

Marine Protected Areas Product Specification

Edition 1.1.0 – December 2024

IHO



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Organization

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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 2014?	S100WG?	Approved edition of S-411
1.1.0	Nov 2024	S100WG	Basic document structure in place tidied up some of the S-102 elements

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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://iho.int/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://iho.int/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://iho.int/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.iho.int/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

Title Marine Protected Area Product Specification.

Abstract 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 Ma

Acronym S-122

Content 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. [Annex A](#), in addition to [\[tsf\]](#), will provide implementation guidance for developers.

Spatial Extent **Description:** Global coverage of maritime areas.
East Bounding Longitude: 180°
West Bounding Longitude: -180°
North Bounding Latitude: 90°
South Bounding Latitude: -90°

Purpose 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](#).

Title Marine Protected Area Product Specification

S-100 Version 5.2.0

S-122 Version 1.2.1

Date November 2024

Language English

Classification Unclassified

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Identifier S-122

Maintenance 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.

Scope Identification

GeneralScope

3 Data Product Identification

Title	Marine Protected Areas
Alternate Title	None
Abstract	<p>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.</p> <p>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. This sanctuary includes both national and international waters.</p>

Figure 3-1

Topic Category	<p>Main topics for the product, as according to ISO 19115-1:2014/Amd 1:2018 MD_TopicCategoryCode:</p> <p>006 — elevation</p> <p>014 — oceans</p> <p>012 — inlandWaters</p>
Geographic Description	Areas specific to marine navigation.
Spatial Resolution	...
Purpose	...n.
Language	English (Mandatory), other (Optional)
Classification	<p>Data can be classified as one of the following:</p> <ol style="list-style-type: none"> 1) Unclassified; 2) Restricted; 3) Confidential; 4) Secret; 5) Top Secret; 6) Sensitive but unclassified; 7) For official use only; 8) Protected; 9) Limited distribution
Spatial Representation Type	<p>Type of spatial representation for the product, as defined by the ISO 19115-1:2014/Amd 1:2018 MD_SpatialRepresentationTypeCode: XXX — XXX.</p>

Point of Contact Producing Agency

4 Data Content and Structure

4.1 Introduction

intro here.

4.2 Application Schema

4.2.1 Application Schema implementation classes

4.2.1.1 Implementation classes description

4.3 Feature Catalogue

4.3.1 Introduction

4.3.2 Feature types

4.3.2.1 Geographic

4.3.2.2 Meta

4.3.3 Feature relationship

4.3.4 Attributes

4.3.4.1 Simple attributes

4.3.4.2 Complex attributes

4.4 Dataset types

4.4.1 Introduction

4.5 Geometry

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 https://epsg.org .	

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

5.3 Vertical Coordinate Reference System

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

9.2 Portrayal Catalogue

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).

Format Name	HDF5
Version	1.8.8
Character Set	UTF-8
Specification	https://www.hdfgroup.org/

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 List</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](#).

