Single-valued attributes as described in <a href="#">Table 10-6</a>
	Dataset	domainExtent.polygon	0..1	Compound (Float, Float)	Spatial extent of the domain of the coverage Array (1-d): i=0, P Components: , latitude> or , Y> (coordinates of bounding polygon vertices as a closed ring; that is, the first and last elements will contain the same values) Either this or the bounding box attribute must be populated.
/BathymetryCoverage/ BathymetryCoverage.nn	attributes	(see Remarks)	1	(see Remarks)	Single-valued attributes as described in <a href="#">Table 10-6</a>
	Dataset	domainExtent.polygon	0..1	Compound (Float, Float)	Spatial extent of the domain of the coverage Array (1-d): i=0, P Components: , latitude> or , Y> (coordinates of bounding polygon vertices as a closed ring; that is, the first and last elements will contain the same values) Either this or the bounding box attribute must be populated.

**Table 10-6 — Attributes of BathymetryCoverage feature instance group**

No	Name	Camel Case	Mult	Data Type	Remarks
1a	Bounding box	westBoundLongitude	0..1	Float 32-bit	Coordinates should refer to the previously defined Coordinate Reference System. Either this or the domainExtent.polygon dataset must be populated
1b		eastBoundLongitude	0..1	Float 32-bit	
1c		southBoundLatitude	0..1	Float 32-bit	
1d		northBoundLatitude	0..1	Float 32-bit	
2	Number of groups	numGRP	1	Integer unsigned 8-bit	The number of data values groups contained in this instance group. Value: 1
3	Longitude of grid origin	gridOriginLongitude	1	Float 64-bit	Longitude or easting of grid origin. Unit: (to correspond with previously defined Coordinate Reference System)
4	Latitude of grid origin	gridOriginLatitude	1	Float 64-bit	Latitude or northing of grid origin. Unit: (to correspond with previously defined Coordinate Reference System)

No	Name	Camel Case	Mult	Data Type	Remarks
5	Grid spacing, longitude	gridSpacingLongitudinal	1	Float 64-bit	Cell size in x dimension.
6	Grid spacing, latitude	gridSpacingLatitudinal	1	Float 64-bit	Cell size in y dimension.
7	Number of points, longitude	numPointsLongitudinal	1	Integer unsigned 32-bit	Number of points in x dimension.
8	Number of points, latitude	numPointsLatitudinal	1	Integer unsigned 32-bit	Number of points in y dimension.
9	Start sequence	startSequence	1	String	<p>Grid coordinates of the grid point to which the first in the sequence of values is to be assigned.</p> <p>The choice of a valid point for the start sequence is determined by the sequencing rule.</p> <p>Format: n, n Example: "0,0" (without quotes)</p>
10	Vertical datum	verticalDatum	0..1	Integer unsigned 16-bit	<p>see remark <a href="#">Table 10-2</a>  <b>row vertical datum</b>          and <a href="#">[mvvdvr]</a></p> <p>Mandatory for feature instance groups with a different vertical datum from that specified in the Root Group (prohibited otherwise)</p>
11	Vertical datum reference	verticalDatumReference	0..1	Integer unsigned 8-bit	<p>The only allowed value is 1: <b>s100VerticalDatum</b>          (see <a href="#">S-100, Part 10c, Table 23</a>).          see <a href="#">[mvvdvr]</a></p> <p>Mandatory if this value were to differ from what is contained in the Root Group</p>

The *gridOriginLongitude*, *gridOriginLatitude*, *gridSpacingLongitudinal*, and *gridSpacingLatitudinal* attributes should be in the same geographic units as the bounding box. Note that this practice deviates from S-100 where it indicates that this value should be in Arc Degrees.

*numPointsLongitude* and *numPointsLatitude* must contain the number of cells in the x and y dimensions of the values table.

The S-102 uses the “Overriding of Attributes” concept of the [S-100, Part 10c, Clause 9.7.1](#). This usage allows the feature instance group to overwrite the attributes of a higher group, in this case the *verticalDatum*. The default vertical datum is specified in the root group (see [Table 10-2](#)). The feature instance group for this default vertical datum must not use the additional attributes *verticalDatum* and *verticalDatumReference* (on the feature instance group).

If multiple vertical datums are present in the product, a separate feature instance group must be created for each vertical datum. These feature instance groups must use the additional attribute *verticalDatum* (on the feature instance group).

*Note: At present, this Product Specification does not allow values other than 1: s100VerticalDatum for verticalDatumReference. However, if future changes allow the value of 2: EPSG (and if the value at the feature instance group differs from what is contained in the Root Group), then this value would become mandatory.*

According to S-100, either the *BoundingBox* at the Feature Instance Group or the *domainExtent.polygon* must be specified. If *domainExtent.polygon* is specified, the *BoundingBox* is not specified in this case.

The grid cells that do not belong to the area of the respective vertical datum should be assigned the fill value. If more than one *domainExtent.polygon* is used, those of different feature instance groups should not overlap. At positions where the polygons of different Feature Instance groups touch, the edges should be identical. The *domainExtent.polygon* does not have to follow grid cell boundaries but is an independent vector geometry based on the *SoundingDatum* surface from S-101. The *domainExtent.polygon* only supports a simple polygon geometry in accordance with [S-100, Part 10c, Table 11](#). The mapping of multi-polygons and inner rings is not possible.

#### 10.2.6 The values group—Group\_001

This group contains 5 attributes, all of which are mandatory. According to [S-100, Part 10c, Table 19](#), *timePoint* applies because the *dataCodingFormat* = 2. The other four attributes for this group are an extension of this Product Specification and, thus, are not defined by [S-100, Part 10c, Table 10-7](#) lists all 5 attributes.

**Table 10-7 — Attributes of values group**

No	Name	Camel Case	Mult	Data Type	Remarks
1	minimum Depth	minimumDepth	1	Float 32-bit	The minimum depth value in the values dataset(s) of this group
2	maximum Depth	maximumDepth	1	Float 32-bit	The maximum depth value in the values dataset(s) of this group
3	minimum Uncertainty	minimumUncertainty	1	Float 32-bit	The minimum uncertainty value in the values dataset(s) of this group. If no uncertainty values are in the dataset(s) the value must be the <i>fillValue</i>
4	maximum Uncertainty	maximumUncertainty	1	Float 32-bit	The maximum uncertainty value in the values dataset(s) of this group. If no uncertainty values are in the dataset(s) the value must be the <i>fillValue</i>
5	Time stamp	timePoint	1	String	Because S-102 specifies survey dates elsewhere in its structure, this value should always be the <i>fillValue</i> : <i>00010101T000000Z</i>

The group contains an HDF5 dataset named values containing the bathymetric gridded data.

