Paper for Consideration by S-101PT

Depth Resolution in S-101 ENCs

Submitted by:	IHO Secretariat (TSSO); Danish Geodata Agency.
Executive Summary:	This paper reports on the resolution for depths currently included in S-101 and resultant conflict with S-4 clauses B-130 and B-412; and proposes possible options for moving forward.
Related Documents:	S-4; S-101 Main document; S-101 Annex A.
Related Projects:	S-101 development.

Introduction / Background

1.   For S-101 Edition 1.0.0 (December 2018) the coordinate multiplication factor for depths [CMFZ] has been set to 100, allowing soundings to be encoded to centimetre resolution. Additionally, the resolution for the S-101 simple attribute valueOfSounding has correspondingly been set to 0.01 metres.

2.   IHO Publication S-4 – *Regulations of the IHO for International (INT) Charts and Chart Specifications of the IHO* provides the specifications for the structure and content of nautical charts, including both paper charts and ENCs. The specification included in S-4 for the resolution of depths on charts currently states that the standard units for depths and heights must be metres and decimetres (clause B-130).

3.   The inclusion of centimetre resolution for encoded depths in S-101 ENCs introduces an inconsistency with the fundamental IHO specification for chart content (S-4). This paper is intended to facilitate the resolution of this inconsistency, taking into account additional factors that may influence any decision taken.

Discussion

4.   The S-4 specification for the units of measure for depths on charts, as stated in clause B-130, is as follows:

> **B-130   UNITS**
>
> The standard units for **depths** and **heights** must be metres (m) and decimetres (dm).
>
> ……..

S-4 clause B-412 also includes the following guidance related to soundings and recommended rounding rules[1]:

> **B-412   SOUNDINGS**
>
> Charted soundings must represent the depth measured from Chart Datum to the sea floor placed in such a way that the centre of gravity (geometric centre) of the set of numerals coincides with the position referred to.
>
> **Rounding of depths**, including drying heights, must always be on the safe (shoaler) side (that is: soundings must be rounded down and drying heights rounded up, if necessary)**.** The rounding should be:
>
> For depths
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> - to the nearest decimetre between 0,1 and 21:
>   0,001 to 0,099 rounds **down** to the nearest decimetre for example: a recorded depth of 4,38m rounds down to 4,3m
> - to the nearest half metre from 21 to 31m:
>   0,001 to 0,499 rounds **down** to 0,0 for example: a recorded depth of 23,49m rounds down to 23m;
>   0,500 to 0,999 rounds **down** to 0,5 for example: a recorded depth of 23,51m rounds down to 23,5m;
> - thereafter, to the nearest metre:

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[1] A paper has been submitted to the NCWG7 meeting (November 2021) proposing amendments to S-4 clause B-412 to better take into account requirements for ENCs and derivation of charted depths from source databases.

0,001 to 0,999 rounds **down** to 0,0 for example: a recorded depth of 31,85m rounds down to 31m

For drying heights

- to the nearest decimetre:
0,001 to 0,099 rounds **up** to the nearest decimetre for example: a recorded drying height of -2,32m rounds up to -2,4m

However, these soundings must be adjusted as a function of the degree of accuracy with which depths were actually measured, so that the precision with which soundings are recorded on charts can never be misleading as to the accuracy of such soundings.

5.   The current S-101 specification regarding the encoding of depths, as stated in clause 10.1.2 of the S-101 Edition 1.0.0 Main document, is as follows:

10.1.2   Encoding of Depths

Depths are converted from decimal metres to integers by means of the [CMFZ] (see Annex B – clause B5.1.2). This Product Specification limits the resolution to two decimal places and therefore the [CMFZ] must be set to {100}. [2]

EXAMPLE: A depth = 4.2 is converted in Z = depth*CMFZ = 4.2*100 = 420

6.   The inconsistency that exists between the specification defined in S-4 and the S-101 ENC Product Specification is that the units of measurement for depths on charts as defined in S-4 is constrained to metres and decimetres; while the soundings stored in an ENC dataset may be encoded to centimetre resolution, which may be intended to better facilitate interoperability with other S-100 based products such as S-102 and S-104. The following paragraphs raise issues related to this inconsistency, taking into account some additional factors.

7.   Encoding v display in S-101: While the S-101 ENC Product Specification specifies the resolution to which depths can be encoded (stored) in an ENC dataset, there is no specification at present that defines the resolution to which encoded depths are to be displayed in S-100 ECDIS. In S-57/S-52, depth information is encoded to decimetre resolution and displayed to decimetre resolution for depths up to 31 metres and metre resolution thereafter; and requires no specification in regard to any manipulation of encoded depths beyond truncating depths over 31 metres to metre resolution where they have been encoded to decimetre resolution (in accordance with S-4). Assuming the encoding of depths to centimetre resolution is retained, is the same principle as specified in S-4 and currently applied in S-57/S-52 going to be applied for the display of depths for S-101 ENCs? If so, can this be managed within the Portrayal Catalogue; and where is this going to be specified? Any discussion on this point will also need to take into account features containing the simple attribute valueOfSounding as an allowable attribute (in particular underwater hazards), for which the depth is displayed in some ECDIS settings. In this situation the issue is complicated by the fact that the depth value as encoded will be discoverable to the mariner in an ECDIS Pick Report, which may be different to the actual displayed value.

