S-104

Water Level Information for Surface Navigation Product Specification

Edition 0.0.8 – February 2021

IHO

International Hydrographic Organization

Published by the
International Hydrographic Organization
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~~Web: www.iho.int~~

Version Number	Date	Editor	Purpose
0.0.0	11-Feb-15	Z Jayaswal	Initial Draft
0.0.1	1-May-16	Z Jayaswal	TWCWG 1 – Working group input incorporated from Brazil meeting
0.0.2	Aug-16	Z Jayaswal	TWCWG – incorporate feedback on Portrayal and Attributes
0.0.3	Mar-17	Z Jayaswal	Extract commonality from S-111 v0.1.10 to ensure consistency between standards.
0.0.4	May-17	Z Jayaswal	As edited during TWCWG 2
0.0.5	Nov-17	Z Jayaswal	Feedback from TWCWG and S100 WG
0.0.6	Sep-18	Z Jayaswal	Feedback from TWCWG3 and S-129 WG
0.0.7	Mar 19	Z Jayaswal	Feedback from S100 Test Strategy Working Group Sep 2018
0.0.8	Apr 19	Z Jayaswal	Feedback from NOAA and 4th TWCWG

Contents

1 Overview

S-104 is the Water Level Information for Surface Navigation Product Specification, produced by the IHO.

The development of electronic navigation with high resolution bathymetric data, and the drive to increase safety of navigation are now demanding time-sensitive data. IHO has identified the requirement for a product specification for dynamic tidal and water level data.

Tidal height information has traditionally been provided as high/low predictions however with increasing drafts and technology, there has been a move to hourly predictions with major ports providing real-time height information to their pilots and web-sites.

There is now a requirement to supply tidal and water level data as a single point time-series and as a surface time series to manage critical depths and provide tidal windows.

1.1 Introduction

This document describes an S-100 compliant product specification for the encapsulation and data transfer of tidal and water level data for use in an Electronic Chart Display and Information System (ECDIS) or any proposed dynamic tide application. Tidal and water level predictions have been fundamental in route planning and entry to ports (SOLAS Chapter V). These have traditionally been supplied as a physical hard copy publication and recently as a separate software installation that may not be integrated with the ECDIS. To improve safety of navigation, this product specification will ensure that tidal and water level data supplied for dynamic capability is consistent by all approved authorities.

1.1.1 Data Types

There are two~~three~~ different data types that can be delivered to a ship and/or to an ECDIS:

1. a time series of water level height relative to a vertical datum and trend. The data can represent either a single point (i.e. one geographic location) or for an array of points contained in a grid. Time and datum information are contained in the metadata. One purpose of this ~~standard~~data type is to update water depths for under-keel clearance management.

~~2. area (zone) of influence information, which consists of a set of polygons that describe specific geographic areas. Each polygon may be represented by a specific geographic location (centroid) for data transfer purposes. Time and datum information are contained in the metadata. The purpose of this data type is to update water depths for under-keel clearance management.~~

3. a datum separation (difference) product (“hydroid”), which provides the separation between two vertical datum fields, such as a tidal/chart datum and a defined ellipsoid. Information defining the specific datums is contained in the metadata. The purpose of this data type is to support hydrographic surveying.

Commented [GS1]: Suggested to remove this for Ed 1.0.0 for simplicity. We didn’t include this in our recent development of the HDF5 formats, metadata, Feature Catalogue, Data Classification and Encoding Guide (Annex A), and Registry. We can always add it back in for later Editions if there are important use cases for it.

1.1.2 Display

There are ~~three~~two different means of displaying water level data to support navigation, route planning, and route monitoring:

1. display of water level at a single point. The portrayal options for this are:
    a. a symbol at the location of the water level data source
    b. a text box containing information on the water level height, trend, etc.
    c. graphic time series plot(s) showing water level height over time at one or more locations

2. display of a single point location from gridded data, where a mouse click on the chart area will display the information at that point from the nearest node in the grid. The display has the qualities as described in type (1) - display of water level at a single point.

~~3. display of zones of influence, which are regions where the water level, which varies in time, is essentially spatially uniform. The depiction of a zone, which is optional, is by a polygon, and may also include additional data such as the zone-specific water level height and a location.~~

1.1.3 Encoding

There ~~is~~are ~~three~~one ~~different~~ encoding~~s~~ of water level data:

1. HDF5 (Hierarchical Data Format version 5) is used for encoding time series of water level heights and trends at a single point or at an array of points in a grid, and for encoding the ellipsoid-to-chart datum separation product ("hydroid"). HDF5 promotes compatible data exchange due to its common neutral encoding format. HDF5 is object oriented and suitable for many types of data and forms the basis of the Network Common Data Form (NetCDF), a popular format used for scientific data.

~~2. GML (Geography Markup Language) is used for encoding the zones of influence. The data will include a set of longitude-latitude pairs describing the vertices of the area-of-influence polygons plus additional information describing connecting line shapes (straight or curved).~~

~~3. AIS ASM (Automatic Identification System's Application-Specific Message) is used for encoding water level height, trend, time, and location information for multiple stations, for the purpose of providing real-time water levels. The specific ASM is the Meteorological and Hydrological Message.~~

Table 1.1 summarizes Clauses 1.1.1 through 1.1.3.

Table 1.1 – S-104 data variables, formats, encoding and display. Note: O = Overlay: a layer superimposed on and georeferenced to a nautical chart. I = Inset: a graphic that can be placed anywhere on the screen.

Data Variable	Data Format	Encoding	Display
Water Level Height and Trend	Single Location, Single Time (e.g. ~~Real-time~~ Obs.)	HDF5	Symbol (O), Text Box (O)
		~~AIS~~	~~Determined by Ship/Mfgr~~
	Single Location, Time Series (e.g. Harmonic Constant Prediction)	HDF5	Symbol (O), Text Box (O), Graphic Plot (I)
	Multiple Locations, Time Series (e.g. Gridded Forecast)	HDF5	Symbol (O), Text Box (O), Graphic Plot (I)
~~Area of Influence~~	~~Set of Polygons~~	~~GML?~~	~~Lines (O)~~
Datum Separation	Multiple Locations (e.g. Gridded Field)	HDF5	None

1.2 References

~~1.1.2~~1.2.1 Normative

S-44 *IHO Standards for Hydrographic Surveys,* 5th Edition February 2008

S-100 *IHO Universal Hydrographic Data Model*, version 3.0.0 (June 2017)

S-101 *IHO Electronic Navigational Chart Product Specification*, July 2014

Commented [GS2]: Should ISO/IEC 8211 be considered for this?

Commented [GS3]: Is information about direction of connecting the lines needed? E.g. clockwise or counter clockwise

Commented [GS4]: Real-time water levels will be included in Ed 2.0.0 or later. Removing here and throughout rest of doc

Commented [GS5]: Consider adding "1.2.1 Normative" and "1.2.2 Informative" as in S-111 v1.0.0, especially if "normative references" is used in 1.3.2 below.

S-102 *IHO Bathymetric Surface Product Specification*, April 2012

S-111 *IHO Surface Currents Product Specification, December 2018*

netCDF – Network Common Data Form Unidata - www.unidata.ucar.edu/software/netcdf

***HDF5 –** Hierarchical Data Format version 5 – www.hdfgroup.org*

1.2.2 Informative

ISO 8601:2004 *Data elements and interchange formats - Information interchange - Representation of dates and times*

ISO 3166-1:1997 Country Codes

ISO/TS 19103:2005 *Geographic information – Conceptual schema language*

ISO 19111:2003 *Geographic information – Spatial referencing by coordinates*

ISO 19115:2003 *Geographic information – Metadata updated by Corr1 (2006)*

ISO 19115-2:2009 *Geographic information – Metadata: Extensions for imagery and gridded data*

ISO 19123:2005 *Geographic information – Schema for coverage geometry and functions*

ISO 19129:2009 *Geographic information – Imagery gridded and coverage data framework*

ISO 19131:2007 *Geographic information – Data product specifications*

ISO/IEC 19501-1 and 19505-2, *Information technology — Open Distributed Processing – Unified Modelling Language Version 2.4.1*

~~1.2~~1.3 Terms, Definitions and Abbreviations

~~1.2.1~~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.

~~1.2.2~~1.3.2 Terms and Definitions

Terms and definitions have been taken from the normative references cited in clause 1.2. Only those which are specific to this document have been included and modified where necessary. Additional terms are defined in this document.

1.3.2.1 Coordinate

one of a sequence of numbers designating the position of a point in N-dimensional space [ISO 19111]

1.3.2.2 coordinate reference system

coordinate system which is related to the real world by a datum [ISO 19111]

1.3.2.3 coverage

feature that acts as a **function** to return values from its **range** for any **direct position** within its spatial, temporal, or spatiotemporal **domain**
EXAMPLE: Examples include a raster **image**, polygon overlay, or digital elevation matrix
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 [ISO 19123]

1.3.2.4 coverage geometry

configuration of the **domain** of a **coverage** described in terms of **coordinates** [ISO 19123]

1.3.2.5 data product

dataset or **dataset series** that conforms to a **data product specification**
NOTE: The S-104 data product consists of metadata and one or more sets of water level height and trend, and/or vertical datum difference values [ISO 19131]

1.3.2.6 direct position

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

1.3.2.7 domain

well-defined set [ISO 19103]
NOTE: Domains are used to define the domain set and range set of operators and functions.

1.3.2.8 Elevation

the altitude of the ground level of an object, measured from a specified vertical datum. [IHO S100 GFM]

1.3.2.9 Feature
abstraction of real world phenomena [ISO 19101]
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**
EXAMPLE 1: A **feature attribute** named *colour* may have an **attribute** value *green* which belongs to the **data type** *text*
EXAMPLE 2: A **feature attribute** named *length* may have an **attribute** value *82.4* which belongs to the **data type** *real*
NOTE 1: A **feature attribute** may occur as a **type** or an **instance**. **Feature attribute** type or **feature attribute** instance is used when only one is meant

NOTE 2: 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 **domain** of the **feature attribute** type
NOTE 3: In a **feature catalogue**, a **feature attribute** may include a value **domain** but does not specify **attribute** values for **feature** instances
[ISO 19101, ISO 19109, ISO 19110, ISO 19117]

1.3.2.11 Height

distance of a point from a chosen reference surface measured upward along a line perpendicular to that surface. [ISO 19111:2006]
NOTE 1: Height is distinguished from elevation in that is a directional measurement.
NOTE 2: Height is used when referring to water level.

1.3.2.12 georeferenced grid

grid for which cells can be located by the use of specific algorithms. See **ungeorectified grid**.

1.3.2.13 grid

network composed of a set of elements, or cells, whose vertices, or nodes, have defined positions within a coordinate system. See also **georeferenced grid, regular grid, ungeorectified grid, node,** and **grid point**. [ISO 19123]
NOTE 1: A rectangular grid has axes perpendicular to each other
NOTE 2: A uniform rectangular grid has constant spacing in the X-direction and constant spacing in the Y-direction, although the two spacing values are not necessarily equal

1.3.2.14 grid cell

element of a grid defined by its vertices, or **nodes**

1.3.2.15 grid point

point located at the intersection of two or more **grid cells** in a **grid.** Also called a **node**. [ISO 19123]

1.3.2.16 Record

Finite, named collection of related items (objects or values) [ISO 19107]
NOTE: Logically, a record is a set of pairs <name,item>

1.3.2.17 uncertainty

The interval (about a given value) that will contain the true value of the measurement at a specific confidence level [IHO S-44].

NOTE: Errors exists 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.

1.3.2.18 water level trend

Change of water level at a given time, such as 'increasing', 'decreasing', or 'steady'.
When the average ~~rate of~~ change of the water level ~~observations~~ over a one hour period is ~~less~~greater than or equal to ~~0.20~~a value set by the producing authority in m ~~m~~ it is considered "increasing". When it is less than or equal to - value set by the producing

Commented [GS6]: Is "Water Level Height", and "Datum Difference Value" needed here too?

authority in m ~~0.2 m~~, it is “decreasing”. When it is between ~~0.2 and -0.2~~the value set by the producing authority~~.~~, it is “steady”.
In areas of small water level range, e.g. Baltic Sea, use of “not available” is optional.

1.3.2.19 ungeorectified grid

grid with non-uniform point spacing in any coordinate system. Includes triangular irregular networks (TINs) and those curvilinear coordinate grids whose node positions cannot be calculated analytically.

~~1.2.3~~1.3.3 Abbreviations

CRS	Coordinate Reference System
ECDIS	Electronic Chart Display Information System
EPSG	European Petroleum Survey Group
ENC	Electronic Navigational Chart
IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization

~~1.2.3.1~~1.3.3.1 Notation

In this document conceptual schemas are presented in the Unified Modelling Language (UML). Several model elements used in this schema are defined in ISO standards developed by ISO TC 211, or in IHO S-100. In order to ensure that class names in the model are unique ISO TC/211 has adopted a convention of establishing a prefix to the names of classes that define the TC/211 defined UML package in which the UML class is defined. Since the IHO standards and this product specification make use of classes derived directly from the ISO standards this convention is also followed here. In the IHO standards the class names are identified by the name of the standard, such as “S100” as the prefix optionally followed by the bialpha prefix derived from ISO. For the classes defined in this product specification the prefix is *“S104”.* In order to avoid having multiple classes instantiating the same root classes, the ISO classes and S-100 classes have been used where possible; however, a new instantiated class is required if there is a need to alter a class or relationship to prevent a reverse coupling between the model elements introduced in this document and those defined in S-100 or the ISO model.

Table 1.3.3-1 – Sources of externally defined UML classes

Prefix	Standard	Package
CI	ISO 19115	Citation and Responsible Party
CV	ISO 19123	Coverage Core & Discrete Coverages
DQ	ISO 19115	Data Quality Information
DS	ISO 19115	Metadata Application Information
EX	ISO 19115	Metadata Extent information
IF	ISO 19129	Imagery Gridded and Coverage Data Framework
LI	ISO 19115	Linage Information
MD	ISO 19115	Metadata entity set information
MI	ISO 19115-2	Metadata entity set imagery
S100	IHO S-100	IHO Standard for Hydrographic Data
SC	ISO 19111	Spatial Referencing by Coordinates
SD	ISO 19130	Sensor Data
S101	IHO S-101	IHO Electronic Navigational Chart Product Specification
S102	IHO S-102	IHO Bathymetric Surface Product Specification
S111	IHO S-111	IHO Surface Currents Product Specification

~~1.3~~1.4 General Data Product Description

Title: Water Level Information for Surface Navigation Product Specification

Abstract: Encodes information and parameters for use in making a tidal and water level product.

Content: Describes the tidal and water level data contained in the product. The specific content is defined by the feature catalogue and schema.

Spatial Extent:

Description: Areas where Tidal Information is available

East Bounding Longitude: 180

West Bounding Longitude: -180

North Bounding Latitude: 90

South Bounding Latitude: -90

Purpose: The data shall be used to produce a dataset to be used for dynamic water level applications, including an ECDIS.

~~1.4~~1.5 Data Product Specification Metadata

Title: IHO S-104 Water Level Product Specification

S-100 Version: ~~5~~3.0.0

S-104 Version: 0.0.~~8~~6

IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

Date: February~~September~~ 2021~~18~~

Language: English

Classification: Unclassified (TBC)

Contact: International Hydrographic ~~Bureau~~Organization.
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B.P. 445 MC 98011 MONACO CEDEX
Telephone: +377 93 10 81 00
Telefax: + 377 93 10 81 40

URL: www.iho.int

Identifier: S-104

Maintenance: Changes to the Product Specification S-104 are coordinated by Tides, Water Level and Currents Working Group (TWCWG) of the IHO and made available via the IHO Publications website. Maintenance of the Product Specification must conform to IHO Technical Resolution 2/2007 (revised 2010). This specification will be a standing agenda item for TWCWG meeting with clarifications, revisions and new editions released as required. A new edition will be released every 5-10 years depending on technological advances.

Commented [JZM7]: Need to point to final version of specification once published

~~1.4.1~~1.5.1 IHO Product Specification Maintenance

~~1.4.1.1~~1.5.1.1 Introduction

Changes to S-104 will be released by the IHO as a new edition, revision, or clarification.

~~1.4.1.2~~1.5.1.2 New Edition

New Editions of S-104 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-104.

~~1.4.1.3~~1.5.1.3 Revisions

Revisions are defined as substantive semantic changes to S-104. Typically, revisions will change S-104 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-104. All cumulative *clarifications* must be included with the release of approved corrections 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-104.

~~1.4.1.4~~1.5.1.4 Clarification

Clarifications are non-substantive changes to S-104. 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-104.

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 catalogues.

Changes in a clarification are minor and ensure backward compatibility with the previous versions

~~1.4.1.5~~1.5.1.5 Version Numbers

The associated version control numbering to identify changes (n) to S-104 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 Scopes

This product specification outlines the types of water level products from the national Hydrographic Office (HO) or authorised producer, to the end user. The data may be historical observation, real-time observation, astronomical prediction, analysis or hybrid method, hindcast or forecast models. Requirements for data and metadata are provided. The ~~three~~ two data products are:

Commented [GS8]: Does area of influence information need to be here too, to match 1.1.1 and 4.1?

a) Time series product, including series of water level heights relative to a vertical datum and the water level trend (rising, falling, etc.). The data products are i) single point product– provision of water level information for a single point in the traditional graphic display mariners are familiar with from hard copy publications and digital tide tables, and ii) gridded data product– provision of water level information for a defined region as a surface, allowing any grid point to be queried as per a traditional single point.

~~Areas of influence product– a set of polygons that describe specific geographic areas where the water level, which varies in time, is essentially spatially uniform.~~

b) Datum separation ("hydroid") product– this product will provide the mariner the separation surface between ~~the Ellipsoid~~two vertical datum fields, such as a defined ellipsoid and a tidal, or chart, datum for a defined region.

Scope ID: Global
Level: 006- series
Level name: Water Level Dataset

3 Dataset Identification

Title: Water Level Data Product

Alternate Title: None

Abstract: This data product is a file containing water level data for a particular geographic region and set of times, along with the accompanying

metadata describing the content, variables, applicable times, locations and structure of the data product. Water level data is the height of the water observed or mathematically-predicted. The data may consist of water level at a small set of points where observations/or predictions are available or may consist of numerous points organized in a grid as from a hydrodynamic model forecast.

Topic Category: Producing authority to choose the most appropriate from the list below:

Name	ISO 19115 Domain Code	Definition
Elevation	006	Height above or below mean sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products
Inland Waters	012	Inland water features, drainage systems and their characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, Hydrographic charts
Oceans	014	Features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs

Geographic Description: Areas specific to water navigation

Spatial Resolution: The spatial resolution, or the spatial dimension of the earth covered by the size of a grid matrix cell (nominal ground sample distance), varies according to the model adopted by the producer.

Purpose: Water level data is intended to be used as stand-alone data or as a layer in an ENC.

Language: English

Classification: Data can be classified as one of the following:

- Unclassified
- Restricted
- Confidential
- Secret
- Top Secret

Spatial Representation Type: Coverage

Point of Contact: Producing Authority.

Use Limitation: Invalid over land

4 Data Content and structure

4.1 Introduction

This section discusses the application schema, which is described in UML; the feature catalogue; dataset types, in which there is an extensive discussion of the water level data; dataset loading and unloading; and geometry.

Water level data consist of ~~three~~ two basic types:

1. a time series of water level ~~at a point of time~~height and trend relative to a vertical datum. The data can be represented ~~as a time series of values~~ for either a single point (i.e. one geographic location) or for an array of points contained in a grid. Time and datum information are contained in the metadata.

~~The gridded Hydroidarea of influence information, which consists of a set of polygons that describe specific geographic areas, plus a centroid location(?). Time and datum information are contained in the metadata.~~

2. a datum separation product (e.g., a hydroid), which provides the separation between a chart datum ~~relative to~~and a defined ellipsoid ~~that matches what~~. Datum information is ~~used for the chart created by~~contained in the ~~same product producer~~metadata.

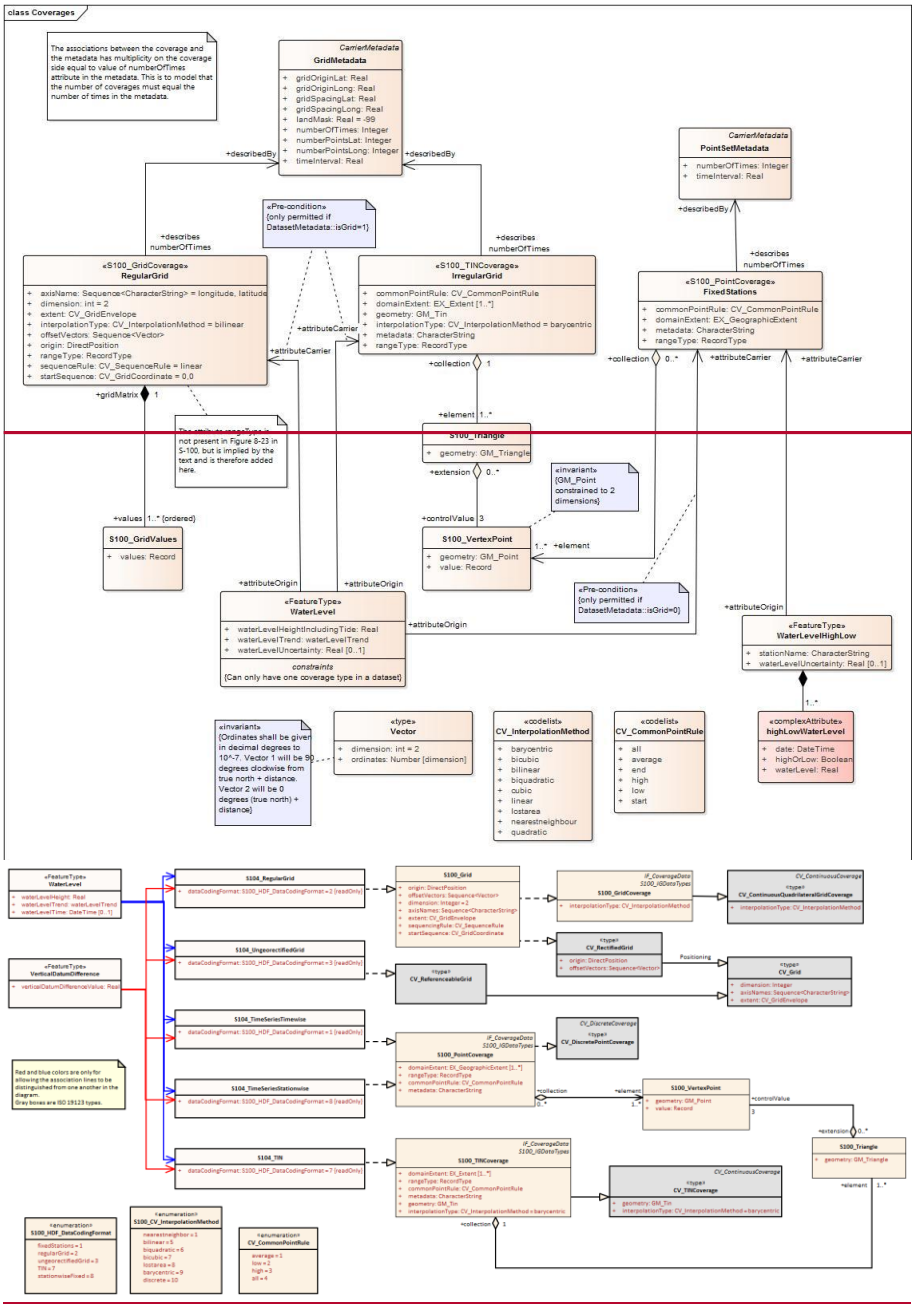

Figure 4.1 – Spatial Types - Coverages

4.2 Application Schema

This application schema~~e~~ is expressed in UML. The details of the application schema are given in ANNEX C.

4.3 Feature Catalogue

4.3.1 Introduction

The S-104 Feature Catalogue describes the feature types, information types, attributes, attribute values, associations and roles which may be used in the product. See ANNEX D – Feature Catalogue

The S-104 Feature Catalogue is available in an XML document which conforms to the S-100 XML Feature Catalogue Schema and can be downloaded from the IHO website.

4.3.2 Feature Types

4.3.2.1 Geographic

Geographic (geo) feature types form the principle content of S-104 and fully defined by their associated attributes.

4.3.2.2 Meta

Meta features contain information about other features within a data set. Information defined by meta features override the default metadata values defined by the data set descriptive records. Meta attribution on individual features overrides attribution on meta features.

4.3.3 Feature Relationship

A feature relationship links instances of one feature type with instances of the same or a different feature type. There are three common types of feature relationship: Association, Aggregation and Composition. In S-104 there are no relationships used.

4.3.4 Attributes

S-100 defines attribute~~s~~ as either simple or complex. S-104 uses ~~eight~~ three types of simple attributes, listed in Table 4.1. There are no complex attributes.

Table 4-1 - Simple feature attribute types.

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values
~~Boolean~~	~~A value representing binary logic. The value can be either *True* or *False*. The default state for Boolean type attributes (i.e. where the attribute is not populated for the feature) is *False*.~~
Real	A signed Real (floating point) number consisting of a mantissa and an exponent
~~Integer~~	~~A signed integer number. The representation of an integer is encapsulation and usage dependent.~~

Commented [GS9]: These are being updated with the help of S-100WG

Commented [GS10]: Are only Enumeration and Real types used for feature attributes in S-104?

Commented [GS11R10]: Real, Enumeration, and DateTime are the 3 types of simple attributes used. They are used for waterLevelHeight, waterLevelTrend, and waterLevelTime, respectively.

~~CharacterString~~	~~An arbitrary-length sequence of characters including accents and special characters from a repertoire of one of the adopted character sets~~
~~Date~~	~~A date provides values for year, month and day according to the Gregorian Calendar. Character encoding of a date is a string which must follow the calendar date format (complete representation, basic format) for date specified by ISO 8601:1988.~~ ~~EXAMPLE 19980918 (YYYYMMDD)~~
~~Time~~	~~A time is given by an hour, minute and second. Character encoding of a time is a string that follows the local time (complete representation, basic format) format defined in ISO 8601:1988.~~ ~~EXAMPLE 183059 or 183059+0100 or 183059Z~~
Date and Time	A DateTime is a combination of a date and a time type. Character encoding of a DateTime shall follow ISO 8601:1988 EXAMPLE 19850412T101530

4.3.5 Spatial Quality

Spatial quality attributes (Figure 4.2~~1~~) are carried in an information class called **spatial quality**. Only points, multipoint and curves can be associated with spatial quality.

Water levels are usually defined at one or more individual locations, so spatial quality applies to these locations. The spatial quality will list the following:

Commented [JZM12]: S100 Review: Describe how quality is handled by the data created in S-104 and create specific examples that relates to S-104 including diagram

For Single station data product:

1) Port Type- a) Standard/Major or b) Secondary/minor

2) Sigma confidence of predictions/models or

3) Instrument measuring accuracy for observed

For Gridded data product:

1) Sigma confidence of predictions/model

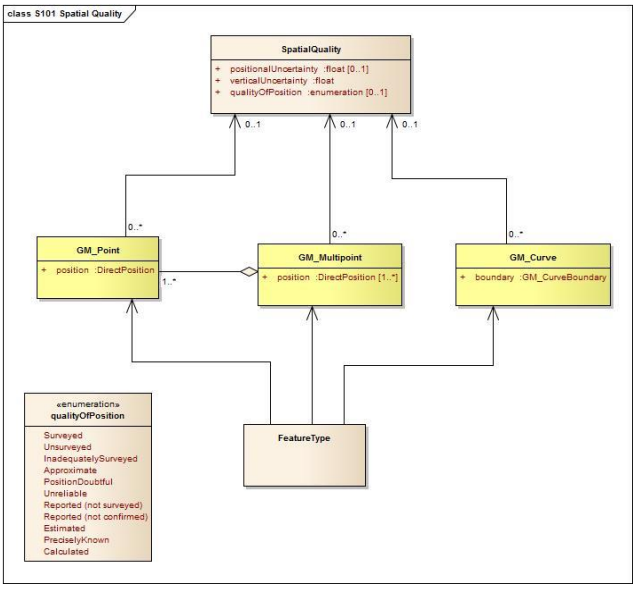

Figure 4.2 - Spatial Quality Information Type

Commented [GS13]: Figure is missing- use same as in S-111, or different?