#### 10.2.7 BathymetryCoverage feature instance group—values dataset

This dataset contains the compound data arrays containing bathymetric gridded data. These components are explained below.

For bathymetric gridded data, the dataset includes a two-dimensional array containing always the depth and under certain conditions uncertainty data. These dimensions are defined by *numPointsLongitudinal* and *numPointsLatitudinal*. By knowing the grid origin and the grid spacing, the position of every grid point and grid cell can be simply computed.

If the *uncertainty* for each grid cell is equal, it is not necessary to store it at each cell in the grid. The uniqueness of the uncertainty results from the equality of the attributes *minimumUncertainty* and *maximumUncertainty* of Group\_001 of the BathymetryCoverage (see [Table 10-7](#) No. 3 & 4). If the uncertainty values at the grid cells are omitted, it must be ensured that the entry of the *uncertainty* of the BathymetryCoverage in the Group\_F is also omitted (see [Table 10-3](#)). This type of storage technique can reduce the amount of memory required for the uncertainty without loss of information. The uncertainty of each grid cell can be immediately obtained from the *minimumUncertainty* or *maximumUncertainty* attributes of Group\_001 of the BathymetryCoverage.

If the *uncertainty* is not the same for each grid cell, it must be stored at each cell in the grid. For unknown or unused uncertainty data, it must be filled with the *fillValue* specified in the Group\_F feature information dataset.

The grid cell values are stored in two-dimensional arrays with a prescribed number of columns (*numCOL*) and rows (*numROW*). This grid is defined as a regular grid (*dataCodingFormat* = 2); therefore, the *depth* and *uncertainty* values will be for each cell in the grid. The data type of the array values is a compound with one or two members.

#### 10.2.8 Root QualityOfBathymetryCoverage

The QualityOfBathymetryCoverage container group has the same metadata attributes as BathymetryCoverage container group (see [Table 10-4](#)). The values of the attributes must also be the same as the BathymetryCoverage container group. An exception is the attribute *dataCodingFormat*, which must be '9'. The use of multiple BathymetryCoverage Feature Instance groups (different Vertical Datums) does not affect the multiplicity of the QualityOfBathymetryCoverage, which remains 0 to 1. This means that the different BathymetryCoverage Feature Instance groups share a common QualityOfBathymetryCoverage.

The QualityOfBathymetryCoverage container group contains an additional 1-dimensional array named featureAttributeTable ([S-100, Part 10c, Table 9](#); [S-100, Part 10c, Clause 9.6.2](#)). This dataset is mandatory within the QualityOfBathymetryCoverage group. Each element of this array is a metadata record of HDF5 compound type. The fields are described in [Table 10-8](#) below.

**Table 10-8 — Elements of featureAttributeTable compound datatype**

No	Attribute	Description	Mult	Data Type	Remarks
1	id	Metadata record identifier	1	Integer unsigned 32-bit	Each record must have a unique identifier.
2	dataAssessment	The categorization of the assessment level of bathymetric data for an area.	0..1	Integer unsigned 8-bit	*1: Assessed *2: Unassessed *3: Oceanic
3	featuresDetected. leastDepthOfDetectedFeaturesMeasured	Expression stating if the least depth of detected features in an area was measured.	0..1	Integer unsigned 8-bit	Boolean, Values: *1 (TRUE) *0 (FALSE). See <a href="#">Clause 10.2.8, Note 1</a> .
4	featuresDetected. significantFeaturesDetected	A statement expressing if significant features have or have not been detected in the course of a survey.	0..1	Integer unsigned 8-bit	Boolean, Values: *1 (TRUE) *0 (FALSE). See <a href="#">Clause 10.2.8, Note 2</a> .
5	featuresDetected. sizeOfFeaturesDetected	The size of detected bathymetric features in an area.	0..1	Float 32-bit	See <a href="#">Clause 10.2.8, Note 3</a> and <a href="#">Clause 10.2.8, Note 4</a> .
6	featureSizeVar	Percentage of depth that a feature of such size could be detected.	0..1	Float 32-bit	Set to zero if the feature size does not scale with depth. See <a href="#">Clause 10.2.8, Note 3</a> and <a href="#">Clause 10.2.8, Note 4</a> .

No	Attribute	Description	Mult	Data Type	Remarks
					<a href="#">10.2.8, Note 4.</a>
7	fullSeafloorCoverageAchieved	Expression stating if full seafloor coverage has been achieved in the area by hydrographic surveys.	0..1	Integer unsigned 8-bit	Boolean, Values: *1 (TRUE) *0 (FALSE). See <a href="#">Clause 10.2.8, Note 5.</a>
8	bathyCoverage	<b>False</b> for grid cells populated by interpolation.	0..1	Integer unsigned 8-bit	Boolean, Values: *1 (TRUE) *0 (FALSE). See <a href="#">Clause 10.2.8, Note 6.</a>
9	zoneOfConfidence.horizontalPositionUncertainty.uncertaintyFixed	The best estimate of the fixed horizontal or vertical accuracy component for positions, depths, heights, vertical distances, and vertical clearances.	0..1	Float 32-bit	
10	zoneOfConfidence.horizontalPositionUncertainty.uncertaintyVariableFactor	The factor to be applied to the variable component of an uncertainty equation so as to provide the best estimate of the variable horizontal or vertical accuracy component for positions, depths, heights, vertical distances, and vertical clearances.	0..1	Float 32-bit	
11	surveyDateRange.dateStart	The start date of the period of the hydrographic survey.	0..1	Date	ISO 8602:2004 date format. Complete or truncated date, see <a href="#">S-100, Part 1, Table 2.</a>
12	surveyDateRange.dateEnd	The end date of the period of the hydrographic survey.	0..1	Date	ISO 8602:2004 date format. Complete or truncated date, see <a href="#">S-100, Part 1, Table 2.</a>

No	Attribute	Description	Mult	Data Type	Remarks
13	sourceSurveyID	The survey filename or ID.	0..1	String	
14	surveyAuthority	The authority which was responsible for the survey.	0..1	String	
15	typeOfBathymetricEstimationUncertainty	The measure used to estimate the magnitude of the difference between true and estimated bathymetric depth, after all appropriate corrections are made.	0..1	Enumeration	See <a href="#">Table 10-9</a> . See <a href="#">Clause 10.2.8, Note 7</a> .