8.   Uncertainty: For S-101 ENC, the parameters for the value of the vertical uncertainty of depths as a component of an overall indication of the quality of bathymetric data for an area is included in the S-101 meta feature QualityOfBathymetricData and retains the same values as defined for the S-57 attribute CATZOC. For the highest (A1) CATZOC value, the vertical uncertainty component is quoted as "0.50m + 1%d" (d = depth), therefore the best accuracy for a depth measurement that is at or close to the Chart datum is half a metre. This is a large disparity from the centimetre resolution to which depths can currently be encoded in S-101, taking into account the specification at B-412, last paragraph, (see paragraph 4 above) *"… that the precision to which soundings are recorded on charts can never be misleading as to the accuracy of such soundings"*. In addition, the vertical uncertainty of a measured depth may be encoded on individual feature instances (and is mandatory for underwater hazards and the meta feature QualityOfBathymetricData) using the complex attribute verticalUncertainty, for which the fixed component of the uncertainty (sub-attribute uncertaintyFixed; for example the 0.50m specified to satisfy CATZOC A1) can only be encoded to decimetre resolution. It seems illogical to allow depths to be encoded to centimetre accuracy but have the accuracy of such depths indicated only to decimetre accuracy.

9.   Physical factors: Such factors include tides (including the uncertainty of predicted tide values); weather factors such as atmospheric pressure and wind; and vessel related factors such as vessel squat. These factors all add to the uncertainty for the mariner of charted depths in regard to developing and executing a voyage plan, which have all been taken into account in the specification in S-4 for the units of measure for depths on charts.

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10.   Purpose of ENCs: The S-101 ENC Product Specification states that "*The purpose of an ENC dataset is to provide official navigational data for navigation systems for the safe passage and route planning of vessels between destinations.*" (S-101 Main document clause 1.4). It is important that the Product Specification is developed within this purpose, scope and in conformance with related IHO Specifications such as S-4; and as such avoid inclusion of data modelling that is not required to satisfy the purpose and scope. This will then provide information that is fit for purpose for the intended use in regard to conformance to specifications/conventions for data content so as to best satisfy the requirements of the end-user. S-101 is not intended to be a generic data transfer standard or provide a definitive model for data producer's database structures and data resolutions. It is likely that within the S-100 environment S-101 will be just one output from such databases, with other outputs intended to satisfy the requirements for other S-100 based Product Specifications. Such Product Specifications may have different resolution for bathymetry implemented to satisfy the specific purpose and use of that particular product and it may be considered that differing set-for-purpose resolutions included in S-100 based Product Specifications should not be an issue with regard to interoperability in a S-100 ECDIS. An unfortunate side-effect of S-57 implementation is that many data producers have developed their source databases using the S-57 data model as reflected in the S-57 Object Catalogue, including the resolutions for units of measure such as depth and distance; and continue to look to resolutions quoted in IHO Product Specifications/Standards to inform such decision making.

11.   An additional discrepancy in the allowable resolutions of encoded depth information in S-101 exists between the centimetre resolution for soundings and the attribute valueOfSounding; and the decimetre resolution allowable for the attributes depthRangeMaximumValue, depthRangeMinimumValue, maximumPermittedDraught and valueOfDepthContour. Note also that attributes related to heights (elevation, height, verticalClearanceValue and verticalLength) can only be encoded to decimetre resolution, however this should be considered acceptable given the use of such information by the mariner in the navigational ENC.

Conclusions

12.   In order to comply with the specifications for nautical chart content as included in S-4, depths in ENC must be represented in metres and decimetres. Taking into account the centimetre resolution to which soundings can currently be encoded in an ENC dataset ([CMFZ] = {100}), this representation may be achieved in two ways:

12.1. Amending [CMFZ] to {10} to reflect decimetre resolution of depths in ENC; and ensuring any S-101 attributes that quote depth information (for example valueOfSounding) also have decimetre resolution; or

12.2. Retaining [CMFZ] = {100} and including S-101 portrayal rules such that all displayed depths, including depths that may be included in the ECDIS Pick Report, are displayed in metres and decimetres.

13. If the S-101PT considers that there is a requirement to depict any depth information (through representation of soundings or through the ECDIS Pick Report) to centimetre resolution in ECDIS, this should be brought to the attention of the NCWG for corresponding amendments to S-4 so as to ensure consistency within the IHO Publications.

14. There is a requirement that all resolutions of related measurements (depth, height, distance etc) in S-101 are consistent within the Product Specification. An activity should be initiated within the S-101 data model (DCEG and Feature Catalogue) to ensure that this consistency is realised, with the consistency for depths to be resolved in accordance with the decision made in relation to paragraph 12 above.

Recommendations

15.   That the S-101PT determine the most appropriate method for ensuring conformance with the specifications for the depiction of depths on charts as mandated in S-4, as summarised in paragraph 12 above, and apply this methodology to S-101.

16.   If the above is determined to be in line with paragraph 12.2 above, S-101PT to develop portrayal rules such that all depths are displayed to decimetre resolution; and ensure these rules are documented in the appropriate location.

17.   That the S-101PT discuss any requirement that may be relevant to justify depiction of any depth information derived from ENCs in ECDIS to greater than decimetre resolution. It is suggested that any such discussion should also involve the NCWG and DQWG. If any such requirement is identified, this should be communicated to the NCWG so that appropriate action can be taken to update S-4.

18.   That the S-101PT, through the DCEG Sub-Group, conduct a review of all attributes related to a unit of measure and ensure that there is consistency throughout S-101 in regard to the application of the unit of measure. For depths, this will need to take into account the decision made for the resolution of soundings in ENC data.

Action Requested of the S-101PT

19. The S-101PT is invited to:

 1) **Agree** on a methodology to ensure that all depth depiction from ENC in ECDIS is in metres and decimetres in line with S-4 regulations for the depiction of depths on charts.

 2) **Discuss** any possible requirement to display depths from ENC in ECDIS to greater resolution than metres and decimetres and initiate any appropriate action, including notification to the NCWG for possible amendments to S-4.

 3) **Instruct** the DCEG Sub-Group to review the resolution of all attributes related to a unit of measure to ensure consistency within the S-101 ENC Product Specification.