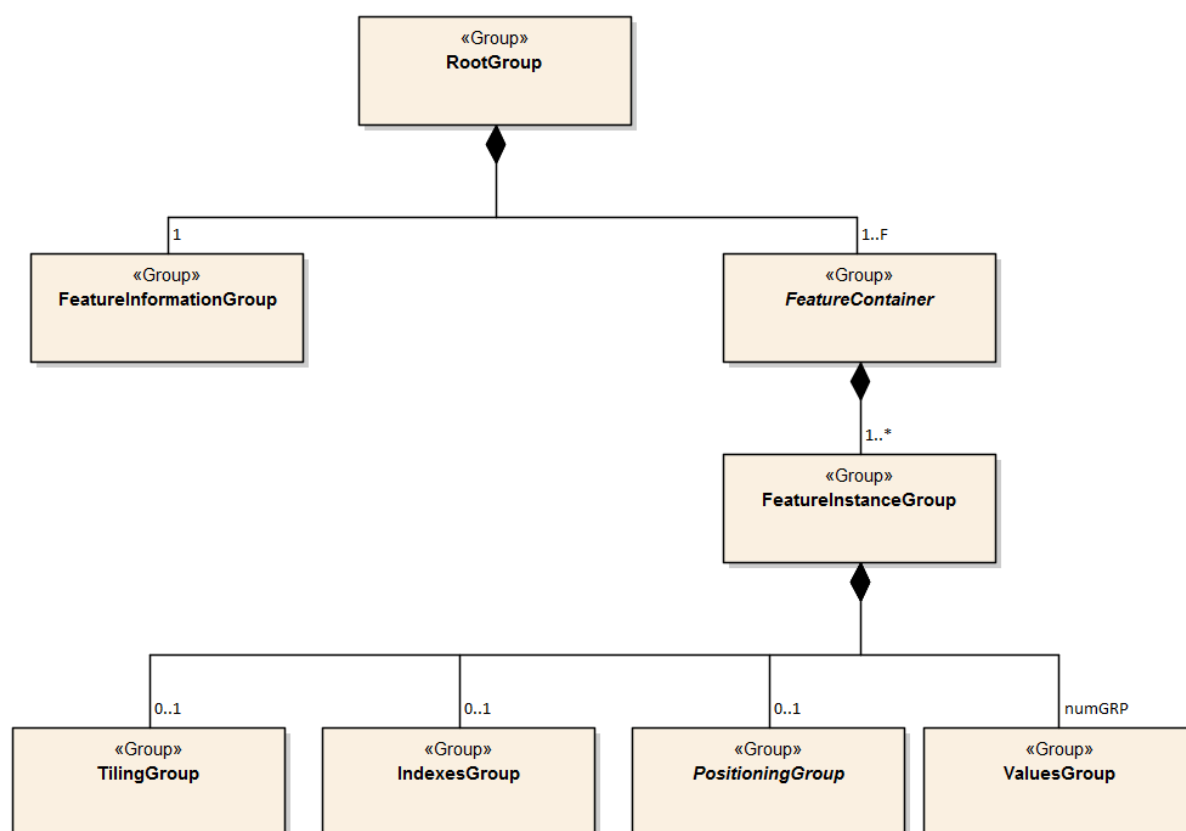


Figure 10-1 — Outline of the generic data file structure

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>)			