This may be updated with the help of S-100WG

4.4 Dataset Types

Datasets for S-104 include ~~three~~one basic type~~s~~:

1. HDF5 files, which may contain (a) time series of predicted or observed water level heights and trends at one or more fixed stations, (b) gridded hydrodynamic model forecast fields, and (c) gridded datum separation (e.g., ellipsoid-to-chart datum) fields.

~~2. GML files, which may contain a set of longitude-latitude pairs describing the vertices of the area-of-influence polygons plus additional information describing connecting line shapes (e.g. straight or curved).~~

~~**NOTE:** potentially, some of the information in GML files may be included in the HDF5 files.~~

~~3. AIS ASM files, which may contain time, location, water level height, and water level trend information for one or morea single stations.~~

Commented [ZJ14]: Not files – relayed message

~~**NOTE:** it has not been determined where some additional information, such as that identifying the area of influence for the water level data, will reside.~~

4.5 Dataset Loading and Unloading

< This section is only needed if the intended product specification has datasets that have multiple scales and would require a loading strategy>

Commented [JZM15]: S100 Review: use this section if intended to restrict data loading e.g. gridded data to certain scale of ENC.

4.6 Spatial Schema

Commented [JZM16]: S100 Review: Expand section to provide sufficient details on geometry structures used in S-104.

4.6.1 Coverages

For an ECDIS, water level data and datum separation fields ("hydroid"), are formatted in two ways: arrays of points contained in a regular grid, and sets of points not described by a regular grid. Further details on the data products are given in Clause 10 – Data Product Format.

Water level data have three basic types, based on their sources:

1. observed or predicted values at a number of stationary locations,
2. predicted values (often from hydrodynamic models) arranged in a regular grid, and
3. values at multiple locations but not in a regular grid.

The three types of water level data and the datum separation fields have structures that can be described by two S-100 coverages: S100_PointCoverage and S100_GridCoverage (S-100 v 4.0.0, Clause 8-7).

Grid Coverage The class S100_GridCoverage represents a set of values assigned to the points in a two-dimensional grid. Attributes include *interpolationType, dimension, axisNames, origin, coordinateReferenceSystem, offsetVectors, origin, extent, sequencingRule, startSequence, and rangeType.*

Point Coverage The class S100_PointCoverage represents a set of values, such as water level height and trend values, assigned to a set of arbitrary X,Y points. Each point is identified by a horizontal coordinate geometry pair (X,Y) and assigned one or more values as attribute values. These values are organized in a record for each point. Attributes include *domainExtent, rangeType, metadata, commonPointRule, geometry*, and *value*.

The types of water level data and their corresponding coverages are shown in Table 4.2.

Table 4.2 – Water level data types and their coverages.

N	Type of Data	Coverage
1	Time series data at one or more stationary locations	S100_Point
2	Regularly-gridded data at one or more times	S100_Grid
3	Ungeorectified gridded data, TIN, or point set data at one or more times	S100_Point

The datum separation field data and their corresponding coverages are shown in Table 4.3.

Table 4.3 – Datum separation data types and their coverages.

N	Type of Data	Coverage
1	Separation distance at one location	S100_Point
2	Regularly-gridded separation distance	S100_Grid
3	Ungeorectified gridded data or point set data of separation distance	S100_Point

~~Surfaces~~

~~Areas of influence are formatted in polygons whose vertices are described by arrays of longitude-latitude pairs.~~

~~The areas of influence have structures that can be described by GM_Surface (S-100 v 4.0.0, Clause 7-4).~~

5 Coordinate Reference Systems (CRS)

The location of a feature in the S-100 standard is defined by means of coordinates, which relate a feature to a position. The S-104 CRS is a compound system, with a two-dimensional ellipsoidal horizontal component and a one-dimensional datum-related vertical component (cf. S-100, Part 6 – Coordinate Reference Systems).

5.1 Horizontal Reference System

For S-104 products, the horizontal CRS must be the ellipsoidal (geodetic) system EPSG:4326 (WGS 84). The full reference to EPSG: 4326 can be found at www.epsg-registry.org.

Horizontal coordinate reference system:	EPSG: 4326 (WGS 84)
Projection:	None
Coordinate reference system registry:	EPSG Geodetic Parameter Registry
Date type (according to ISO 19115):	002 - publication
Responsible party:	International Association of Oil and Gas Producers (IOGP)

5.2 Vertical Reference System

The vertical coordinate is directed upwards (i.e. away from the Earth's centre) from its origin, the vertical datum, and is expressed in units of metres. That is, a positive value for the level of the water level relative to the vertical datum means that the level is above the vertical datum. The vertical datum is not an ellipsoid but is the defined chart datum for the area of interest. The vertical datum must be consistent with the bathymetric CRS in S-102.

5.3 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 19108:2002, Temporal Schema clause 5.4.4. A date variable will have the following 8-character format: *yyyymmdd*. A time variable will have the following 7-character format: *hhmmssZ*. A date-time variable will have the following 16-character format: *yyyymmddThhmmssZ*

6 Data Quality

6.1 Introduction

Quality of water level data for navigation consists of quality of the observed/predicted/forecast data, quality of the positional data, and quality of the time stamp. Quality of the observed data depends on the accuracy of the water level gauges and their processing techniques, and is normally available in

Commented [JZM17]: S-100 Review: Add explanation of how data quality is captured and move how data quality is calculated to the Data Classification and Encoding Guide (ection.

field survey reports or quality controlled analyses. Quality of predicted/forecast data depends on quality, timeliness, and spatial coverage of the input data as well as the mathematical techniques. Temporal accuracy for observational data is normally available in field survey reports or quality controlled analyses. Temporal accuracy for predicted/forecast data is normally described in technical reports.

6.2 Completeness

A time series is complete when there is a value or a null indicator at every time in the series. A water level coverage data set is complete when the grid or point set coverage value matrix contains height value or null (missing) value for every vertex point defined in the grid, and when all of the mandatory associated metadata is provided. See ANNEX E – TEST OF COMPLETENESS (NORMATIVE)

Commented [GS18]: Ensure this Annex is there

Treatment of null (missing) values for real-time observations (no data sent for that time stamp),. manufacturers to default to predicted/modelled information on ECDIS.

NLD propose the use of "NaN" – not a Number to indicate missing data.

Commented [GS19]: Add other components to this section. See S-111, e.g. Assessment of data, Additional components of data quality, and Validation checks.

7 Data Capture and Classification

The water level product contains data processed from sensors or derived from the output from mathematical models. In most cases, the data collected by the producing authority must be translated, sub-setted, reorganized, or otherwise processed to restructure into a usable data format.

7.1 Data Sources for Water Levels

Water level data comes primarily from a few specific sources: observations, astronomical predictions, analyses, and forecast models. When such data are produced and quality-controlled by an approved producing authority (IHO Resolution A6.3 & A6.9, S-62), they are suitable for inclusion in the Water level data product. See ANNEX F – WATER LEVEL DATA

Commented [GS20]: Ensure this Annex is there, if cited here.

Observational Data: Observational water level data comes initially from *in situ* sensors in the field (.e.g. tide gauges deployed along channel) and are monitored by the data collecting authority. After reception, the data are quality controlled and stored by the producing authority. Some of the observed data may be available for distribution within minutes of being collected and are ~~this~~ described as being 'in real time. Other data may be days or years old, and are called historical data.

Astronomical Predictions: Astronomical predictions are produced when a sufficiently long time series of observed water level has been obtained and the data has been harmonically analyzed by the producing authority to produce a set of amplitude and phase constants. The harmonic values can then be used to predict the astronomical component of the water level as a time series covering any desired time interval. Data available for single stations or numerous, may be arranged by the producing authority into a gridded field.

Analyzed and Hybrid Values: Analyzed water level values may be produced from sea-surface topography, data assimilation, statistical correlations or other means. A hybrid method combines two of or more approaches.

Hindcast and Forecast Data: Hydrodynamic models numerically solve a set of fluid dynamic equations in two or three dimensions, and rely on observational data, including water levels and winds, to supply boundary conditions. Model grids may be either regular or irregular. Such models are often run several times per day, and in each run there is usually a hindcast and a forecast. The hindcast is a model simulation that attempts to recreate present conditions by using the most recent observational data, while a forecast is a simulation made for many hours in to the future using predicted winds, water levels, etc. The results are saved for a limited number of times, and are stored as arrays that derive from the model's grid. These models and methods are developed, run and monitored by the HO.

These descriptions are summarized in Tables 7.1.

Table 7.1 – Types of water level data, based on the source of the data.

Type	Name	Description
1	Historical observation	Observation made hours, days, etc., in the past
2	Real-time observation	Observation no more than a few minutes old
3	Astronomical prediction	Value computed using harmonic constants only
4	Analysis or hybrid method	Calculation by statistical or other indirect methods, or a combination of methods
5	Hindcast	Gridded data from a two- or three-dimensional dynamic simulation of past conditions using only observed data for boundary forcing, via statistical method or combination
6	Forecast	Gridded data from a two- or three-dimensional dynamic simulation of future conditions using predicted data for boundary forcing, via statistical method or combination

7.2 Data Sources for Datum Separation Fields

For datum separation fields, ~~usually a~~ knowledge of the separation at a number of locations is required, generally at water level stations (where a tidal datum is available). Spatial variations over the regions can be estimated by spatial interpolation methods or with the help of hydrodynamic models.

~~7.2~~7.3 The Production Process

Nearly all available information on water level from the Producer must be reformatted to meet the standards of this Product Specification (Figure 10.1 - the S-104 format). This means (a) populating the carrier metadata block (Section 12.3) and values group attributes (Section 12.4) with the relevant metadata and (b) reorganizing the water level data when using the encoding rules (see ANNEX G – HDF5 Encoding for gridded data). Need encoding rules for non gridded data.

Commented [JZM21]: S100- Review: add production process for point set datasets as its own chapter.

Commented [GS22]: Ensure this Annex is there, if cited.

~~7.2.1~~7.3.1 Metadata

Commented [JZM23]: S100 Review: Add a section on production metadata; such as when the data is valid, when the data was issued, who compiled the data, datums etc.

Metadata is derivable from the information available from the approved authority. The following variables will require additional processing:

- The bounding rectangle is computable from either the distribution of stations or nodes, or from grid parameters
- Position uncertainties may be available from the approved authority's metadata;
- Water level uncertainty may be available from the prediction model, specification of the water level gauge or calculated from observations;

Commented [JZM24]: S100 review: add text to state the bounding rectangle is encoded using the E_GeographicBoundingBox type in the bounding box attributes of S100_dataCoverage field in S100_datasetDiscoveryMetadata.

~~7.2.2~~7.3.2 Water Level Data

Observational water level and astronomical water level predictions at a single location and gridded forecast data must normally be reformatted to fit the S-104 standard. The following may require additional calculations:

- For gridded data. If a land mask array is included, the mask value ~~(-9999)~~ is substituted into the gridded values as appropriate.

- Time stamps must be encoded as UTC.

8 Maintenance

Maintenance and Update Frequency: Water level is always moving, so more-or-less- continual revision or updating of the data is essential. For real-time observations, new values are periodically collected (e.g. every 6 minutes). For a forecast, the entire field of water levels is created one or more times per day. New issues of real-time observations or forecasts should be considered new editions.

Commented [JZM25]: S100 Review: Reconsider the use of editions for describing new water level datasets. The issue is highlighted is consider the example of a new edition issued for every real-time observation at 6 minute interval will be ~ 600 edition per day.

Commented [ZJ26]: Consider changing editions to "updates"?

Water level harmonic constant data are updated much less often, typically on an annual basis.

Table 8.1 summarizes this information.

Table 8.1 – Typical update/revision intervals and related information

For S-104 products produced by a single Producer.

Data Types	Interval	Number Of Spatial Locations	Number Of Time Values Per Location
Harmonic Constant Tidal Predictions	1 year	100 to 1,000	52560 (10 minute data) or 8,760 (hourly data)
Model Forecasts	6 hr	100,000 to 1,000,000	1 to 24
Real-time Observations	0.1 hr	1 to 10	1 to 240

Data Source: Data is produced by the producing authority through the collection of observed values, predicting astronomical tides, or running analysis or hindcast/forecast. This data is typically quality-controlled and reformatted to conform to file size limitations and the S-104 standard encoding.

Production Process: S-104 datasets, including the metadata and the coverages for water level, are updated by replacement of the entire data product. Producers routinely collect observational data and maintain an analysis and/or forecast capability. When new data becomes available (often several times per day), the data is reformatted and made available for dissemination.

9 Portrayal

Commented [JZM27]: S100 Review: Create a portrayal catalogue, the different product formats need to be considered.

9.1 Introduction

This section describes means of displaying water level data to support navigation, route planning and route monitoring. Three types of data are discussed in depth. The first is point data, which would apply to historical data, astronomical predictions, forecast/hindcast, and real-time data. The second is regularly gridded data, which would apply to analyses, hindcasts and forecasts. For gridded or point set data, the water level portrayal characteristics used for single-point data can be adapted to displaying data at multiple points.

For example, a point portrayal may be provided to display water level at significant locations such as where real-time observations are available. A gridded portrayal may be provided for voyage planning where a mariner's selection of routes may be influenced by water level at certain way points. Note that

not all portrayal categories (point and gridded) may be available for all types of water level data (historical observations, real-time observations, astronomical predictions, and forecast total water level).

All recommended sizes are given assuming a minimum size ECDIS display of 270 by 270 mm or 864 by 864 pixels.

Three portrayal options are provided because of the different types of information that could be supplied. *The options listed below are to allow Members State cater for the information that they have available for their countries. Intent is that the mariner will want to use the data for route planning and real-time navigation.*

9.2 Display of Water Level at a Single Point

Portrayal of water level using single point data should be used in instances where the data source is a water level (e.g. a historical or real-time water level measuring device) at a single geographic location. All text and line colour will be in black unless stated otherwise. The portrayal options are (1) a symbol at the location of the water level data source, (2) a text box containing information on the height, trend, etc., and (3) a graphic plot showing the height over time.

NOTE: All text and line colour will be in black unless stated otherwise.

9.2.1 Symbol

The water level point will be represented by symbol entered in the S-100 GI Registry (see Table 9.1).

Table 9.1 – Beta version of the tide station symbol in the GI Registry.

Symbol	Name	Definition
	TIDEHT01	point for which tide height information is available

9.2.2 Text Box

The information displayed within a window (minimum of 100 x 100 pixels. See Figure 9.2) will be dependent on water level information type. See Table 9.2 for a breakdown of information

Table 9.2 - Numerical information displayed at the location of a water level.

Water Level Type	Information Displayed
All types	UniqueName, date and time stamp (Ship time zone), water level, trend, water level type, additional information (link to create pick report)

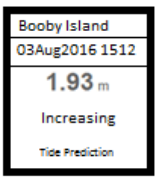

Figure 9.2 – Sample text box for a single water level station.

Commented [JZM28]: S-100WG Define what a Unique name is and how it first within the Maritime Resource Name concept

Commented [GS29]: Consider adding/naming vertical datum reference

Commented [ZJ30R29]: Why? This data should be supplied on the same datum as the chart in use. There should be a machine check that the tide predictions are on the same datum as S-101 and S-102 products and a warning that the data cannot be loaded if conflicting datum.

Commented [GS31R29]: Agreed!

The numerical value of the water level is a number in metres in black text on white background (or the inverse for night vision). This display should be made available when the cursor is held over the data point.

If available, “Additional information” will be supplied on a priority level or possible via “pick report” (S-100 WG on working on this option via statistical method or combination (see Table 9.3).

Table 9-3 Priority for additional information

Priority Level	Additional Information
1	Only that listed in Table 9.2
2	Data Source, Latitude, Longitude, Graphic plot display
3	Uncertainty in water level, uncertainty in horizontal position, uncertainty in vertical position, uncertainty in time

~~The numerical value of the water level is a number in metres in black text on white background (or the inverse for night vision). This display should be made available when the cursor is held over the data point.~~

9.2.3 Graphic Time Series Plot

The availability of the graphic plot display (605x650 pixels), should be a link in the window mentioned in 9.2.1 that creates another window/tab displaying up to 7 days of water level. The mariner will have the option to change between 3 hours, 6 hours, 12 hours, 1 day, 3, 5 or 7 day display. The display will have the option to display two plots within the one window; a primary plot and a secondary plot. The number of plots shown will depend on dataset availability for the area in question.

Line and text transparency must be adjusted according to ECDIS standard (S-57, S-101)~~,~~ see S-111 section 9.2 for guidance. The colours to be used for lines are shown in Table 9.4. Text colour is black.

Table 9.4 - Data Type Colours for Graphic Plot window.
See Clause 7.1 for definitions of predicted and forecast.

Data Type	Plot Colour
Primary plot	
Observed	Magenta
Predicted	Black
Forecast	Blue
Secondary plot	
Observed minus Predicted	Black
Observed minus Forecast	Blue

A maximum limit of ~~three~~ five lines in total are to be plotted: ~~1)~~ Observed, ~~p~~Predicted~~ion~~ (astronomical) and Forecast, and Observed minus Predicted and Observed minus Forecast. ~~or (2) Observed, Predicted, Observed minus Predicted.~~ The following must be included in the plot space: (1) a Unique Name (for the station) and the water level scenario, (2) date and time information, (3) height scale, and (4) vertical datum reference. A sample plot for one station is shown in Figure 9.3.

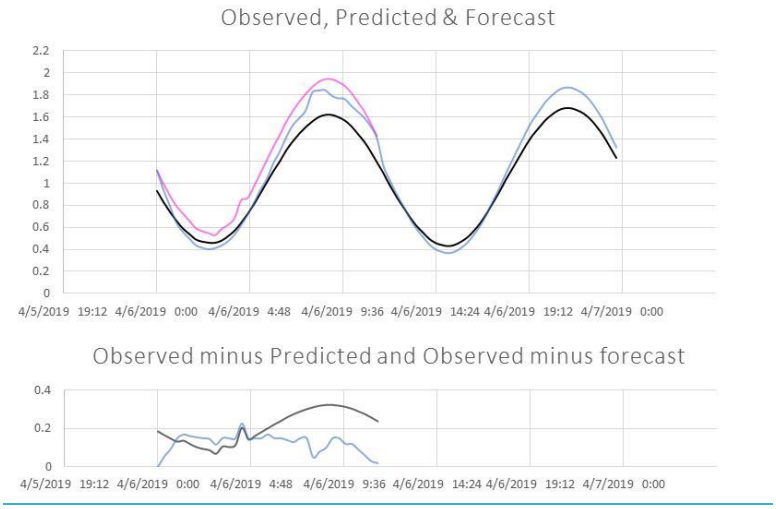

Figure 9.3 – Sample one-day plot of a time series of observed, forecast, and observed minus forecast (Scenario 1) water level heights.

Multiple lines can be plotted on the graphic plot window at the same time and the colours are used to differentiate the data type. Data types with the same colours are plotted on different plots. Note that other ECDIS standards will define when this graphic plot can be displayed, due to the size of the window covering the screen size.

Commented [JZM32]: Note the dashed lines was considered but discounted by the WG members who indicated difficulty following lines on a small plot window.

9.3 Display of Gridded Data

The display of gridded data depicts water level surface information at each individual point having the qualities described in Section 9.2. As with single point water level data, a mouse click on the chart area will display the information from the grid node nearest to that point.

NOTE 1: There is no adjustment of bathymetry data because this option is outside the scope of this Product Specification.

NOTE 2: There are no specifications for the display of a water surface from gridded data in this Product Specification edition.

9.4 Temporal Considerations

The time selected for display (i.e. past, present or future) of the water level by the system will typically not correspond exactly to the timestamp of the input data. For data with only a single record (i.e. the timestamp of the earliest values equals that of the latest value) such as real-time data, the water level values are displayed only if the absolute difference between the display time and the data timestamp is less that a discrimination interval (e.g. 5 minutes). For a single record, the variable *timeRecordInterval* (see Clause 12.3) can be used to set the discrimination interval.

Commented [JZM33]: S100 Review: What happened to data outside of the discrimination interval? Consquences?

For data with multiple times, if selected display time is later than the first timestamp and earlier than the last timestamp, then the closest two timestamps (i.e. one earlier and one later) in the data are found and the water level values are linearly interpolated. However, if the selected display time is earlier than the first timestamp or later than the last timestamp, the water level values at the closest time are displayed only if the absolute time difference between the display time and the data time stamp is less than a discrimination interval (e.g. half the value of the variable *timeRecordInterval*).

9.5 Interoperability

Interoperability principles determine priority in display of elements so that important image elements, such as depth numerals, are not obscured by water level values. Water level portrayal will conform to interoperability rules when they are established.

10 Data Product Format (Encoding)

10.1 Introduction

Commented [JZM34]: S100 Review: need to complete the list of formats for each data type

The Water level Data Products must be encoded using one of the listed formats. The structure of the data product is discussed in the next section. There will be a minimum of ~~two~~ one format~~s~~ to handle data:

~~a) AIS for real-time water level data.~~

Formatted: No bullets or numbering

a) HDF5 for water level height and trend data ~~types~~, as well as datum separation fields~~, for other dissemination methods~~

Character Set: MD_CharacterSetCode (ISO19115) should be set to utf8

Commented [ZJ35]:

Specification: S-100 profile of HDF5 ~~and GML, AIS specification for ASM~~

10.2 AIS ASM Product Structure

Commented [GS36]: Should remove section 10.2 as real-time water level data will go into Ed 2.0.0 or later.

The information that can be delivered through the AIS system is limited to information that can be delivered as part of the AIS FI-31 Meteorological and Hydrographic data.

The AIS FI-31 allows the following fixed order of feature types:

Name:	Meteorological and Hydrographic Data AIS Application-Specific Message Dynamic Water Level Data Feature Catalogue
Scope:	Catalogue containing features associated with making Dynamic Water Level Data available for transmission in Meteorological and Hydrographic Data AIS Application-Specific Messages
Field of application:	Marine navigation (as shown in S-100 Part 11, B-1 Example Product Specification – tbc)
Version Number:	1.0
Version Date:	November 2014
Producer:	International Hydrographic Organization
Functional Language:	English

IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

~~**Spatial Use:** Each AIS station will be limited to ENC NAV 5 and NAV6 boundaries. S-129 services to take precedence.~~

See ANNEX H for additional information.

A summary of the parameters relating to water level are shown in the table below (the complete table is in ANNEX H). Only one station per message is allowed.

Table 10.1 – Summary of the 14 variables in the Meteorological and Hydrographic Data AIS Application-Specific Message that apply to real-time water levels. Default values are used in the remaining slots (Annex H).

N	Parameter	No. bits	Description
1	Message ID	6	Identifier for Message 8, always 8.
2	Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 - 3 0 = default 3 = do not repeat anymore
3	Source ID	30	MMSI number of source station
4	Spare	2	Not used. Set to zero.
5	IAI	16	DAC = 001; FI = 31
6	Longitude	25	Longitude in 1/1,000 min, ±180 degrees as per 2's complement (East = positive, West = negative). 181 = not available = default
7	Latitude	24	Latitude in 1/1,000 min, ±90 degrees as per 2's complement (North = positive, South = negative). 91 = not available = default
8	Position Accuracy	1	1 = high (<10 m; Differential Mode of, e.g., DGNSS receiver) 0 = low (>10 m; Autonomous Mode of, e.g., GNSS receiver or of other electronic position fixing device) default = 0
9	UTC Day	5	1 - 31 0 = not available = default
10	UTC Hour	5	0 - 23 24 = not available = default
11	UTC Minute	6	0 - 59 60 = not available = default
22	Water Level (incl. tide)	12	Deviation from local chart datum, in 0.01 metre steps. -10.0 to +30.0 metres A value representing 0 - 4,000 is sent by the 12 binary bits. The water level is achieved by adding -10.0 to the sent value. Water level = (Integer value /100) – 10 for Integer = 0-4,000 4,001 = not available = default 4,002 – 4,095 (reserved for future use)
23	Water Level Trend	2	0 = steady 1 = decreasing 2 = increasing 3 = not available = default

10.3 HDF5 Product Structure for Time Series and Gridded Data

The key idea at the core of the structure is this: the organization of the information is substantially the same for each of the various types of data, but the information itself will be interpreted differently.

10.3.1 Data Type Definition

HDF5 will be used for all water level data types for dissemination methods other than AIS, as well as for datum separation fields.

Format Name: HDF5
Character Set: MD_CharacterSetCode (ISO 19115)
Specification: S-100 profile of HDF5

This product format is designed to be flexible enough to apply to water level and datum difference values in the form of (a) data at one or more times for one or more individual, fixed stations, (b) regularly-gridded data for one or more times, and (c) ungeorectified gridded data for one or more times. This approach contains, for each type, data in a similar format but which is interpreted differently. Since each type of data will be interpreted differently, the type of data must be identified by the variable *dataCodingFormat,* as shown in Table 10.1.

Table 10.1 – S-104 data types and ~~V~~values of the variable *dataCodingFormat.* (see S-100 Ed 5~~4~~.0.0, Table 10c-4).

dataCodingFormat	Type of Data
1	Time series data at one or more fixed stations (organized by time)
2	Regularly-gridded data at one or more times
3	Ungeorectified gridded data or point set data at one or more times
~~4~~	~~Fixed stations with associated areas~~
7	TIN data
8	Stationwise time series at one or more fixed stations (organized by station)

Commented [GS37]: This is probably a question for S-100WG: Do we release S-104 Ed 1.0.0 compliant with S-100 Ed 4.0.0 or Ed 5.0.0? For example, Ed 5.0.0 will have dataCodingFormat = 8.

For the use of HDF5, the following key concepts (10c-5.1) are important:

- *File* - a contiguous string of bytes in a computer store (memory, disk, etc.), and the bytes represent zero or more objects of the model;
- *Group* - a collection of objects (including groups);
- *Dataset* - a multidimensional array of data elements with attributes and other metadata;
- *Dataspace* - a description of the dimensions of a multidimensional array;
- *Datatype* - a description of a specific class of data element including its storage layout as a pattern of bits;
- *Attribute* - a named data value associated with a group, dataset, or named datatype;
- *Property List* - a collection of parameters (some permanent and some transient) controlling options in the library;
- *Link* - the way objects are connected.

In addition, a dataset may have one, two, or more dimensions, and each element in the dataset may be a compound. That is, each element may itself be an array of possibly different datatypes (float, integer, string, etc).

For all data types, the product structure in HDF5 includes (a) a metadata block, which is followed by (b) one or more Groups which contain the actual water level data. The water level information is saved in arrays that hold either gridded data or a time series.

Commented [JZM38]: S100 Review: in theory HDF5 can support fixed station with zones, e.g. all cells have the same value and where there is no data a null or land mask must be encoded.

10.3.2 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, not just water levels, is given in Figure 10.1.

