11th Meeting of the IHO (S-100WG) S-101 Project Team

Options for Modelling S-101 Metadata Features

Agenda Item 08.10

S-101PT11, Lombok, Indonesia, 27-29 September 2023

- S-101PT9_2022_INF1-01_EN_Metadata_Issues.
- S-101PT10_2023_07.9_EN_Vertical_Datum_Information_in_S-101_V1.
- S-101PT10_2023_07.9A_EN_Metadata_Issues.

Action S-101PT10-25

- S-101 Documentation and FC GitHub Issues
  - Default Value of Vertical Datum for Heights (Issue #59)
  - Adopting a Single Vertical Datum for S-101 Datasets (Issue #72)
  - 101FR00369660.000 no default vertical datum - DCEG issue? (Issue #73)
  - DCEG 3.9 Vertical datum references non-existent Discovery Metadata field (Issue #74)
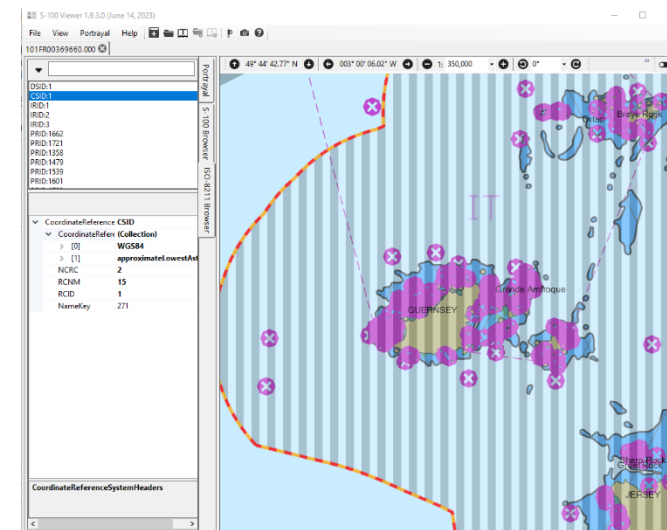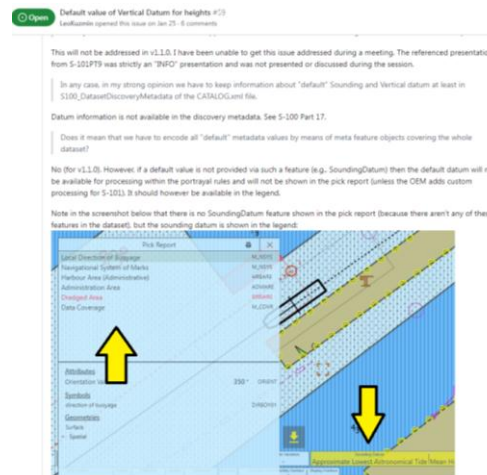

3.9.1 Vertical datum

Vertical datum information is encoded in the dataset metadata, using the meta feature **Vertical Datum of Data**, or by populating the attribute **vertical datum** on individual geo features. The values encoded in the attributes **elevation**, **height** and **clearance vertical** (positive values up) are referenced to the specified datum(s). **vertical datum** must not be encoded on any feature unless at least one of the above attributes is also encoded on that feature.

The default value for the vertical datum is stored in the Dataset Discovery Metadata in the Exchange Set

Catalogue: S100_DatasetDiscoveryMetadata/verticalDatum.

If the vertical datum for an area of an ENC dataset is different from the default value for the dataset, it must be

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```
|--<1>--Dataset Coordinate Reference System record
|   |
|   |--<1>-CSID (3): Coordinate Reference System Record Identifier field
|   |
|   |--<1..*>-CRSH (7): Coordinate Reference System Header field
|   |   |
|   |   |--<0..1>-CSAX (*2): Coordinate System Axes field
|   |   |
|   |   |--<0..1>-VDAT (4): Vertical Datum field
|
```

B-5.1.10 Coordinate Reference System Header field - CRSH

Subfield name	Label	Value	Format	Comment
CRS Index	CRIX		b11	1 – for the horizontal CRS >1 – for the vertical CRSs
CRS Type	CRST	{1} or {5}	b11	{1} – 2D Geographic {5} – Vertical
Coordinate System Type	CSTY	{1} or {3}	b11	{1} – Ellipsoidal CS {3} – Vertical CS
CRS Name	CRNM	"WGS84" for horizontal CRS "Depth - *" for vertical CRS where * is the name of the vertical datum	A()	
CRS Identifier	CRSI	"4326" – for horizontal CRS	A()	
		"omitted for vertical CRS		
CRS Source	CRSS	{2} for horizontal CRS {255} for vertical CRS	b11	{2} – EPSG {255} – Not Applicable
CRS Source Information	SCRI	omitted	A()	

B-5.1.11 Coordinate System Axes field - CSAX

This field is only used for vertical CRS.