NOTE 1: A feature in this context is any object, whether manmade or not, projecting above the sea floor, which may be a danger for surface navigation [S-44](#). Least depth of detected features measured does not describe the least depth of features that were actually detected during a hydrographic survey, but the ability of the survey to detect the least depth of features with a maximum uncertainty as defined in [S-44](#).

NOTE 2: A feature in this context is any object, whether manmade or not, projecting above the sea floor, which may be a danger for surface navigation [S-44](#). Significant features detected does not describe if significant features were actually detected during a hydrographic survey, but whether the survey had the capacity to detect significant features.

NOTE 3: The role of the attribute, *featureSizeVar* is described in [Clause 7.1](#). The expectation is that *featureSizeVar* will be set to zero if the feature size does not scale with depth. As with *featureSize*, *featureSizeVar* should be ignored if *significantFeatures* is False.

NOTE 4: When both *featureSize* and *featureSizeVar* are present, the greater of the two should be considered valid.

NOTE 5: Full seafloor coverage achieved applies to both the spatial completeness of feature detection and to the spatial completeness of the measurement of the regular seafloor. The former is further specified by the complex attribute features detected; the latter by the attributes depth range maximum value and depth range minimum value.

NOTE 6: The attribute *bathyCoverage* is especially useful in side-scan surveys which are characterized by gaps in bathymetric observations with full coverage side-scan imagery. In this case, interpolated gaps between bathymetry coverage would show *fullSeafloorCoverageAchieved* = True and *bathyCoverage* = False. However, if *fullSeafloorCoverageAchieved* = False, *bathyCoverage* must also equal False (e.g., gaps between single beam echosounder data without correlating side-scan sonar coverage).

NOTE 7: Names and listed values which are not currently defined in the IHO GI Registry are subject to change upon acceptance in the Registry.

**Table 10-9 — Codes defining how uncertainty of bathymetric depth was determined**

Role Name	Name	Description	Code	Remarks
Enumeration	S102_BatymetricUncertaintyType	An estimate of the magnitude of the difference between true and estimated bathymetric depth, after all appropriate corrections are made.	-	
Value	rawStandardDeviation	Raw standard deviations of soundings that contributed to the grid cell.	1	-
Value	cUBEStandardDeviation	Standard deviation of soundings captured by a CUBE hypothesis (that is, CUBE's standard output of uncertainty).	2	-
Value	productUncertainty	The greater of (1) standard deviation of the soundings contributing to the depth solution or, (2) the <i>a priori</i>	3	-

Role Name	Name	Description	Code	Remarks
		computed uncertainty estimate (that is, modelled Total Vertical Uncertainty).		
Value	historicalStandardDeviation	Estimated standard deviation based on historical/archive data.	4	-
Value	(fill value representing “unknown”)	(fill value when the uncertainty is an unknown layer type)	0	This is a “fill value” and will not be in the feature catalogue.

### 10.2.9 Instance group QualityOfBathymetryCoverage.01

The QualityOfBathymetryCoverage.01 instance group has the same metadata attributes as BathymetryCoverage.01 instance group (see [Table 10-6](#)). The values of the attributes must also be the same as the BathymetryCoverage instance group.

### 10.2.10 Values group for QualityOfBathymetryCoverage

The values group for QualityOfBathymetryCoverage contains no metadata attributes and a single dataset named values, which is described in [Clause 10.2.11](#).

### 10.2.11 Values dataset for QualityOfBathymetryCoverage

The values dataset for QualityOfBathymetryCoverage is a single two-dimensional array of unsigned integers (the same datatype and size as the “id” field in featureAttributeTable — [Table 10-7](#)). The array must have the same dimensions as the values dataset in the BathymetryCoverage feature instance ([Clause 10.2.7](#)).

Each cell in this values dataset must be populated with a value that is one of the record identifiers in the featureAttributeTable dataset or with the fill value 0 (zero).

### 10.2.12 Mandatory Naming Conventions

The following group and attribute names are mandatory in S-100:

- Group\_F
- featureCode
- (for S-102)
  - **BathymetryCoverage**
  - axisNames
  - **BathymetryCoverage.01**
  - **QualityOfBathymetryCoverage.01**
  - featureAttributeTable
  - Group\_nnn

## 11 Data Product Delivery

### 11.1 Introduction

This clause describes how S-102 data will be delivered from the charting authority to the mariner.

**Units of Delivery** Exchange Set

**Transfer Size** See [Clause 11.2.2](#).

<b>Medium Name</b>	Digital Data Delivery
<b>Other Delivery Information</b>	<p>Each dataset must be contained in a physically separate, uniquely identified file on the transfer medium.</p> <p>Each exchange set has a single exchange catalogue which contains the discovery metadata for each dataset.</p> <p>An exchange set is encapsulated into a form suitable for transmission by a mapping called an encoding. An encoding translates each of the elements of the exchange set into a logical form suitable for writing to media and for transmission online. An encoding may also define other elements in addition to the exchange set contents (This is media identification, data extents etc. ...) and may define commercial constructs such as encryption and compression methods.</p> <p>If the data is transformed in S-102 it must not be changed.</p> <p>This Product Specification defines the encoding which must be used as a default for transmission of data between parties.</p> <p>The encoding encapsulates exchange set elements as follows:</p>
<b>Mandatory Elements</b>	
	<ul style="list-style-type: none"> <li>• S-102 datasets—HDF encoding</li> <li>• Exchange Catalogue—the XML encoded representation of exchange set catalogue features [discovery metadata].</li> </ul>
<b>Optional Elements</b>	
	<ul style="list-style-type: none"> <li>• S-102 Feature Catalogue—if it is necessary to deliver the latest Feature Catalogue to the end user it may be done using the S-102 exchange set mechanism for datasets</li> <li>• S-102 Portrayal Catalogue—if it is necessary to deliver the latest Portrayal Catalogue to the end user it may be done using the S-102 exchange set mechanism for datasets.</li> </ul>

## 11.2 Dataset

### 11.2.1 Dataset management

Three types of dataset files may be produced and contained within an exchange set:

- New dataset: Initial.
- New edition of a dataset: Includes new information. New editions must cover at least the same area as its predecessor.
- Cancellation: The dataset is cancelled and no longer available to be displayed or used.