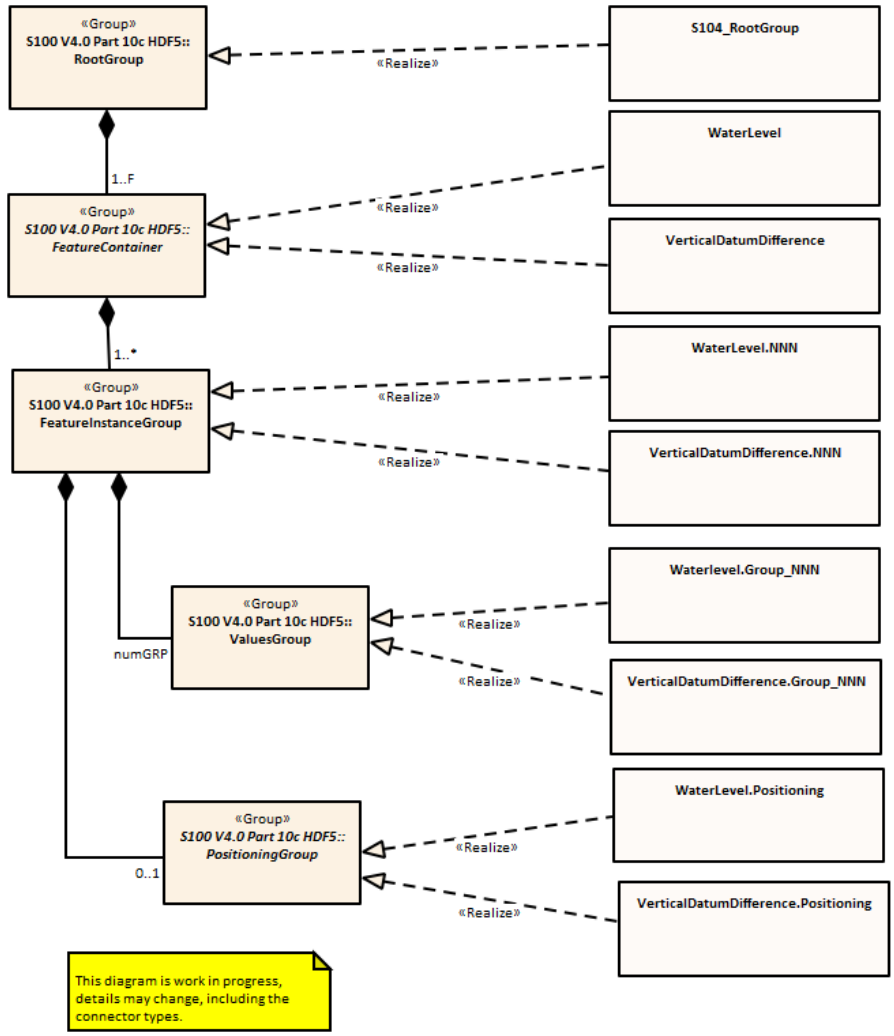

Figure 10.1 – Outline of the data file structure for S-104 data files, showing the realization of S-104 structure from the generic structure described in S-100 (see Part 10c – Figure 10c-7). Note that there are four levels from top to bottom.

In Figure 10.1 there are four levels:

Level 1: At the top level lies the Root Group, and it contains the Root Metadata (Table 12.1) and two subsidiary groups. 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 two datasets: the featureCode, which has the name of the S-100 feature (here WaterLevel), and the feature information dataset (WaterLevel) which contains a

compound array with eight parameters for each S-100 feature attribute (height, trend, and time). The Feature Container Group contains the Feature Metadata (Table 12.2) and one or more Feature Instance Groups. The Feature Metadata is common to all water level products.

Level 3: This contains one or more Feature Instances. A feature instance is, for example, a time series of gridded data for a single region, or a time series of astronomical predictions for a set of stations.

Level 4: This contains the actual data for the feature. S-104 uses only the Values Group and, for only some data, the Positioning Group.

The basic structure of the S-104 data product is shown in Table 10.2. Levels refer to HDF5 structuring. (C.f. S-100 Part 10c, Fig. 10c-9). Naming in each box below header line is as follows: **Generic name**; S-100 or S-104 name; and (*HDF5 type*) group, attribute or attribute list, or dataset.

Table 10.2 – Overview of an S-104 data product

LEVEL 1 (ROOT) CONTENT	**LEVEL 2 CONTENT**	**LEVEL 3 CONTENT**	**LEVEL 4 CONTENT**
General Metadata (see Table 12.1) *(h5_attribute)*			
Feature Codes Group_F *(h5_group)*	**Feature Name** WaterLevel *(h5_dataset)*		
	Feature Codes featureCode *(h5_dataset)*		
Feature Type WaterLevel *(h5_group)*	**Type Metadata** (see Table 12.2) *(h5_attribute)*		
	Horz. & vert. Axis Names axisNames *(h5_dataset)*		
	First Feature Instance WaterLevel.01 *(h5_group)*	**Instance Metadata** (see Table 12.3) *(h5_attribute)*	
		Location Data Positioning *(h5_group)*	**Lon+lat Array** geometryValues *(h5_dataset)*
		Uncertainty Data uncertainty *(h5_dataset)*	
		First data group Group_001 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
		Second data group Group_002 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
		Third data group Group_003 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
	Second Feature Instance WaterLevel.02 *(h5_group)*	**Instance Metadata** (see Table 12.3) *(h5_attribute)*	

The following sections explain entries in Table 10.2 in more detail.

10.3.2.1 Root group

The Root Group contains the Feature Codes group, the Feature Type group, and the simple attributes shown in Table 12.1.

10.3.2.2 Feature Codes (Group F)

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This group specifies the S-100 feature to which the data applies. The group has no attributes and consists of two components:

featureCode – a dataset with the name(s) of the S-100 feature(s) contained in the data product. For S-104, the dataset has a single element, the string "WaterLevel".

WaterLevel – this is a dataset with the name contained in the featureCode dataset. The dataset contains a one-dimensional compound array of length 3 (one for each of the three water level attributes: height, trend, and time). Each of the three elements of string values has 8 values, as shown in Table 10.3.

NOTE 1: This dataset has a single attribute, named *chunking*, which is a string containing the HDF5 chunking values used in creating the values arrays (for example '0.0'). These chunking values can be overridden at the feature instance level by the attribute *instanceChunking* (see Table 12.3).

NOTE 2: Values provided in Table 10.3 for code (waterLevelHeight, waterLevelTrend, and waterLevelTime), uom.name (meters and DateTime), and fillValue (-9999. and 0) are required.

Commented [GS39]: OEM feedback (U.S. NIWC) suggests requiring code, uom.name, and fillValue for all S-104 datasets.

Table 10.3 – Sample contents of the one-dimensional compound array (length = 3, compound elements = 8) WaterLevel. All values are strings.

N	Name	Explanation	S-100 Attribute 1	S-100 Attribute 2	S-100 Attribute 3
1	code	Camel Case Name	waterLevelHeight	waterLevelTrend	waterLevelTime
2	name	plain text	Water level height	Water level trend	Water level time
3	uom.name	Units of Measurement	meters		DateTime
4	fillValue	Denotes missing data	-9999.	0	
5	datatype	HDF5 datatype	H5T_FLOAT	H5T_ENUM	H5T_C_S1
6	lower	Lower bound on attribute	-99.99		19000101T000000Z
7	upper	Upper bound on attribute	99.99		21500101T000000Z
8	closure	Open or Closed data interval. See S100_IntervalType in Part 1.	closedInterval		closedInterval

10.3.2.3 Type group (WaterLevel)

This group contains a dataset called axisNames and one or more instances of the single feature WaterLevel. A single instance may contain a gridded forecast at multiple hours, or a set of time series predictions or observations at several stations. This group has the simple attributes shown in Table 12.2. For S-104, axisNames consists of two elements, the strings 'longitude' and 'latitude'.

10.3.2.4 Instance group (WaterLevel.nn)

This group contains a single instance of the feature (see clause 10.3.2.3). The groups are numbered from 01 to 99. This group has the simple attributes shown in Table 12.3, as well as the (water level, trend, and time) values groups, the (conditional) positioning group, and a dataset called 'uncertainty'.

Uncertainty Dataset – The (optional) uncertainty data is contained in a compound HDF5 dataset named 'uncertainty'. There is a name and an uncertainty value for water level height, which is *waterLevelHeight*. The units of height uncertainty are meters. The default, denoting a missing value, is -1.0.

10.3.2.5 Value groups (Group_nnn)

These groups each contain an attribute (the date-time stamp), and the compound data arrays containing water level height and trend, and optionally water level time. These groups have the simple attributes shown in Table 12.4. These components are explained below.

Date-Time Stamp - The date-time stamp is an attribute named *timePoint* with a single (string) value. For gridded (regular, ungeorectified, and TINs: *dataCodingFormat* = 2, 3, or 7), the time stamp is the time of validity for all points in the grid. For a time series at fixed stations (*dataCodingFormat* = 1), the time stamp is valid for all stations in that Value group.

Value Arrays - The height and trend values (waterLevelHeight and waterLevelTrend) are stored in arrays named *values*, with a prescribed number of rows (*numROWS*) and, if two-dimensional, columns (*numCOLS*).

For a time series of fixed stations (*dataCodingFormat* = 1 and 8), the height and trend values will be for times in the series as determined by the starting date-time and the data time interval. If the time intervals are non-uniform (only for *dataCodingFormat* = 8), then the time for each height and trend value is given by waterLevelTime.

For a regular grid (*dataCodingFormat* = 2), the height and trend values will be for each point in the grid, the data array *values* is two-dimensional, and the time for all points in the grid is given by the date-time stamp.

For an ungeorectified grid and TINs (*dataCodingFormat* = 3 and 7, respectively), the height and trend values will be for each point in the grid, the data array *values* is one-dimensional, and the time for all points in the grid is given by the date-time stamp.

10.3.2.6 Conditional geography group (Positioning)

The group named Positioning contains all the locations (longitude and latitude values) that have associated data values. This group has no attributes. In S-104, this group is present in the data product only for *dataCodingFormat* values of 1, 3, 7, or 8.

The geographic values are stored in the single, one-dimensional compound array named *geometryValues*, of size *numPOS*. Each element in the compound array *geometryValues* contains the pair of float values (longitude, latitude). The value of *numPOS* and the interpretation of the kinds of locations depends on the *dataCodingFormat* as well. The values and number of stations (respectively) for each data type are explained in Table 10.4.

For *dataCodingFormat* = 7, the Positioning group also contains the required *triangles* and optional *adjacency* arrays. Each row in the *triangles* array encodes a triangle as the indexes of 3 coordinates in the *geometryValues* dataset. Each row in the *adjacency* array encodes the triangles adjacent to any given triangle by specifying their indexes in the *triangles* dataset. Elements for edges without adjacent triangles are filled with the value -1. See S-100 Table 10c-16.

NOTE: the variable names in this Group (longitude, latitude) must match in case and spelling those in axisNames.

Table 10.4 - Values of numPOS for the group Positioning

Data	Data Type	Location Data	Array Size:

Coding Format			Value of numPOS
1	Time series at fixed stations	Position of stations	*numberOfStations*
2	Regular grid	(Not applicable)	(Not applicable)
3	Ungeorectified gridded data	Location of the grid nodes	*numberOfNodes*
7	TINs	Location of the grid nodes	*numberOfNodes*
8	Stationwise time series at fixed stations	Position of stations	*numberOfStations*

10.3.2.7 Summary of generalized dimensions

To summarize, for non-regularly gridded data only, there is an initial Positioning Group with X and Y position, stored in one-dimensional arrays of size *numPOS*. Following that, there are data Groups containing water level and trend data, which are stored in either one-dimensional arrays of size *numROWS* or two-dimensional arrays of size *numROWS* by *numCOLS*. The total number of data Groups is *numGRP*.

The four variables that determine the array sizes (*numROWS*, *numCOLS*. *numPOS,* and *numGRP)* are different, depending upon which data coding format is used. Their descriptions are given in Table 10.5.

Table 10.5 – The array dimensions used in the data product

Data Coding Format	Data Type	Positioning	Data Values		
		numPOS	numCOLS	numROWS	numGRP
1	Fixed Stations	numberOfStations	1	numberOfStations	numberOfTimes
2	Regular Grid	(not used)	numPointsLongitudinal	numPointsLatitudinal	numberOfTimes
3	Ungeorectified Grid	numberOfNodes	1	numberOfNodes	numberOfTimes
7	TIN	numberOfNodes	1	numberOfNodes	numberOfTimes
8	Fixed Stations (Stationwise)	numberOfStations	1	numberOfTimes	numberOfStations

10.3.2.8 Mandatory naming conventions

The following group and dataset names are mandatory in S-100: 'Group_F', 'featureCode', and (for S-104) 'WaterLevel', 'axisNames', 'Positioning', (for S-104) 'WaterLevel.nn', and 'Group_nnn' (n is an integer from 0 to 9). Attribute names shown in Clause 12.3 and 12.4 are also mandatory.

10.3.2.9 Summary of product structure

For regularly gridded data, the water level array is two dimensional, with dimensions *numPointsLongitudinal* and *numPointsLatitudinal*. By knowing the grid origin and the grid spacings, the position of every point in the grid can be computed by simple formulae.

However, for time series data, TINs, and ~~irregularly~~ungeorectified gridded data (i.e., when *dataCodingFormat* is 1, ~~or~~ 3, 7, or 8), the location of each point must be specified individually. This is accomplished by the data in Positioning Group ~~XY~~, which gives the individual longitude (X) and latitude (Y) for each location. For time series data, the X and Y values are the positions of the stations; the number of stations is *numberOfStations.* For TINs and ungeorectified~~irregularly~~ gridded data, the X and Y values are the positions of each point in the grid; the number of grid points is *numberOfNodes*.

NOTE: If *dataCodingFormat* is 2, the Positioning Group ~~XY~~ is not present.

The remaining Groups each contain a title, a date-time value (except for *dataCodingFormat* = 8), and the water level array. The title can be used to identify each individual station with time-series data. For *dataCodingFormat* = 2 or 3, the date-time is for the entire grid. The water level array is a two dimensional, with a number of columns (*numCOLS*) and rows (*numROWS*). For a time series, the water level value will be for each time in the series. For a grid, the water value will be for each point in the grid.

The Groups are numbered 1, 2, etc., up to the maximum number of Groups, *numGRP*. For fixed station stationwise data (*dataCodingFormat* = 8), the number of Groups is the number of stations. For regular and ungeorectified grids and TINs~~irregular grids~~(*dataCodingFormat* = 2, 3, and 7), and for fixed station timewise data (*dataCodingFormat* = 1) the number of Groups is the number of time records.

The overall structure of the water level data product is created by assembling the data and metadata. The product structure is compliant with the HDF5 data architecture, which allows multi-dimensional arrays of data to be grouped with metadata. The format of the data product (cf. Figure F.5) described above is portrayed in Figure 10.2~~1~~. The Carrier Metadata is discussed in Clause 12.3, and the Values Group attributes are discussed in Clause 12.4.

Commented [GS40]: Where is this?

NOTE: The name of each Group is the 'Group_nnn', where nnn~~n~~ is numbered from 1 to *numGRP*.

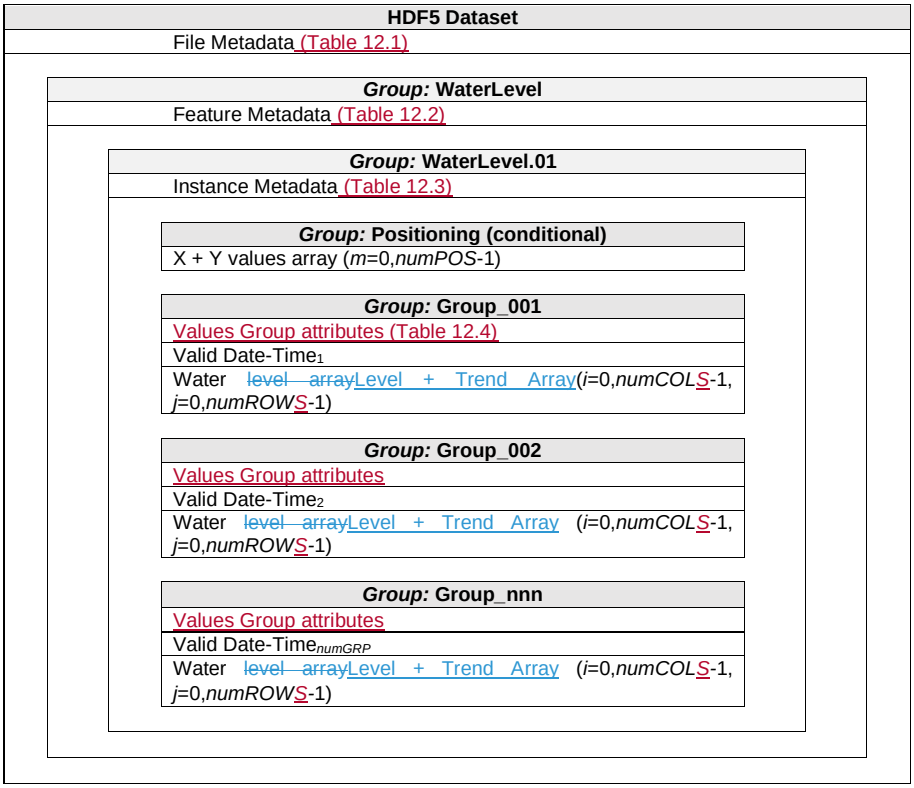


Figure 110.21~~ ~~- Schematic of the S-104 HDF5 data product structure. The four parameters *numPOS, numCOLS, numROWS*, and *numGRP* are explained in Table 10.52.
Group 'Positioning' appears only for *dataCodingFormat* = 1, ~~or~~ 3, 7, or 8 (Table 10.52).

~~10.3.1.1~~10.3.2.10 Digital Certification Block

Information here is used to certify the validity or integrity of the data.

10.3.3 Encoding of Latitude and Longitude

Values of latitude and longitude must be accurate to 7 decimal places. Coordinates must be encoded as decimals in the format described below. The encoding is indicated by multiplication factor fields defined in the dataset identification record.

Commented [GS41]: Should probably remove 10.3.3 and 10.3.4. I think I suggested this as part of the GML specification (for the areas of influence).

10.3.4 Encoding of Coordinates as Decimals

Values should be coded as decimal numbers with 7 or fewer digits after the decimal. The normative encoding is in degrees, with an accuracy of 10^{-7} degrees, i.e., up to 7 digits after the decimal point.

The decimal point must be indicated by the "." character.

Trailing zeroes after the decimal point (and the decimal point itself if appropriate) may be omitted at producer discretion, but the accuracy must still be as indicated (e.g., 10^{-7} degrees for coordinates of default accuracy).

Latitude and longitude multiplication factors held in the Dataset Structure Information field under [coordMultFactorX] and [coordMultFactorY] must be set to a value corresponding to the encoding, i.e., {1} for coordinates encoded in decimal degrees.

EXAMPLE 1 A longitude = 42.0000 is converted into X = longitude * coordMultFactorX = 42.0000 * 1 = 42.0000000.

10.4 Sample HDF5 encoding

The product structure has been designed for compatibility with the HDF5 capabilities. The HDF5 encoding of the data set is discussed in Annex E – Sample HDF5 Encoding.

11 Data Product Delivery

11.1 Introduction

This section describes how the water level data product is to be packaged by the Producer.

Due to the cost of transmitting data via the internet, it is desirable to limit file size and updating frequency whenever possible. The exchange data file size, as created by the Producer and ~~before~~ after compression, is recommended to be limited to 10 MB. Another quantity to be aware of is the total MB to be transferred per year. S-100 (Sec. 15-5.2) allows one data compression scheme: Zip. In addition, the file may be encrypted.

Updating of files typically means issuing a new forecast, or disseminating the latest observed water level for a specific geographic region. This may occur several times per day. Therefore, all files must contain a date-time of issuance of the product. Because of the potentially high frequency (that is, hourly or less) availability of new datasets, the ECDIS system must check for new data at a similar frequency. ~~All datasets must therefore contain the issue date and time.~~

~~**AIS Messages**~~

~~{describe AIS ASM file delivery here}~~

11.2 HDF5 ~~and GML Files~~

The HDF5~~ and GML~~-formatted datasets are packaged ~~in the same manner:~~ with metadata and an exchange catalogue, and then combined into an exchange dataset. The ~~GML files for areas of influence, and the~~ HDF5 files for datum differences may be transferred via media or internet, since they typically do not often change. HDF5 files for time series or gridded water level data may require internet, since they change several or more times a day.

~~11.1.1~~11.2.1 Exchange Datasets

Datasets, or data products, produced by the Producer consist of files containing both the exchange catalogue and one or more data products (of possibly different S-100 types), with each product covering a specific geographic region and specific period of time (Figure 11.1). The Exchange Catalogue lists the products and contains the discovery metadata.

The name of the exchange set will have the character string 'S104' somewhere in it (e.g., 'S104_ExchangeSet'), and this will identify the data as containing water level.

Exchange Set
Exchange Catalogue
Metadata (includes list of files in Exchange Dataset)
Auxiliary files (Feature and Portrayal Catalogue, SVG Files, etc.)
Data Products
Data Product No. 1
Data Product No. 2
Data Product No. 3
Data Product No. 4
Etc.

Figure 11.1 – Schematic diagram of the Exchange Set.

Formatted Table

The dataset size is limited to 10 MB. The size of each file can vary widely, depending on the data. Using the sample HDF5 file (see Figure F.3), a file containing, along with metadata, a single ~~speed~~ water level height array and a single ~~direction~~ water level trend array, each with 100,000 grid points would have a size of approximately 0.21 Mbytes. Exchange files may be compressed using zip methodology. Doing so can reduce file size by 80% or more.

Commented [JZM42]: S100 Review: need to update text to suit water level data in HDF5 format.

~~11.1.2~~11.2.2 Exchange Catalogue

The exchange catalogue normally in XML format acts as the table of contents for the exchange set. The catalogue file of the exchange set must be named ~~S104ed01CAT~~CATALOG.XML; no other file in the exchange set may have the same name. The contents of the exchange catalogue are described in Clause 12.

~~11.1.3~~11.2.3 Dataset File Naming

The dataset file contains both metadata and one or more sets of ~~water level~~height and trend arrays (see CLAUSE 10 – DATA PRODUCT FORMAT). The ~~file naming convention described here~~dataset name must ~~be used for all water level files from all sources. The file naming convention consists of 20 to 22 characters. The first two characters are used to identify~~begin with the ~~producing country code (two characters, ref S-62), four-~~three character product

specification, followed by ~~Producer specific characters to uniquely define~~ the ~~dataset (must be 15 characters). The filename extension (e.g., .hdf5) denotes~~two-character producer code (CC). Thus water level files begin with the ~~file format~~ ~~five~~six character string '~~S~~104CC'. ~~Characters may be lower or upper case.~~ ~~This is summarized in Table 11.1.~~

~~**Table** *11.11-1 - Characters used in the file naming convention*.~~

~~N~~	~~DESCRIPTION~~	~~LENGTH~~	~~EXAMPLE~~
~~1~~	~~Country Code~~	~~2~~	~~CA~~
~~2~~	~~Unrestricted~~	~~15~~	~~Gulf20141106ABC~~
~~3~~	~~Extension~~	~~3 to 5~~	~~.h5, .hdf5~~
	~~Total =~~	~~20 to 22~~	

The unrestricted characters may be used to denote geographical region, valid time, source of the data, version numbers, and/or any other relevant information. Characters may be lower or upper case. For real-time and forecast data, it is recommended that the dateTime of the first record be part of the dataset name, to help distinguish the most recent files.

~~11.5~~

The ~~dataset~~filename extension for HDF5 (e.g., .h5 or .hdf5) ~~or GML (.gml)~~ must be used to denote the file format.

~~11.1.4~~11.2.4 Support Files

This Data Product requires no support files.

12 Metadata <S-100 Part 4>

12.1 Introduction

For information exchange, there are several categories of metadata required: metadata about the overall exchange dataset and catalogue, discovery metadata about each of the datasets contained in the catalogue, and discovery metadata about the support files that make up the package. The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, e.g. decrypt, decompress, load, etc. Other catalogues can be included in the exchange set in support of the datasets such as feature, portrayal, coordinate reference systems, codelists, etc. The attribute "purpose" of the support file metadata provides a mechanism to update support files more easily.

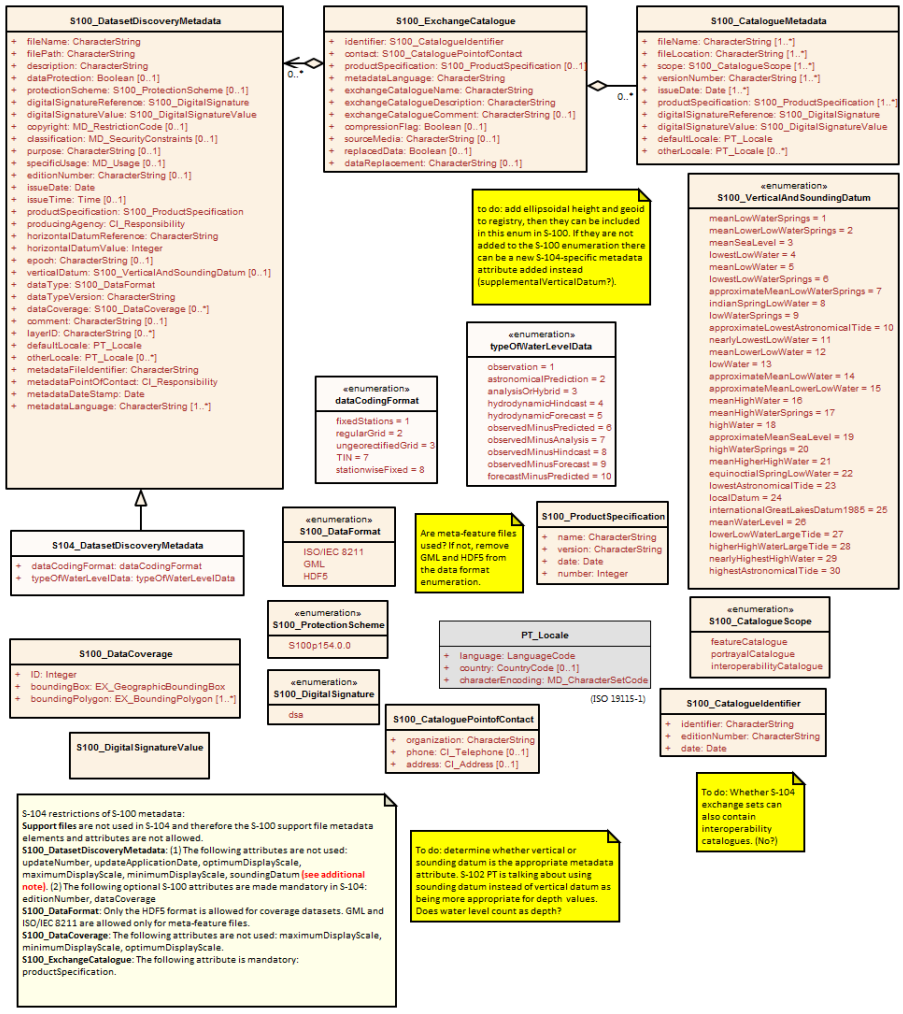
This clause defines the mandatory and optional metadata needed for S-104. ~~For information exchange, there are several categories of metadata required: metadata about the overall exchange catalogue, metadata about each of the datasets contained in the catalogue, and metadata about the support files, if any, that make up the package.~~ In some cases the metadata may be repeated in a national language.