Subfield name	Label	Value	Format	Comment
Axis Type	*AXTY	{12}	b11	{12} – Gravity related depth (orientation down)
Axis Unit of Measure	AXUM	{4}	b11	{4} – Metre

B-5.1.12 Vertical Datum field - VDAT

This field is only used for vertical CRS.

Subfield name	Label	Value	Format	Comment
Datum Name	DTNM		A()	Name of the vertical datum
Datum Identifier	DTID		A()	Identifier of the datum in an external source
Datum Source	DTSR	{2}	b11	{2} – Feature Catalogue
Datum Source Information	SCRI	omitted	A()	

B-5.1.18 3-D Integer Coordinate Tuple field structure - C3IT

Subfield name	Label	Value	Format	Comment
Vertical CRS Id	VCID		b11	Internal identifier of the Vertical CRS
Coordinate in Y axis	YCOO		b24	Y-coordinate or latitude
Coordinate in X axis	XCOO		b24	X-coordinate or longitude
Coordinate in Z axis	ZCOO		b24	Z-coordinate (depth)

5.3 Vertical CRS for Soundings

For ENC the vertical CRS must be in metres. Depths are represented by positive values, while negative values indicate intertidal (drying) soundings.

Although all coordinates in a dataset must refer to the same geodetic CRS, different Vertical Datums can be used for the depth component of a coordinate tuple. Therefore the vertical CRS can be repeated. For each vertical CRS a unique identifier is defined. Those identifiers will be used to indicate which Vertical CRS is used.

The encoding for the Coordinate Reference System record fields can be found at Annex B, clauses B-5.1.9 to B-5.1.12; and is demonstrated with the following examples. The example at Table 5-1 specifies a compound CRS. The first component is a 2D Geographic CRS (WGS84). The second component is a Vertical CRS for depth using the Vertical Datum: Lowest Astronomical Tide.

Table 5-2 – Compound CRS (WGS84 and Mean Sea Level)

Field	Subfield	Value	Description
CSID			**Coordinate Reference System Record Identifier**
	RCNM	15	Record Name (15 = Coordinate Reference System Identifier)
	RCID	1	Record Identification Number
	NCRC	2	Number of CRS Components
CRSH			**Coordinate Reference System Header**
	CRIX	1	CRS Index
	CRST	1	CRS Type (1 = 2D Geographic)
	CSTY	1	Coordinate System Type (1 = Ellipsoidal CS)
	CRNM	WGS84	CRS Name
	CRSI	4326	CRS Identifier
	CRSS	2	CRS Source (2 = EPSG)
	SCRI		CRS Source Information (omitted)
CRSH			**Coordinate Reference System Header**
	CRIX	2	CRS Index
	CRST	5	CRS Type (5 = Vertical)
	CSTY	3	Coordinate System Type (3 = Vertical)
	CRNM	Depth - mean sea level	CRS Name
	CRSI		CRS Identifier (omitted)
	CRSS	255	CRS Source (255 = Not Applicable)
	SCRI		CRS Source Information (omitted)
CSAX			**Coordinate System Axes**
	AXTY	12	Axis Type (12 = Gravity Related Depth)
	AXUM	4	Axis Unit of Measure (4 = Metres)
VDAT			**Vertical Datum**
	DTNM	mean sea level	Datum Name
	DTID	3	Datum Identifier (3 = Mean Sea Level)
	DTSR	2	Datum Source (2 = Feature Catalogue)
	SCRI		Datum Source Information (omitted)

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12.1.2.5 S100_VerticalAndSoundingDatum

Item	Name	Description	Code	Remarks
Enumeration	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	Values listed in S-100 Part 17 but not mentioned in this table are not allowed
Value	meanLowWaterSprings		1	(MLWS)
Value	meanLowerLowWaterSprings		2	
Value	meanSeaLevel		3	(MSL)
Value	lowestLowWater		4	
Value	meanLowWater		5	(MLW)
Value	lowestLowWaterSprings		6	
Value	approximateMeanLowWaterSprings		7	
Value	indianSpringLowWater		8	
Value	lowWaterSprings		9	
Value	approximateLowestAstronomicalTide		10	
Value	nearlyLowestLowWater		11	
Value	meanLowerLowWater		12	(MLLW)
Value	lowWater		13	(LW)
Value	approximateMeanLowWater		14	
Value	approximateMeanLowerLowWater		15	
Value	meanHighWater		16	(MHW)
Value	meanHighWaterSprings		17	(MHWS)
Value	highWater		18	(HW)
Value	approximateMeanSeaLevel		19	
Value	highWaterSprings		20	
Value	meanHigherHighWater		21	(MHHW)
Value	equinoctialSpringLowWater		22	
Value	lowestAstronomicalTide		23	(LAT)
Value	localDatum		24	
Value	internationalGreatLakesDatum1985		25	
Value	meanWaterLevel		26	
Value	lowerLowWaterLargeTide		27	
Value	higherHighWaterLargeTide		28	
Value	nearlyHighestHighWater		29	
Value	highestAstronomicalTide		30	(HAT)
Value	balticSeaChartDatum2000		44	
Value	internationalGreatLakesDatum2020	The 2020 update to the International Great Lakes Datum, the official reference system used to measure water level heights in the Great Lakes, connecting channels, and the St. Lawrence River system	46	Unlike the previous two IGLDs, this datum update will use a geoid-based vertical datum that will be accessible using global navigation satellite systems (GNSS) such as the Global Positioning System (GPS)

NOTE 1: The numeric codes are the codes specified in the IHO GI Registry for the equivalent listed values of the IHO Hydro domain attribute *Vertical datum*, since the Registry does not at present (June 2022) contain entries for Exchange Set metadata and dataset metadata attributes.