#### 11.2.1.1 Production of a cancellation

S-102 uses only the fileless cancellation method described in [S-100, Part 17, Clause 17–4.4.1](#). In order to cancel a dataset, the cancelling authority (generally the producer of the original dataset) must:

- 1) Prepare an exchange catalogue with an S100\_DatasetDiscoveryMetadata block with field values as described in [Clause 11.2.1.2](#).
- 2) Complete other parts of the exchange catalogue as required by [Clause 12.4](#) (for example, provide discovery metadata for a replacement dataset if such is included in the same exchange set).
- 3) Sign and distribute the exchange catalogue in a normally structured exchange set.

#### 11.2.1.2 Metadata for cancellation

S-102 uses only the fileless cancellation method described in [S-100, Part 17, Clause 17–4.4.1](#). For a cancellation, set:

- *fileName* = *fileName* of the cancelled dataset

- *purpose = cancellation*
- *issueDate* and *issueTime* = the issue date and time of the cancellation
- *replacedData* = *true* if and only if the cancelled dataset is replaced by another dataset; otherwise *false*. This attribute must be populated for a cancellation.
- *dataReplacement* = *fileName* of the replacement dataset (if and only if the cancelled dataset is replaced by another dataset). This attribute must be populated when *replacedData=true*.
- all other mandatory attributes to the same values as in the discovery metadata block for the dataset being cancelled.

### 11.2.2 Dataset size

S-102 delivery will take place in one form: network transfer to platform (that is, internet download). An example scenario has been provided below:

NOTE: The use of 10 MB in this and other sections should be treated as informative information only. Additionally, any computed values associated with either file size limit should be treated as approximate answers. Final selection of an appropriate file size limit or grid resolution is left to the discretion of the data producer.

**Network Transfer** To minimize overall file size, the HO produces a 10 MB file for wireless transmission to marine vessels. In uncompressed form, this file would contain roughly 600 by 600 grid cells.

[Table 11-1](#) provides general information to aid in the compilation of S-102 data for specific charting scales.

#### 11.2.2.1 S-102 grid resolution and tiling

**Table 11-1 — Informative Grid Resolution and Resulting Tile Size at Chart Scale**

Scale	Informative Grid Resolution	Resulting Tile Size @ 10 MB
NULL (only allowed on minimum display scale where the maximum display scale = 10,000,000)		Approximate Linear Distance in Nautical Miles (M) for a 600 X 600 cell grid
1:10,000,000	900 metres	291 X 291
1:3,500,000	900 metres	291 X 291
1:1,500,000	450 metres	145 X 145
1:700,000	210 metres	68 X 68
1:350,000	105 metres	34 X 34
1:180,000	54 metres	17.5 X 17.5
1:90,000	27 metres	8.7 X 8.7
1:45,000	13 metres	4.2 X 4.2
1:22,000	6 metres	1.9 X 1.9
1:12,000	3 metres	1.0 X 1.0
1:8,000	2 metres	0.6 X 0.6
1:4,000	1 metres	0.3 X 0.3
1:3,000	1 metres	0.3 X 0.3
1:2,000	1 metres	0.3 X 0.3
1:1,000	1 metres	0.3 X 0.3

### 11.2.3 Dataset file naming

Dataset naming must follow a standard pattern to give implementers greater predictability of incoming datasets (see [S-100, Part 17, Clause 4.3](#)). S-102 dataset naming conventions must follow these rules.

**102YYYY0000000000000000.** 102 the first 3 characters identify the dataset as an S-102 dataset (mandatory).

**H5** YYYY the fourth to seventh characters identify the producer code according to the Producer Code Register.

**0000** 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).

**H5** denotes an HDF5 file.

## 11.3 Exchange Set

The structure of an S-102 Exchange Set must be according to the structure described below, which is based on [S-100, Part 17, Clause 4.2](#).

- 1) An S-102 Exchange Set must contain an Exchange Set Catalogue, CATALOG.XML, its digital signature CATALOG.SIGN, and may contain any number of S-102 conformant dataset files, support files, and Catalogue files.
- 2) All content must be placed inside a top root folder named S100\_ROOT. This is the only top level root folder in an Exchange Set containing only S-100 products.
- 3) The S100\_ROOT folder must contain a subfolder named S-102. This subfolder holds content specific to the S-102 Product Specification.
- 4) The S-102 subfolder must contain subfolders for the component dataset files (DATASET\_FILES) and Catalogues (CATALOGUES) as required.
- 5) The required Exchange Set Catalogue XML document instance must be named CATALOG.XML and placed in the S100\_ROOT folder, together with its digital signature (CATALOG.SIGN) file. All other digital signatures are included within their corresponding resource metadata records in the CATALOG.XML.
- 6) Support files are not allowed in S-102 exchange sets for this edition of S-102.

## 11.4 Exchange Catalogue

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

## 11.5 Data integrity and encryption

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

### 11.5.1 Use of compression

The data producer decides if compression will be used on the S-102 product files (HDF5). It is expected that a hydrographic office will make a policy decision and that all the S-102 datasets from the producer will be either compressed or uncompressed.

It is recommended to compress all the dataset files, for example HDF5 files. The ZIP compression method defined in [S-100, Part 15, Clause 5.2](#) must be applied to the product files.

### 11.5.2 Use of data protection

It is recommended to encrypt all the dataset files, for example HDF5. The encryption method defined in [S-100, Part 15](#) must be applied.

### 11.5.3 Use of digital signatures

Digital signatures shall be used on all files included in a S-102 compliant Exchange Set to meet the requirements of IMO resolution MSC.428(98) to reduce cyber security risks among users, especially when used in navigation systems at sea. The recommended signature method is defined in [S-100, Part 15](#).

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

## 12 Metadata

### 12.1 Introduction

The Metadata elements used in the Bathymetric Surface product are derived from S-100 and from [ISO 19115-1:2014/Amd 1:2018](#) and [ISO 19115-2:2009](#). Optionally additional metadata may be derived from [ISO/TS 19130:2010](#) and [ISO/TS 19130-2:2014](#) especially metadata relating to the sonar equipment which may have been used to acquire the bathymetric data.

S-102 metadata is encoded in two places:

- Metadata used for the discovery, identification, and use of S-102 datasets in S-100-based navigation systems (specifically, an S-100-capable ECDIS) is encoded in the exchange catalogue. This metadata conforms to S-100 Part 17, with product-specific restrictions added.
- Metadata required by the S-100 HDF5 encoding ([S-100, Part 10c](#)) and product-specific metadata defined by this product specification are encoded at various levels in the HDF5 group hierarchy, as specified by [S-100, Part 10c](#) or [Clause 10.2](#).