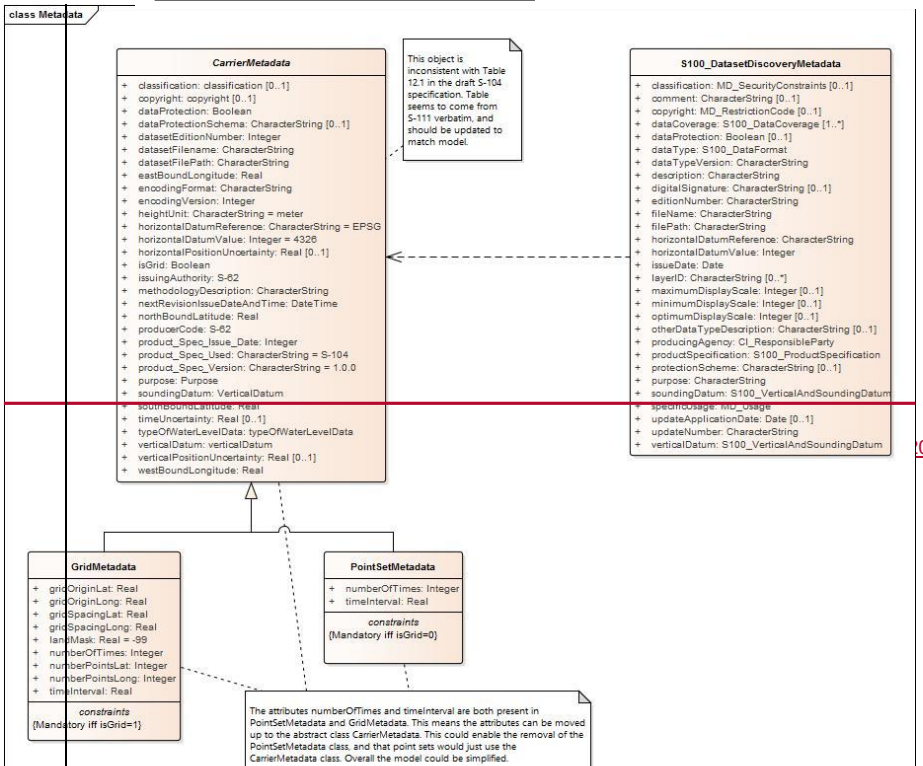
12.2 Discovery Metadata

An outline of the overall concept of an S-104 exchange set for the interchange of geospatial data and its relevant metadata is explained in the following figures. Figure 12.1 depicts the realization of the ISO 19139 classes which form the foundation of the exchange set. The overall structure of the S-104 metadata for exchange sets is modelled in ~~shown in~~ ANNEX C.. More detailed information about the various classes and a textual description are in the tables at Clause 12.3.

Figure 12.1 - Realization of the exchange set classes. Note that there are no support files.

Commented [GS43]: This was updated with the help of S-100WG.


S100_DatasetDiscoveryMetadata
+ fileName: CharacterString
+ filePath: CharacterString
+ description: CharacterString
+ dataProtection: Boolean [0..1]
+ protectionScheme: S100_ProtectionScheme [0..1]
+ digitalSignatureReference: S100_DigitalSignature
+ digitalSignatureValue: S100_DigitalSignatureValue
+ copyright: MD_RestrictionCode [0..1]
+ classification: MD_SecurityConstraints [0..1]
+ purpose: CharacterString [0..1]
+ specificUsage: MD_Usage [0..1]
+ editionNumber: CharacterString [0..1]
+ issueDate: Date
+ issueTime: Time [0..1]
+ productSpecification: S100_ProductSpecification
+ producingAgency: CI_Responsibility
+ horizontalDatumReference: CharacterString
+ horizontalDatumValue: Integer
+ epoch: CharacterString [0..1]
+ verticalDatum: S100_VerticalAndSoundingDatum [0..1]
+ dataType: S100_DataFormat
+ dataTypeVersion: CharacterString
+ dataCoverage: S100_DataCoverage [0..*]
+ comment: CharacterString [0..1]
+ layerID: CharacterString [0..*]
+ defaultLocale: PT_Locale
+ otherLocale: PT_Locale [0..*]
+ metadataFileIdentifier: CharacterString
+ metadataPointOfContact: CI_Responsibility
+ metadataDateStamp: Date
+ metadataLanguage: CharacterString [1..*]
0..*
S100_ExchangeCatalogue
+ identifier: S100_CatalogueIdentifier
+ contact: S100_CataloguePointofContact
+ productSpecification: S100_ProductSpecification [0..1]
+ metadataLanguage: CharacterString
+ exchangeCatalogueName: CharacterString
+ exchangeCatalogueDescription: CharacterString
+ exchangeCatalogueComment: CharacterString [0..1]
+ compressionFlag: Boolean [0..1]
+ sourceMedia: CharacterString [0..1]
+ replacedData: Boolean [0..1]
+ dataReplacement: CharacterString [0..1]
0..*
S100_CatalogueMetadata
+ fileName: CharacterString [1..*]
+ fileLocation: CharacterString [1..*]
+ scope: S100_CatalogueScope [1..*]
+ versionNumber: CharacterString [1..*]
+ issueDate: Date [1..*]
+ productSpecification: S100_ProductSpecification [1..*]
+ digitalSignatureReference: S100_DigitalSignature
+ digitalSignatureValue: S100_DigitalSignatureValue
+ defaultLocale: PT_Locale
+ otherLocale: PT_Locale [0..*]
to do: add ellipsoidal height and geoid to registry, then they can be included in this enum in S-100. If they are not added to the S-100 enumeration there can be a new S-104-specific metadata attribute added instead (supplementalVerticalDatum?).
«enumeration»
S100_VerticalAndSoundingDatum
meanLowWaterSprings = 1
meanLowerLowWaterSprings = 2
meanSeaLevel = 3
lowestLowWater = 4
meanLowWater = 5
lowestLowWaterSprings = 6
approximateMeanLowWaterSprings = 7
indianSpringLowWater = 8
lowWaterSprings = 9
approximateLowestAstronomicalTide = 10
nearlyLowestLowWater = 11
meanLowerLowWater = 12
lowWater = 13
approximateMeanLowWater = 14
approximateMeanLowerLowWater = 15
meanHighWater = 16
meanHighWaterSprings = 17
highWater = 18
approximateMeanSeaLevel = 19
highWaterSprings = 20
meanHigherHighWater = 21
equinoctialSpringLowWater = 22
lowestAstronomicalTide = 23
localDatum = 24
internationalGreatLakesDatum1985 = 25
meanWaterLevel = 26
lowerLowWaterLargeTide = 27
higherHighWaterLargeTide = 28
nearlyHighestHighWater = 29
highestAstronomicalTide = 30
«enumeration»
dataCodingFormat
fixedStations = 1
regularGrid = 2
ungeoreectifiedGrid = 3
TIN = 7
stationwiseFixed = 8
«enumeration»
typeOfWaterLevelData
observation = 1
astronomicalPrediction = 2
analysisOrHybrid = 3
hydrodynamicHindcast = 4
hydrodynamicForecast = 5
observedMinusPredicted = 6
observedMinusAnalysis = 7
observedMinusHindcast = 8
observedMinusForecast = 9
forecastMinusPredicted = 10
S104_DatasetDiscoveryMetadata
+ dataCodingFormat: dataCodingFormat
+ typeOfWaterLevelData: typeOfWaterLevelData
«enumeration»
S100_DataFormat
ISO/IEC 8211
GML
HDF5
Are meta-feature files used? If not, remove GML and HDF5 from the data format enumeration.
S100_ProductSpecification
+ name: CharacterString
+ version: CharacterString
+ date: Date
+ number: Integer
«enumeration»
S100_ProtectionScheme
S100p154.0.0
«enumeration»
S100_CatalogueScope
featureCatalogue
portrayalCatalogue
interoperabilityCatalogue
S100_DataCoverage
+ ID: Integer
+ boundingBox: EX_GeographicBoundingBox
+ boundingPolygon: EX_BoundingPolygon [1..*]
PT_Locale
+ language: LanguageCode
+ country: CountryCode [0..1]
+ characterEncoding: MD_CharacterSetCode
(ISO 19115-1)
«enumeration»
S100_DigitalSignature
dsa
S100_CatalogueIdentifier
+ identifier: CharacterString
+ editionNumber: CharacterString
+ date: Date
S100_CataloguePointofContact
+ organization: CharacterString
+ phone: CI_Telephone [0..1]
+ address: CI_Address [0..1]
S100_DigitalSignatureValue
To do: Whether S-104 exchange sets can also contain interoperability catalogues. (No?)
S-104 restrictions of S-100 metadata:
Support files are not used in S-104 and therefore the S-100 support file metadata elements and attributes are not allowed.
S100_DatasetDiscoveryMetadata: (1) The following attributes are not used: updateNumber, updateApplicationDate, optimumDisplayScale, maximumDisplayScale, minimumDisplayScale, soundingDatum (see additional note). (2) The following optional S-100 attributes are made mandatory in S-104: editionNumber, dataCoverage
S100_DataFormat: Only the HDF5 format is allowed for coverage datasets. GML and ISO/IEC 8211 are allowed only for meta-feature files.
S100_DataCoverage: The following attributes are not used: maximumDisplayScale, minimumDisplayScale, optimumDisplayScale.
S100_ExchangeCatalogue: The following attribute is mandatory: productSpecification.
To do: determine whether vertical or sounding datum is the appropriate metadata attribute. S-102 PT is talking about using sounding datum instead of vertical datum as being more appropriate for depth values. Does water level count as depth?


class Metadata
CarrierMetadata
+ classification: classification [0..1]
+ copyright: copyright [0..1]
+ dataProtection: Boolean
+ dataProtectionSchema: CharacterString [0..1]
+ datasetEditionNumber: Integer
+ datasetFilename: CharacterString
+ datasetFilePath: CharacterString
+ eastBoundLongitude: Real
+ encodingFormat: CharacterString
+ encodingVersion: Integer
+ heightUnit: CharacterString = meter
+ horizontalDatumReference: CharacterString = EPSG
+ horizontalDatumValue: Integer = 4326
+ horizontalPositionUncertainty: Real [0..1]
+ isGrid: Boolean
+ issuingAuthority: S-62
+ methodologyDescription: CharacterString
+ nextRevisionIssueDateAndTime: DateTime
+ northBoundLatitude: Real
+ producerCode: S-62
+ product_Spec_Issue_Date: Integer
+ product_Spec_Used: CharacterString = S-104
+ product_Spec_Version: CharacterString = 1.0.0
+ purpose: Purpose
+ soundingDatum: VerticalDatum
+ southBoundLatitude: Real
+ timeUncertainty: Real [0..1]
+ typeOfWaterLevelData: typeOfWaterLevelData
+ verticalDatum: verticalDatum
+ verticalPositionUncertainty: Real [0..1]
+ westBoundLongitude: Real
This object is inconsistent with Table 12.1 in the draft S-104 specification. Table seems to come from S-111 verbatim, and should be updated to match model.
S100_DatasetDiscoveryMetadata
+ classification: MD_SecurityConstraints [0..1]
+ comment: CharacterString [0..1]
+ copyright: MD_RestrictionCode [0..1]
+ dataCoverage: S100_DataCoverage [1..*]
+ dataProtection: Boolean [0..1]
+ dataType: S100_DataFormat
+ dataTypeVersion: CharacterString
+ description: CharacterString
+ digitalSignature: CharacterString [0..1]
+ editionNumber: CharacterString
+ fileName: CharacterString
+ filePath: CharacterString
+ horizontalDatumReference: CharacterString
+ horizontalDatumValue: Integer
+ issueDate: Date
+ layerID: CharacterString [0..*]
+ maximumDisplayScale: Integer [0..1]
+ minimumDisplayScale: Integer [0..1]
+ optimumDisplayScale: Integer [0..1]
+ otherDataTypeDescription: CharacterString [0..1]
+ producingAgency: CI_ResponsibleParty
+ productSpecification: S100_ProductSpecification
+ protectionScheme: CharacterString [0..1]
+ purpose: CharacterString
+ soundingDatum: S100_VerticalAndSoundingDatum
+ specificUsage: MD_Usage
+ updateApplicationDate: Date [0..1]
+ updateNumber: CharacterString
+ verticalDatum: S100_VerticalAndSoundingDatum
GridMetadata
+ gridOriginLat: Real
+ gridOriginLong: Real
+ gridSpacingLat: Real
+ gridSpacingLong: Real
+ landMask: Real = -99
+ numberOfTimes: Integer
+ numberPointsLat: Integer
+ numberPointsLong: Integer
+ timeInterval: Real
constraints
{Mandatory iff isGrid=1}
PointSetMetadata
+ numberOfTimes: Integer
+ timeInterval: Real
constraints
{Mandatory iff isGrid=0}
The attributes numberOfTimes and timeInterval are both present in PointSetMetadata and GridMetadata. This means the attributes can be moved up to the abstract class CarrierMetadata. This could enable the removal of the PointSetMetadata class, and that point sets would just use the CarrierMetadata class. Overall the model could be simplified.

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. decrypt, decompress, load etc. Other catalogues can be included in the exchange set in support of the datasets such as feature, ~~and~~ portrayal, coordinate reference systems, codelists, etc~~.~~.

The language used for the metadata is English.

Time reference for all **data will be UTC.**

All water level values to be given in metres (up to ~~three~~ two decimal places for real values).

12.2.1 S100_ExchangeCatalogue

Each exchange set has a single S100_ExchangeCatalogue which contains meta information for the data in the exchange set.

Name	Description	Mult	Value	Type	Remarks
S100_ExchangeCatalogue	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-		-	-
Identifier	Uniquely identifies this exchange catalogue	1		S100_CatalogueIdentifier	
Contact	Details about the issuer of this exchange catalogue	1		S100_CataloguePointOfContact	
productSpecification	Details about the product specifications used for the datasets contained in the exchange catalogue	0..1		S100_ProductSpecification	Conditional on all the datasets using the same product specification
exchangeCatalogueName	Catalogue filename	1		CharacterString	In S-104 it would be CATLOG.104
exchangeCatalogueDescription	Description of what the exchange catalogue contains	1		CharacterString	
exchangeCatalogueComment	Any additional Information	0..1		CharacterString	
compressionFlag	Is the data compressed	0..1		Boolean	Yes or No

Commented [GS44]: Ensure all S-100 tables (and their correct attributes) are here. There seem to be several missing, e.g. S100_ExchangeSet, S100_Dataset, S100_DigitalSignature, S100_DigitalSignatureValue, S100_ProtectionScheme, S100_DatasetDiscoveryMetadata, PT_Locale, and S104_DatasetDiscoveryMetadata.

These will have to follow S-100 Edition 4.0.0 for now, and we can always update them once S-100 Edition 5.0.0 is released.

Name	Description	Mult	Value	Type	Remarks
algorithmMethod	Type of compression algorithm	0..1		CharacterString	Eg. RAR or ZIP
sourceMedia	Distribution media	0..1		CharacterString	
replacedData	If a data file is cancelled is it replaced by another data file	0..1		Boolean	
dataReplacement	Cell name	0..1		CharacterString	

12.2.2 S100_CatalogueIdentifier *Does this need to remain? Use of file naming convention to assist with identifiying latest replacement file.

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueIdentifier	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-	-	-
Attribute	identifier	Uniquely identifies this exchange catalogue	1	CharacterString	
Attribute	editionNumber	The edition number of this exchange catalogue	1	CharacterString	
Attribute	date	Creation date of the exchange catalogue	1	Date	

12.2.3 S100_CataloguePointofContact

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CataloguePointOfContact	Contact details of the issuer of this exchange catalogue	-	-	-

Attribute	organization	The organization distributing this exchange catalogue	1	CharacterString	This could be an individual producer, value added reseller, etc.
Attribute	phone	The phone number of the organization	0..1	CI_Telephone	
Attribute	address	The address of the organization	0..1	CI_Address	

12.2.4 S100_DatasetDiscoveryMetad~~D~~ata

Data in the Discovery Metadata are used to identify the relevance of the dataset to the particular application.

Name	Description	Mult	Value	Type	Remarks
S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the exchange catalogue	-		-	-
fileName	Dataset file name	1		CharacterString	
filePath	Full path from the exchange set root directory	1		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<filename>
description	Short description giving the area or location covered by the dataset	1		CharacterString	E.g. a harbour or port name, between two named locations etc.
dataProtection	Indicates if the data is encrypted	0..1		Boolean	0 indicates an unencrypted dataset 1 indicates an encrypted dataset
protectionScheme	specification or method used for data protection	0..1		CharacterString	Eg S-63
digitalSignature	Indicates if the data has a digital signature	0..1		Boolean	0: unsigned 1: datafile is digitally signed [to be reconciled when S-100 finalizes digital signature elements]
digitalSignatureValue	Digital signature	0..1		CharacterString	This contains a base64 encoding of the hexadecimal numbers comprising the digital signature itself. The content of these fields are defined, along with the algorithms for their calculation, in S-63 ed2.0 Part (C).

Commented [JZM45]: S100 Review: Review remarks against text in section 11.1 for consistency.

Name	Description	Mult	Value	Type	Remarks
					[to be reconciled when S-100 finalizes digital signature elements]
classification	Indicates the security classification of the dataset	0..1		Enumeration	One of the following from ISO 19115 MD_SecurityConstraints> MD_ClassificationCode (codelist) 1. unclassified 2. restricted 3. confidential 4. secret 5. top secret
purpose	The purpose for which the dataset has been issued	1		MD_Identification>purpose CharacterString	E.g. new, re-issue, new edition, update etc.
specificUsage	The use for which the dataset is intended	1		CharacterString	E.g. in the case of ENCs this would be a navigation purpose classification.
editionNumber	The edition number of the dataset	1		CharacterString	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.
issueDate	date on which the data was made available by the data producer	1		Date	
productSpecification	The product specification used to create this dataset	1		S100_ProductSpecification	
producingAgency	Agency responsible for producing the data	1		CI_ResponsibleParty	
horizontalDatumReference	Reference to the register from which the horizontal datum value is taken	1		characterString	EPSG
horizontalDatumValue	Horizontal Datum of the entire dataset	1		Integer	4326
verticalDatum	Vertical Datum of the entire dataset	0..1		S100_VerticalAndSoundingDatum	
dataType	The encoding format of the dataset	1		S100_DataFormat	
otherDataTypeDescription	Encoding format other than those listed.	0..1		CharacterString	
dataTypeVersion	The version number of the dataType.	1		CharacterString	

Commented [JZM45]: S100 Review: Review remarks against text in section 11.1 for consistency.

Commented [JZM46]: S100 Review: suggest adding clarification about water level datum elsewhere and reference that here or add comment that this attribute is the datum the water level data is referenced to.

Name	Description	Mult	Value	Type	Remarks
dataCoverage	Area covered by the dataset	1		S100_DataCoverage	
comment	Any additional information	0..1		CharacterString	

Commented [JZM45]: S100 Review: Review remarks against text in section 11.1 for consistency.

12.2.5 S100_DataCoverage

Name	Description	Mult	Value	Type	Remarks
S100_DataCoverage		-		-	-
ID	Uniquely identifies the coverage	1		Integer	-
boundingBox	The extent of the dataset limits	1		EX_GeographicBoundingBox	-
boundingPolygon	A polygon which defines the actual data limit	1..*		EX_BoundingPolygon	-
optimumDisplayScale	The scale with which the data is optimally displayed	0..1		Integer	
maximumDisplayScale	The maximum scale with which the data is displayed	0..1		Integer	
minimumDisplayScale	The minimum scale with which the data is displayed	0..1		Integer	

12.2.6 EX_GeographicBoundingBox

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_GeographicBoundingBox	geographic position of the dataset	-	-	Defined in ISO 19115
westBoundLongitude	western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees
eastBoundLongitude	eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees
southBoundLatitude	southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees

Name	Description	Mult	Type	Remarks
northBoundLatitude	northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees

12.2.7 EX_BoundingPolygon

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_BoundingPolygon	boundary enclosing the dataset, expressed as the closed set of (x,y) coordinates of the polygon (last point replicates first point)	-	-	Defined in ISO 19115
polygon	sets of points defining the bounding polygon	1	GM_Object	Must be a GM_Polygon (See S-100 Part 7, ISO 19107, ISO 19136)

12.2.8 S100_VerticalAndSoundingDatum

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	-	-
Value	meanLowWaterSprings		-	-	1
Value	meanSeaLevel		-	-	2
Value	meanLowerLowWaterSprings		-	-	3
Value	lowestLowWater		-	-	4
Value	meanLowWater		-	-	5
Value	lowestLowWaterSprings		-	-	6
Value	approximateMeanLowWaterSprings		-	-	7
Value	indianSpringLowWater		-	-	8
Value	lowWaterSprings		-	-	9
Value	approximateLowestAstronomicalTide		-	-	10
Value	nearlyLowestLowWater		-	-	11
Value	meanLowerLowWater		-	-	12
Value	lowWater		-	-	13
Value	approximateMeanLowWater		-	-	14
Value	approximateMeanLowerLowWater		-	-	15
Value	meanHighWater		-	-	16
Value	meanHighWaterSprings		-	-	17
Value	highWater		-	-	18
Value	approximateMeanSeaLevel		-	-	19
Value	highWaterSprings		-	-	20
Value	meanHigherHighWater		-	-	21
Value	equinoctialSpringLowWater		-	-	22
Value	lowestAstronomicalTide		-	-	23
Value	localDatum		-	-	24
Value	internationalGreatLakesDatum1985		-	-	25
Value	meanWaterLevel		-	-	26
Value	lowerLowWaterLargeTide		-	-	27
Value	higherHighWaterLargeTide		-	-	28
Value	nearlyHighestHighWater		-		29
Value	highestAstronomicalTide		-		30(HAT)
Value	Ellipsoidal Height	Not in S100!			31

Commented [JZM47]: S100 Review: Ask for an extension to the S-100 list

Commented [GS48]: IGLD-2000 and other vertical datums were also requested. There is a way to use datums not on this list, as long as there is an EPSG code for it. See verticalDatumReference and verticalDatum in Table 12.1, which describes how to do so for the carrier (file) metadata.

However, using a vertical datum that is not on this list for exchange dataset metadata is trickier. Technically it can be left out of the exchange dataset metadata, since vertical datum is optional there.

But this would force the ECDIS to read the dataset to find out the vertical datum. We may want to ask S-100 to cover situations when the datum is not in this S100_VerticalAndSoundingDatum list, so that the ECDIS can know what vertical datum is used in a dataset without actually reading the dataset.

Value	Geoid	Not in S100			32

12.2.9 S100_DataFormat

Commented [JZM49]: S100 Review: ask for extension to list for new data formats

Role Name	Name	Description	Code	Remarks
Enumeration	S100_DataFormat	Encoding format	-	ISO/IEC 8211 and GML are allowed only for metafeature files, if included in the exchange set. The S-100 value 'undefined' is not used
Value	ISO/IEC 8211	The ISO 8211 data format as defined in Part 10a	-	-
Value	GML	The GML data format as defined in Part 10b	-	-
Value	HDF5	The HDF5 data format as defined in Part 10c	-	-
~~Value~~	~~BAG~~	~~Format~~	-	~~S102 Bathymetric Attributed Grid~~

12.2.10 S100_ProductSpecification

Name	Description	Mult	Type	Remarks
S100_ProductSpecification	The Product Specification contains the information needed to build the specified product	-	-	-
name	The name of the product specification used to create the datasets	1	CharacterString	S-104 ~~Surface Current~~Water Level Product Specification
version	The version number of the product specification	1	CharacterString	1.0.0
date	The version date of the product specification	1	Date	

12.2.11 S100_CatalogueMetadata

Commented [JZM50]: S100 Review: add explanation for class. This class is used to provide metadata about feature and portrayal catalogues.

Name	Description	Mult	Value	Type	Remarks
S100_CatalogueMetadata		-		-	-
filename	The name for the catalogue	1..*		CharacterString	

fileLocation	Full location from the exchange set root directory	1..*		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<file name>
scope	Subject domain of the catalogue	1..*		S100_CatalogueScope	
versionNumber	The version number of the product specification	1..*		CharacterString	
issueDate	The version date of the product specification	1..*		Date	
productSpecification	The product specification used to create this file	1..*		S100_ProductSpecification	
digitalSignatureReference	Digital Signature of the file	1		CharacterString	Reference to the appropriate digital signature algorithm
digitalSignatureValue	Value derived from the digital signature	1		CharacterString	

12.2.12 S100_CatalogueScope

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueScope		-	-	-
Value	featureCatalogue				
Value	portrayalCatalogue				

12.3 Carrier Metadata

The metadata for the S-104 product is divided in three sections, corresponding to the General Metadata (Table 12.1), the Feature Metadata (Table 12.2), and the Instance Metadata (Table 12.3). Since these values do not reside in the Metadata blocks, but are in the HDF5 files, they are referred to as Carrier Metadata. The ~~c~~Carrier M~~m~~etadata consists of the data and parameters needed to read and interpret the information in the Water Level product even if the other S-104 Meta~~D~~data files are unavailable.

Note that in Tables 12.1, 12.2, and 12.3, some of the metadata variables have restrictions on their core values (i.e., whether they are optional or mandatory, the specific values allowed, etc.) that are not imposed in S-100. These are grouped under the heading '*Additional restrictions on core metadata for S-104*.' It is suggested for any enumeration in S-104, to use native integer type H5T_NATIVE_UINT8 for the base type of the numeric code when creating the enumeration.

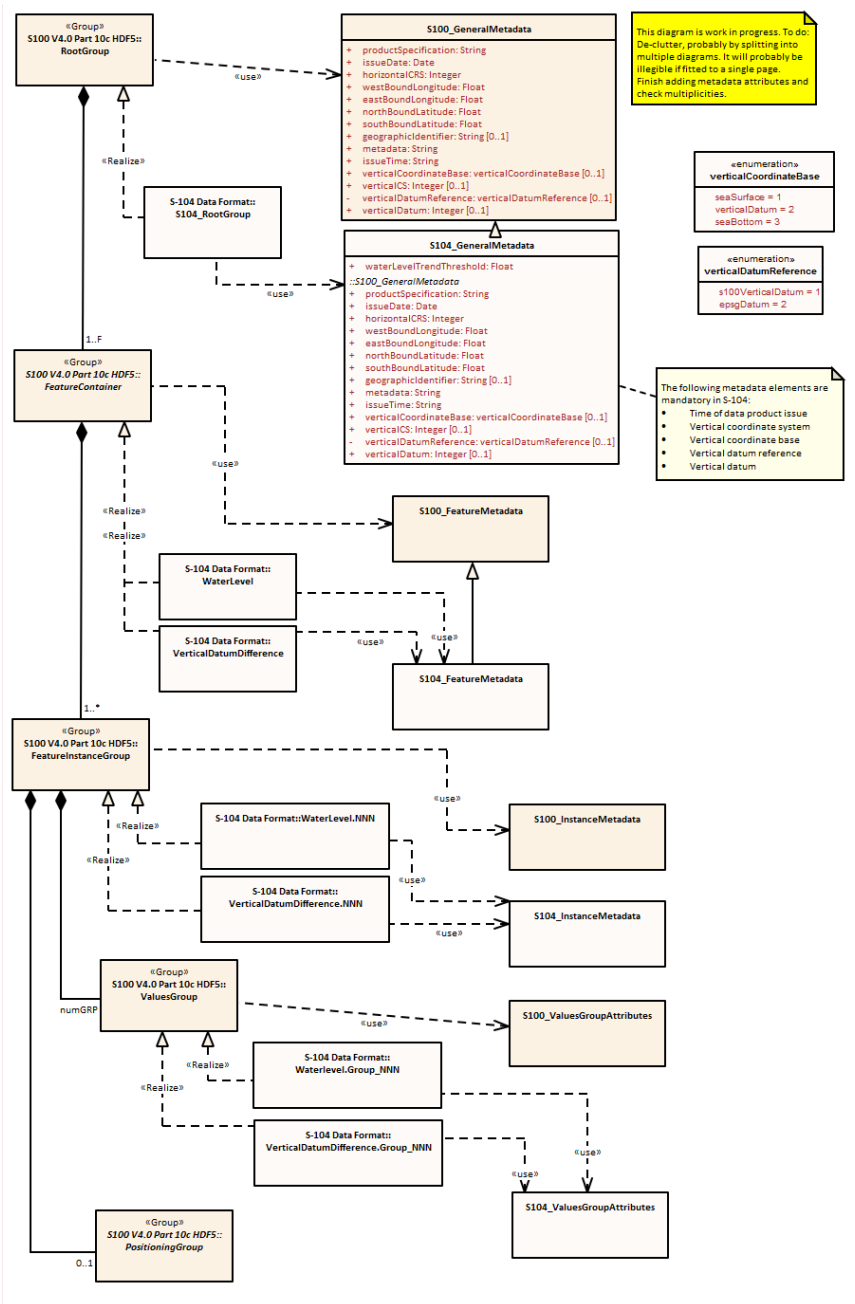


Figure 12.2 – Carrier metadata for the S-104 HDF5 group hierarchy.