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

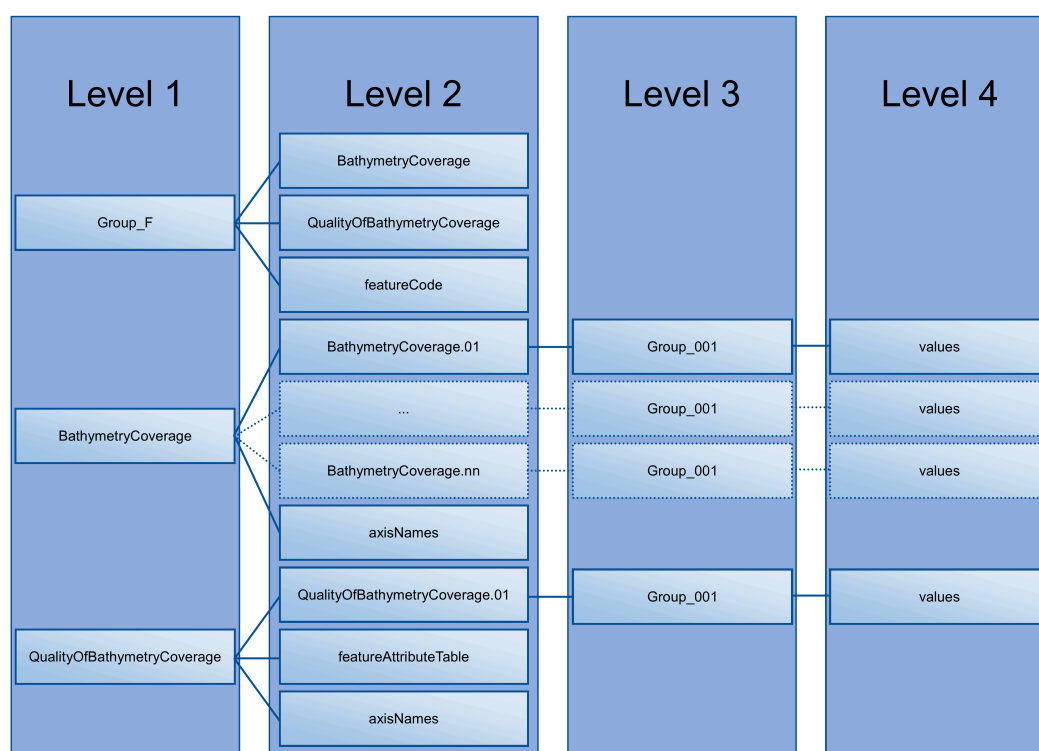


Figure 10-2 — Hierarchy of S-102 Data Product

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	S-100, Part 10c, Table 6 Example: INT.IHO.S-102.3.0.0
2	Time of data product issue	issueTime	0..1	String (Time format)	S-100, Part 1, Table 2 S-100, Part 10c, Table 1
3	Issue date	issueDate	1	String (Date format)	S-100, Part 1, Table 2 S-100, Part 10c, Table 1
4	Horizontal CRS	horizontalCRS	1	Integer 32-bit	The identifier (EPSG code) of the horizontal CRS as defined in Clause 5.2 (see Clause 10.2.1, Note 2).
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
				32-bit	the baseCRS underlying the projected CRS (see Clause 10.2.1, Note 3). 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 S-100, Part 10c, Clause 12 & S-100, Part 8).
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 S-100, Part 10c, Table 22).
10	Vertical datum reference	verticalDatumReference	1	Enumeration	Mandatory in S-102. The only allowed value is 1: <i>s100VerticalDatum</i> (see S-100, Part 10c, Table 23).
11	Vertical datum	verticalDatum	1	Integer unsigned 16-bit	Numeric code from IHO GI Registry <i>Vertical Datum</i> attribute 1 – 30 & 44 see Clause 10.2.1, Note 4

NOTE 1: The *productIdentifier* (“S-102”) and *version* fields (X.X.X) of S100_ProductSpecification must be used.

NOTE 2: The value *horizontalCRS* 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 [S-100, Part 10c, Table 6](#).

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 [S-100, Part 6, Table 6](#)).

NOTE 4: This is the default vertical datum. If and only if a **BathymetryCoverage** feature instance group does not specify a vertical datum, this (Root Group) vertical datum shall apply.

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 S-100, Part 1 .	closedInterval	geSemiInterval	geSemiInterval
NOTE: The <i>uncertainty</i> 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 S-100, Part 8, Table 11 .
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 Clause 10.2.4, Note
7a	Sequencing rule	sequencingRule.type	1	Enumeration	Value: 1 (linear) see S-100, Part 8, Table 12 .
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 [scanDirection]
8	Interpolation type	interpolationType	1	Enumeration	Value: 1 (nearestneighbor). See S-100, Part 8, Table 13
9	Offset of data point in cell	dataOffsetCode	1	Enumeration	Value: 5 barycenter (centroid) of cell. See S-100, Part 10c, Table 10
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 Table 10-6
	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 Table 10-6
	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	Grid coordinates of the grid point to which the first in the sequence of values is to be assigned. The choice of a valid point for the start sequence is determined by the sequencing rule. Format: n, n Example: "0,0" (without quotes)
10	Vertical datum	verticalDatum	0..1	Integer unsigned 16-bit	see remark Table 10-2 row vertical datum and [mvdvdr] Mandatory for feature instance groups with a different vertical datum from that specified in the Root Group (prohibited otherwise)
11	Vertical datum reference	verticalDatumReference	0..1	Integer unsigned 8-bit	The only allowed value is 1: <code>s100VerticalDatum</code> (see S-100, Part 10c, Table 23). see [mvdvdr] Mandatory if this value were to differ from what is contained in the Root Group

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 fillValue
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 fillValue
5	Time stamp	timePoint	1	String	Because S-102 specifies survey dates elsewhere in its structure, this value should always be the fill value: <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 Clause 10.2.8, Note 1 .
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 Clause 10.2.8, Note 2 .
5	featuresDetected. sizeOfFeaturesDetected	The size of detected bathymetric features in an area.	0..1	Float 32-bit	See Clause 10.2.8, Note 3 and Clause 10.2.8, Note 4 .
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 Clause 10.2.8, Note 3 and Clause

No	Attribute	Description	Mult	Data Type	Remarks
					10.2.8, Note 4.
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 Clause 10.2.8, Note 5.
8	bathyCoverage	False for grid cells populated by interpolation.	0..1	Integer unsigned 8-bit	Boolean, Values: *1 (TRUE) *0 (FALSE). See Clause 10.2.8, Note 6.
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 S-100, Part 1, Table 2.
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 S-100, Part 1, Table 2.