### 12.2 Exchange Set metadata

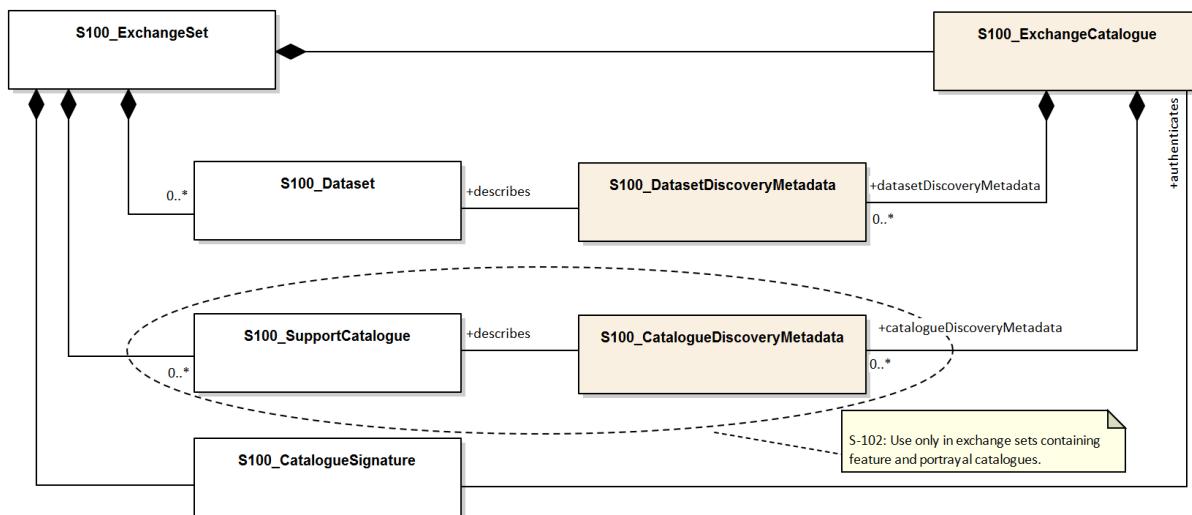
For information exchange, there are several categories of metadata required: metadata about the overall Exchange Catalogue, metadata about each of the datasets contained in the Catalogue.

[Figure 12-1](#) depicts the relationships of exchange set elements (datasets and feature/portrayal catalogues) and exchange set metadata. This figure is derived from [S-100, Part 17, Figure 2](#) with relationships not applicable to S-102 omitted.

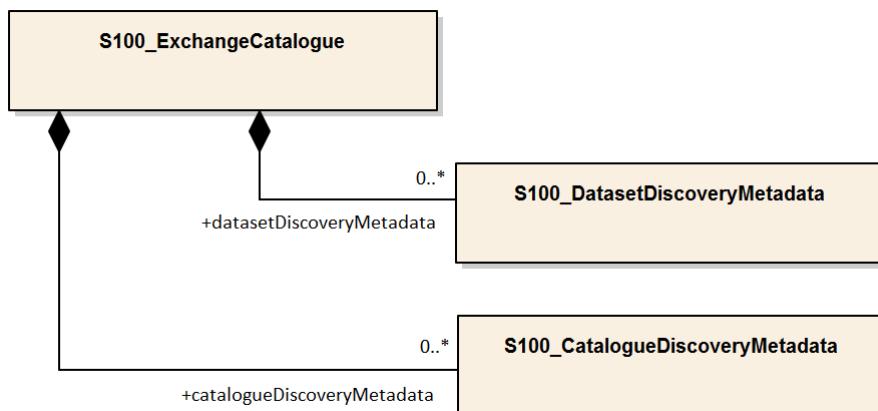
[Figure 12-2](#) depicts the structure of the exchange catalogue and its component discovery metadata blocks. The structure is the same as in [S-100, Part 17](#).

More detailed information about the various classes is shown in [Figure 12-3](#) with further description in [Table 12-1](#) to [Clause 12.8.2](#). In the cases in which classes are used without modification, refer to [S-100, Part 17](#) for their descriptions.

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



**Figure 12-1 — Components and associated metadata for the S-102 exchange set ([S-100, Part 17, Figure 2](#) with items not used by S-102 omitted)**



**Figure 12-2 — Relationship between exchange catalogue, discovery metadata, and dataset ([S-100, Part 17, Figure 6](#) with items not used by S-102 omitted)**

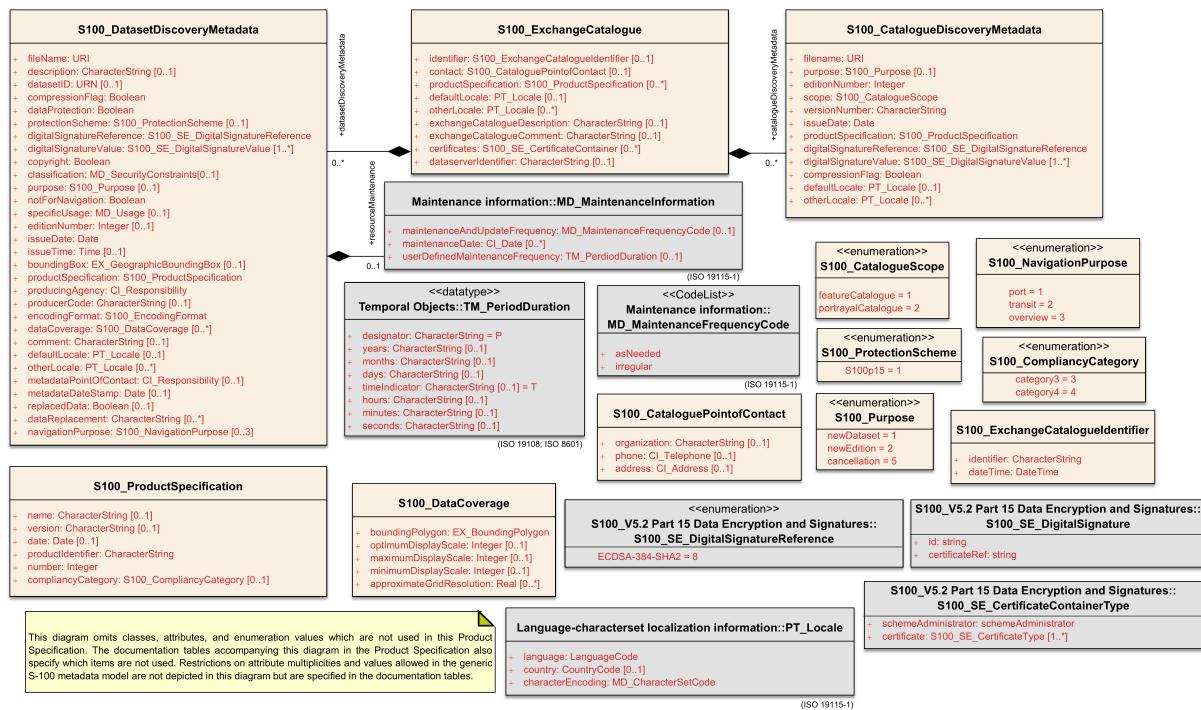


Figure 12-3 — S-102 Exchange Set Class Details ([S-100, Part 17, Figure 7](#) with items not used by S-102 omitted)