Commented [GS51]: This figure is a work in progress by S-100WG

Table 12.1 – ~~S-104 Carrier~~General M~~m~~etadata, related to the entire HDF5 file (see S-100 Table 10c-6). ~~with~~ Latitude and longitude values precise to 10^{-7} deg. All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
1	Product specification number and version	productSpecification	1	String	This must be encoded as 'INT.IHO.S-104.X.Y', with X representing the edition number and Y the revision number
2	Date of data product issue	issueDate	1	String	Date must be consistent with issueDate in discovery metadata.
3	Horizontal Coord. Ref. Sys.	horizontalCRS	1	Integer	EPSG code. E.g., 4326 (for WGS84) See https://spatialreference.org/ref/epsg/?page=1
4	Bounding box	westBoundLongitude	1	Float	Area encompassing all feature instances
5		eastBoundLongitude	1	Float	Units are Degrees.
6		southBoundLatitude	1	Float	
7		northBoundLatitude	1	Float	
8	Geographic locator	geographicIdentifier	0..1	String	Description
9	Metadata file name	metadata	1	String	Name of XML metadata file for the HDF5 file. Form: MD_<hdf file name>.XML.
Additional metadata for S-104					
10	Water level trend threshold	waterLevelTrendThreshold	1	Float	Critical value used to determine steady water level trend. Units are meters/hour (m/hr). E.g., 0.2. See Annex A (DCEG).
Additional restrictions on core general metadata for S-104					
11	Time of data product issue	issueTime	1	String	Mandatory for S-104. S-100 Time format. All times are in UTC. E.g., 123000Z
12	Vertical coordinate system	verticalCS	1	Integer	Mandatory for S-104. EPSG Code; Allowed Values • 6498 (Depth– Metres–Orientation Down) • 6499 (Height– Metres– Orientation Up)
13	Vertical coordinate base	verticalCoordinateBase	1	Enumeration	Mandatory for S-104. 1: Sea Surface 2: Vertical Datum 3: Sea Bottom
14	Vertical datum reference	verticalDatumReference	1	Enumeration	Mandatory for S-104. Only if verticalCoordinateBase = 2. 1: S-100 vertical datum 2: EPSG
15	Vertical datum	verticalDatum	1	Integer	Mandatory for S-104. Only if verticalCoordinateBase = 2. If verticalDatumReference = 1 this is a value from S100_VerticalAndSoundingDatum. If verticalDatumReference = 2 this is an EPSG code for vertical datum

No	Name	Camel Case	Mult	Data Type	Remarks and/or Units
1	Data organization index (Used to read the data. See Table 10.1)	dataCodingFormat	1	Enumeration	1: Time series at fixed stations 2: Regularly-gridded arrays 3: Ungeorectified gridded arrays 4: Moving platform 5: Irregular grid 6: Variable cell size 7: TIN 8: Time series at fixed stations (stationwise) This Product Specification only covers the use of only 1-3 and 7-8.
2	Dimension	dimension	1	Integer	The (spatial) dimension of the feature instances. For water levels, use 2.
3	Common Point Rule	commonPointRule	1	Enumeration	The procedure used for evaluating the coverage at a position that falls on the boundary or in an area of overlap between geometric objects. 1: average 2: low 3: high 4: all (recommended)
4	Horizontal position uncertainty	horizontalPositionUncertainty	1	Float	-1.0 (unknown) or positive value (m)
5	Vertical position uncertainty	verticalUncertainty	1	Float	-1.0 (unknown) or positive value (m)
6	Time uncertainty	timeUncertainty	0..1	Float	-1.0 (unknown) or positive value (s)
7	Number of feature instances	numInstances	1	Integer	
Additional metadata for S-104					
8	Methodology	methodWaterLevelProduct	0..1	String	Brief description of tide gauge type, forecast method or model, etc.
9	Min. water level height in dataset	minDatasetHeight	1	Float	Height in verticalCS in Table 12.1
10	Max. water level height in dataset	maxDatasetHeight	1	Float	Height in verticalCS in Table 12.1
dataCodingFormat = 2					
11	Sequencing Rule	sequencingRule.type	1	Enumeration	Method to be used to assign values from the sequence of values to the grid coordinates. Components: type: Enumeration CV_SequenceType For example 1 (for 'linear')
12		sequencingRule.scanDirection	1	String	scanDirection: String <axisNames entry> (comma-separated). For example "latitude,longitude"
13	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123).
dataCodingFormat = 3					
Additional restrictions on core feature metadata for S-104 for dataCodingFormat = 3					
11	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123). For S-104 dataCodingFormat = 3, use 10 (for 'discrete').
dataCodingFormat = 7					
11	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123).
dataCodingFormat = 8					
Additional metadata for S-104 for dataCodingFormat = 8					
11	Order of series in pick report	pickPriorityType	1	String	Default priority of series for pick report. Use "0" for differences (*typeOfWaterLevelData* = 6, 7, 8, 9, 10). E.g., "2,1,4,5,3,0,0,0,0,0" (without quotes). See Table

					12.3. Total numbers (here 10) must be equal to numInstances.

Table 12.2 – Feature metadata, pertaining to the Water Level feature (see S-100 Table 10c-10)

Table 12.3 – Instance metadata, pertaining to the feature instance (see S-100 Table 10c-12). All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
1	Bounding box	westBoundLongitude	0..1	Float	Area of grid, set of stations, etc.
2		eastBoundLongitude	0..1	Float	Units are decimal degrees.
3		southBoundLatitude	0..1	Float	
4		northBoundLatitude	0..1	Float	
5	Number of time records	numberOfTimes	0..1	Integer	The total number of time records. For dataCodingFormat = 8, this variable migrates to the values group attributes (Table 12.4).
6	Time interval	timeRecordInterval	0..1	Integer	The interval between time records. Units: Seconds. For dataCodingFormat = 8, this variable migrates to the values group attributes (Table 12.4).
7	Valid time of earliest value	dateTimeOfFirstRecord	0..1	String	DateTime format. First record in the Instance. All times are in UTC.
8	Valid time of latest value	dateTimeOfLastRecord	0..1	String	DateTime format.
9	Number of values groups	numGRP	1	Integer	Number of Values Groups. For dataCodingFormat = 1, 2, 3, and 7, equals the number of time points. For dataCodingFormat = 8, equals the number of stations.
10	Instance chunking value	instanceChunking	0..1	String	For example “1,256” (without quotes). If present, overrides attribute value in Group_F.
Additional metadata for S-104					
11	Type of water level data	typeOfWaterLevelData	1	Enumeration	1: Observation 2: Astronomical prediction 3: Analysis or hybrid method 4: Hydrodynamic model hindcast 5: Hydrodynamic model forecast 6: Observed minus predicted 7: Observed minus analysis 8: Observed minus hindcast 9: Observed minus forecast 10: Forecast minus predicted Note: if a difference is provided (6-10), suggested to also provide the other two series.
dataCodingFormat = 1					
12	Number of fixed stations	numberOfStations	1	Integer	Number of individual fixed stations in this instance.
dataCodingFormat = 2					
12	Longitude of grid origin	gridOriginLongitude	1	Float-Double	Degrees
13	Latitude of grid origin	gridOriginLatitude	1	Float-Double	Degrees
14	Grid spacing, long.	gridSpacingLongitudinal	1	Float-Double	Degrees
15	Grid spacing, lat.	gridSpacingLatitudinal	1	Float-Double	Degrees
16	Number of points, long.	numPointsLongitudinal	1	Integer	numCOLS
17	Number of points, lat.	numPointsLatitudinal	1	Integer	numROWS
18	Start sequence	startSequence	1	String	E.g., “0,0” (without quotes) for scans starting at lower left corner i=0, j=0. For upper left, “0,n”, where n is the value of numROWS-1. First character represents first axis in sequencingRule.scanDirection. (Table 12.2), which here is latitude.

dataCodingFormat = 3					
12	Number of nodes	numberOfNodes	1	Integer	The total number of grid points
dataCodingFormat = 7					
12	Number of nodes	numberOfNodes	1	Integer	The total number of grid points
13	Number of triangles	numberOfTriangles	1	Integer	The total number of triangles in the TIN
dataCodingFormat = 8					
12	Number of fixed stations	numberOfStations	1	Integer	Number of individual fixed stations in this instance. Must equal numGRP.

12.4 Values Group Attributes

An expanded new metadata block is required for the Values Groups (Table 12.4). The variables *stationName* and *stationIdentification* have been added for both identification and possibly for inclusion in the text of the graph. Note that additional variables such as Marine Resource Names (MRN) and station category (e.g. high or long-term, medium, or low) can be added here. The series start and end times, number of records, and time interval index are included since they may differ for each series.

NOTE: These attributes will be incorporated in S-100 Ed 5.0.0.

Table 12.4 – Values Group attributes (see S-100 Table 10c-18). All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
dataCodingFormat = 1, 2, 3, or 7					
1	Time stamp	timePoint	1	String	DateTime. All times are in UTC.
dataCodingFormat = 8					
1	Index for time interval	timeIntervalIndex	1	(Integer)	1 (TRUE) denotes uniform time interval: interval provided by *timeRecordInterval*. 0 (FALSE) denotes non-uniform time interval. This is a boolean data type implemented as described in S-100 Table 10c-1.
2	Time interval	timeRecordInterval	0..1	Integer	Only if *timeIntervalIndex* = 1. The uniform interval between time records. Units: Seconds. Value here overrides corresponding value at Instance level.
Additional restrictions on core values group metadata for S-104 for dataCodingFormat = 8					
3	Name of the station	stationName	1	String	Mandatory for S-104. E.g., a geographic description or 'Not Available'
4	Station identification	stationIdentification	1	String	Mandatory for S-104. E.g., a letter-number combination for the station or 'Not Available'
5	Number of time records	numberOfTimes	1	Integer	Mandatory for S-104. Value here overrides corresponding value at Instance level
6	Valid time of earliest value	startDateTime	1	String	Mandatory for S-104. DateTime format. All times are in UTC.
7	Valid time of latest value	endDateTime	1	String	Mandatory for S-104. DateTime format.

12.5 Language

The language used for the Discovery Metadata and the Carrier Metadata is English.

IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

~~N~~	~~Name~~	~~Camel Case~~	~~Data Type~~	~~Remarks and/or Units~~
~~1~~	~~Product Spec and version~~	~~productSpecification~~	~~Character~~	~~This must be encoded as 'S-104.X.X.X', with Xs representing the version number~~
~~2~~	~~Date-Time of data product issue~~	~~dateTimeOfIssue~~	~~Character~~	~~DateTime. Must be consistent with issueDate in discovery metadata.~~
~~3~~	~~Name of geographic region~~	~~nameRegion~~	~~Character~~	
~~4~~	~~Name of geographic sub-region~~	~~nameSubregion~~	~~Character~~	
~~5~~	~~Horizontal datum~~	~~horizontalDatumReference~~	~~Character~~	~~EPSG~~
~~6~~	~~Horizontal datum number~~	~~horizontalDatumValue~~	~~Integer~~	~~4326 (for WGS84)~~
~~7~~	~~Indicates if the data is encrypted~~	~~dataProtection~~	~~Enumeration~~	~~0: unencrypted dataset~~ ~~1: encrypted dataset~~
~~8~~	~~Specification or method used for data protection~~	~~protectionScheme~~	~~Character~~	~~Eg. S-63~~
~~9~~	~~Valid Time of Earliest Value~~	~~dateTimeOfFirstRecord~~	~~Character~~	~~DateTime~~
~~10~~	~~Valid Time of Latest Value~~	~~dateTimeOfLastRecord~~	~~Character~~	~~DateTime~~
~~11~~	~~Time interval~~	~~timeRecordInterval~~	~~Integer~~	~~Seconds~~
~~12~~	~~Number of time records~~	~~numberOfTimes~~	~~Integer~~	
~~13~~	~~Type of Waterlevel data~~	~~typeOfWaterlvelData~~	~~Enumeration~~	~~1. Historical observation~~ ~~2. Real-time observation~~ ~~3. Astronomical prediction~~ ~~4. Analysis or hybrid method~~ ~~5. hindcast~~ ~~6. forecast~~
~~14~~	~~Data organization index, used to read the data~~	~~dataCodingFormat~~	~~Enumeration~~	~~1: Time series at fixed stations~~ ~~2: Regularly-gridded arrays~~ ~~3: Irregularly-gridded arrays~~
~~15~~	~~Number of fixed stations~~	~~numberOfStations~~	~~Integer~~	~~Used only if dataCodingFormat = 1~~
~~16~~	~~Vertical datum reference~~	~~verticalDatum~~	~~Enumeration~~	~~Chart datum as per Clause 12.2.6~~
~~17~~	~~Longitude of grid origin~~	~~gridOriginLongitude~~	~~Real~~	~~Arc Degrees (if dataCodingFormat=2)~~
~~18~~	~~Latitude of grid origin~~	~~gridOriginLatitude~~	~~Real~~	~~Arc Degrees (if dataCodingFormat=2)~~
~~19~~	~~Grid spacing, long.~~	~~gridSpacingLongitudinal~~	~~Real~~	~~Arc Degrees (if dataCodingFormat=2)~~
~~20~~	~~Grid spacing, lat.~~	~~gridSpacingLatitudinal~~	~~Real~~	~~Arc Degrees (if dataCodingFormat=2)~~
~~21~~	~~Number of points, long.~~	~~numPointsLongitudinal~~	~~Integer~~	~~iMax (if dataCodingFormat=2)~~
~~22~~	~~Number of points, lat.~~	~~numPointsLatitudinal~~	~~Integer~~	~~jMax (if dataCodingFormat=2)~~
~~23~~	~~First grid point num., long.~~	~~minGridPointLongitudinal~~	~~Integer~~	~~0 (if dataCodingFormat=2)~~
~~24~~	~~First grid point num., lat.~~	~~minGridPointLatitudinal~~	~~Integer~~	~~0 (if dataCodingFormat=2)~~
~~25~~	~~Nodes in irregular grid~~	~~numberOfNodes~~	~~Integer~~	~~Used if dataCodingFormat=3~~
~~26~~	~~Land mask value~~	~~gridLandMaskValue~~	~~Real~~	~~Negative value (e.g. -1.0 or -99.999). Also denotes a missing value.~~
~~27~~	~~Horizontal position uncertainty~~	~~uncertaintyOfHorizontalPosition~~	~~Real~~	~~-1.0 (unknown) or positive value (m)~~
~~28~~	~~Vertical position uncertainty~~	~~uncertaintyOfVerticalPosition~~	~~Real~~	~~-1.0 (unknown) or positive value (m)~~

~~29~~	~~Time uncertainty~~	~~uncertaintyOfTime~~	~~Real~~	~~1.0 (unknown) or positive value (s)~~
~~30~~	~~Methodology~~	~~methodCurrentsProduct~~	~~Character~~	~~Brief description of current meter type, forecast method or model, etc.~~

~~12.5~~12.6 Data Type Specific Metadata

Commented [JZM52]: S100 Review: clarify text or move to correct section.

Commented [GS53R52]: Agreed, not sure how it fits into S-104 product so clarifying text would help. These might now be in the above metadata, e.g. Tables 12.1-12.4.

Single point metadata

Name/Role	Source	Multiplicity	Value	Type	Remarks
Time_interval (delivery)		1		Real	
Unique Identifier		1		Character/numerical	Port Number as given in Tide Table
Unique Name		1		Character string	Port Name as given in Tide Table
MNR unique code		1		Character/numerical	
Port Quality type		1		Boolean	0 – Standard / Major 1 – Secondary / Minor
Value for missing data		1		Real	

Commented [ZJ54]: Add port quality, for that countries that provided additional information to standard port.

Feature Type: WaterLevel

Name/Role	Source	Multiplicity	Value	Type	Remarks
Position (x,y)	S100	1			Latitude and Longitude of the entity
Water level Height including tide		1			metres Maximum 2 decimal places Observed/ predicted
Water level uncertainty		1		Real	metres – maximum 2 decimetres

					-99 if uncertainty is unknown
Water level trend	ASM	1	* to be confirmed in enumeration list starts at 1 or 0 0 1 2 3	Enumerate	0 = steady 1 = decreasing 2 = increasing 3 = not available

ANNEX A – DATA CLASSIFICATION AND ENCODING GUIDE

~~There are two features described herein: water level and vertical datum difference.~~

A.1 ~~Water Level~~Features

~~Feature:~~ Water Level (*WaterLevel*)

IHO Definition: FEATURE: **WATER LEVEL:** The vertical position of a water surface			
S-104 Geo Feature: Water Level			
Primitives: ~~S100_GridCoverage, S100_PointCoverage~~pointSet, coverage			
S-104 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Water Level Height	must be in decimal metres, maximum resolution of 0.01 metres	RE	1
Water Level Trend	1: Decreasing ~~Steady~~ 2: Increasing ~~Decreasing~~ 3: Steady ~~Increasing~~ ~~4: Not available~~	EN	1
Water Level Time	YYYYMMDDTHHMMSSZ	DT	0..1

A.2 Feature Attributes

The number of attributes for *Water Level* is ~~two~~three: water level height, ~~and~~ water level trend, and water level time.

1. Water Level Height (*waterLevelHeight*)

Water Level Height: The height of a water surface relative to a vertical datum

Unit: metre (m)
Minimum Resolution: 0.01 m
Format: xxx.xx
Example: 10.54
Remarks:

- Land mask or missing value is denoted by a unique number as specified in the metadata.
- The height is relative to some vertical datum, which is defined in the metadata.
- 0.01 m equals 0.3937 in (1 cm)

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2. Water Level Trend (*waterLevelTrend*)

Water Level Trend: The tendency of water level to change in a particular direction.

1: Decreasing (*decreasing*)
2: Increasing (*increasing*)
3: Steady (*steady*)

Unit: none (enumeration)
Minimum Resolution: N/A (enumeration)
Format: x
Example: 3: Steady
Remarks:

- To determine category, use metadata variable *waterLevelTrendThreshold* (See Table 12.1):
  - Decreasing: trend <= -*waterLevelTrendThreshold*
  - Increasing: trend >= +*waterLevelTrendThreshold*
  - Steady: -*waterLevelTrendThreshold* < trend < +*waterLevelTrendThreshold*
- Where a value is not known, the fill value must be populated, which is 0: Unknown. The fill value may be used in non-tidal or similar regions.
- The fill value of 0: Unknown is recommended for all difference series (*typeOfWaterLevelData* = 6, 7, 8, 9, or 10).
- Native integer type H5T_NATIVE_UINT8 should be used for the base type of the numeric code (1, 2, or 3 here) when creating the enumeration.

3. Water Level Time (*waterLevelTime*)

Water Level Time: The time of the water level height, expressed in Date-time format as specified by ISO 8601.

Unit: Years, months, days, hours, minutes, seconds

Resolution: 1 second

Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second

Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.

Remarks:

- Required only for fixed station (stationwise) time series data (*dataCodingFormat* = 8) with non-uniform time intervals.
- All times are in UTC (Universal Time Coordinated).

A.2 Vertical Datum Difference

Feature: Vertical Datum Difference (*VerticalDatumDifference*)

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Commented [GS55]: Should we remove this feature? It is not currently included in the Feature Catalogue, IHO Registry, or metadata.

IHO Definition: FEATURE: **VERTICAL DATUM DIFFERENCE:** the separation distance between an ellipsoid and a chart datum			
S-104 Geo Feature: Datum Difference			
Primitives: S100_GridCoverage, S100_PointCoverage			
S-104 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Vertical Datum Difference Value	must be in decimal metres, maximum resolution of 0.01 metres	RE	1

The number of attributes for *Vertical Datum Difference* is one.

Vertical Datum Difference Value (*verticalDatumDifferenceValue*)

Vertical Datum Difference Value: The value of the separation distance between two vertical datums, such as an ellipsoid and a tidal datum.

Unit: metre (m)
Minimum Resolution: 0.01 m
Format: xxx.xx
Example: 8.37
Remarks:

- Land mask or missing value is denoted by a unique number as specified in the metadata.
- Datum information is contained in the metadata.
- 0.01 m equals 0.3937 in (1 cm)

Commented [GS56]: Should this be verticalDatumDifferenceValue? If not, definition may need to read something like "The value of the separation distance between two datums, such as an ellipsoid and a tidal datum in the vertical."

~~ANNEX B – Data Product Format (Encoding)~~

Commented [GS57]: Add Annex B Additional Terms and Definitions? See S-111

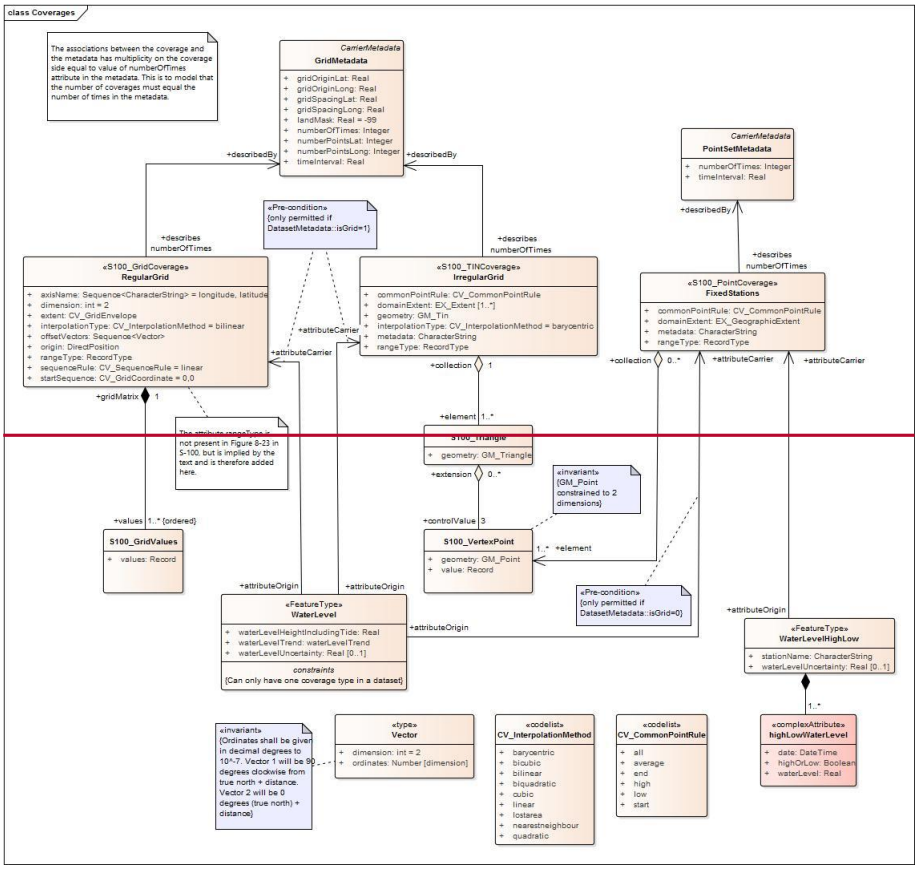
~~B.1 GML Example Code~~

The following is an example of a GML file for zones of influence:

```
<?xml version="1.0" encoding="UTF-8"?>
<waterlevelzones:DataSet xmlns:waterlevelzones="http://www.iho.int/S104/gml/1.0"
    xsi:schemaLocation="http://www.iho.int/S104/gml/1.0 S104.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:gml="http://www.opengis.net/gml/3.2"
    xmlns:S100="http://www.iho.int/s100gml/1.0"
    xmlns:xlink="http://www.w3.org/1999/xlink" gml:id="test1">
    <gml:boundedBy><gml:Envelope srsName="urn:ogc:def:crs:epsg::4326">
        <gml:lowerCorner>-20.0000 -180.0000</gml:lowerCorner>
        <gml:upperCorner>90.0000 180.0000</gml:upperCorner>
    </gml:Envelope></gml:boundedBy>
    <DatasetIdentificationInformation>
        <S100:encodingSpecification>S-100 Part 10b</S100:encodingSpecification>
        <S100:encodingSpecificationEdition>1.0</S100:encodingSpecificationEdition>
        <S100:productIdentifier>S-104</S100:productIdentifier>
        <S100:productEdition>0.6</S100:productEdition>
        <S100:applicationProfile>1</S100:applicationProfile>
        <S100:datasetFileIdentifier>test1.gml</S100:datasetFileIdentifier>
        <S100:datasetTitle>points and polygons</S100:datasetTitle>
        <S100:datasetReferenceDate>2018-10-25</S100:datasetReferenceDate>
        <S100:datasetLanguage>EN</S100:datasetLanguage>
        <S100:datasetTopicCategory>transportation</S100:datasetTopicCategory>
    </DatasetIdentificationInformation>
    <member>
    <waterlevelzones:Centroid gml:id="CENTROID_001">
        <geometry>
        <S100:pointProperty>
        <S100:Point gml:id="CENTROID000001">
            <gml:pos>36.7189990 -74.6455280</gml:pos>
        </S100:Point>
        </S100:pointProperty>
        </geometry>
    </waterlevelzones:Centroid>
    </member>
    <member>
    <waterlevelzones:AreaOfInfluence gml:id="AREAINFL_001">
        <geometry>
        <S100:surfaceProperty>
        <S100:Polygon gml:id="AREAINFL000001">
            <gml:exterior>
                <gml:LinearRing>
                    <gml:posList>36.5951740 -74.9939270 37.1464370 -74.9924610
37.2255560 -73.9721970 36.4206690 -73.9513520 36.5951740 -74.9939270</gml:posList>
                </gml:LinearRing>
            </gml:exterior>
        </S100:Polygon>
        </S100:surfaceProperty>
        </geometry>
    </waterlevelzones:AreaOfInfluence>
    </member>
</waterlevelzones:DataSet>
```

Annex C – Application Schema (UML Diagrams)

Commented [GS58]: These are being updated with the help of S-100WG.