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 Table 10-9 . See Clause 10.2.8, Note 7 .

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	cUBESstandardDeviation	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](#).

Medium Name	Digital Data Delivery
Other Delivery Information	<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> <p>Mandatory Elements</p> <ul style="list-style-type: none"> • S-102 datasets — HDF encoding • Exchange Catalogue—the XML encoded representation of exchange set catalogue features [discovery metadata]. <p>Optional Elements</p> <ul style="list-style-type: none"> • 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 • 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.

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.

102YYYYØØØØØØØØØØØØØØØØ.	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.
	ØØØØ	the eighth to the maximum nineteenth characters are optional and may be used in any way by the producer to provide the unique file name. The following characters are allowed in the dataset name: A to Z, 0 to 9 and the special character _ (underscore).
	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 navigations 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 navigations systems (specifically, an S-100-capable ECDIS) is encoded in the exchange catalogue. This metadata conforms to S-100 Part 17, with product-specific restrictions added.
- 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.

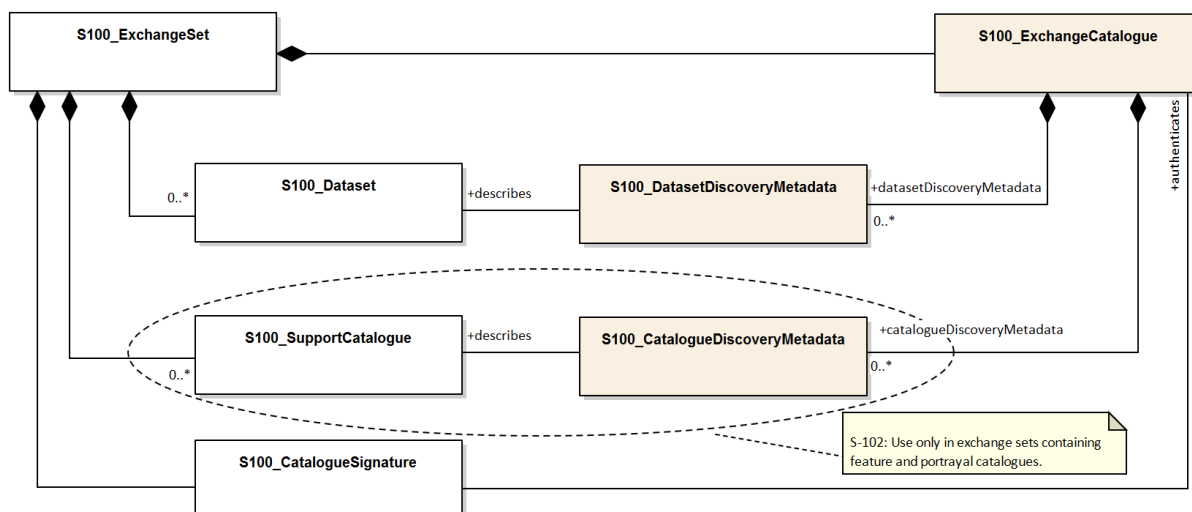


Figure 12-1 — Components and associated metadata for the S-102 exchange set (S-100, Part 17, Figure 2 with items not used by S-102 omitted)

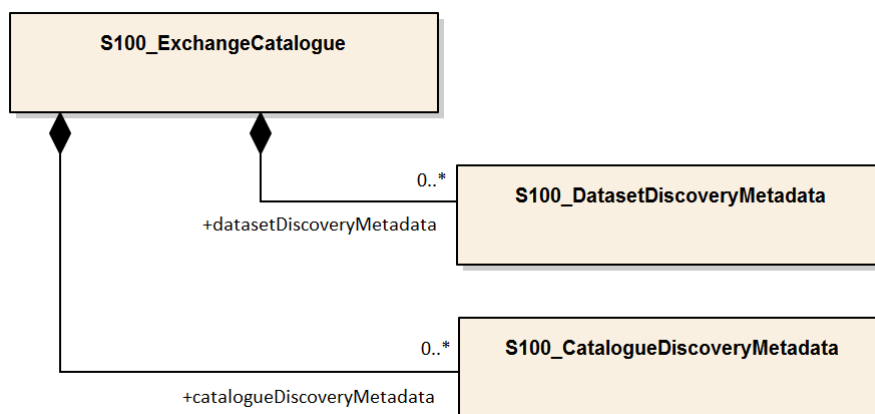


Figure 12-2 — Relationship between exchange catalogue, discovery metadata, and dataset (S-100, Part 17, Figure 6 with items not used by S-102 omitted)