NOTE 2: This enumeration is not depicted in Figure 12-3 because it is not used in the Exchange Catalogue. The table is retained because the encoding format uses it.

3.8.1 Sounding datum

For depth information that is encoded using the attributes **value of sounding**, **depth range minimum value**, **depth range maximum value** and **value of depth contour** the sounding datum is encoded in the Dataset Discovery Metadata or by the meta feature **Sounding Datum**, and must be constant over large areas.

The default value for the sounding datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/soundingDatum.

If the sounding datum for an area of an ENC dataset is different from the default value, it must be encoded using a **Sounding Datum** meta feature. The areas covered by these meta features must not overlap.

Sounding groups, depth contours and depth areas going across areas having different values of sounding datum must be split at the border of those areas. Other features that should be split include **Marine Farm/Culture**, **Obstruction** and **Wreck**, but only where the value of **value of sounding** is known; and **Berth**, **Cable Submarine**, **Deep Water Route Centreline**, **Deep Water Route Part**, **Dredged Area**, **Dry Dock**, **Fairway**, **Floating Dock**, **Gate**, **Pipeline Submarine/On Land**, **Recommended Route Centreline**, **Recommended Track**, **Swept Area**, **Two-Way Route Part** and **Quality of Bathymetric Data**, but only if the value of **depth range minimum value** and/or **depth range maximum value** is known.

For sounding features both the position and depth information is encoded by means of coordinates, with the depth information stored in the Z-coordinate. The sounding datum is defined by the Coordinate Reference System (CRS) for the Z-Coordinate ("Coordinate in Z Axis" [ZCOO] subfield of the "3-D Integer Coordinate Tuple" [C3IT] field or the "3-D Integer Coordinate List" [C3IL] field).

The definition of the CRS is stored in the "Dataset Coordinate Reference System" record and referred by the "Vertical CRS Id" [VCID] subfield of the "3-D Integer Coordinate Tuple" [C3IT] field or the "3-D Integer Coordinate List" [C3IL] field.

The CRS for the Z-coordinate should also have the subfield "Axis Type" [AXTY] of the corresponding "Coordinate System Axes" [CSAX] field set to *12* (Gravity Related Depth).

Note, that because every ZCOO value is explicitly linked to sounding datum there is no default value.

3.9.1 Vertical datum

Vertical datum information is encoded in the dataset metadata, using the meta feature **Vertical Datum of Data**, or by populating the attribute **vertical datum** on individual geo features. The values encoded in the attributes **elevation**, **height** and **clearance vertical** (positive values up) are referenced to the specified datum(s). **vertical datum** must not be encoded on any feature unless at least one of the above attributes is also encoded on that feature.

The default value for the vertical datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/verticalDatum.

If the vertical datum for an area of an ENC dataset is different from the default value for the dataset, it must be encoded using a **Vertical Datum of Data** meta feature. The areas covered by these meta features must not overlap.

Height contours, going across areas having different values of vertical datum, must be split at the border of these areas.

Various height datums may be used within an ENC. For example, different datums may be used for the following:
- altitude of spot heights, height contours, landmarks,
- elevation of lights,
- vertical clearance.

Where different vertical datums are used for the various vertical measurements, the default value given in the metadata for the dataset or **Vertical Datum of Data** applies to the first group of the above list. The attribute **vertical datum** on an individual feature applies to the elevation of lights and vertical clearances and must only be populated if different from the value given by the dataset metadata or **Vertical Datum of Data**.