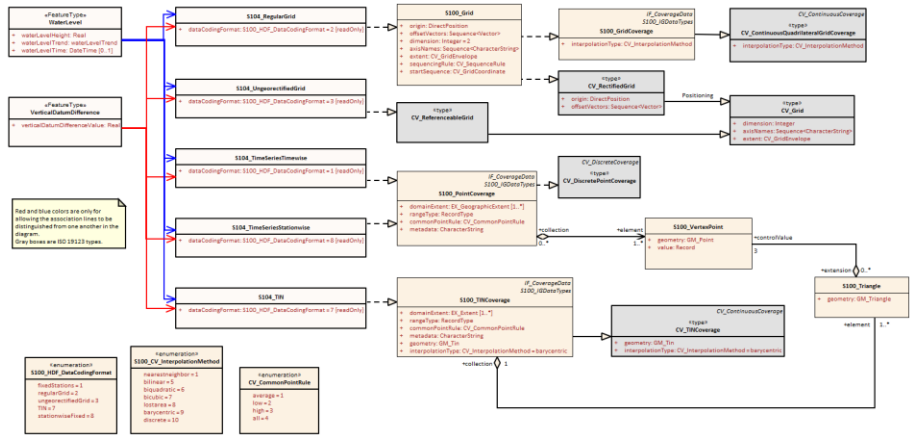


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Figure C.1 Spatial Types – Coverages

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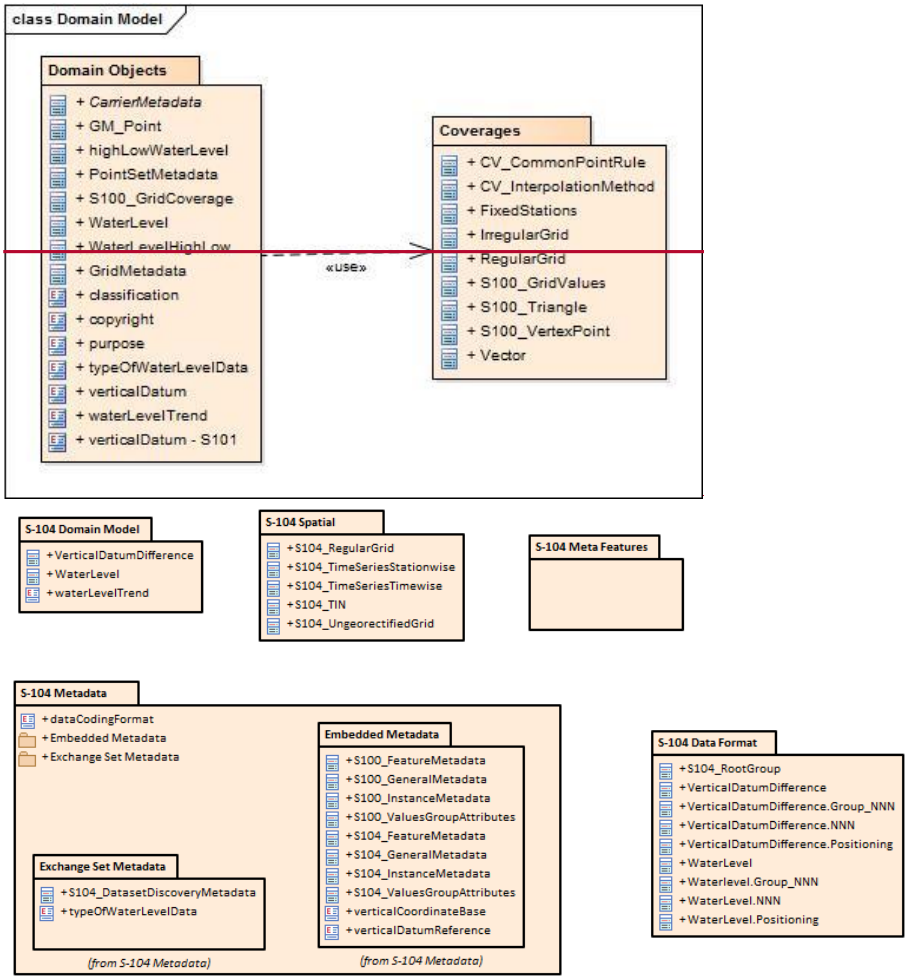


Figure C.2 Domain Model

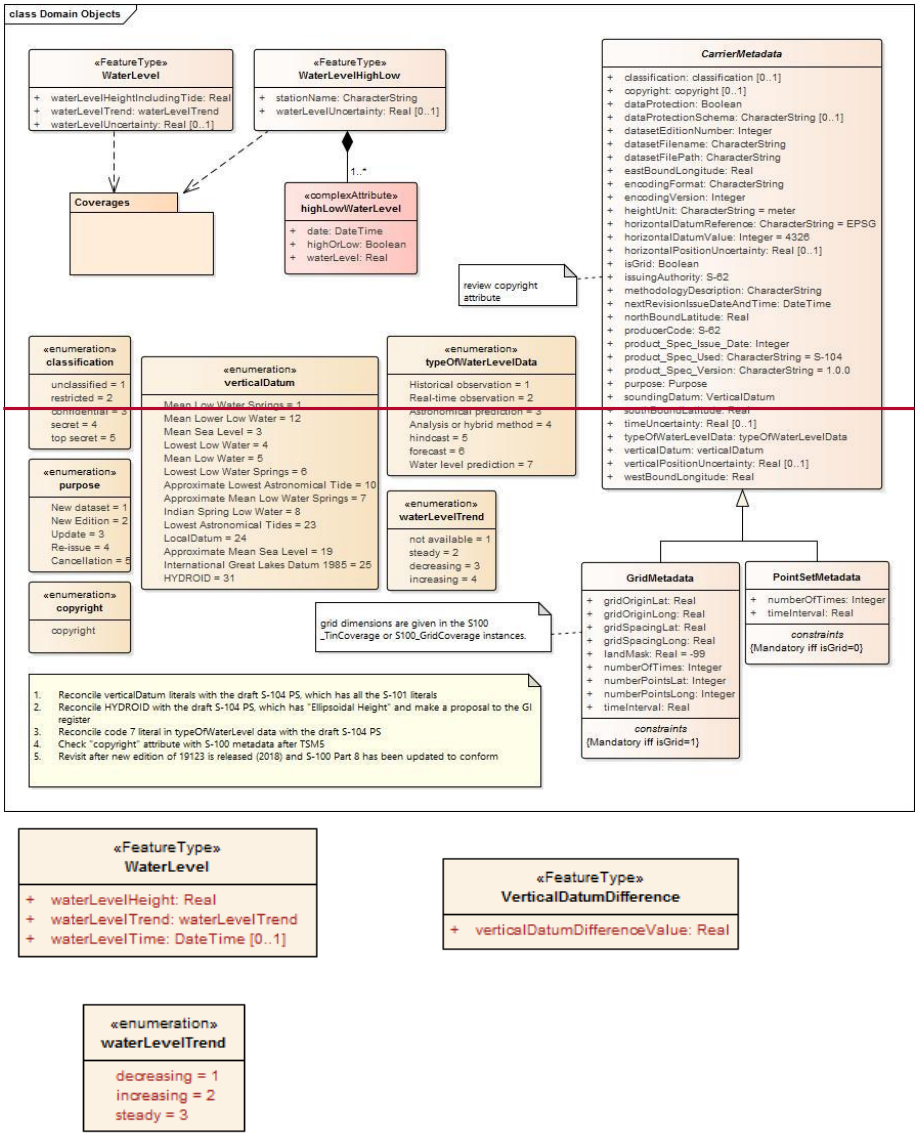
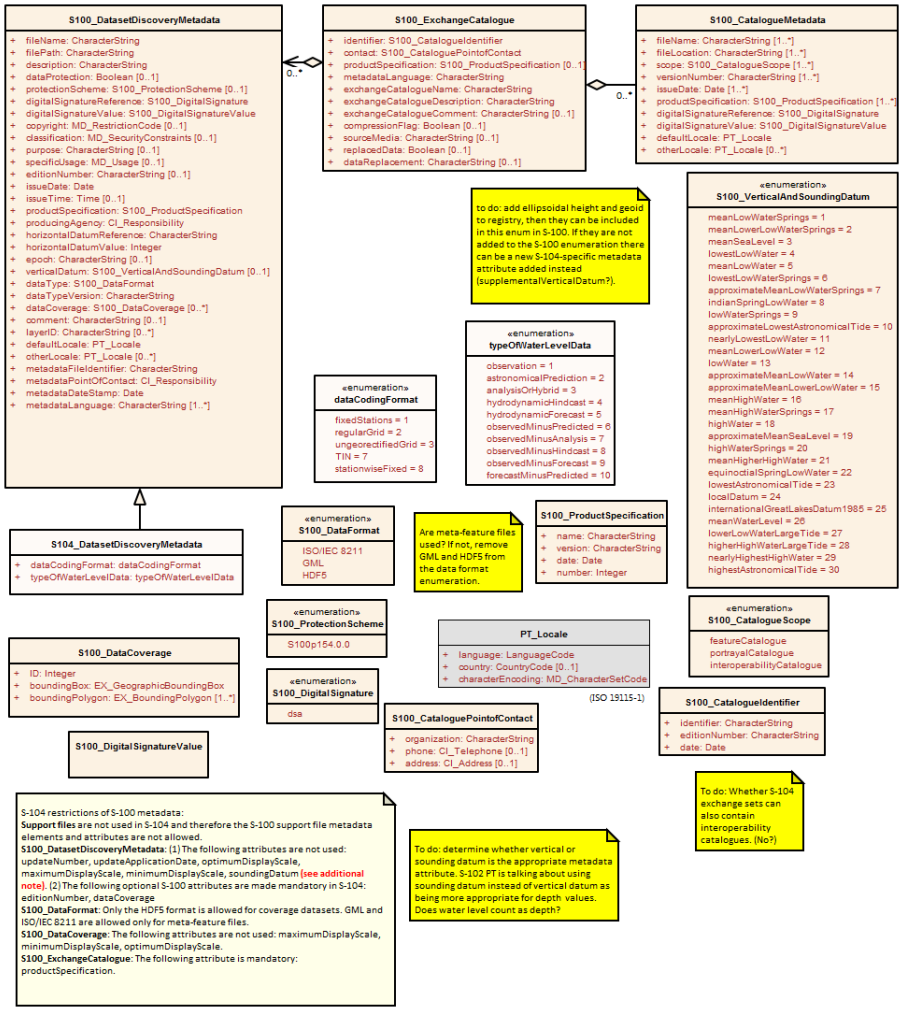


Figure C.3 Domain Objects


S100_DatasetDiscoveryMetadata
+ fileName: CharacterString
+ filePath: CharacterString
+ description: CharacterString
+ dataProtection: Boolean [0..1]
+ protectionScheme: S100_ProtectionScheme [0..1]
+ digitalSignatureReference: S100_DigitalSignature
+ digitalSignatureValue: S100_DigitalSignatureValue
+ copyright: MD_RestrictionCode [0..1]
+ classification: MD_SecurityConstraints [0..1]
+ purpose: CharacterString [0..1]
+ specificUsage: MD_Usage [0..1]
+ editionNumber: CharacterString [0..1]
+ issueDate: Date
+ issueTime: Time [0..1]
+ productSpecification: S100_ProductSpecification
+ producingAgency: CI_Responsibility
+ horizontalDatumReference: CharacterString
+ horizontalDatumValue: Integer
+ epoch: CharacterString [0..1]
+ verticalDatum: S100_VerticalAndSoundingDatum [0..1]
+ dataType: S100_DataFormat
+ dataTypeVersion: CharacterString
+ dataCoverage: S100_DataCoverage [0..*]
+ comment: CharacterString [0..1]
+ layerID: CharacterString [0..*]
+ defaultLocale: PT_Locale
+ otherLocale: PT_Locale [0..*]
+ metadataFileIdentifier: CharacterString
+ metadataPointOfContact: CI_Responsibility
+ metadataDateStamp: Date
+ metadataLanguage: CharacterString [1..*]
0..*
S100_ExchangeCatalogue
+ identifier: S100_CatalogueIdentifier
+ contact: S100_CataloguePointofContact
+ productSpecification: S100_ProductSpecification [0..1]
+ metadataLanguage: CharacterString
+ exchangeCatalogueName: CharacterString
+ exchangeCatalogueDescription: CharacterString
+ exchangeCatalogueComment: CharacterString [0..1]
+ compressionFlag: Boolean [0..1]
+ sourceMedia: CharacterString [0..1]
+ replacedData: Boolean [0..1]
+ dataReplacement: CharacterString [0..1]
0..*
S100_CatalogueMetadata
+ fileName: CharacterString [1..*]
+ fileLocation: CharacterString [1..*]
+ scope: S100_CatalogueScope [1..*]
+ versionNumber: CharacterString [1..*]
+ issueDate: Date [1..*]
+ productSpecification: S100_ProductSpecification [1..*]
+ digitalSignatureReference: S100_DigitalSignature
+ digitalSignatureValue: S100_DigitalSignatureValue
+ defaultLocale: PT_Locale
+ otherLocale: PT_Locale [0..*]
to do: add ellipsoidal height and geoid to registry, then they can be included in this enum in S-100. If they are not added to the S-100 enumeration there can be a new S-104-specific metadata attribute added instead (supplementalVerticalDatum?).
«enumeration»
S100_VerticalAndSoundingDatum
meanLowWaterSprings = 1
meanLowerLowWaterSprings = 2
meanSeaLevel = 3
lowestLowWater = 4
meanLowWater = 5
lowestLowWaterSprings = 6
approximateMeanLowWaterSprings = 7
indianSpringLowWater = 8
lowWaterSprings = 9
approximateLowestAstronomicalTide = 10
nearlyLowestLowWater = 11
meanLowerLowWater = 12
lowWater = 13
approximateMeanLowWater = 14
approximateMeanLowerLowWater = 15
meanHighWater = 16
meanHighWaterSprings = 17
highWater = 18
approximateMeanSeaLevel = 19
highWaterSprings = 20
meanHigherHighWater = 21
equinoctialSpringLowWater = 22
lowestAstronomicalTide = 23
localDatum = 24
internationalGreatLakesDatum1985 = 25
meanWaterLevel = 26
lowerLowWaterLargeTide = 27
higherHighWaterLargeTide = 28
nearlyHighestHighWater = 29
highestAstronomicalTide = 30
«enumeration»
typeOfWaterLevelData
observation = 1
astronomicalPrediction = 2
analysisOrHybrid = 3
hydrodynamicHindcast = 4
hydrodynamicForecast = 5
observedMinusPredicted = 6
observedMinusAnalysis = 7
observedMinusHindcast = 8
observedMinusForecast = 9
forecastMinusPredicted = 10
«enumeration»
dataCodingFormat
fixedStations = 1
regularGrid = 2
ungeorectifiedGrid = 3
TIN = 7
stationwiseFixed = 8
S104_DatasetDiscoveryMetadata
+ dataCodingFormat: dataCodingFormat
+ typeOfWaterLevelData: typeOfWaterLevelData
«enumeration»
S100_DataFormat
ISO/IEC 8211
GML
HDF5
Are meta-feature files used? If not, remove GML and HDF5 from the data format enumeration.
S100_ProductSpecification
+ name: CharacterString
+ version: CharacterString
+ date: Date
+ number: Integer
«enumeration»
S100_ProtectionScheme
S100p154.0.0
«enumeration»
S100_CatalogueScope
featureCatalogue
portrayalCatalogue
interoperabilityCatalogue
PT_Locale
+ language: LanguageCode
+ country: CountryCode [0..1]
+ characterEncoding: MD_CharacterSetCode
(ISO 19115-1)
S100_DataCoverage
+ ID: Integer
+ boundingBox: EX_GeographicBoundingBox
+ boundingPolygon: EX_BoundingPolygon [1..*]
«enumeration»
S100_DigitalSignature
dsa
S100_CataloguePointofContact
+ organization: CharacterString
+ phone: CI_Telephone [0..1]
+ address: CI_Address [0..1]
S100_CatalogueIdentifier
+ identifier: CharacterString
+ editionNumber: CharacterString
+ date: Date
S100_DigitalSignatureValue
To do: Whether S-104 exchange sets can also contain interoperability catalogues. (No?)
S-104 restrictions of S-100 metadata:
Support files are not used in S-104 and therefore the S-100 support file metadata elements and attributes are not allowed.
S100_DatasetDiscoveryMetadata: (1) The following attributes are not used: updateNumber, updateApplicationDate, optimumDisplayScale, maximumDisplayScale, minimumDisplayScale, soundingDatum [see additional note]. (2) The following optional S-100 attributes are made mandatory in S-104: editionNumber, dataCoverage
S100_DataFormat: Only the HDF5 format is allowed for coverage datasets. GML and ISO/IEC 8211 are allowed only for meta-feature files.
S100_DataCoverage: The following attributes are not used: maximumDisplayScale, minimumDisplayScale, optimumDisplayScale.
S100_ExchangeCatalogue: The following attribute is mandatory: productSpecification.
To do: determine whether vertical or sounding datum is the appropriate metadata attribute. S-102 PT is talking about using sounding datum instead of vertical datum as being more appropriate for depth values. Does water level count as depth?

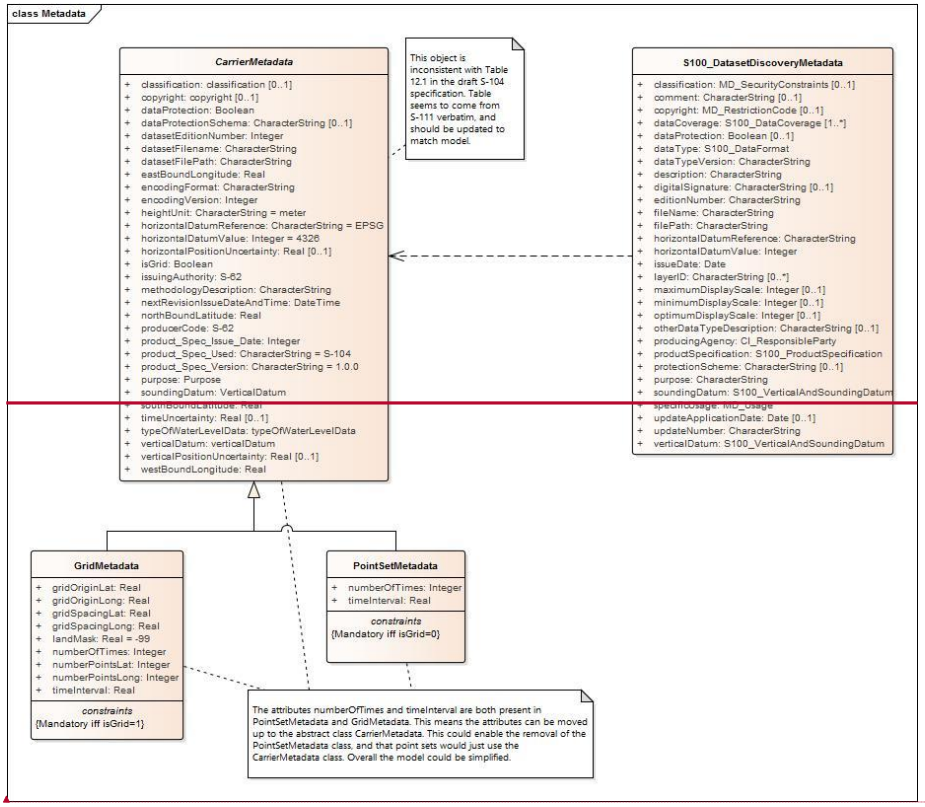


Figure C.4 ~~Metadata~~Exchange set class details

Annex D – Feature Catalogue

D.1. Meta Feature Types

D.2. Geo Feature Types

D.2.1. Water Level

Definition: The vertical position of a water surface.

CamelCase: WaterLevel

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IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

Alias:

Super type:

Feature use type: geographic

Primitive: pointSet, coverage

Remarks: No remarks.

Attribute Bindings:

S-104 Attribute	Allowable Encoding Value	Type	Multiplicity
Water Level Height		RE	1, 1
Water Level Trend	1 : Decreasing 2 : Increasing 3 : Steady	EN	1, 1
Water Level Time		DT	0, 1

D.3. Carto Feature Types

D.4. Information Types

D.5. Simple Attributes

D.5.1. Water Level Height

Definition: The height of a water surface relative to a vertical datum.

CamelCase: waterLevelHeight

Alias:

Value type: real

Remarks: No remarks.

D.5.2. Water Level Time

Definition: The time of the water level height, expressed in Date-time format as specified by ISO 8601.

CamelCase: waterLevelTime

Alias:

Value type: dateTime

Remarks: Unit: Years, months, days, hours, minutes, seconds; Resolution: 1 second; Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second; Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.

D.5.3. Water Level Trend

Definition: The tendency of water level to change in a particular direction.

CamelCase: waterLevelTrend

Alias:

IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

Value type: enumeration

Remarks: No remarks.

Listed Values:

Code	Label	Definition
1	Decreasing	Becoming smaller in magnitude.
2	Increasing	Becoming larger in magnitude.
3	Steady	Constant.

D.6. Complex Attributes

D.7. Roles

D.8. Information Associations

D.9. Feature Associations

D.10. Feature Catalogue XML

```
<?xml version="1.0" encoding="utf-8" ?>
- <S100FC:S100_FC_FeatureCatalogue xmlns:S100FC="http://www.iho.int/S100FC"
    xmlns:S100Base="http://www.iho.int/S100Base"
    xmlns:S100CI="http://www.iho.int/S100CI"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:S100FD="http://www.iho.int/S100FD"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.iho.int/S100FC S100FC.xsd">
  <S100FC:name>S-104</S100FC:name>
  <S100FC:scope>Water level data are intended to be used as stand-alone data or as
    a layer in an ENC.</S100FC:scope>
  <S100FC:fieldOfApplication>Marine navigation</S100FC:fieldOfApplication>
  <S100FC:versionNumber>0.0.7</S100FC:versionNumber>
  <S100FC:versionDate>2020-07-30</S100FC:versionDate>
- <S100FC:producer>
  <S100CI:role>owner</S100CI:role>
- <S100CI:party>
- <S100CI:CI_Organisation>
  <S100CI:name>International Hydrographic Organization</S100CI:name>
- <S100CI:contactInfo>
- <S100CI:phone>
  <S100CI:number>+377 93 10 81 00</S100CI:number>
  <S100CI:numberType>voice</S100CI:numberType>
    </S100CI:phone>
- <S100CI:address>
  <S100CI:administrativeArea>4b quai Antoine 1er</S100CI:administrativeArea>
  <S100CI:postalCode>B.P.445</S100CI:postalCode>
  <S100CI:country>MONACO</S100CI:country>
  <S100CI:electronicMailAddress>info@iho.int</S100CI:electronicMailAddress>
    </S100CI:address>
  <S100CI:hoursOfService>24h</S100CI:hoursOfService>
    </S100CI:contactInfo>
    </S100CI:CI_Organisation>
    </S100CI:party>
    </S100FC:producer>
  <S100FC:classification>unclassified</S100FC:classification>
- <S100FC:S100_FC_SimpleAttributes>
- <S100FC:S100_FC_SimpleAttribute>
  <S100FC:name>Water Level Height</S100FC:name>
```

<S100FC:definition>**The height of a water surface relative to a vertical datum.**</S100FC:definition>
<S100FC:code>**waterLevelHeight**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**324**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
<S100FC:valueType>**real**</S100FC:valueType>
</S100FC:S100_FC_SimpleAttribute>
- <S100FC:S100_FC_SimpleAttribute>
<S100FC:name>**Water Level Time**</S100FC:name>
<S100FC:definition>**The time of the water level height, expressed in Date-time format as specified by ISO 8601.**</S100FC:definition>
<S100FC:code>**waterLevelTime**</S100FC:code>
<S100FC:remarks>**Unit: Years, months, days, hours, minutes, seconds; Resolution: 1 second; Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second; Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.**</S100FC:remarks>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**313**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
<S100FC:valueType>**dateTime**</S100FC:valueType>
</S100FC:S100_FC_SimpleAttribute>
- <S100FC:S100_FC_SimpleAttribute>
<S100FC:name>**Water Level Trend**</S100FC:name>
<S100FC:definition>**The tendency of water level to change in a particular direction.**</S100FC:definition>
<S100FC:code>**waterLevelTrend**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**378**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
<S100FC:valueType>**enumeration**</S100FC:valueType>
- <S100FC:listedValues>
- <S100FC:listedValue>
<S100FC:label>**Decreasing**</S100FC:label>
<S100FC:definition>**Becoming smaller in magnitude.**</S100FC:definition>
<S100FC:code>**1**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**2070**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
</S100FC:listedValue>
- <S100FC:listedValue>
<S100FC:label>**Increasing**</S100FC:label>
<S100FC:definition>**Becoming larger in magnitude.**</S100FC:definition>
<S100FC:code>**2**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**2071**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>

```
    </S100FC:listedValue>
- <S100FC:listedValue>
  <S100FC:label>Steady</S100FC:label>
  <S100FC:definition>Constant.</S100FC:definition>
  <S100FC:code>3</S100FC:code>
- <S100FC:definitionReference>
  <S100FC:sourceIdentifier>2072</S100FC:sourceIdentifier>
  <S100FC:definitionSource>IHO:DDR</S100FC:definitionSource>
    </S100FC:definitionReference>
    </S100FC:listedValue>
    </S100FC:listedValues>
    </S100FC:S100_FC_SimpleAttribute>
    </S100FC:S100_FC_SimpleAttributes>
- <S100FC:S100_FC_FeatureTypes>
- <S100FC:S100_FC_FeatureType isAbstract="false">
  <S100FC:name>Water Level</S100FC:name>
  <S100FC:definition>The vertical position of a water surface.</S100FC:definition>
  <S100FC:code>WaterLevel</S100FC:code>
- <S100FC:definitionReference>
  <S100FC:sourceIdentifier>369</S100FC:sourceIdentifier>
  <S100FC:definitionSource>IHO:DDR</S100FC:definitionSource>
    </S100FC:definitionReference>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
  <S100Base:lower>1</S100Base:lower>
  <S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
    </S100FC:multiplicity>
  <S100FC:attribute ref="waterLevelHeight" />
    </S100FC:attributeBinding>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
  <S100Base:lower>1</S100Base:lower>
  <S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
    </S100FC:multiplicity>
- <S100FC:permittedValues>
  <S100FC:value>1</S100FC:value>
  <S100FC:value>2</S100FC:value>
  <S100FC:value>3</S100FC:value>
    </S100FC:permittedValues>
  <S100FC:attribute ref="waterLevelTrend" />
    </S100FC:attributeBinding>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
  <S100Base:lower>0</S100Base:lower>
  <S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
    </S100FC:multiplicity>
  <S100FC:attribute ref="waterLevelTime" />
    </S100FC:attributeBinding>
  <S100FC:featureUseType>geographic</S100FC:featureUseType>
  <S100FC:permittedPrimitives>pointSet</S100FC:permittedPrimitives>
  <S100FC:permittedPrimitives>coverage</S100FC:permittedPrimitives>
```

```
</S100FC:S100_FC_FeatureType>
</S100FC:S100_FC_FeatureTypes>
</S100FC:S100_FC_FeatureCatalogue>
```

Annex E – Sample HDF5 Encoding

The following are examples of HDF5 water level data files for each of the five data coding formats. The general structure of the data product is shown in Table 10.2, and the specific variables contained in the attributes are explained in Tables 12.1, 12.2, 12.3 and 12.4. The sample HDF5 files were produced by MATLAB® and were displayed in HDFView version 2.14.

E.1 Common Groups and Attributes

Information shown in Figures E.1 through E.4 is common to all the data coding formats.