The following clauses define the mandatory and optional metadata needed for S-102. In some cases, the metadata may be repeated in a national language. If this is the case it is noted in the Remarks column.

The XML schemas for S-102 exchange catalogues will be available from the IHO Geospatial Information (GI) Registry and/or the S-100 GitHub site (<https://github.com/IHO-S100WG>).

The S-102 exchange catalogue uses the S-100 exchange catalogue schemas which are available from the S-100 schema server at <https://schemas.s100dev.net> (downloadable archives are also available on the site for offline use). Implementation of the S-102-specific constraints described in following clauses below is left to developer decision as it can be done in various ways depending on implementation frameworks and the requirements of production or application software.

### 12.3 Language

The exchange language must be English.

Character strings must be encoded using the character set defined in [ISO/IEC 10646-1:2000](https://www.iso.org/standard/60000.html), in Unicode Transformation Format-8 (UTF-8). A BOM (byte order mark) must not be used.

## 12.4 S100\_ExchangeCatalogue

Each Exchange Set has a single S100\_ExchangeCatalogue which contains meta information for the data in the Exchange Set.

S-102 uses S100\_ExchangeCatalogue without modification.

### 12.4.1 S100\_ExchangeCatalogueIdentifier

S-102 uses S100\_ExchangeCatalogueIdentifier without modification.

### 12.4.2 S100\_CataloguePointOfContact

S-102 uses S100\_CataloguePointOfContact without modification.

## 12.5 S100\_DatasetDiscoveryMetadata

Dataset discovery metadata in S-102 restricts certain attributes and roles as described in [Table 12-1](#). Optional S-100 attributes which are mandatory in S-102 are indicated in the Remarks column.

**Table 12-1 — S100\_DatasetDiscoveryMetadata parameters**

Role name	Name	Description	Mult	Type	Remarks
Class	S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the Exchange Catalogue	-	-	The optional S-100 attributes <i>updateNumber</i> , <i>updateApplicationDate</i> , <i>referenceID</i> , and <i>temporalExtent</i> are not used in S-102. References to support file discovery metadata are not permitted because S-102 does not use support files.
Attribute	fileName	Dataset file name	1	URI	See <a href="#">S-100, Part 1, Clause 4.6</a> Format: file:/S-102/DATASET_FILES/<dsname> Dataset file name <dsname> must be according to format defined in <a href="#">Clause 11.2.3</a> .
Attribute	description	Short description giving the area or location covered by the dataset	0..1	CharacterString	For example a harbour or port name, between two named locations, etc.

<b>Role name</b>	<b>Name</b>	<b>Description</b>	<b>Mult</b>	<b>Type</b>	<b>Remarks</b>
Attribute	datasetID	Dataset ID expressed as a Maritime Resource Name	0..1	URN	The URN must be an MRN. See <a href="#">S-100, Part 3, Clause 10</a>
Attribute	compressionFlag	Indicates if the resource is compressed	1	Boolean	<i>True</i> indicates a compressed dataset resource. <i>False</i> indicates an uncompressed dataset resource.
Attribute	dataProtection	Indicates if the data is encrypted	1	Boolean	<i>True</i> indicates an encrypted dataset resource. <i>False</i> indicates an unencrypted dataset resource.
Attribute	protectionScheme	Specification of method used for data protection	0..1	S100_ProtectionScheme	<b>Populate if and only if <i>dataProtection</i> = <i>True</i>.</b>
Attribute	digitalSignatureReference	Specifies the algorithm used to compute <i>digitalSignatureValue</i>	1	S100_SE_DigitalSignatureReference	<b>See <a href="#">clause8.11.7 &amp; Clause 12.9</a></b>
Attribute	digitalSignatureValue	Value derived from the digital signature	1..*	S100_SE_DigitalSignature	<b>see <a href="#">S-100, Part 15, Clause 15–8.11.3</a></b> The value resulting from application of <i>digitalSignatureReference</i> Implemented as the digital signature format specified in <a href="#">S-100, Part 15</a>
Attribute	copyright	Indicates if the dataset is copyrighted	1	Boolean	<i>True</i> indicates the resource is copyrighted. <i>False</i> indicates the resource is not copyrighted.
Attribute	classification	Indicates the security classification of the dataset	1	Class MD_SecurityConstraints>MD_ClassificationCode (codelist)	<b>Mandatory in S-102</b> a) unclassified b) restricted c) confidential d) secret e) top secret f) sensitive but unclassified g) for official use only h) protected i) limited distribution
Attribute	purpose	The purpose for which the dataset has been issued	1	S100_Purpose	<b>Mandatory in S-102</b>

Role name	Name	Description	Mult	Type	Remarks
Attribute	notForNavigation	Indicates the dataset is not intended to be used for navigation	1	Boolean	<i>True</i> indicates the dataset <b>is not</b> intended to be used for navigation. <i>False</i> indicates the dataset <b>is</b> intended to be used for navigation.
Attribute	specificUsage	The use for which the dataset is intended	0..1	MD_USAGE>specificUsage (character string)	-
Attribute	editionNumber	The edition number of the dataset	1	Integer	When a data set is initially created, the Edition number 1 is assigned to it. The Edition number is increased by 1 at each new Edition. Edition number remains the same for a re-issue. <b>Mandatory in S-102</b>
Attribute	issueDate	Date on which the data was made available by the Data Producer	1	Date	-
Attribute	issueTime	Time of day at which the data was made available by the Data Producer	0..1	Time	The S-100 datatype Time <b>May be required if multiple instances of a product are issued on the same day.</b>
Attribute	boundingBox	The extent of the dataset limits	1	EX_GeographicBoundingBox	<b>Mandatory in S-102</b> Defined as a rectangle coincident with the outermost cell boundaries of the dataset.
Attribute	productSpecification	The Product Specification used to create this dataset	1	S100_ProductSpecification	<a href="#">Table 12-5</a>
Attribute	producingAgency	Agency responsible for producing the data	1	CI_Responsibility>CI_Organisation	See <a href="#">S-100, Part 17, Table 17-3</a>
Attribute	producerCode	The official IHO Producer Code from S-62	1	CharacterString	<b>Mandatory in S-102</b>
Attribute	encodingFormat	The encoding format of the dataset	1	S100_EncodingFormat	<b>The only allowed value is HDF5</b> <a href="#">Table 12-4</a>
Attribute	dataCoverage	Provides information about data coverages within the dataset	1..*	S100_DataCoverage	<b>Mandatory in S-102</b> <a href="#">Table 12-2</a>