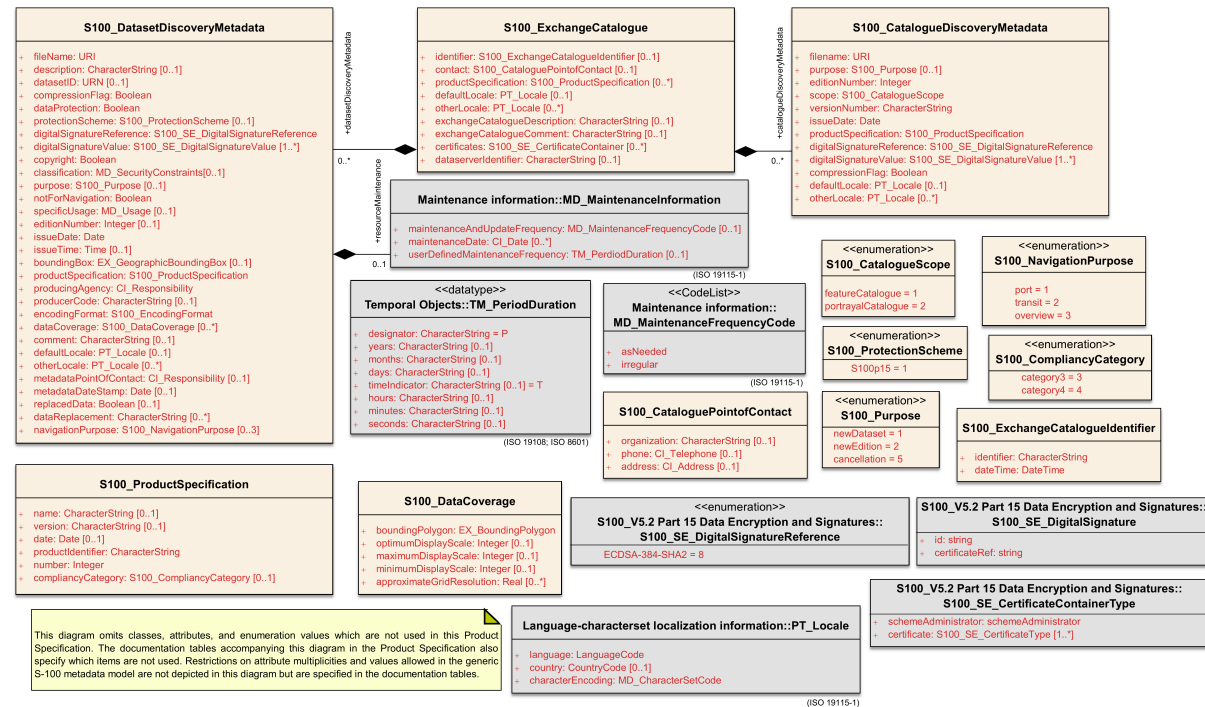


Figure 12-3 — S-102 Exchange Set Class Details (S-100, Part 17, Figure 7 with items not used by S-102 omitted)

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](#), 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 S-100, Part 1, Clause 4.6 Format: file:/S-102/DATASET_FILES/<dsname> Dataset file name <dsname> must be according to format defined in Clause 11.2.3.
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.

Role name	Name	Description	Mult	Type	Remarks
Attribute	datasetID	Dataset ID expressed as a Maritime Resource Name	0..1	URN	The URN must be an MRN. See S-100, Part 3, Clause 10
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	Populate if and only if <i>dataProtection</i> = <i>True</i>.
Attribute	digitalSignatureReference	Specifies the algorithm used to compute <i>digitalSignatureValue</i>	1	S100_SE_DigitalSignatureReference	See clause8.11.7 & Clause 12.9
Attribute	digitalSignatureValue	Value derived from the digital signature	1..*	S100_SE_DigitalSignature	see S-100, Part 15, Clause 15–8.11.3 The value resulting from application of <i>digitalSignatureReference</i> Implemented as the digital signature format specified in S-100, Part 15
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)	Mandatory in S-102 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	Mandatory in S-102

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 is not intended to be used for navigation. <i>False</i> indicates the dataset is 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. Mandatory in S-102
Attribute	issueDate	Date on which the data was made available by the Data Producer	1	Date	-
Attribute	issueTime	Time of day at which the data was made available by the Data Producer	0..1	Time	The S-100 datatype Time May be required if multiple instances of a product are issued on the same day.
Attribute	boundingBox	The extent of the dataset limits	1	EX_GeographicBoundingBox	Mandatory in S-102 Defined as a rectangle coincident with the outermost cell boundaries of the dataset.
Attribute	productSpecification	The Product Specification used to create this dataset	1	S100_ProductSpecification	Table 12-5
Attribute	producingAgency	Agency responsible for producing the data	1	CI_Responsibility>CI_Organisation	See S-100, Part 17, Table 17-3
Attribute	producerCode	The official IHO Producer Code from S-62	1	CharacterString	Mandatory in S-102
Attribute	encodingFormat	The encoding format of the dataset	1	S100_EncodingFormat	The only allowed value is HDF5 Table 12-4
Attribute	dataCoverage	Provides information about data coverages within the dataset	1..*	S100_DataCoverage	Mandatory in S-102 Table 12-2

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

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	Clause 12.5.2, Note
Attribute	temporalExtent	Specification of the temporal extent of the coverage	0	S100_TemporalExtent	The <i>temporalExtent</i> is not used in S-102.
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	Mandatory in S-102 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	-	The S-100 values <i>update</i>, <i>reissue</i>, and <i>delta</i> are not used in S-102.
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	-	The only value allowed in S-102 is “HDF5”.
Value	HDF5	The HDF5 data format as defined in S-100, Part 10c	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. For S-102, this name is “Bathymetric Surface” (as of 25 June 2024).
Attribute	version	The version number of the Product Specification	1	CharacterString	TR 2/2007 specifies versioning of Product Specifications Example: 3.0.0 for S-102 Edition 3.0.0
Attribute	date	The version date of the Product Specification	1	Date	-
Attribute	productIdentifier	Machine readable unique identifier of a product type	1	CharacterString (Restricted to Product ID values from the IHO Product Specification Register in the IHO Geospatial Information (GI) Registry)	For S-102, this identifier is “S-102” (without quotes).
Attribute	number	The number used to lookup the product in the Product Specification Register of the IHO GI registry	1	Integer	For IHO Product Specifications, these numbers should be taken from the IHO Product Specification Register in the IHO GI Registry. The corresponding Idx-number of the IHO Registry for S-102 is numbered 199.
Attribute	complianceCategory	The level of compliance of the Product Specification to S-100	0..1	S100_ComplianceCategory	See S-100, Part 4a, Clause 4a-5.5 and Clause 12.5.6 below.

12.5.6 S100_ComplianceCategory

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 *complianceCategory* metadata attribute is populated. Because S-98 interoperability assumes *category4* datasets, *category4* may be used for test purposes, though the absence of test datasets and of a published IHO interoperability catalogue mean this edition of S-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_ComplianceCategory

Role Name	Name	Description	Code	Remarks
Enumeration	S100_ComplianceCategory	-	-	S-102 should use <i>category3</i> or <i>category4</i> , subject to the guidance provided in Clause 12.5.6 .
Value	category3	IHO S-100 compliant with standard encoding	3	Qualifies as <i>category2</i> ; plus “The Product Specification uses only an encoding method defined in S-100, Part 10 and Part 4a, Clause 5.5.3 ”
Value	category4	IHO S-100 and IMO harmonized display compliant	4	Qualifies as <i>category3</i> ; plus additional requirements, including a portrayal catalogue, cybersecurity (digital signatures and encryption), test material, use of a CRS from the EPSG Registry, and compliance with the IHO S-98 interoperability catalogue. S-100, Part 4a, Clause 5.5.4

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

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

A.1.2 QualityOfBathymetryCoverage

Table A-2 — QualityOfBathymetryCoverage feature parameters

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

A.2 Feature Attributes

A.2.1 BathymetryCoverage

Table A-3 — BathymetryCoverage feature attribute parameters

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

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

A.2.2 QualityOfBathymetryCoverage

Table A-4 — QualityOfBathymetryCoverage feature attribute parameters

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