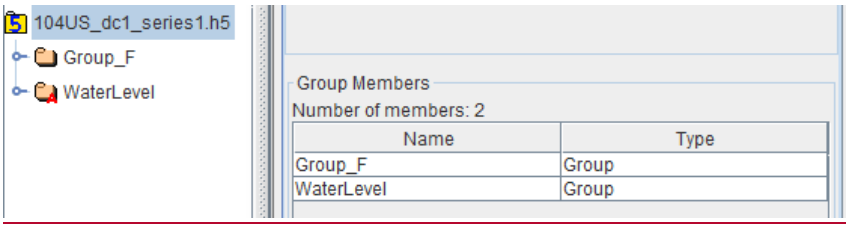


Figure E.1 - Typical HDF5 file (left) and its two groups, 'Group_F' and 'WaterLevel' (right)

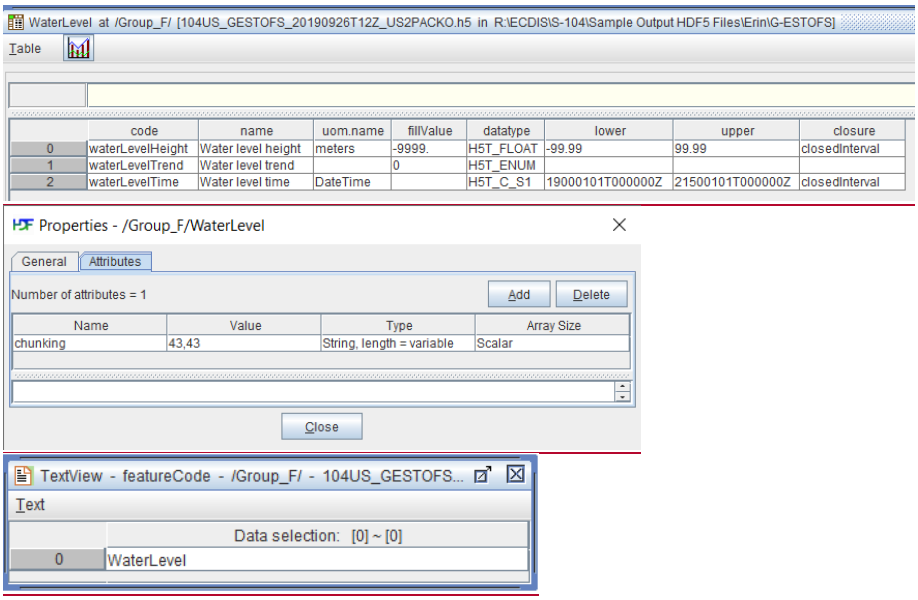


Figure E.2 - Group_F includes the (top panel) compound dataset 'WaterLevel' and (bottom panel) the scalar dataset 'featureCode'. The dataset 'WaterLevel' (middle panel) contains the attribute 'chunking'.

Values provided here for code (waterLevelHeight, waterLevelTrend, and waterLevelTime), uom.name (meters and DateTime), and fillValue (-9999. and 0) are required.

Commented [GS59]: OEM feedback (U.S. NIWC) suggests requiring code, uom.name, and fillValue for all S-104 datasets.

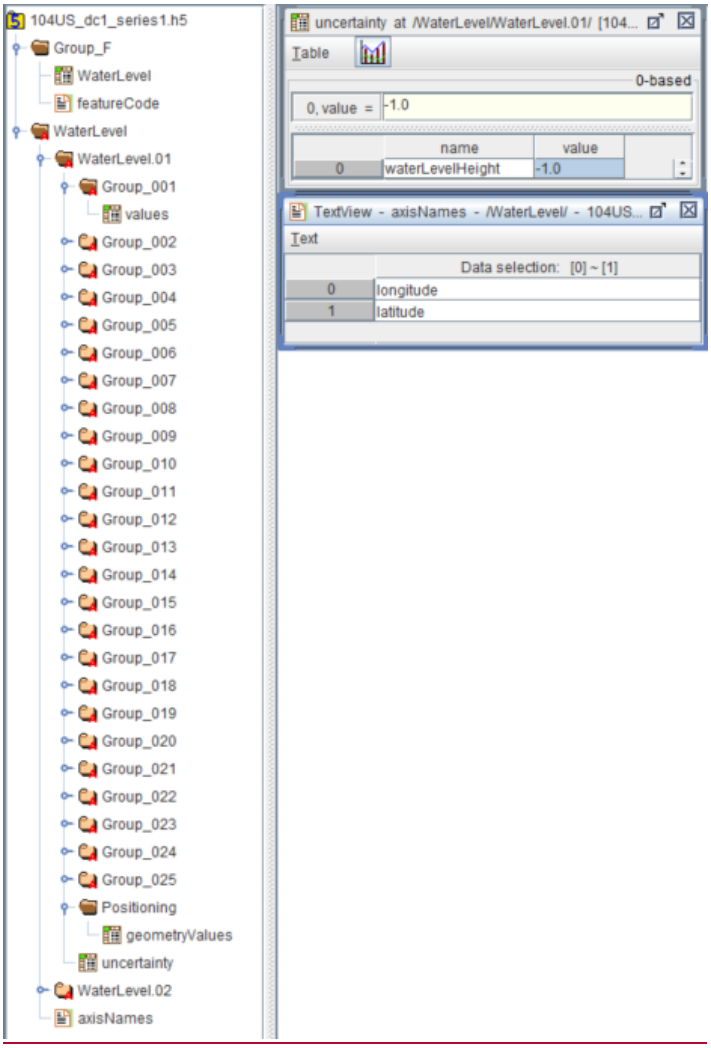
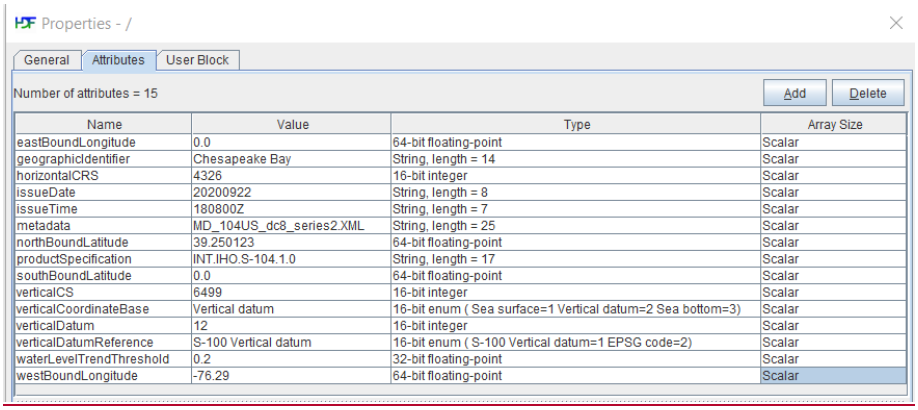


Figure E.3 – General structure of the HDF5 dataset (left panel); however, for dataCodingFormat =2, the group 'Positioning' is absent. On the right, the contents of the datasets 'uncertainty' (top right panel) within the group WaterLevel.01, and 'axisNames' (bottom right panel) within the group WaterLevel

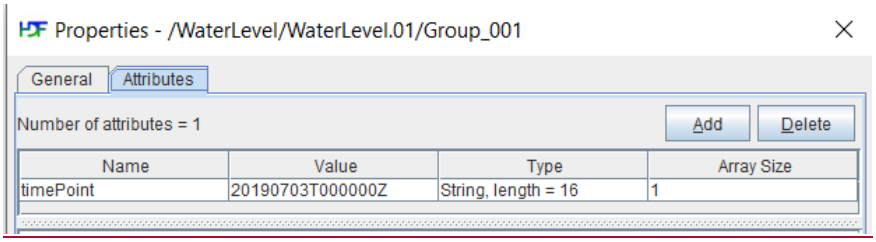


Name	Value	Type	Array Size
eastBoundLongitude	0.0	64-bit floating-point	Scalar
geographicIdentifier	Chesapeake Bay	String, length = 14	Scalar
horizontalCRS	4326	16-bit integer	Scalar
issueDate	20200922	String, length = 8	Scalar
issueTime	180800Z	String, length = 7	Scalar
metadata	MD_104US_dc8_series2.XML	String, length = 25	Scalar
northBoundLatitude	39.250123	64-bit floating-point	Scalar
productSpecification	INT.IHO.S-104.1.0	String, length = 17	Scalar
southBoundLatitude	0.0	64-bit floating-point	Scalar
verticalCS	6499	16-bit integer	Scalar
verticalCoordinateBase	Vertical datum	16-bit enum (Sea surface=1 Vertical datum=2 Sea bottom=3)	Scalar
verticalDatum	12	16-bit integer	Scalar
verticalDatumReference	S-100 Vertical datum	16-bit enum (S-100 Vertical datum=1 EPSG code=2)	Scalar
waterLevelTrendThreshold	0.2	32-bit floating-point	Scalar
westBoundLongitude	-76.29	64-bit floating-point	Scalar

Figure E.4 – Sample HDF5 attributes (cf. Table 12.1) of the root group

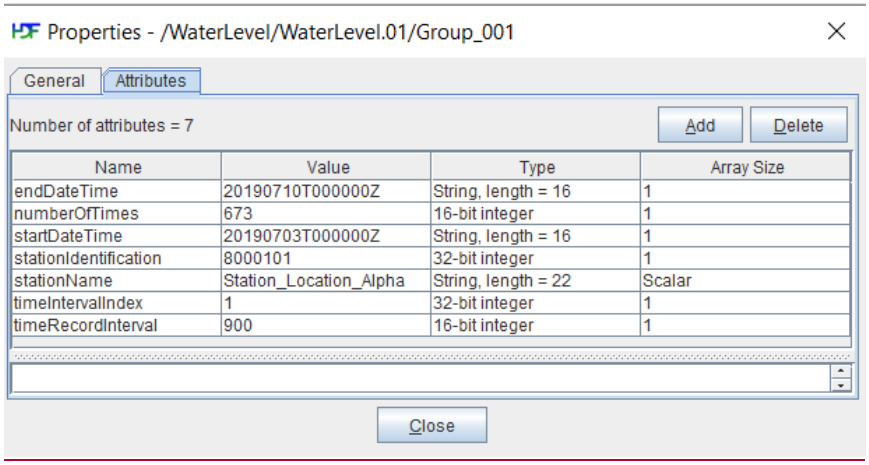
E.2 Values Groups Attributes

Attributes for the values groups have two forms: a short form for *dataCodingFormat* 1 through 7 (Figure E.5), and a longer form for *dataCodingFormat* 8 (Figure E.6).



Name	Value	Type	Array Size
timePoint	20190703T000000Z	String, length = 16	1

Figure E.5 – Short form of attributes of the values group 'Group_001.' Used for dataCodingFormat = 1 to 7.



Name	Value	Type	Array Size
endDateTime	20190710T000000Z	String, length = 16	1
numberOfTimes	673	16-bit integer	1
startDateTime	20190703T000000Z	String, length = 16	1
stationIdentification	8000101	32-bit integer	1
stationName	Station_Location_Alpha	String, length = 22	Scalar
timeIntervalIndex	1	32-bit integer	1
timeRecordInterval	900	16-bit integer	1

Figure E.6 - Long form of attributes of the values group 'Group_001'. Used for dataCodingFormat = 8.

E.3 Fixed Stations (dataCodingFormat=1)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values', corresponding to data at all stations at one point in time. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.

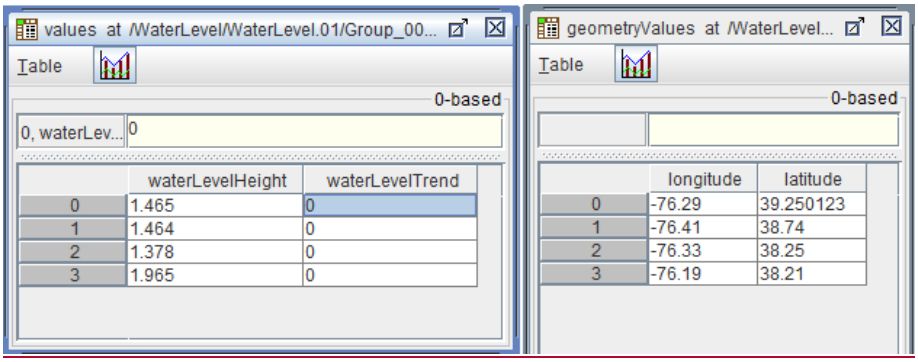


Figure E.7 – (left) For dataCodingFormat=1, sample contents of the dataset 'values' in Group_001 and (right) the geometry group 'Positioning', which contains location information on four fixed stations in the dataset 'geometryValues'. The HDF5 file structure is shown in Figure E.3

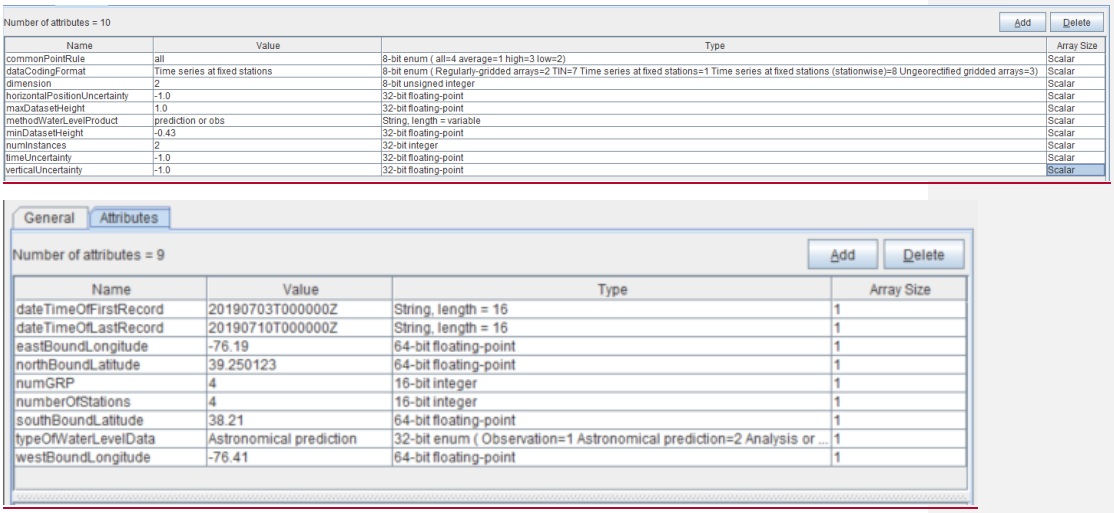


Figure E.8 – Attributes for (top panel) the feature metadata (cf. Table 12.2) and (bottom panel) the instance metadata (cf. Table 12.3)

E.4 Regular Grid (dataCodingFormat=2)

For this coding format, the height and trend are stored in the two-dimensional compound array 'values'. The entire array in the values group represents one point in time. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.

Using the values in the metadata, the longitude and latitude of any point (*i_index* and *j_index*) in the grid is computed by

longitude = gridOriginLongitude + (i_index)(gridSpacingLongitudinal)

latitude = gridOriginLatitude + (j_index)(gridSpacingLatitudinal).

The values of *i_index* start at 0 and increase up to *numPointsLongitudinal-1,* and similarly for *j_index.*

General | Attributes

Number of attributes = 13 — Add | Delete

Name	Value	Type	Array Size
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	Regularly-gridded arr...	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed stations=1 Time series at fixed stations...	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
interpolationType	bilinear	32-bit enum (nearestneighbor=1 bilinear=5 biquadratic=6 barycentric=9)	1
maxDatasetHeight	2.082	32-bit floating-point	1
methodWaterLevelProduct	gridded model	String, length = 13	1
minDatasetHeight	1.229	32-bit floating-point	1
numInstances	1	16-bit integer	1
sequencingRule.scanDirection	latitude,longitude	String, length = 18	1
sequencingRule.type	linear	32-bit enum (linear=1 boustrophedonic=2 CantorDiagonal=3 spiral=4 Morton=5 Hilbert=6)	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

General | Attributes

Number of attributes = 17 — Add | Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190606T120000Z	String, length = 16	1
dateTimeOfLastRecord	20190606T160000Z	String, length = 16	1
eastBoundLongitude	-74.373398	64-bit floating-point	1
gridOriginLatitude	33.567799	64-bit floating-point	1
gridOriginLongitude	-75.123398	64-bit floating-point	1
northBoundLatitude	35.317799	64-bit floating-point	1
numGRP	5	16-bit integer	1
numberOfTimes	5	16-bit integer	1
southBoundLatitude	33.567799	64-bit floating-point	1
startSequence	0,0	String, length = 3	1
timeRecordInterval	3600	16-bit integer	1
typeOfWaterLevelData	Hydrodynamic model forecast	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or hybrid method=3 Hydrodynamic ...	1
westBoundLongitude	-75.123398	64-bit floating-point	1
gridSpacingLongitudinal	0.25	64-bit floating-point	1
gridSpacingLatitudinal	0.25	64-bit floating-point	1
numPointsLatitudinal	8	16-bit integer	1
numPointsLongitudinal	4	16-bit integer	1

Figure E.9 – Attributes for (top panel) the feature metadata (cf. Table 12.2) and (bottom panel) the instance metadata (cf. Table 12.3)

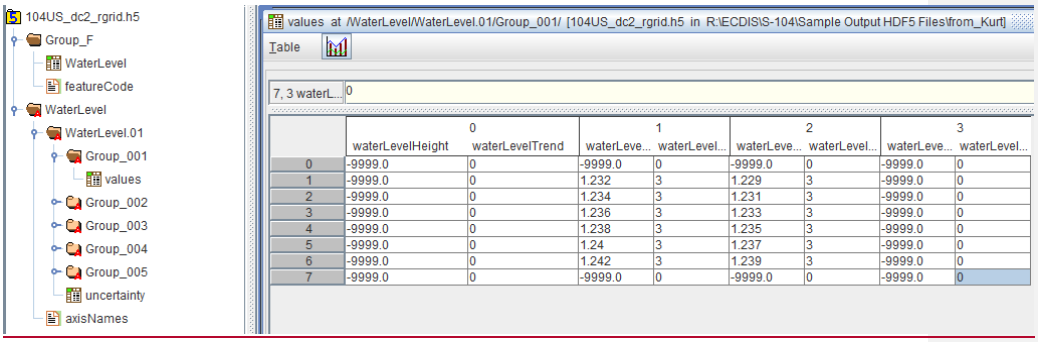
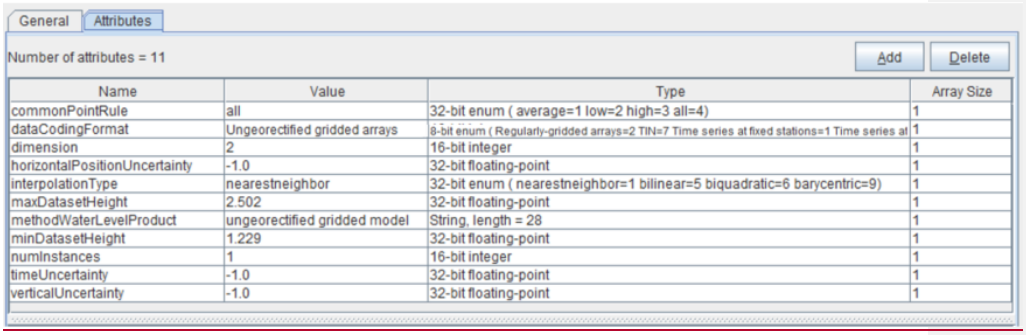


Figure E.10 – Sample HDF5 structure (left panel) and the dataset 'values' (right panel) for a two-dimensional array of regularly gridded data.

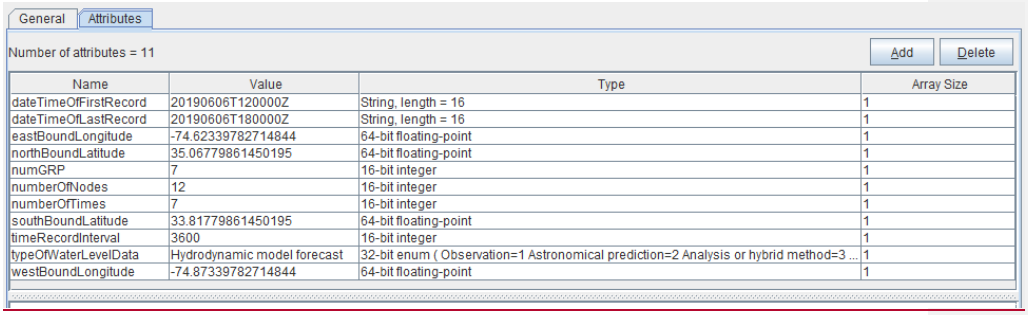
E.5 Ungeorectified Grid (dataCodingFormat=3)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values'. Data in the values group is for all nodes in the grid at one time point. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.



Name	Value	Type	Array Size
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	Ungeorectified gridded arrays	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed stations=1 Time series at	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
interpolationType	nearestneighbor	32-bit enum (nearestneighbor=1 bilinear=5 biquadratic=6 barycentric=9)	1
maxDatasetHeight	2.502	32-bit floating-point	1
methodWaterLevelProduct	ungeorectified gridded model	String, length = 28	1
minDatasetHeight	1.229	32-bit floating-point	1
numInstances	1	16-bit integer	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

Figure E.11 – Attributes for the feature metadata (cf. Table 12.2).



Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190606T120000Z	String, length = 16	1
dateTimeOfLastRecord	20190606T180000Z	String, length = 16	1
eastBoundLongitude	-74.62339782714844	64-bit floating-point	1
northBoundLatitude	35.06779861450195	64-bit floating-point	1
numGRP	7	16-bit integer	1
numberOfNodes	12	16-bit integer	1
numberOfTimes	7	16-bit integer	1
southBoundLatitude	33.81779861450195	64-bit floating-point	1
timeRecordInterval	3600	16-bit integer	1
typeOfWaterLevelData	Hydrodynamic model forecast	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or hybrid method=3 ...	1
westBoundLongitude	-74.87339782714844	64-bit floating-point	1

Figure E.12 – Attributes for the instance metadata (cf. Table 12.3).

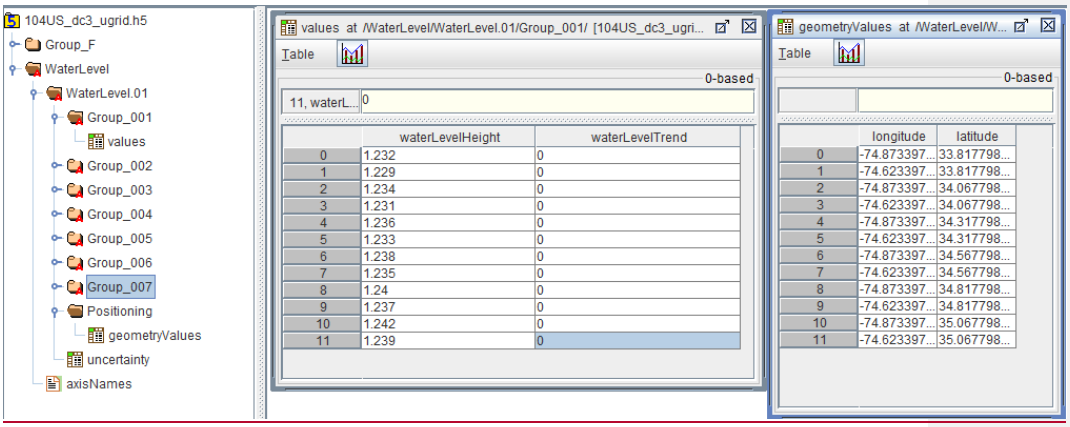


Figure E.13 – Sample HDF5 file (left panel) for ungeorectified gridded data. The middle panel shows the dataset 'values' and the right panel the dataset 'geometryValues'

E.6 TINs (dataCodingFormat=7)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values'. Data in the values group is for all nodes in the TIN grid at one time point. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. There are also the required *triangles* and optional *adjacency* arrays for TINs. The spelling and order of variable names are important.

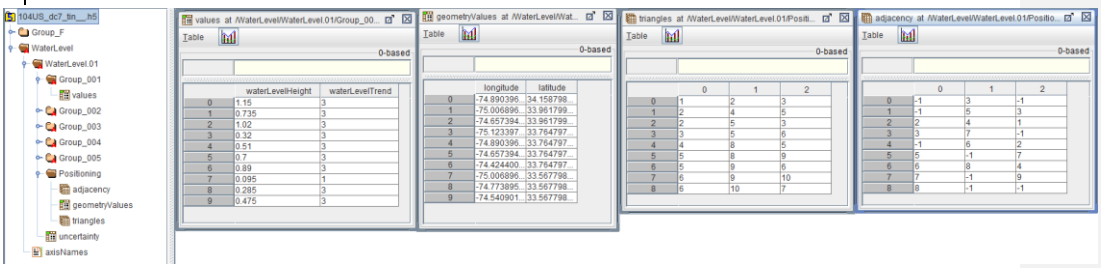


Figure E.14 – Sample HDF5 file (left panel) for a TIN. The second panel shows the dataset 'values', the third panel the dataset 'geometryValues', the fourth panel the dataset 'triangles', and the fifth panel the dataset 'adjacency'

General | Attributes

Number of attributes = 11 — Add | Delete

Name	Value	Type	Array Size
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	TIN	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed s!	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
interpolationType	barycentric	32-bit enum (nearestneighbor=1 bilinear=5 biquadratic=6 barycentric=9)	1
maxDatasetHeight	2.1486	32-bit floating-point	1
methodWaterLevelProduct	TIN model	String, length = 9	1
minDatasetHeight	0.095	32-bit floating-point	1
numInstances	1	16-bit integer	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

Figure E.15 – Attributes for the feature metadata (cf. Table 12.2).

General | Attributes

Number of attributes = 12 — Add | Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190606T120000Z	String, length = 16	1
dateTimeOfLastRecord	20190606T160000Z	String, length = 16	1
eastBoundLongitude	-74.42440032958984	64-bit floating-point	1
northBoundLatitude	34.15879821777344	64-bit floating-point	1
numGRP	5	16-bit integer	1
numberOfNodes	10	16-bit integer	1
numberOfTimes	5	16-bit integer	1
numberOfTriangles	9	16-bit integer	1
southBoundLatitude	33.56779861450195	64-bit floating-point	1
timeRecordInterval	3600	16-bit integer	1
typeOfWaterLevelData	Hydrodynamic model forecast	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or hybrid method=3 Hydrodynamic model hin...	1
westBoundLongitude	-75.12339782714844	64-bit floating-point	1

Figure E.16 – Attributes for the instance metadata (cf. Table 12.3).

E.7 Stationwise Fixed Stations (dataCodingFormat=8)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values', corresponding to data at one station for all time points (c.f., *dataCodingFormat*=1, where the data is for all stations for one time point.)

Formatted: Left

Formatted: Font: 11 pt, Not Bold, Not Italic

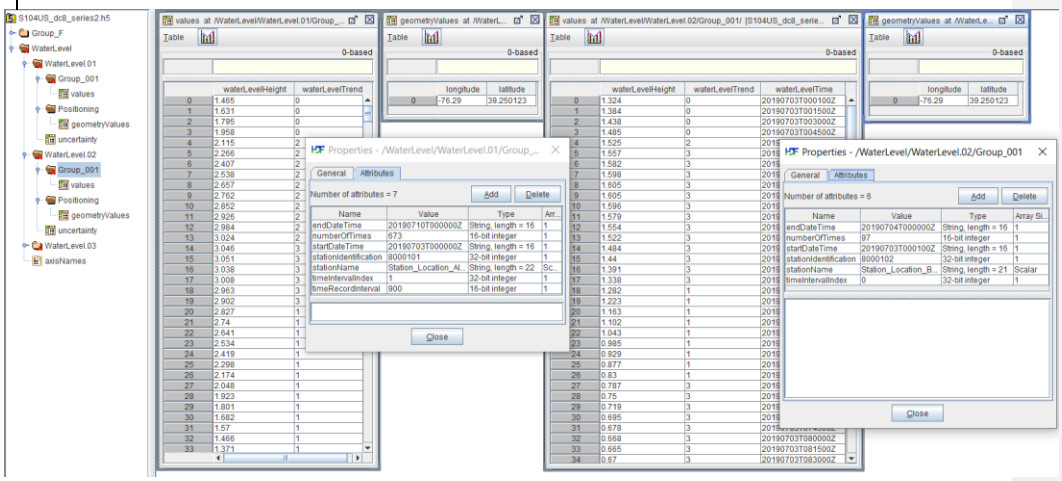


Figure E.17 – Sample HDF5 file (left panel) for stationwise fixed stations data. The second panel shows the dataset 'values' (for one station), and the third panel the dataset 'geometryValues'. The fourth panel

shows the dataset 'values' (for a station but different type of time series) but with non-uniform time interval data so waterLevelTime at each element is provided. The fifth panel shows the dataset 'geometryValues' for that second station. Also shown in foreground are the Values Group Attributes for each station time series.

General | Attributes

Number of attributes = 11 — Add — Delete

Name	Value	Type	Array ...
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	Time series at fixed sta...	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
maxDatasetHeight	3.051	32-bit floating-point	1
methodWaterLevelProduct	pred, obsv, fcst	String, length = 16	1
minDatasetHeight	0.655	32-bit floating-point	1
numInstances	3	16-bit integer	1
pickPriorityType	2,1,5	String, length = 5	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

Figure E.18 – Attributes for the feature metadata (cf. Table 12.2.)

General | Attributes

Number of attributes = 9 — Add — Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190703T000000Z	String, length = 16	1
dateTimeOfLastRecord	20190710T000000Z	String, length = 16	1
eastBoundLongitude	0.0	64-bit floating-point	1
northBoundLatitude	39.250123	64-bit floating-point	1
numGRP	1	16-bit integer	1
numberOfStations	1	16-bit integer	1
southBoundLatitude	0.0	64-bit floating-point	1
typeOfWaterLevelData	Astronomical prediction	32-bit enum (Observation=1 Astronomic...	1
westBoundLongitude	-76.29	64-bit floating-point	1

Figure E.19 - Attributes for the instance metadata (cf. Table 12.3)

Annex F – Portrayal Catalogue

Annex G – Validation Checks

Commented [GS60]: Do we need to add an Annex for Tests of Completeness? See S-111 Annex D.

Annex H – Meteorological and Hydrographic Data AIS Application-Specific Message

Commented [GS61]: Probably need to remove this Annex as real-time data won't be in S-104 until Ed 2.0.0 or later.

1.1 This message allows the distribution of meteorological and hydrographic information.

1.2 This message should not be transmitted when positional information or time of measurement are not available. If there is no data available for that particular data field, it should be displayed as "not available".

1.3 Not all the information specified in the table below will be available at all stations.

Number	Parameter	No. of bits	Description
1	Message ID	6	Identifier for Message 8, always 8.
2	Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 - 3 0 = default 3 = do not repeat anymore
3	Source ID	30	MMSI number of source station
4	Spare	2	Not used. Set to zero.
5	IAI	16	DAC = 001; FI = 31
6	Longitude	25	Longitude in 1/1,000 min, ±180 degrees as per 2's complement (East = positive, West = negative). 181 = not available = default
7	Latitude	24	Latitude in 1/1,000 min, ±90 degrees as per 2's complement (North = positive, South = negative). 91 = not available = default
8	Position Accuracy	1	1 = high (<10 m; Differential Mode of, e.g., DGNSS receiver) 0 = low (>10 m; Autonomous Mode of, e.g., GNSS receiver or of other electronic position fixing device) default = 0
	Time Stamp		UTC date and time of the data.
9	UTC Day	5	1 - 31 0 = not available = default
10	UTC Hour	5	0 - 23 24 = not available = default
11	UTC Minute	6	0 - 59 60 = not available = default

12	Average Wind Speed	7	Average of wind speed values for the last 10 minutes, in 1 knot steps. 0 - 125 knots 126 = wind 126 knots or greater 127 = not available = default
13	Wind Gust	7	Maximum wind speed reading during the last 10 minutes, in 1 knot steps. 0 - 125 knots 126 = wind 126 knots or greater 127 = not available = default
14	Wind Direction	9	Direction of the average wind during the last 10 minutes, in 1 degree steps. 0 - 359 degrees 360 = not available = default 361 - 511 (reserved for future use)
15	Wind Gust direction	9	Direction of the maximum wind during the last 10 minutes, in 1 degree steps. 0 - 359 degrees 360 = not available = default 361 - 511 (not for use)
16	Air Temperature	11	Dry bulb temperature in degrees Celsius (as per 2's complement), in 0.1 degree steps. -60 to +60 degrees Celsius 601 - 1,023 (reserved for future use) -1,024 = data not available = default -1,023 to -601 (reserved for future use)
17	Relative Humidity	7	Relative Humidity, in 1% steps. 0 - 100% 101 = not available = default 102 -127 (reserved for future use)
18	Dew Point	10	Dew point temperature in degrees Celsius (as per 2's complement), in 0.1 degree steps. -20.0 to +50.0 degrees 501 = not available = default 502 - 511 (reserved for future use) -511 to -201 (reserved for future use)
19	Air Pressure	9	Air pressure, defined as pressure reduced to sea level, in 1 hPa steps. 0 = pressure 799 hPa or less 1 - 401 = 800 - 1200 hPa 402 = pressure 1201 hPa or greater 403 - 510 (reserved for future use) 511 = not available = default
20	Air Pressure Tendency	2	0 = steady 1 = decreasing 2 = increasing 3 = not available = default

21	Horizontal Visibility	8	Horizontal visibility, in 0.1 Nautical Miles steps (00000000 to 01111111). 0.0 - 12.6 Nautical Miles The most significant bit (MSB) indicates that the maximum range of the visibility equipment was reached and the reading shall be regarded as > x.x NM. (e.g., if 10110010, then visibility is 5.0 NM or greater) 127 = data not available = default
22	Water Level (incl. tide)	12	Deviation from local chart datum, in 0.01 metre steps. -10.00 to +30.00 metres A value representing 0 - 4,000 is sent by the 12 binary bits. The water level is achieved by adding -10.0 to the sent value. Water level = (Integer value /100) – 10 for Integer = 0-4,000 4,001 = not available = default 4,002 – 4,095 (reserved for future use)
23	Water Level Trend	2	0 = steady 1 = decreasing 2 = increasing 3 = not available = default
24	Surface Current Speed (incl. tide)	8	Speed of Current measured at the sea surface, in 0.1 knot steps. 0.0 - 25.0 knots 251 = speed 25.1 knots or greater 255 = not available = default 252-254 (reserved for future use)
25	Surface Current Direction	9	Direction of Current at the sea surface, in 1 degree steps. 0 - 359 degrees 360 = not available = default 361 - 511 (reserved for future use)
26	Current Speed, #2	8	Speed of Current 2 measured at a chosen level below the sea surface, in 0.1 knot steps. (Same as Surface Current Speed)
27	Current Direction, #2	9	Direction of Current 2, in 1 degree steps. (Same as Surface Current Direction)
28	Current Measuring level, #2	5	Measuring level below sea surface, in 1 metre increment. 0 - 30 metres 31 = not available = default
29	Current Speed, #3	8	Speed of Current 3 measured at a chosen level below the sea surface, in 0.1 knot steps. (Same as Surface Current Speed)

30	Current Direction, #3	9	Direction of Current 3, in 1 degree steps. (Same as Surface Current Direction)
31	Current Measuring level, #3	5	Measuring level below sea surface, in 1 metre steps. 0 - 30 metres 31 = data not available = default
32	Significant Wave Height	8	Height of the waves, in 0.1 metre steps. 0.0 - 25.0 metres 251 = height 25.1 metres or greater 255 = data not available = default 252 - 254 (reserved for future use)
33	Wave Period	6	Wave period, in 1 second steps. 0 - 60 seconds 61 - 62 (reserved for future use) 63 = not available = default
34	Wave Direction	9	Direction of waves, in 1 degree steps. 0 - 359 degrees 360 = data not available = default 361 - 511 (reserved for future use)
35	Swell Height	8	Height of the swell, in 0.1 metre steps. 0.0 - 25.0 metres 251 = height 25.1 metres or greater 255 = data not available = default 252 - 254 (reserved for future use)
36	Swell Period	6	Swell period, in 1 second steps. 0 - 60 seconds 61 - 62 (reserved for future use) 63 = not available = default
37	Swell Direction	9	Direction of swells, in 1 degree steps. 0 - 359 degrees 360 = not available = default 361 - 511 (reserved for future use)
38	Sea State	4	Beaufort Scale, defined in the table below. 0 = calm 1 = light air 2 = light breeze 3 = gentle breeze 4 = moderate breeze 5 = fresh breeze 6 = strong breeze 7 = near gale 8 = gale 9 = strong gale 10 = storm 11 = violent storm 12 = hurricane 13 = not available = default 14 - 15 = (reserved for future use)

39	Water Temperature	10	Temperature of the water in degrees Celsius (as per 2's complement), in 0.1 degree steps. -10.0 to +50.0 degrees 501 = data not available = default 502 - 511 (reserved for future use) -511 to -101 (reserved for future use)
40	Precipitation (type)	3	According to WMO 306 Code table 4.201: 0 = reserved 1 = rain 2 = thunderstorm 3 = freezing rain 4 = mixed/ice 5 = snow 6 = reserved 7 = not available = default
41	Salinity	9	Salinity, in 0.1‰ (ppt) steps. 0.0 - 50.0 ‰ 50.1 = salinity 50.1 ‰ or greater 510 = not available = default 511 = sensor not available 502 - 509 (reserved for future use)
42	Ice	2	0 = No 1 = Yes 2 = (reserved for future use) 3 = not available = default
43	Spare	10	Not used. Set to zero
44	**Total**	**360**	**Occupies 2 slots**

- All times should be indicated as Coordinated Universal Time (UTC).
- All directions indicated are true north.

Beaufort scale

Scale	Sea Conditions
0	Flat.
1	Ripples without crests.
2	Small wavelets. Crests of glassy appearance, not breaking.
3	Large wavelets. Crests begin to break; scattered whitecaps.
4	Small waves.
5	Moderate (1.2 m) longer waves. Some foam and spray.
6	Large waves with foam crests and some spray.

7	Sea heaps up and foam begins to streak.
8	Moderately high waves with breaking crests forming spindrift. Streaks of foam.
9	High waves (6-7 m) with dense foam. Wave crests start to roll over. Considerable spray.
10	Very high waves. The sea surface is white and there is considerable tumbling. Visibility is reduced.
11	Exceptionally high waves.
12	Huge waves. Air filled with foam and spray. Sea completely white with driving spray. Visibility greatly reduced.
13	not available = default
14 -15	(reserved for future use)

Feature Type

Name: Meteorological and Hydrographic Data AIS Application-Specific Message
Definition: This message allows the distribution of meteorological and hydrographic information via AIS
camelCase: MetHydroDataAISMessage
Remarks: - This message must not be transmitted when positional information or time of measurement are not available.
Alias: -

Feature Attributes

Name: Message ID
Attribute Type: Simple
Definition: Identifier for Message 8; always 8. Message ID 8 - Binary broadcast message (provides a structure which can accommodate data suited for a specific application (e.g. meteorological and hydrographic data))
camelCase: messageID
Cardinality: 1
Data Type: text

Name: Repeat Indicator
Attribute Type: Simple
Definition: Used by the repeater to indicate how many times a message has been repeated. 0 - 3, 0 = default, 3 = do not repeat anymore.
camelCase: repeatIndicator
Cardinality: 0..1 (tbc)
Data Type: real (tbc)
Name: Source ID
Attribute Type: Simple
Definition: MMSI number of source station.
camelCase: sourceID

Cardinality: 1
Data Type: text

Name: Spare
Attribute Type: Simple
Definition: Not used. Set to zero.
camelCase: spare
Cardinality: 0..1 (tbc)
Data Type: text (tbc)

Name: IAI (tbc)
Attribute type: Complex
Definition: International Application Identifier, DAC = 001; FI = 31
camelCase: IAI (tbc)
Cardinality: 1..* (tbc)

Sub Attributes

Name: DAC
Definition: Designated Area Code
Attribute Type: Simple
Data Type: text

Name: FI
Definition: Function Identifier
Attribute Type: Simple
Data Type: text

Feature Attributes

Name: Longitude
Attribute Type: Simple
Definition: Longitude in 1/1,000 min, ±180 degrees as per 2's complement (East = positive, West = negative). 181 = not available = default
camelCase: longitude
Cardinality: 1
Data Type: (tbc)

Name: Latitude
Attribute Type: Simple
Definition: Latitude in 1/1,000 min, ±90 degrees as per 2's complement (North = positive, South = negative). 91 = not available = default
camelCase: latitude
Cardinality: 1
Data Type: (tbc)
Name: Positional Accuracy
Attribute Type: Simple

Definition: 1 = high (<10 m; Differential Mode of, e.g., DGNSS receiver) 0 = low (>10 m; Autonomous Mode of, e.g., GNSS receiver or of other electronic position fixing device) default = 0
camelCase: positionalAccuracy
Cardinality: 1
Data Type: real (tbc)

Name: Time Stamp
Attribute type: Complex
Definition: UTC date and time of the data
camelCase: timeStamp
Cardinality: 1 (tbc)

Sub Attributes

Name: UTC Day
Definition: 1 - 31, 0 = not available = default
Attribute Type: Simple
Data Type: real (tbc)

Name: UTC Hour
Definition: 0 - 23, 24 = not available = default
Attribute Type: Simple
Data Type: real (tbc)

Name: UTC Minute
Definition: 0 - 59, 60 = not available = default
Attribute Type: Simple
Data Type: real (tbc)

Feature Attributes

Name: Average Wind Speed
Attribute Type: Simple
Definition: Average of wind speed values for the last 10 minutes, in 1 knot steps. 0 - 125 knots, 126 = wind 126 knots or greater, 127 = not available = default.
camelCase: averageWindSpeed
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Wind Gust
Attribute Type: Simple
Definition: Maximum wind speed reading during the last 10 minutes, in 1 knot steps. 0 - 125 knots, 126 = wind 126 knots or greater, 127 = not available = default.
camelCase: windGust
Cardinality: 0..1 (tbc)
Data Type: real (tbc)
Name: Wind Direction

Attribute Type: Simple
Definition: Direction of the average wind during the last 10 minutes, in 1 degree steps. 0 - 359 degrees, 360 = not available = default, 361 - 511 (reserved for future use).
camelCase: windDirection
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Wind Gust Direction
Attribute Type: Simple
Definition: Direction of the maximum wind during the last 10 minutes, in 1 degree steps. 0 - 359 degrees, 360 = not available = default, 361 - 511 (not for use).
camelCase: windGustDirection
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Air Temperature
Attribute Type: Simple
Definition: Dry bulb temperature in degrees Celsius (as per 2's complement), in 0.1 degree steps. -60 to +60 degrees Celsius, 601 - 1,023 (reserved for future use), -1,024 = data not available = default, -1,023 to -601 (reserved for future use).
camelCase: airTemperature
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Relative Humidity
Attribute Type: Simple
Definition: Relative Humidity, in 1% steps. 0 - 100%, 101 = not available = default, 102 -127 (reserved for future use).
camelCase: relativeHumidity
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Dew point
Attribute Type: Simple
Definition: Dew point temperature in degrees Celsius (as per 2's complement), in 0.1 degree steps. -20.0 to +50.0 degrees, 501 = not available = default, 502 - 511 (reserved for future use), -511 to -201 (reserved for future use).
camelCase: dewPoint
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Air Pressure
Attribute Type: Simple
Definition: Air pressure, defined as pressure reduced to sea level, in 1 hPa steps. 0 = pressure 799 hPa or less, 1 - 401 = 800 - 1200 hPa, 402 = pressure 1201 hPa or greater, 403 - 510 (reserved for future use), 511 = not available = default.
camelCase: airPressure
Cardinality: 0..1 (tbc)

Data Type: real (tbc)

Name: Air Pressure Tendency
Attribute Type: Simple
Definition:
camelCase: airPressureTendency
Cardinality: 0..1 (tbc)
Data Type: Enumeration
Values: 1: steady
2: decreasing
3: increasing
4: not available = default

Name: Horizontal Visibilty
Attribute Type: Simple
Definition: Horizontal visibility, in 0.1 Nautical Miles steps (00000000 to 01111111). 0.0 - 12.6 Nautical Miles. The most significant bit (MSB) indicates that the maximum range of the visibility equipment was reached and the reading shall be regarded as > x.x NM. (e.g., if 10110010, then visibility is 5.0 NM or greater), 127 = data not available = default.
camelCase: horizontalVisibility
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Water Level (including tide)
Attribute Type: Simple
Definition: Deviation from local chart datum, in 0.01 metre steps. -10.00 to +30.00 metres.
A value representing 0 - 4,000 is sent by the 12 binary bits. The water level is achieved by adding -10.0 to the sent value. Water level = (Integer value /100) – 10 for Integer = 0-4,000. 4,001 = not available = default 4,002 – 4,095 (reserved for future use).
camelCase: waterLevelIncTide
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Water Level Trend
Attribute Type: Simple
Definition:
camelCase: waterLevelTrend
Cardinality: 0..1 (tbc)
Data Type: Enumeration
Values: 1: steady
2: decreasing
3: increasing
4: not available = default

Name: Surface Current Speed (including tide)
Attribute Type: Simple

Definition: Speed of Current measured at the sea surface, in 0.1 knot steps. 0.0 - 25.0 knots, 251 = speed 25.1 knots or greater, 255 = not available = default, 252-254 (reserved for future use).
camelCase: surfaceCurrentSpeedIncTide
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Surface Current Direction
Attribute Type: Simple
Definition: Direction of Current at the sea surface, in 1 degree steps. 0 - 359 degrees, 360 = not available = default, 361 - 511 (reserved for future use).
camelCase: surfaceCurrentDirection
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Speed, #2
Attribute Type: Simple
Definition: Speed of Current 2 measured at a chosen level below the sea surface, in 0.1 knot steps. (Same as Surface Current Speed)
camelCase: currentSpeed2
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Direction, #2
Attribute Type: Simple
Definition: Direction of Current 2, in 1 degree steps. (Same as Surface Current Direction)
camelCase: currentDirection2
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Measuring Level, #2
Attribute Type: Simple
Definition: Measuring level below sea surface, in 1 metre increment. 0 - 30 metres, 31 = not available = default.
camelCase: currentMeasuringLevel2
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Speed, #3
Attribute Type: Simple
Definition: Speed of Current 3 measured at a chosen level below the sea surface, in 0.1 knot steps. (Same as Surface Current Speed)
camelCase: currentSpeed3
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Direction, #3

Attribute Type: Simple
Definition: Direction of Current 3, in 1 degree steps. (Same as Surface Current Direction)
camelCase: currentDirection3
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Current Measuring Level, #3
Attribute Type: Simple
Definition: Measuring level below sea surface, in 1 metre increment. 0 - 30 metres, 31 = not available = default.
camelCase: currentMeasuringLevel3
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Significant Wave Height
Attribute Type: Simple
Definition: Height of the waves, in 0.1 metre steps. 0.0 - 25.0 metres, 251 = height 25.1 metres or greater, 255 = data not available = default, 252 - 254 (reserved for future use).
camelCase: significantWaveHeight
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Wave Period
Attribute Type: Simple
Definition: Wave period, in 1 second steps. 0 - 60 seconds, 61 - 62 (reserved for future use), 63 = not available = default.
camelCase: wavePeriod
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Wave Direction
Attribute Type: Simple
Definition: Direction of waves, in 1 degree steps. 0 - 359 degrees, 360 = data not available = default 361 - 511 (reserved for future use).
camelCase: waveDirection
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Swell Height
Attribute Type: Simple
Definition: Height of the swell, in 0.1 metre steps. 0.0 - 25.0 metres, 251 = height 25.1 metres or greater, 255 = data not available = default, 252 - 254 (reserved for future use).
camelCase: swellHeight
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Swell Period

Attribute Type: Simple
Definition: Swell period, in 1 second steps. 0 - 60 seconds, 61 - 62 (reserved for future use), 63 = not available = default.
camelCase: swellPeriod
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Swell Direction
Attribute Type: Simple
Definition: Direction of swells, in 1 degree steps. 0 - 359 degrees, 360 = not available = default, 361 - 511 (reserved for future use).
camelCase: swellDirection
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Sea State
Attribute Type: Simple
Definition: Beaufort Scale
camelCase: seaState
Cardinality: 0..1 (tbc)
Data Type: Enumeration
Values:

1: calm
2: light air
3: light breeze
4: gentle breeze
5: moderate breeze
6: fresh breeze
7: strong breeze
8: near gale
9: gale
10: strong gale
11: storm
12: violent storm
13: hurricane
14: not available
15: reserved
16: reserved for future use

Name: Water Temperature
Attribute Type: Simple
Definition: Temperature of the water in degrees Celsius (as per 2's complement), in 0.1 degree steps. -10.0 to +50.0 degrees, 501 = data not available = default, 502 - 511 (reserved for future use), -511 to -101 (reserved for future use).
camelCase: waterTemperature
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Precipitation type
Attribute Type: Simple
Definition:
camelCase: precipitationType
Cardinality: 0..1 (tbc)
Data Type: Enumeration
Values:
1: reserved
2: rain
3: thunderstorm
4: freezing rain
5: mixed/ice
6: snow
7: reserved for future use
8: not available

Name: Salinity
Attribute Type: Simple
Definition: Salinity, in 0.1‰ (ppt) steps. 0.0 - 50.0 ‰, 50.1 = salinity 50.1 ‰ or greater, 510 = not available = default, 511 = sensor not available, 502 - 509 (reserved for future use).
camelCase: salinity
Cardinality: 0..1 (tbc)
Data Type: real (tbc)

Name: Ice
Attribute Type: Simple
Definition:
camelCase: ice
Cardinality: 0..1 (tbc)
Data Type: Enumeration
Values:
1: no
2: yes
3: reserved for future use
4: not available

Name: Spare End of Message
Attribute Type: Simple
Definition: Not used. Set to zero.
camelCase: spareEndOfMessage
Cardinality: 0..1 (tbc)
Data Type: text (tbc)

Annex I – Informative Implementation Guidance and General Notes for AIS Message (*To be developed).*

Commented [GS62]: Probably can remove this as real-time data won't be included in S-104 until Ed 2.0.0 or later

System requirements

- AIS Application-Specific Messages are transmitted and received by shipborne mobile AIS devices and AIS base stations. Shore-based stations can receive AIS Application-Specific Messages and distribute them to shore-based users.
- The display capability of AIS Application-Specific Messages is not part of the mandatory functions of the Minimum Keyboard and Display (MKD). The display of the information transmitted by AIS Application-Specific Messages requires external hardware and dedicated software in addition to the AIS equipment.
- The generation and transmission of AIS Application-Specific Messages also requires dedicated software and suitable equipment for entering the information.

Points to note:

- IALA Guideline No. 1082 - An Overview of AIS Edition 1 June 2011 - AIS uses an open protocol and is not intended for secure communications. The means for ensuring the quality and correctness of the AIS information needs to be secured.
- Radio Technical Commission for Maritime Services RTCM is preparing a standard - RTCM standard for the Creation and Qualification of Application-Specific Messages.
- SN.1/Circ.289, 12 Environmental - messages providing environmental information from one to eight sensor reports. Each sensor report carries the dynamic or static information relating to a specific sensor, such as the Water level report.
- IALA Guideline No. 1028 - Use of AIS for Meteorological and Hydrographic purposes. Where such an application is intended for international use, the message format will be registered by IALA prior to being made available to system manufacturers. This will facilitate the correct presentation of the information on systems from different manufacturers.
- IALA Recommendation A-124 - This section introduces the AIS Service Data Model. It is meant to describe what data is used, received and transmitted by the AIS Service. It is important to understand that the data objects used by the AIS Service are derived from an over-arching data model called the IALA Universal Maritime Data Model (UMDM).

  The Basic AIS Services define the functionality provided by the AIS Service. They are operations performed on certain data objects. To provide a complete picture of what the AIS Service can deliver its clients, it is necessary to consider those data objects and their structure and mutual relationship. Eventually, it is the data, which is only relevant for the clients.
- IALA Guideline No. 1095 - Once the Common Shared Maritime Datamodel (CSDM), which is based on IHO's Registry, is developed, data elements used in ASMs should be drawn from and directly linked to that registry. There may be a requirement for a Dynamic Water Level Data domain or a Meteorological and Hydrographic AIS Application-Specific Message domain or similar in the IHO Registry.
- There may be a requirement for an AIS Application-Specific Messages section in S-100.
- IALA Guideline No. 1095 - Frequency of transmission. ASMs may be sent in different modes: Automatic, On request and Sequencing.

IHO S-104 Water Level Information For Surface Navigation~~IHO S-104 Water Level Information for Surface Navigation~~

Extracts from papers to note:

AIS Binary Message updates IMO SN.1/Circ.289 and IMO SN.1/Circ.290 review, US Hydro conference 2011 - Tampa - Ted Read MRIN

Consequences from message changes from Circ.236 to Circ.289:

- Binary message restructure, needs two parses
- Variance from ITU-R M.1371 standard

Future requirements: Security and Website information

Conclusions:

Incorporation within the ECDIS standard, Expand on graphic display format, Harmonize Inland/Coastal usage

Range and accuracy Water Level - The new message has overcome the previous limit on Water Level resolution from 0.1m to 0.01m. Unfortunately it has parted from the AIS standard for 2"s compliment numbers by having a constant offset of -10.0m.

Subjective or derived values - Many of the parameters defined in the IMO TideMet standard message are subjective so are not suitable for automated instrumentation (e.g. Sea State, Visibility, Precipitation). Other parameters such as Dew Point and Significant Wave Height are derived so could be calculated by a client program. A standard calculation of derived values should be formally stated.

Tide and Metrological data over AIS, written by E.F.Read & W.S.Heaps

The structure of an AIS message

As can be seen by the large number of zeros in the previous example of type 8 output the IMO specified message formats appear to suffer from the following faults:

- Over specified, much of the message is not of interest to many users.
- Badly aligned bit format so that data is not byte aligned and computer friendly.
- Messages not size optimised by splitting into rapid and slow change data.

The individual tide and metrological message is defined by parameters DAC=1 and FI=11, this is not very easy to use, as the software has to first decode a message as a type 8 then work out from the DAC/FI code if the data is relevant as a TideMet message. The limitations on use of a DAC code having been assigned to countries leaving the 63 possible FI codes a little limited.

Other useful references in this paper include: Standalone 'Real' AtoN TideMet station, Receiving software, Licensing of AIS AtoN devices, AIS TideMet applications.

Annex J – Bibliography

- RTCM Standard for the Creation and Qualification of Application-Specific Messages (CDV-RTCM 12100.0 draft)
- IALA Guideline No. 1028 - The Automatic Identification System (AIS) Volume 1, Part 1 Operational Issues, December 2004
- IALA Guideline No. 1082 - An Overview of AIS, June 2011
- IALA Guideline No. 1095 - Harmonised Implementation of Application-Specific Messages, May 2013
- IALA Recommendation A-124 - The AIS Service, December 2012
- IALA Recommendation A-126 - The Use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services, June 2011
- AIS Binary Message updates IMO SN.1/Circ.289 and IMO SN.1/Circ.290 review, US Hydro conference 2011 - Tampa - Ted Read MRIN
- Tide and Metrological data over AIS - E.F.Read & W.S.Heaps
- Dynamic Application of Tides in ECDIS - submitted by IHB, TWLWG 5/4.4/1
- Proposed AIS Binary Message Format Using XML for Providing Hydrographic-related Information - Kurt Schwehr and Lee Alexander
- Providing Meteorological and Hydrographic Information via AIS Application-Specific Messages: Challenges and Opportunities - Dr. Lee Alexander

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