<b>Role name</b>	<b>Name</b>	<b>Description</b>	<b>Mult</b>	<b>Type</b>	<b>Remarks</b>
Attribute	comment	Any additional information	0..1	CharacterString	-
Attribute	defaultLocale	Default language and character set used in the dataset	0..1	PT_Locale	In absence of defaultLocale, the language is English, and the character set is UTF-8.
Attribute	otherLocale	Other languages and character sets used in the dataset	0..*	PT_Locale	
Attribute	metadataPointOfContact	Point of contact for metadata	0..1	CI_Responsibility>CI_Individual or CI_Responsibility>CI_Organisation	Only if metadataPointOfContact differs from producingAgency
Attribute	metadataTimeStamp	Date stamp for metadata	0..1	Date	May or may not be the issue date
Attribute	replacedData	Indicates if a cancelled dataset is replaced by another data file(s)	0..1	Boolean	See note following <a href="#">S-100, Part 17, Table S100_DatasetDiscoveryMetadata</a> <b>Mandatory when purpose = cancellation</b>
Attribute	dataReplacement	Dataset name	0..*	CharacterString	A dataset may be replaced by 1 or more datasets. <b>Dataset name must be according to format defined in Clause 11.2.3.</b> <b>For example, 102DE00KD54.H5</b> See note following <a href="#">S-100, Part 17, Table S100_DatasetDiscoveryMetadata</a> <b>Mandatory when replacedData = true</b>
Attribute	navigationPurpose	Classification of intended navigation purpose (for Catalogue indexing purposes)	1..3	S100_NavigationPurpose	If Product Specification is intended for creation of navigational products, this attribute should be mandatory. <b>Mandatory in S-102</b>
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..1 and adds specific restrictions on the ISO 19115 structure and content. See <a href="#">S-100, Part 17</a> . Format: PnYnMnDTnHnMnS (XML built-in type for ISO 8601 duration). See <a href="#">S-100, Part 17, Clause 4.9</a> . <b>S-102 discovery metadata blocks should populate maintenance information if and only if the date of</b>

Role name	Name	Description	Mult	Type	Remarks
					the next edition is definite, whether it is due on a regular or irregular schedule.

### 12.5.1 S100\_NavigationPurpose

S-102 uses S100\_NavigationPurpose without modification.

### 12.5.2 S100\_DataCoverage

S-102 uses S100\_DataCoverage without modification, but with additional remarks and changes to the multiplicity.

**Table 12-2 — S100\_DataCoverage parameters**

Role name	Name	Description	Mult	Type	Remarks
Class	S100_DataCoverage	A spatial extent where data is provided along with the display scale information for the provided data	-	-	This field is used by user systems as part of the data loading and unloading algorithms, and it is strongly encouraged that Product Specifications mandate the use of one or more of the displayScale provided as part of S100_DataCoverage.
Attribute	boundingPolygon	A polygon which defines the actual data limit	1	EX_BoundingPolygon	<a href="#">Clause 12.5.2, Note</a>
Attribute	temporalExtent	Specification of the temporal extent of the coverage	0	S100_TemporalExtent	<b>The <i>temporalExtent</i> is not used in S-102.</b>
Attribute	optimumDisplayScale	The scale at which the data is optimally displayed	0..1	Integer	Example: A scale of 1:25000 is encoded as 25000
Attribute	maximumDisplayScale	The maximum scale at which the data is displayed	0..1	Integer	
Attribute	minimumDisplayScale	The minimum scale at which the data is displayed	0..1	Integer	
Attribute	approximateGridResolution	The resolution of gridded or georeferenced data (in metres)	1..2	Real	<b>Mandatory in S-102</b> A single value may be provided when all axes have a common resolution. For multiple value provision, use axis order as specified in dataset.

Role name	Name	Description	Mult	Type	Remarks
					For example, for 5 metre resolution, the value 5 must be encoded. If the grid cell size varies over the extent of the grid (i.e., when using a geographic grid), an approximated value should be used.
NOTE: <i>boundingPolygon</i> is restricted to a single GML Polygon with one exterior and 0 or more interiors expressed as Linear Rings using SRS EPSG:4326. The exterior and optional interiors shall be composed of a closed sequence of >=4 coordinate positions expressed individually or as a list (posList). The GML polygon shall have a valid GML identifier.					

### 12.5.3 S100\_Purpose

S-102 uses S100\_Purpose without modification, but with a restriction on the allowed values.

**Table 12-3 — S100\_Purpose**

Role name	Name	Description	Code	Remarks
Enumeration	S100_Purpose	The purpose of the dataset	-	<b>The S-100 values <i>update</i>, <i>reissue</i>, and <i>delta</i> are not used in S-102.</b>
Value	newDataset	Brand new dataset	1	No data has previously been produced for this area.
Value	newEdition	New edition of the dataset or Catalogue	2	Includes new information which has not been previously distributed by updates.
Value	cancellation	Dataset or Catalogue that has been cancelled	5	Indicates the dataset or Catalogue should no longer be used and can be deleted.

### 12.5.4 S100\_EncodingFormat

S-102 uses S100\_EncodingFormat with a restriction on the allowed values to permit only the S-100 HDF5 format for S-102 datasets.

**Table 12-4 — S100\_EncodingFormat parameters**

Role name	Name	Description	Code	Remarks
Enumeration	S100_EncodingFormat	The encoding format	-	<b>The only value allowed in S-102 is “HDF5”.</b>
Value	HDF5	The HDF5 data format as defined in <a href="#">S-100, Part 10c</a>	3	-

### 12.5.5 S100\_ProductSpecification

S-102 uses S100\_ProductSpecification without modification, but with additional remarks and changes to the multiplicity.