CURRENT S-57 SPECIFICATION

6.3.1 Base cell file structure

Base cell file

```
Base cell file
|
|--<1>--Data Set General Information record
|       |
|       |--0001 - ISO/IEC 8211 Record Identifier
|       |
|       |--<1>-- DSID - Data Set Identification field
|       |
|       |--<1>--DSSI    - Data Set Structure Information field
|
|--<1>--Data Set Geographic Reference record
|       |
|       |--0001 - ISO/IEC 8211 Record Identifier
|       |
|       |--<1>--DSPM - Data Set Parameter field
|
|--<R>--Vector record
|
```

6.3.2.3 Data Set Parameter field - DSPM

NB : Subfield values are encoded as ASCII or binary as indicated.

Tag	subfield name	use	value	comment
RCNM	Record name	M	{20}	= DP, binary
RCID	Record identification number	M		binary
HDAT	Horizontal geodetic datum	M	{2}	= WGS 84, binary
VDAT	Vertical datum	M		binary
SDAT	Sounding datum	M		binary
CSCL	Compilation scale of data	M		binary
DUNI	Units of depth measurement	M	{1}	=metres, binary
HUNI	Units of height measurement	M	{1}	=metres, binary
PUNI	Units of positional accuracy	M	{1}	=metres, binary
COUN	Coordinate units	M	{1}	= lat/long, binary
COMF	Coordinate multiplication factor	M		binary, see clause 4.4
SOMF	3-D (sounding) multiplication factor	M	{10}	binary, see clause 4.4
COMT	Comment			ASCII

2.1.2 Vertical datum

Vertical datum information is encoded using the subfield VDAT, the meta object **M_VDAT**, or the attribute VERDAT on individual objects. The values encoded in the attributes ELEVAT, HEIGHT, VERCCL, VERCLR, VERCOP and VERCSA are referenced to the specified datum(s). VERDAT must not be encoded on an object unless at least one of the above attributes is also encoded on that object.

The default value for the entire data set must be given in the "Vertical Datum" [VDAT] subfield of the "Data Set Parameter" [DSPM] field.

2.1.3 Sounding datum

Sounding datum information is encoded using the subfield SDAT or the meta object **M_SDAT**, and must be constant over large areas. The values encoded in the attributes VALSOU, DRVAL1, DRVAL2 and VALDCO, and the sounding values encoded in **SOUNDG** objects, are referenced to this datum.

The default value for the entire data set must be given in the "Sounding Datum" [SDAT] subfield of the "Data Set Parameter" [DSPM] field.

3.5.6 Hierarchy of meta data

The following table indicates :
∃ individual attributes that supersede meta object attributes,
∃ meta object attributes that supersede the data set subfields (see clauses 6.3.2 and 6.4.2).

Field	Subfield	Meta object class	Meta object attribute	Geo or spatial object attribute
DSID	AGEN	The use of M_PROD is prohibited		
DSID	UADT	The use of M_PROD is prohibited		
DSID	ISDT	The use of M_PROD is prohibited		
DSPM	HDAT	The use of M_HDAT is prohibited		The use of HORDAT is prohibited
DSPM	VDAT	M_VDAT	VERDAT	VERDAT
DSPM	SDAT	M_SDAT	VERDAT	VERDAT
DSPM	CSCL	M_CSCL	CSCALE	
DSPM	DUNI	The use of M_UNIT is prohibited		The use of DUNITS is prohibited
DSPM	HUNI	The use of M_UNIT is prohibited		The use of HUNITS is prohibited
DSPM	PUNI	The use of M_UNIT is prohibited		The use of PUNITS is prohibited
		M_ACCY	HORACC	HORACC
		M_ACCY	POSACC	POSACC
		M_ACCY	SOUACC	SOUACC
		M_ACCY	VERACC	VERACC
		M_NSYS	MARSYS	MARSYS
		M_NSYS	ORIENT	Attribute ORIENT of an individual object does not supersede the meta object attribute.
		M_QUAL	CATZOC	POSACC,SOUACC and TECSOU
		M_QUAL	SOUACC	SOUACC
		M_QUAL	POSACC	POSACC
		M_SREL	SURATH	SORIND
		M_SREL	SUREND	SORDAT
		M_SREL	SURSTA	SORDAT
		M_SREL	TECSOU	TECSOU

table 3.3

When there is no meta object attribute, an individual attribute can supersede a data set subfield.

It is prohibited to use an attribute on an individual object, if this attribute has the same value as the general value defined by the meta object or the equivalent data set subfield.
It is prohibited to use a meta object, if the information given by this meta object is the same as the value given by the equivalent data set subfield.

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12.1.2.5 S100_VerticalAndSoundingDatum

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Enumeration	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	Values listed in S-100 Part 17 but not mentioned in this table are not allowed
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Value	meanLowerLowWaterSprings		2	
Value	meanSeaLevel		3	(MSL)
Value	lowestLowWater		4	
Value	meanLowWater		5	(MLW)
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Value	indianSpringLowWater		8	
Value	lowWaterSprings		9	
Value	approximateLowestAstronomicalTide		10	
Value	nearlyLowestLowWater		11	
Value	meanLowerLowWater		12	(MLLW)
Value	lowWater		13	(LW)
Value	approximateMeanLowWater		14	
Value	approximateMeanLowerLowWater		15	
Value	meanHighWater		16	(MHW)
Value	meanHighWaterSprings		17	(MHWS)
Value	highWater		18	(HW)
Value	approximateMeanSeaLevel		19	
Value	highWaterSprings		20	
Value	meanHigherHighWater		21	(MHHW)
Value	equinoctialSpringLowWater		22	
Value	lowestAstronomicalTide		23	(LAT)
Value	localDatum		24	
Value	internationalGreatLakesDatum1985		25	
Value	meanWaterLevel		26	
Value	lowerLowWaterLargeTide		27	
Value	higherHighWaterLargeTide		28	
Value	nearlyHighestHighWater		29	
Value	highestAstronomicalTide		30	(HAT)
Value	balticSeaChartDatum2000		44	
Value	internationalGreatLakesDatum2020	The 2020 update to the International Great Lakes Datum, the official reference system used to measure water level heights in the Great Lakes, connecting channels, and the St. Lawrence River system	46	Unlike the previous two IGLDs, this datum update will use a geoid-based vertical datum that will be accessible using global navigation satellite systems (GNSS) such as the Global Positioning System (GPS)

NOTE 1: The numeric codes are the codes specified in the IHO GI Registry for the equivalent listed values of the IHO Hydro domain attribute *Vertical datum*, since the Registry does not at present (June 2022) contain entries for Exchange Set metadata and dataset metadata attributes.

NOTE 2: This enumeration is not depicted in Figure 12-3 because it is not used in the Exchange Catalogue. The table is retained because the encoding format uses it.

3.8.1 Sounding datum

For depth information that is encoded using the attributes **value of sounding, depth range minimum value, depth range maximum value** and **value of depth contour** the sounding datum is encoded in the Dataset Discovery Metadata or by the meta feature **Sounding Datum**, and must be constant over large areas.

The default value for the sounding datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/soundingDatum.

If the sounding datum for an area of an ENC dataset is different from the default value, it must be encoded using a **Sounding Datum** meta feature. The areas covered by these meta features must not overlap.

Sounding groups, depth contours and depth areas going across areas having different values of sounding datum must be split at the border of those areas. Other features that should be split include **Marine Farm/Culture, Obstruction** and **Wreck**, but only where the value of **value of sounding** is known; and **Berth, Cable Submarine, Deep Water Route Centreline, Deep Water Route Part, Dredged Area, Dry Dock, Fairway, Floating Dock, Gate, Pipeline Submarine/On Land, Recommended Route Centreline, Recommended Track, Swept Area, Two-Way Route Part** and **Quality of Bathymetric Data**, but only if the value of **depth range minimum value** and/or **depth range maximum value** is known.

3.9.1 Vertical datum

Vertical datum information is encoded in the dataset metadata, using the meta feature **Vertical Datum of Data**, or by populating the attribute **vertical datum** on individual geo features. The values encoded in the attributes **elevation, height** and **clearance vertical** (positive values up) are referenced to the specified datum(s). **vertical datum** must not be encoded on any feature unless at least one of the above attributes is also encoded on that feature.

The default value for the vertical datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/verticalDatum.

If the vertical datum for an area of an ENC dataset is different from the default value for the dataset, it must be

- Remove default value from CRSH field in S-101 to remove confusion; datums applicable to geometry remain.
  - Needs further discussion? Prior feedback is that only a single (sounding) vertical CRS needs to be included in the ISO 8211 as the only feature that uses vertical CRS is soundings (all other vertical datum related information included via attribution).

Field	Subfield	Meta object class	Meta object attribute	Geo or spatial object attribute
DSID	AGEN	The use of M_PROD is prohibited		
DSID	UADT	The use of M_PROD is prohibited		
DSID	ISDT	The use of M_PROD is prohibited		
DSPM	HDAT	The use of M_HDAT is prohibited		The use of HORDAT is prohibited
DSPM	VDAT	M_VDAT	VERDAT	VERDAT
DSPM	SDAT	M_SDAT	VERDAT	VERDAT
DSPM	CSCL	M_CSCL	CSCALE	
DSPM	DUNI	The use of M_UNIT is prohibited		The use of DUNITS is prohibited
DSPM	HUNI	The use of M_UNIT is prohibited		The use of HUNITS is prohibited
DSPM	PUNI	The use of M_UNIT is prohibited		The use of PUNITS is prohibited
		M_ACCY	HORACC	HORACC
		M_ACCY	POSACC	POSACC
		M_ACCY	SOUACC	SOUACC
		M_ACCY	VERACC	VERACC
		M_NSYS	MARSYS	MARSYS
		M_NSYS	ORIENT	Attribute ORIENT of an individual object does not supersede the meta object attribute.
		M_QUAL	CATZOC	POSACC,SOUACC and TECSOU
		M_QUAL	SOUACC	SOUACC
		M_QUAL	POSACC	POSACC
		M_SREL	SURATH	SORIND
		M_SREL	SUREND	SORDAT
		M_SREL	SURSTA	SORDAT
		M_SREL	TECSOU	TECSOU

Assumption is that only vertical CRS is required to be displayed in the ECDIS marginalia?

Table 5-2 – Compound CRS (WGS84 and Mean Sea Level)

Field	Subfield	Value	Description
CSID			Coordinate Reference System Record Identifier
	RCNM	15	Record Name (15 = Coordinate Reference System Identifier)
	RCID	1	Record Identification Number
	NCRC	2	Number of CRS Components
CRSH			Coordinate Reference System Header
	CRIX	1	CRS Index
	CRST	1	CRS Type (1 = 2D Geographic)
	CSTY	1	Coordinate System Type (1 = Ellipsoidal CS)
	CRNM	WGS84	CRS Name
	CRSI	4326	CRS Identifier
	CRSS	2	CRS Source (2 = EPSG)
	SCRI		CRS Source Information (omitted)
CRSH			Coordinate Reference System Header
	CRIX	2	CRS Index
	CRST	5	CRS Type (5 = Vertical)
	CSTY	3	Coordinate System Type (3 = Vertical)
	CRNM	Depth - mean sea level	CRS Name
	CRSI		CRS Identifier (omitted)
	CRSS	255	CRS Source (255 = Not Applicable)
	SCRI		CRS Source Information (omitted)
	AXTY	12	Axis Type (12 = Gravity Related Depth)
	AXUM	4	Axis Unit of Measure (4 = Metres)
VDAT			Vertical Datum
	DTNM	mean sea level	Datum Name
	DTID	3	Datum Identifier (3 = Mean Sea Level)
			Datum Source (2 = Feature Catalogue)
	SCRI		Datum Source Information (omitted)

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- Retain existing Meta features but require complete coverage of the Data Coverage (conversion tools will need to create new features).

3 Metadata Features

The maximum use must be made of meta features to reduce the attribution on individual features. In a Base dataset (see S-101 Annex B, clause B5), some meta features are mandatory.

These mandatory meta features are in the following list:

Data Coverage: In order to assist in data discovery, the meta feature **Data Coverage** must be used to provide coverage of the part of the dataset covered by Skin of the Earth features. See clause 3.4.

Navigational System of Marks: The meta feature **Navigational System of Marks** must provide an exhaustive non-overlapping coverage of the **Data Coverage** feature(s). See clause 3.5.

Quality of Bathymetric Data: The meta feature **Quality of Bathymetric Data** defines areas within which uniform assessment exists for the quality of bathymetric data, and is used to provide an assessment of the overall quality of bathymetric data to the Mariner. Areas of a dataset at maximum display scale 1:700000 and larger containing depth data or bathymetry must be covered by one or more **Quality of Bathymetric Data** features, which may overlap vertically (see clause 3.7.1). At maximum display scales smaller than 1:700000, **Quality of Bathymetric Data** features are optional.

Sounding Datum: The meta feature **Sounding Datum** must provide an exhaustive non-overlapping coverage of the **Quality of Bathymetric Data** feature(s). See clause 3.8.

Vertical Datum of Data: The meta feature **Vertical Datum of Data** must provide an exhaustive non-overlapping coverage of the **Data Coverage** feature(s). See clause 3.9.

Suggest that **Sounding Datum** only needs to cover the area of data covered by **Quality of Bathymetric Data** features.

3.9.1 Vertical datum

Vertical datum information is encoded in the dataset metadata, using the meta feature **Vertical Datum of Data**, or by populating the attribute **vertical datum** on individual geo features. The values encoded in the attributes **elevation**, **height** and **clearance vertical** (positive values up) are referenced to the specified datum(s). **vertical datum** must not be encoded on any feature unless at least one of the above attributes is also encoded on that feature.

The vertical datum of the dataset must be encoded using the meta feature **Vertical Datum of Data**:

All parts of the dataset containing data must be covered by **Vertical Datum of Data** features, with the attribute **vertical datum** indicating the vertical (height) datum. **Vertical Datum of Data** must not overlap.

The default value for the vertical datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/verticalDatum.

If the vertical datum for an area of an ENC dataset is different from the default value for the dataset, it must be encoded using a **Vertical Datum of Data** meta feature. The areas covered by these meta features must not overlap.

Height contours, going across areas having different values of vertical datum, must be split at the border of these areas.

Various height datums may be used within an ENC. For example, different datums may be used for the following:
- altitude of spot heights, height contours, landmarks,
- elevation of lights,
- vertical clearance.

Where different vertical datums are used for the various vertical measurements, the default value given in the metadata for the dataset or **Vertical Datum of Data** applies to the first group of the above list. The attribute **vertical datum** on an individual feature applies to the elevation of lights and vertical clearances and must only be populated if different from the value given by the dataset metadata or **Vertical Datum of Data**.

3.8.1 Sounding datum

For depth information that is encoded using the attributes **value of sounding, depth range minimum value, depth range maximum value** and **value of depth contour** the sounding datum is encoded in the Dataset Discovery Metadata or by the meta feature **Sounding Datum**, and must be constant over large areas.

The default sounding datum of the dataset must be encoded using the meta feature **Sounding Datum**, and must be equivalent to the definition of the CRS as stored in the "Dataset Coordinate Reference System" record for the dataset.

If an area of the dataset is referenced to a different sounding datum than the default, a separate **Sounding Datum** feature must be encoded. All parts of the dataset covered by **Quality of Bathymetric Data** features (see clause 3.7) must be covered by **Sounding Datum** features, with the attribute **vertical datum** indicating the sounding (depth) datum. **Sounding Datum** features must not overlap.

The default value for the sounding datum is stored in the Dataset Discovery Metadata in the Exchange Set Catalogue: S100_DatasetDiscoveryMetadata/soundingDatum.

If the sounding datum for an area of an ENC dataset is different from the default value, it must be encoded using a **Sounding Datum** meta feature. The areas covered by these meta features must not overlap.

Sounding groups, depth contours and depth areas going across areas having different values of sounding datum must be split at the border of those areas. Other features that should be split include **Marine Farm/Culture, Obstruction** and **Wreck**, but only where the value of **value of sounding** is known; and **Berth, Cable Submarine, Deep Water Route Centreline, Deep Water Route Part, Dredged Area, Dry Dock, Fairway, Floating Dock, Gate, Pipeline Submarine/On Land, Recommended Route Centreline, Recommended Track, Swept Area, Two-Way Route Part** and **Quality of Bathymetric Data**, but only if the value of **depth range minimum value** and/or **depth range maximum value** is known.

For sounding features both the position and depth information is encoded by means of coordinates, with the depth information stored in the Z-coordinate. The sounding datum is defined by the Coordinate Reference System (CRS) for the Z-Coordinate ("Coordinate in Z Axis" [ZCOO] subfield of the "3-D Integer Coordinate Tuple" [C3IT] field or the "3-D Integer Coordinate List" [C3IL] field).

The definition of the CRS is stored in the "Dataset Coordinate Reference System" record and referred by the "Vertical CRS Id" [VCID] subfield of the "3-D Integer Coordinate Tuple" [C3IT] field or the "3-D Integer Coordinate List" [C3IL] field.

The CRS for the Z-coordinate should also have the subfield "Axis Type" [AXTY] of the corresponding "Coordinate System Axes" [CSAX] field set to 12 (Gravity Related Depth).

Note, that because every ZCOO value is explicitly linked to sounding datum there is no default value.

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- Use an association to connect geo features to meta features where an override is used (for example vertical clearances) (impact on conversion tools, validation check needed to enforce).
  - NOTE: Only applies to vertical datum. There is no override at the feature level for the depth-related features in S-101.
  - Is this required? The current "hierarchy of metadata" for the features that have attribution that "overrides" the values encoded on the meta features is the same as is included in S-57.
  - However, if it is considered that an association is warranted, this could be done as:

25.**XX**   Vertical datum association

IHO Definition: **VERTICAL DATUM ASSOCIATION**. The association between the vertical datum (plane of reference for heights) to which features are referenced and the features themselves.

Remarks:
- The association is only required where the vertical datum referenced by the features is different to the vertical datum defined by the underlying **Vertical Datum of Data** feature (see clause 3.9), for example to define the high water datum for clearance heights.

| Role Type	Role	Associated With	Multiplicity
Association	Defines	Vertical Datum of Data	1,1
	Defined for	Building, Cable Overhead, Conveyor, Crane, Gate, Light Air Obstruction, Light All Around, Light Fog Detector, Light Sectored, Pipeline Overhead, Span Fixed, Span Opening, Tunnel, Wind Turbine	0,* {1,* [C]}

This solution would include a requirement to have **Vertical Datum of Data** to be encoded with no geometry (refer to Paper S-101PT11-08.9 for similar solution for **Quality of Bathymetric Data**).

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- Add an additional information type to allow the relationship to another datum to be included for example from a sounding datum to a geoidal reference frame.
  - Is this a requirement for charts? Requirement not identified in S-4.
  - Suggest that, if a use case can be identified for charting purposes, this is raised to the NCWG.

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ADDITIONAL RECOMMENDATION
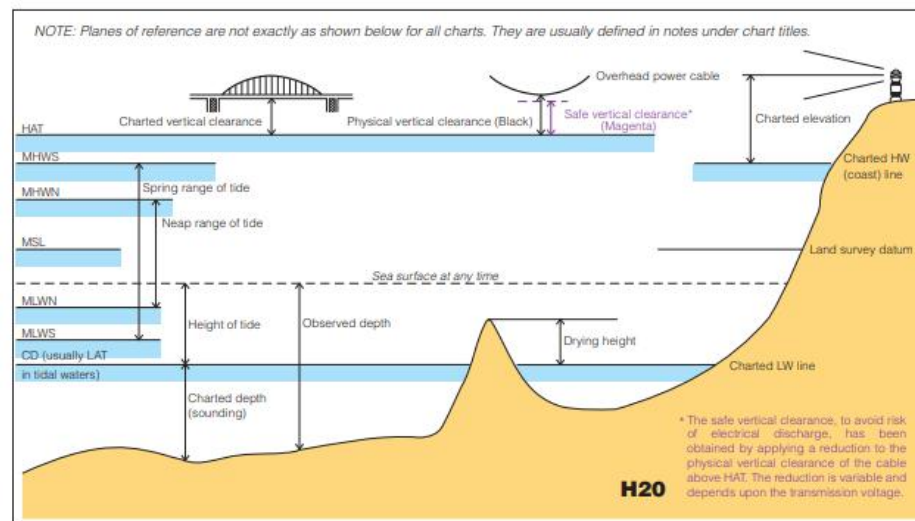
- To provide additional clarity, include a clause in S-101 for "hierarchy of metadata" (including Table) similar to that included in S-57 (ref. S-57 Appendix B.1, clause 3.5.6).
  - If agreed, Main document or DCEG? If Main document, suggest at new clause 4.3.7. If DCEG, suggest new clause 2.5.3.

3.5.6 Hierarchy of meta data

The following table indicates :
∃ individual attributes that supersede meta object attributes,
∃ meta object attributes that supersede the data set subfields (see clauses 6.3.2 and 6.4.2).

Field	Subfield	Meta object class	Meta object attribute	Geo or spatial object attribute
DSID	AGEN	The use of M_PROD is prohibited		
DSID	UADT	The use of M_PROD is prohibited		
DSID	ISDT	The use of M_PROD is prohibited		
DSPM	HDAT	The use of M_HDAT is prohibited		The use of HORDAT is prohibited
DSPM	VDAT	M_VDAT	VERDAT	VERDAT
DSPM	SDAT	M_SDAT	VERDAT	VERDAT
DSPM	CSCL	M_CSCL	CSCALE	
DSPM	DUNI	The use of M_UNIT is prohibited		The use of DUNITS is prohibited
DSPM	HUNI	The use of M_UNIT is prohibited		The use of HUNITS is prohibited
DSPM	PUNI	The use of M_UNIT is prohibited		The use of PUNITS is prohibited
		M_ACCY	HORACC	HORACC
		M_ACCY	POSACC	POSACC
		M_ACCY	SOUACC	SOUACC
		M_ACCY	VERACC	VERACC
		M_NSYS	MARSYS	MARSYS
		M_NSYS	ORIENT	Attribute ORIENT of an individual object does not supersede the meta object attribute.
		M_QUAL	CATZOC	POSACC,SOUACC and TECSOU
		M_QUAL	SOUACC	SOUACC
		M_QUAL	POSACC	POSACC
		M_SREL	SURATH	SORIND
		M_SREL	SUREND	SORDAT
		M_SREL	SURSTA	SORDAT
		M_SREL	TECSOU	TECSOU

table 3.3

When there is no meta object attribute, an individual attribute can supersede a data set subfield.

It is prohibited to use an attribute on an individual object, if this attribute has the same value as the general value defined by the meta object or the equivalent data set subfield.
It is prohibited to use a meta object, if the information given by this meta object is the same as the value given by the equivalent data set subfield.

ACTIONS REQUESTED OF S-101PT

- **Discuss** the recommendations included in this presentation.
- **Agree** on required changes to S-101 documentation for inclusion in Edition 1.2.0.
- **Initiate** further action as required.

THANK YOU