**Table 12-5 — S100\_ProductSpecification parameters**

Role name	Name	Description	Mult	Type	Remarks
Class	S100_ProductSpecification	The Product Specification contains the information needed to build the specified product.	-	-	-
Attribute	name	The name of the Product Specification used to create the datasets	1	CharacterString	The name in the GI Registry should be used for this field. <b>For S-102, this name is “Bathymetric Surface” (as of 25 June 2024).</b>
Attribute	version	The version number of the Product Specification	1	CharacterString	TR 2/2007 specifies versioning of Product Specifications <b>Example: 3.0.0 for S-102 Edition 3.0.0</b>
Attribute	date	The version date of the Product Specification	1	Date	-
Attribute	productIdentifier	Machine readable unique identifier of a product type	1	CharacterString (Restricted to Product ID values from the IHO Product Specification Register in the IHO Geospatial Information (GI) Registry)	<b>For S-102, this identifier is “S-102” (without quotes).</b>
Attribute	number	The number used to lookup the product in the Product Specification Register of the IHO GI registry	1	Integer	For IHO Product Specifications, these numbers should be taken from the IHO Product Specification Register in the IHO GI Registry. <b>The corresponding Idx-number of the IHO Registry for S-102 is numbered 199.</b>
Attribute	complianceCategory	The level of compliance of the Product Specification to S-100	0..1	S100_ComplianceCategory	See <a href="#">S-100, Part 4a, Clause 4a-5.5</a> and <a href="#">Clause 12.5.6</a> below.

### 12.5.6 S100\_CompliancyCategory

S-102 exchange sets conforming to this edition of S-102 and using a CRS from the EPSG registry may be encoded as category 3 or 4 when the *compliancyCategory* metadata attribute is populated. Because S-98 interoperability assumes *category4* datasets, *category4* may be used for test purposes, though the absence of test datasets and of a published IHO interoperability catalogue mean this edition of S-102 does not yet qualify for *category4*. Given the uncertainty about interoperability testing requirements and availability of test datasets, the S-100 WG chair and S-102 PT chair should be consulted for up-to-date guidance.

Table 12-6 — S100\_CompliancyCategory

Role Name	Name	Description	Code	Remarks
Enumeration	S100_CompliancyCategory	-	-	<b>S-102 should use <i>category3</i> or <i>category4</i>, subject to the guidance provided in <a href="#">Clause 12.5.6</a>.</b>
Value	category3	IHO S-100 compliant with standard encoding	3	<b>Qualifies as <i>category2</i>; plus “The Product Specification uses only an encoding method defined in <a href="#">S-100, Part 10 and Part 4a, Clause 5.5.3</a>”</b>
Value	category4	IHO S-100 and IMO harmonized display compliant	4	<b>Qualifies as <i>category3</i>; plus additional requirements, including a portrayal catalogue, cybersecurity (digital signatures and encryption), test material, use of a CRS from the EPSG Registry, and compliance with the IHO S-98 interoperability catalogue. <a href="#">S-100, Part 4a, Clause 5.5.4</a></b>

### 12.5.7 S100\_ProtectionScheme

S-102 uses S100\_ProtectionScheme without modification.

## 12.6 MD\_MaintenanceInformation

S-102 uses MD\_MaintenanceInformation without modification.

## 12.7 MD\_MaintenanceFrequencyCode

S-102 uses MD\_MaintenanceFrequencyCode without modification.

## 12.8 S100\_CatalogueDiscoveryMetadata

S-102 uses S100\_CatalogueDiscoveryMetadata without modification.

### 12.8.1 S100\_CatalogueScope

S-102 uses S100\_CatalogueScope without modification.

### 12.8.2 PT\_Locale

S-102 uses PT\_Locale without modification. The class PT\_Locale is defined in [ISO 19115-1:2014/Amd 1:2018](#). LanguageCode, CountryCode, and MD\_CharacterSetCode are ISO codelists which are defined in a codelists file which is part of the S-100 Edition 5.2.0 schema distribution.

## 12.9 Certificates and Digital Signatures

The classes S100\_SE\_CertificateContainerType ([S-100, Part 15, Clause 8.11.1](#)), S100\_SE\_DigitalSignatureReference ([S-100, Part 15, Clause 8.11.7](#)), and S100\_SE\_DigitalSignature are defined in [S-100, Part 15](#) and implemented in the S-100 generic schemas.

In accordance with [S-100, Part 15](#), only the ECDSA algorithm is allowed from the S100\_SE\_DigitalSignatureReference enumeration.

S-102 uses S100\_SE\_DigitalSignature without modification. As stated in [S-100, Part 15, Clause 15–8.11.3](#):

“The class S100\_SE\_DigitalSignature is realized as one of either S100\_SE\_SignatureOnData (a digital signature of a particular identified resource) or an additional digital signature defined using the class S100\_SE\_AdditionalSignature, each of which is either a S100\_SE\_SignatureOnData or S100\_SE\_SignatureOnSignature element as described in [S-100, Part 15, Clause 8.8](#). [S-100, Part 17](#) metadata thus allows for multiple digital signatures, a single mandatory S100\_SE\_SignatureOnData and any number of additional signatures, either of the data or other signatures.”

## Annex A

### Data Classification and Encoding Guide

#### A.1 Features

##### A.1.1 BathymetryCoverage

**Table A-1 — BathymetryCoverage feature parameters**

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

##### A.1.2 QualityOfBathymetryCoverage

**Table A-2 — QualityOfBathymetryCoverage feature parameters**

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

#### A.2 Feature Attributes

##### A.2.1 BathymetryCoverage

**Table A-3 — BathymetryCoverage feature attribute parameters**

IHO Definition: <b>depth</b> . The vertical distance from a given water level to the bottom [S-32].
Unit: metres
Resolution: 0.01
Remarks:
<ul style="list-style-type: none"> <li>Drying heights (drying depths) are indicated by a negative value.</li> </ul>
IHO Definition: <b>uncertainty</b> . Estimate characterising the range of values within which the true value of a measurement is expected to lie as defined within a particular confidence level. It is expressed as a positive value.
Unit: metres
Resolution: 0.01
Remarks:

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

### A.2.2 QualityOfBathymetryCoverage

**Table A-4 — QualityOfBathymetryCoverage feature attribute parameters**

IHO Definition: <b>ID</b> . Meta data record identifier for QualityOfBathymetryCoverage
Unit:
Resolution:
Remarks: