

Paper for Consideration by S-101PT6

Alternative for Modelling of Quality of Bathymetric Data

Submitted by:	S-101 DCEG Sub-Group
Executive Summary:	This paper summarizes the recommendations of the DQWG for the display and performance of bathymetric data quality indicators in ECDIS, and proposes alternative S-101 DCEG modelling to cater for these recommendations.
Related Documents:	<p>Papers for DQWG15, Agenda Item 5 and report on Agenda Item 5 in DQWG15 final Minutes.</p> <p>S-100WG5-03.8 – <i>Data Quality Working Group Report</i></p> <p>S-101PT5-16 – <i>Quality of Bathymetric Data and ECDIS Performance</i></p> <p>DQWG Decision Tree for evaluation of quality of bathymetric data (https://iho.int/uploads/user/Services%20and%20Standards/DQWG/Refference%20Documents/Data%20Quality%20Decision%20Tree_9July2019.pdf)</p> <p>HSSC12-05.5C – <i>Conversion of M_QUAL/CATZOC to S-101</i></p> <p>S-101 Annex A – <i>Data Classification and Encoding Guide</i></p>
Related Projects:	S-101 development; presentation of data quality information in ECDIS.

Introduction / Background

1. The IHO Data Quality Working Group (DQWG) has been tasked since 2007 by the Hydrographic Services and Standards Committee (HSSC) to develop recommendations for improvements in the presentation of data quality indicators in ECDIS. These recommendations were finalised at the DQWG15 meeting in January 2020 and presented to the HSSC, where it was decided to pass the outcome and recommendations to the S-101PT for further action (HSSC Decision and Action HSSC12/48 refers).
2. This Paper provides a summary of the recommendations as determined by the DQWG and describes the possible impacts of these recommendations on the S-101 Data Model; in particular in relation to the Quality of Bathymetric Data Meta feature. Two options for alternative modelling of the Quality of Bathymetric Data feature are also proposed for consideration of the S-101PT, in addition to corresponding changes to other impacted features from the DQWG recommendations.

Discussion

3. The HSSC12 (October 2020) decisions and actions relating to the visualisation of quality of bathymetric data are as follows:

AGENDA ITEM	SUBJECT	ACTION No.	ACTIONS (in bold, action by)	TARGET DATE/EVENT	STATUS (at 27 Nov. 2020)
5.5	Conditional Visualization of Quality of Bathymetric Data	HSSC12/48	HSSC approved the completion of the task on the conditional visualization of quality of bathymetric data by the DQWG and the transfer of the outcome and recommendations to the S-101PT for their consideration	HSSC-13	Decision
5.5	Data Quality in existing S-57 ENC's	HSSC12/49	HSSC encouraged Member States to start populating appropriate POSACC / SOUACC values in existing S-57 ENC's for relevant spatial objects in preparation of conversion to S-101 (iaw UOC 2.2).	Permanent	

4. The recommendations of the DQWG were presented to the S-101PT5 meeting (September 2020 – paper S-101PT5-03.8), with the following actions being assigned:

No.	Agenda	Action	Who
S-101PT5-02	Visualization of Quality of Bathymetric Data	Develop proposal for S-101PT consideration on possible amendments to S-101 modelling of the Quality of Bathymetric Data feature based on the outcome of the DQWG investigation of improved portrayal of this information in ECDIS (for TSM8).	JW
S-101PT5-03	Visualization of Quality of Bathymetric Data	Consider the implementation of DQWG recommendations on improved portrayal of Quality of Bathymetric Data information in ECDIS (for S-101PT6).	S-101 Portrayal Sub-Group

5. The following is a summary of the recommendations of the DQWG related to the improvement of the modelling of the quality of bathymetric data as included in paper S-101PT5-03.8. Each of these recommendations will then be addressed individually in following paragraphs, taking into account the requirements for S-101 and the impact on the S-57 to S-101 (and vice-versa) conversion process, as to recommended changes to the S-101 modelling:

- The S-57 attribute Category of Zone of Confidence (CATZOC) should be added to the **Quality of Bathymetric Data** feature;
- Removal of the **category of temporal variation** attribute from the **Quality of Bathymetric Data** feature;
- A new attribute **temporal validity** should be added to the **Quality of Bathymetric Data** feature;
- Functionality is required to display “positional uncertainty circles” around features that may be dangerous to navigation at the request of the mariner. In addition, functionality is required in ECDIS route checking to generate Warnings when a vessels’ safety corridor crosses a “positional uncertainty circle” or a feature that has a depth less than the mariners’ set safety depth taking into consideration vertical uncertainty. Similar functionality to this is also required for checking vertical clearances. In order to achieve this:
 - The attributes **horizontal position uncertainty** and **vertical uncertainty** should be mandatory for all **Obstruction, Sounding, Underwater/Awash Rock** and **Wreck** features;
 - The attribute **vertical uncertainty** should be mandatory for all features carrying a vertical clearance;
- In order to avoid screen clutter, a new Boolean attribute **display uncertainties** should be added to the **Obstruction, Sounding, Underwater/Awash Rock** and **Wreck** features in order to provide encoders with the option as to which charted features are to display the “positional uncertainty circle”;
- Consideration should be given to renaming the **Quality of Bathymetric Data** feature to **Zone of Confidence**.

6. Addition of CATZOC to Quality of Bathymetric Data: The current modelling within S-101 for the **Quality of Bathymetric Data** feature “deconstructs” the S-57 CATZOC attribute into its component criteria (position accuracy, depth accuracy and seafloor coverage). Concerns have been raised by some Producing Authorities as to the capability of S-57 to S-101 conversion software to reliably transpose values of CATZOC to the corresponding attributes in S-101 (and vice versa), which would result in considerable resources having to be dedicated to checking/amending converted data. This concern becomes more apparent with some of the additional changes proposed in this paper. Further concern has been raised as to the ability to provide consistent, “seamless” ECDIS display of S-57 M_QUAL and S-101 **Quality of Bathymetric Data** where S-57 and S-101 data sets adjoin in a “dual-fuel” ECDIS. By including the attribute **category of zone of confidence in data** in the **Quality of Bathymetric Data** feature and relating the S-101 portrayal of the quality information to this attribute (as for S-57) these concerns would be resolved, although this may be considered by some to be “double-encoding”. For this reason, it is proposed that the addition of **category of zone of confidence in data** be a temporary measure for the period covering the transition from S-57 to S-101. During the conversion process, CATZOC can be converted directly to **category of zone of confidence in data** in addition to the population of the new CATZOC-specific S-101 attributes. This will allow Producing Authorities an extended period of time to ensure “full” S-101-specific attribute population without impacting on the use of their data in ECDIS.

Recommendation 1: Add the attribute **categoryOfZoneOfConfidenceInData** (as modelled in S-57 M_QUAL) to the **QualityOfBathymetricData** feature for the period of transition from S-57 to S-101. ECDIS portrayal to be associated with this attribute; and S-57 to S-101 conversion software to map to both this attribute and the S-101-specific quality related attributes.

7. Removal of category of temporal variation from Quality of Bathymetric Data; addition of temporal validity to Quality of Bathymetric Data: The DQWG has recommended that the attribute **category of temporal variation** is removed from the **Quality of Bathymetric Data** feature. The principal justifications for this are that determination of a value for this attribute is not possible in areas not previously surveyed; and is difficult to determine where full seafloor coverage has not been previously achieved. At the S-101PT5 meeting, Australia submitted a paper with an alternative modelling option with the intention of retaining the **category of temporal variation** attribute in S-101

(S-101PT5-16). Additional factors to be taken into consideration, taking into account the recommendation of the DQWG and the proposal from Australia, are:

- In the DQWG Decision Tree, **category of temporal variation** is the second attribute considered when determining a final quality value. This means that for values other than 6 (unlikely to change) it is not possible for an area to be assigned the highest quality value for ECDIS portrayal. This has been raised as a concern by some Producing Authorities. Consideration should be given to removing **category of temporal variation** from the DQWG Decision Tree, particularly if the new attributes proposed by Australia or the alternate modelling proposed in this paper are approved;
- The value **category of temporal variation** = 6 (unassessed) is not taken into account in the DQWG Decision Tree (and may not have been taken into account in DQWG discussions);
- If the proposal by Australia is implemented, it is suggested that the temporal variation component for the quality of bathymetric data is remodelled to a complex attribute, with all the components as sub-attributes. However, as a possible alternative to the Australian proposal, it is suggested that the vertical and horizontal accuracy components of **Quality of Bathymetric Data** are included in a new complex attribute **spatial accuracy**, which also has the sub-complex attribute **fixed data range** included so as to allow for the indication of degrading spatial accuracy of bathymetric data included in the dataset over time. This modelling is proposed as an alternative to the proposal from Australia to introduce a new attribute **temporal validity** and associated new ECDIS performance requirements. For the purposes of furthering discussions and testing, the redline changes included in the Annex have implemented this option;
- The lack of the ability to encode a temporal component for the indication of the quality of bathymetric data in an ENC has been identified as a deficiency in the S-57 data model. It may be considered to be a “backward step” in S-101 for the temporal component of the **Quality of Bathymetric Data** feature to be removed.

Recommendation 2: Attribute **categoryOfTemporalVariation** to be retained as a non-mandatory attribute for **QualityOfBathymetricData** for ongoing implementation and testing purposes. A new complex attribute **spatialAccuracy** to be introduced and modelled in accordance with one of the options included in the Annex to this Paper.

8. Display of “positional uncertainty circles”: In addition to providing a more concise indication of positional accuracy for the mariner, it is considered that the encoding of horizontal and vertical accuracies on individual features in S-101 will be a mandatory requirement for navigation of autonomous/semi-autonomous vessels. The simplest method for achieving this recommendation in the current modelling of the S-101 DCEG is to mandate the encoding of a **Spatial Quality** information type instance, associated to the appropriate **Obstruction**, **Sounding**, **Underwater/Awash Rock** and **Wreck** features using the association **Spatial Association**. This avoids the requirement of having to encode attribution individually on discrete geo feature instances, by allowing the **Spatial Quality** information type to carry the attribution for multiple feature instances having identical spatial quality. However, it is noted that the complex attribute **vertical uncertainty** is listed as an allowable attribute for **Obstruction**, **Sounding**, **Underwater/Awash Rock** and **Wreck** features (essentially creating the ability to encode the same information in more than one way – a possible oversight in the original DCEG development). It is therefore recommended that, in addition to a mandatory requirement to encode **Spatial Quality** associated to all **Obstruction**, **Sounding**, **Underwater/Awash Rock** and **Wreck** features, the attribute **vertical uncertainty** is removed as an allowable attribute for these features. It is also suggested that, in order to establish the relationship between the (proposed) complex attribute **spatial accuracy** on **Quality of Bathymetric Data** and the vertical and horizontal uncertainty values associated with individual features, guidance is added in the DCEG that the most prevalent uncertainty values on the individual features must be reflected in the **spatial accuracy** on **Quality of Bathymetric Data**.

Recommendation 3: The complex attribute **verticalUncertainty** is removed as an allowable attribute for the features **Obstruction**, **Sounding**, **UnderwaterAwashRock** and **Wreck**. New guidance added to relevant clauses of the DCEG mandating the association of the information type **SpatialQuality** to all encoded **Obstruction**, **Sounding**, **UnderwaterAwashRock** and **Wreck** features of type point or pointset and of depth 30 metres or less; and that the values for the complex attributes **horizontalPositionAccuracy** and **verticalAccuracy** on a **QualityOfBathymetricData** feature must reflect the most prevalent values for these attributes associated with the point or pointset bathymetric features in the area. Additional consideration may also be given to removing **verticalUncertainty** from all other geo features that do not have a vertical clearance attribute, for consistency.

9. Mandating complex attribute **vertical uncertainty** for feature types carrying a vertical clearance: Vertical clearances can be measured much more reliably than depths, and therefore it may be assumed that vertical uncertainties related to vertical clearances are minimised, such that in most cases the uncertainty does not exceed the resolution of the encoded clearance. In addition, uncertainties regarding vertical clearances may not

be easily acquired by Producing Authorities. For these reasons, it may not be practical to mandate the encoding of vertical uncertainty for vertical clearances. However, consideration should be given to including additional guidance in the DCEG for Producing Authorities to include this information if it is considered important in route planning or monitoring. It is also considered that, although not included in the original DQWG recommendations, this guidance should also be extended to horizontal clearances.

Recommendation 4: Vertical and horizontal uncertainty to remain optional in relation to clearances in S-101, however additional guidance should be considered for inclusion if it is considered that this information is important in certain circumstances and if the information is available.

10. Addition of new Boolean attribute **display uncertainties**: It is considered that the addition of this attribute, in association with the mandatory encoding of vertical and horizontal position accuracies for all feature types that may constitute a hazard to navigation and the intended ECDIS portrayal and performance outcomes, is critical in managing undesired screen clutter. Note that for the redline included in the Annex, this attribute is included as non-mandatory as it is intended that this attribute is only populated for features of depth 30 metres or less. It is also noted that the recommendation for the population of this attribute in S-57 to S-101 conversion is that this attribute is set to “no”.

Recommendation 5: New Boolean attribute **displayUncertainties to be added to S-101 and bound to Obstruction, Sounding, UnderwaterAwashRock and Wreck features, with appropriate guidance added for its encoding for depths of 30 metres or less. For S-57 to S-101 conversion, this attribute to be set to “no”.**

11. Renaming **Quality of Bathymetric Data** to **Zone of Confidence**: The justification for this recommendation from the DQWG is that the term “Zone of Confidence” (or “ZOC”) is the term most familiar to mariners when relating to the bathymetric data quality indicators in ECDIS. While this may be the case, it is important to note that the term “Zone of Confidence” implies no relevance to bathymetric data specifically; in S-57 this is achieved by having the attribute “Category of Zone of Confidence in Data” (CATZOC) bound to the Meta feature “Quality of Data” (M_QUAL), which for S-57 ENC is specific to bathymetry. In drafting S-101 Edition 1.0.0, it was decided that a more direct relationship between the Meta feature name and its specificity to bathymetric data was required, resulting in the naming of the feature “Quality of Bathymetric Data”. This also provided a clear distinction from the Meta features “Quality of Non-Bathymetric Data” and “Quality of Survey”; not just in S-101 but also in terms of the registered terms in the IHO GI Registry. While the familiarity of the term “Zone of Confidence” (or “ZOC”) to the end user warrants further discussion, it is also considered desirable to maintain relevance and consistency between other quality-related terms from a more holistic perspective.

Recommendation 6: Meta feature name **Quality of Bathymetric Data to be retained. However, “Zone of Confidence” and “ZOC” to be included as aliases.**

Conclusions

12. The DQWG has achieved a significant milestone in providing its recommendations for improvements in the presentation of S-101 data quality indicators in ECDIS. This paper extends these recommendations to allow for their ability to be implemented from a modelling perspective, as discussed by the S-101 DCEG Sub-Group.

Recommendations

13. Refer to recommendations 1-6 as included in paragraphs 6-11.

Action Requested of the S-101PT

14. The S-101PT is invited to:

- 1) **Note** the recommendations of the DQWG in relation to improving the portrayal and performance of bathymetric data quality indicators in ECDIS.
- 2) **Discuss** the recommendations included in this paper.
- 3) **Agree** on a way forward and further actions in regard to the recommendations and the annexed redlines.

Annex:

A – Proposed redline changes to S-101 Annex A – *Data Classification and Encoding Guide*

2.4.3 Mandatory and conditional attributes

Some attributes are mandatory and must be populated for a given feature type. The following are reasons why attribute values may be considered mandatory:

- They are required to support correct portrayal by determining
 - whether a feature is in the display base
 - which symbol is to be displayed;
- Certain features make no logical sense without specific attributes;
- Some attributes are required for safety of navigation.

Within this document, mandatory attributes (multiplicity 1,1; 1,n (n>1); or 1,*) are identified in the description of each feature type. For easy reference, Table 2.3 below summarises the mandatory attributes for each feature type (note that mandatory sub-attributes of complex attributes are not included in this Table):

Feature	Mandatory Attributes
Administration Area	jurisdiction
Archipelagic Sea Lane Part	nationality
.....	
Obstruction	water level effect; display uncertainties at least one of: value of sounding ; height
.....	
Sounding	display uncertainties
.....	
Underwater/Awash Rock	display uncertainties ; value of sounding ; water level effect
.....	
Wreck	display uncertainties ; water level effect at least one of: category of wreck ; value of sounding
.....	
Quality of Bathymetric Data	category of temporal variation ; data assessment ; features detected ; full seafloor coverage achieved ; horizontal position uncertainty ; spatial accuracy (option 1); survey date range ; vertical uncertainty ; zone of confidence (option 2)
.....	

NOTE: These proposed amendments are aligned with the remodelling of the **Quality of Bathymetric Data** feature as included in Options 1 and 2 below.

3.1 Horizontal uncertainty

The attributes **quality of horizontal measurement** and **horizontal position uncertainty** may be applied to any spatial type, in order to qualify the location of a feature.

If it is required to encode the uncertainty of a horizontal clearance (complex attributes **horizontal clearance fixed** and **horizontal clearance open**), it must be done using the sub-attribute **horizontal distance uncertainty**.

horizontal distance uncertainty applies only to **horizontal clearance fixed** and **horizontal clearance open**. There is no attribute to express the accuracy of the attributes **horizontal length** and **horizontal width**.

horizontal distance uncertainty, ~~**horizontal position uncertainty**~~ and **quality of horizontal measurement** must not be applied to the spatial type of any geo feature if they are identical to the **horizontal distance uncertainty**, ~~**horizontal position uncertainty**~~ and **quality of horizontal measurement** values of the underlying meta feature. ~~**horizontal position uncertainty** must not be applied to the spatial type of any geo feature if they are identical to the **horizontal position uncertainty** values of the underlying meta feature, except for **Sounding** features; and **Obstruction**, **Underwater/Awash Rock** and **Wreck** features of type point (see clauses 3.7.1.3, 11.3 and 13.4-7).~~

quality of horizontal measurement gives qualitative information, whereas **horizontal position uncertainty** gives quantitative information.

Remarks:

No remarks.

Additional Remarks bullet to be included in clauses 6.2.1, 6.6.1, 6.7.1, 6.8.1, 6.9.1, 6.10.1, 6.15.1, 7.4.1 and 8.12.1:

- If available and considered important for route planning and/or monitoring, the vertical uncertainty associated with encoded vertical clearance values should also be encoded.

3.7 Quality of bathymetric data (Option 1)

IHO Definition: **QUALITY OF BATHYMETRIC DATA.** An area within which a uniform assessment of the quality of the bathymetric data exists. (S-57 Edition 3.1, Appendix A – Chapter 1, Page 1.216, November 2000).

S-101 Metadata Feature: Quality of Bathymetric Data (M_QUAL)

Primitives: Surface

Real World	Paper Chart Symbol	ECDIS Symbol		
S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
category of temporal variation		1 : extreme event 2 : likely to change and significant shoaling expected 3 : likely to change but significant shoaling not expected 5 : unlikely to change 6 : unassessed	EN	0,1
data assessment		1 : assessed 2 : assessed (oceanic) 3 : unassessed	EN	1,1
depth range maximum value	(DRVAL2)		RE	0,1
depth range minimum value	(DRVAL1)		RE	0,1
features detected			C	1,1
least depth of detected features measured			(S) BO	1,1
significant features detected			(S) BO	1,1
size of features detected			(S) RE	0,1
full seafloor coverage achieved			BO	1,1
horizontal position uncertainty			C	1,1
—uncertainty fixed	(POSACC)		(S) RE	1,1
—uncertainty variable factor			(S) RE	0,1
spatial accuracy			C	1,*
category of zone of confidence in data	CATZOC	1 : zone of confidence A1 2 : zone of confidence A2 3 : zone of confidence B 4 : zone of confidence C 5 : zone of confidence D 6 : zone of confidence U (data not assessed)	EN	1,1
fixed date range			(S) C	0,1
date end	(DATEND)	ISO 8601: 2004	(S) TD	0,1
date start	(DATSTA)	ISO 8601: 2004	(S) TD	0,1
horizontal position uncertainty			(S) C	1,1
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
vertical uncertainty			C	1,1
uncertainty fixed	(SOUACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1

survey date range			C	1,1
date end	(SUREND)	ISO 8601:2004	(S) TD	1,1
date start	(SURSTA)	ISO 8601:2004	(S) TD	0,1
vertical uncertainty			G	1,1
—uncertainty fixed	(SQUACC)		(S)-RE	1,1
—uncertainty variable factor			(S)-RE	0,1

INT 1 Reference:

3.7.1 Quality, reliability and uncertainty of bathymetric data (see S-4 – B-297)

Information about quality, reliability and uncertainty of bathymetric data is given using:

- the meta feature **Quality of Bathymetric Data** for an assessment of the quality of bathymetric data;
- the meta feature **Quality of Survey** for additional information about individual surveys (see clause 3.10);
- the attributes **quality of vertical measurement**, **and technique of vertical measurement** ~~and complex attribute vertical uncertainty~~ on groups of soundings or individual features;
- the attributes **horizontal position uncertainty**, **quality of horizontal measurement** and **vertical uncertainty** on the spatial types (see clause 2.4.7).

Bathymetric data quality comprises the following:

- completeness of data (for example, seafloor coverage);
- currency of data (for example, temporal degradation);
- uncertainty of data;
- source of data.

All horizontal positional (2D), vertical (1D), horizontal distance (1D) and orientation (1D) uncertainty attributes concern the 95% confidence level of the variation associated with all sources of measurement, processing and visualization error. Uncertainty due to temporal variation should not be included in these attributes.

For the mariner, **Quality of Bathymetric Data** provides the most useful information. Therefore, the use of **Quality of Bathymetric Data** is mandatory for areas containing depth data or bathymetry on ENC datasets at maximum display scale 1:700000 and larger.

More detailed information about a survey may be given using **Quality of Survey** (see clause 3.10). For example, in incompletely surveyed areas, lines of passage soundings may be indicated as such using a curve **Quality of Survey** feature. This information is more difficult for the mariner to interpret, therefore the use of **Quality of Survey** is optional.

For individual features (wrecks, obstructions etc), or small groups of soundings, **quality of vertical measurement**, **technique of vertical measurement**, **horizontal position uncertainty** and **vertical uncertainty** may be used to provide additional information about quality and uncertainty.

The meta feature **Quality of Bathymetric Data** defines areas within which uniform assessment exists for the quality of bathymetric data, and must be used to provide an assessment of the overall quality of bathymetric data to the mariner. Areas of a dataset containing depth data or bathymetry must be covered by one or more **Quality of Bathymetric Data**, which may overlap vertically in order to define the quality of bathymetric data at varying depths in the water column.

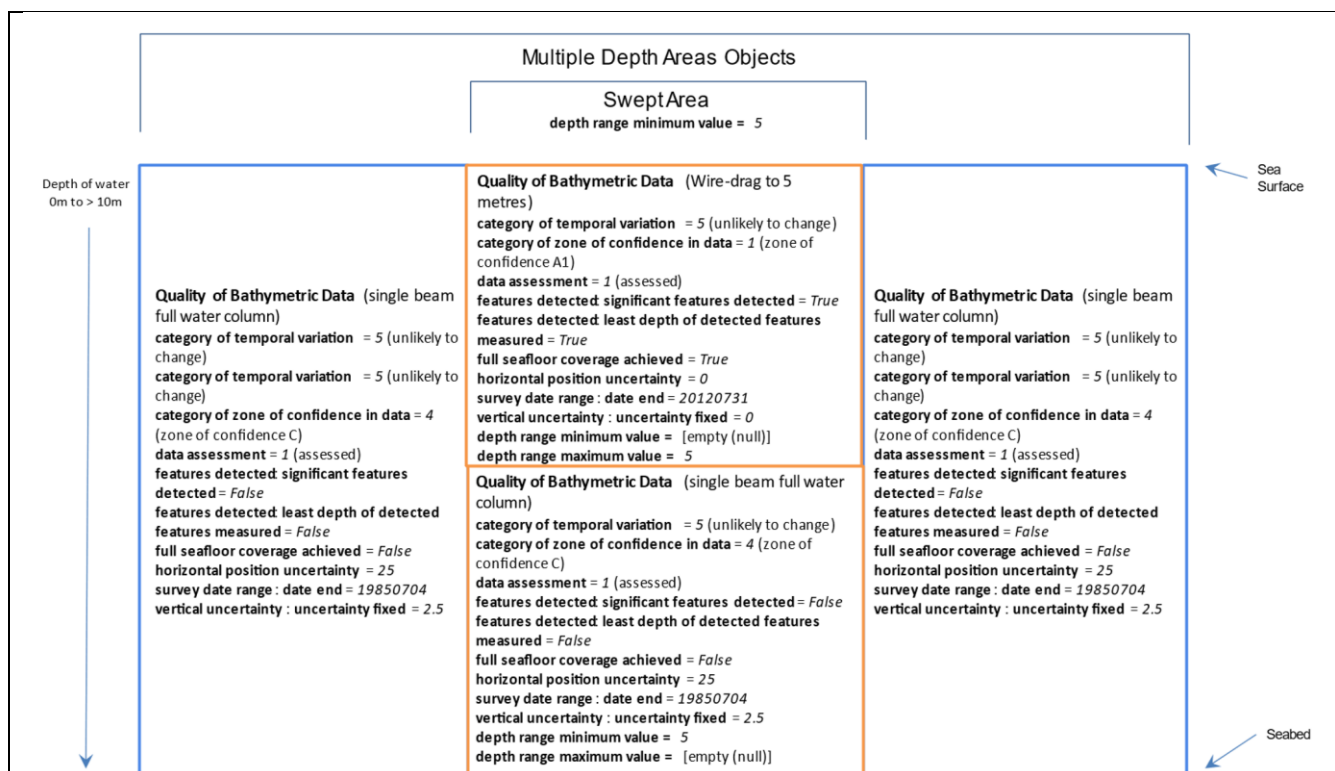


Figure 3.2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a wire swept area to a depth of 5 metres that has also been previously surveyed using single beam echo sounder to the seabed. For the **Quality of Bathymetric Data** feature that defines the data quality for the swept area, it is important to note that the recommended attribution shown below is intended to provide the highest (best) quality indicator for vessels navigating at a safety depth of less than 5 metres in the area.

Remarks:

- The mandatory attribute **data assessment** provides an overall indicative level of assessment of bathymetric data from which further attribution is derived, and assists with portrayal of bathymetric data quality information in ECDIS:
 - Where the value for **data assessment** is set to 1 (assessed), all additional attribution for the **Quality of Bathymetric Data** feature must be indicative of the quality of bathymetric data for the area.
 - Where the value for **data assessment** is set to 2 (assessed (oceanic)), all additional attribution for the **Quality of Bathymetric Data** feature should be indicative of the quality of bathymetric data for the area for a mariner's ECDIS pick report, however no portrayal of the quality information will display on the ECDIS. This value should only be used to cover open ocean (oceanic) depths in waters deeper than 200 metres.
 - Where the value for **data assessment** is set to 3 (unassessed), the mandatory attributes **category of temporal variation** = 6 (unassessed); **features detected** (least depth of detected features measured and significant features detected) = False; **full seafloor coverage achieved** = False; **category of zone of confidence in data** = 6 (zone of confidence U (data not assessed)); and **horizontal position uncertainty** (uncertainty fixed) and **vertical uncertainty** (uncertainty fixed) = [empty (null)] must be populated.
- Wherever possible, meaningful and useful values for the attributes **category of temporal variation**, **full seafloor coverage achieved**, and the complex attribute **features detected** must be used for areas of bathymetry. For areas of unstable seafloors, the complex attribute **survey date range** (date end) must be used to indicate the date of the survey of the underlying bathymetric data.
- As a result of some disasters, for example earthquakes, tsunamis, hurricanes, it is possible that large areas of seafloor have moved and/or become cluttered with dangerous obstructions. Emergency surveys may subsequently be conducted over essential shipping routes and inside harbours. Outside these surveys, all existing detail is now suspect, whatever the quality of the previous surveys. In such cases, the attribute **category of temporal variation** should be reclassified to value 1 (extreme event); the Boolean attribute **full seafloor coverage achieved** set to False; and complex attribute **features detected**, Boolean sub-attributes **least depth of detected features measured** and **significant features detected** set to False; the **spatial accuracy** sub-attribute **category of zone of confidence in data** reclassified to 5 (zone of confidence D); and **spatial accuracy** sub-attributes **horizontal position accuracy** (uncertainty fixed) and **vertical uncertainty** (uncertainty fixed) populated with an empty (null) value in the affected areas outside the area covered by emergency surveys.

- To express completeness of bathymetric data, the complex attribute **features detected** must be encoded. **features detected** indicates that a systematic method of exploring the sea floor, or the water column to the depth indicated by population of the attribute **depth range maximum value**, was undertaken to detect significant features. The sub-attributes **size of features detected** and **least depth of detected features measured** must not be encoded unless the sub-attribute **significant features detected** is set to *True*.
- The mandatory complex attribute **spatial accuracy** is used on a **Quality of Bathymetric Data** feature to specify the vertical and horizontal position uncertainty of the depths covered by the surface; and provide an overall indication of the accuracy of the bathymetric data in the area. Where **category of temporal variation** is set to values 2 (likely to change and significant shoaling expected) or 3 (likely to change but significant shoaling not expected), multiple instances of **spatial accuracy** should be encoded to provide an indication of the degradation of the overall accuracy as well as the vertical and horizontal position accuracy of the charted bathymetric information over time.
 - Wherever possible, meaningful and useful values of the mandatory sub-attribute **category of zone of confidence in data** should be used (that is, values other than **category of zone of confidence in data** = 6 (zone of confidence U (data not assessed))) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.XX) in accordance with the values populated for the attribute **full seafloor coverage achieved**, the complex attribute **features detected** and **spatial accuracy** sub-complex attributes **horizontal position uncertainty** and **vertical uncertainty**.
 - The sub-complex attribute **fixed date range** is used to define the date range(s) where the quality is degraded over time. Where multiple date ranges are specified, the **date start** of an instance must be equal to the **date end** of the previous instance. Within the sequence, the **date start** of the first instance and the **date end** of the last instance should not be populated.
 - The sub-complex attribute **vertical uncertainty** is used ~~on a Quality of Bathymetric Data feature~~ to specify the vertical uncertainty of the depths covered by the surface ~~within a specified date range (where encoded)~~. When **depth range minimum value** is specified, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
 - The sub-complex attribute **horizontal position uncertainty** is used ~~on a Quality of Bathymetric Data feature~~ to specify the positional uncertainty of the depths covered by the surface ~~within a specified date range (where encoded)~~.
- **depth range minimum value** must only be used on a **Quality of Bathymetric Data** feature where a swept area occupies the entire **Quality of Bathymetric Data** surface, or **Quality of Bathymetric Data** features overlap. Where these features overlap such that varying bathymetric data qualities exist at different depths in the water column, the **depth range minimum value** for a **Quality of Bathymetric Data** must be equal to the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see ~~diagram-Figure 3.2~~ above).
- **depth range maximum value** must only be used on a **Quality of Bathymetric Data** feature to specify the maximum depth to which all other attributes for the **Quality of Bathymetric Data** feature applies. When **depth range maximum value** is specified, values populated for all other attributes apply only to depths equal to or shallower than **depth range maximum value**. No quality information is provided for depths deeper than **depth range maximum value**. Where **Quality of Bathymetric Data** features overlap such that varying bathymetric data qualities exist at different depths in the water column, the **depth range maximum value** for a **Quality of Bathymetric Data** must be equal to the **depth range minimum value** for the **Quality of Bathymetric Data** feature defining the quality for the level below (see ~~diagram-Figure 3.2~~ above).
- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area** that contains any depth data or bathymetry (depth contours, obstructions, soundings, underwater rocks, wrecks); and must have mandatory attributes **data assessment** = 1 (assessed) **category of temporal variation** = 6 (unassessed); **features detected** (least depth of detected features measured and significant features detected) = *False*; **full seafloor coverage achieved** = *False*; and **spatial accuracy** sub-attributes **category of zone of confidence in data** = 5 (zone of confidence D) and **vertical uncertainty** (uncertainty fixed) and **horizontal position uncertainty** (uncertainty fixed) = [empty (null)].
- For **Unsurveyed Area** that does not contain any depth data or bathymetry, it is not required to encode a **Quality of Bathymetric Data** feature that covers the area.
- If the attribute **technique of vertical measurement** is required, it must be encoded on either the meta feature **Quality of Survey** (see clause 3.10) or on individual geo features (for example **Sounding**).
- When the **Quality of Bathymetric Data** surface contains data from only one survey, the date of survey must be specified using the complex attribute **survey date range**, sub-attribute **date end**. When the **Quality of Bathymetric Data** surface contains data from two or more surveys, the date of the most recent and the oldest survey must be specified using the complex attribute **survey date range**.
- **Quality of Bathymetric Data** areas must not be encoded over land.
- **spatial accuracy** (**horizontal position uncertainty**) on the **Quality of Bathymetric Data** applies to bathymetric data situated within the surface, while **quality of horizontal measurement** or **horizontal position uncertainty** on the associated spatial types (see clause 24.5) qualifies the location of the **Quality of Bathymetric Data** feature itself.
- Meta features **Quality of Bathymetric Data** and **Quality of Non-Bathymetric Data** may overlap.

- Additional quality information may be given using the meta feature **Quality of Survey**.

3.7.1.1 Temporal variation

The changeability of the bathymetry must be encoded using **category of temporal variation**. In order for a time reference to be given for the expression of temporal variation, the relevant dates of the bathymetric data must be encoded using the complex attribute **survey date range** if **category of temporal variation** is set to 1 (extreme event), 2 (likely to change and significant shoaling expected) or 3 (likely to change but significant shoaling not expected).

3.7.1.2 Feature detection

In the context of bathymetry, a feature is any object, whether manmade or not, projecting above the sea floor, which may be considered to be a danger to surface navigation. Refer to IHO Publication S-44.

The ability to detect bathymetric features must be encoded using the complex attribute **features detected**. The sub-attribute **significant features detected** indicates whether the survey was capable of detecting features of a size indicated by the sub-attribute **size of features detected**. The sub-attribute **least depth of detected features measured** indicates whether the least depth of detected features was found. For instance, if a wreck was found, but it is not certain that the least depth of that wreck was measured, **least depth of detected features measured** must be set to *False*.

3.7.1.3 Sounding uncertainty

Sounding uncertainty is encoded using the **complex attribute spatial accuracy**, sub-complex attribute **vertical uncertainty** on **Quality of Bathymetric Data**. If it is required to encode additional sounding uncertainty information, it must be done using the complex attribute **vertical uncertainty on individual features where available**; or by associating an instance of the information type **Spatial Quality** (see clause 24.5) to the spatial type associated with the on-individual geo features ~~(for example Sounding)~~. Note that this is a mandatory requirement for the features **Sounding** and **Obstruction, Underwater/Awash Rock** and **Wreck** of type point and of depth 30 metres or less.

The vertical and horizontal position uncertainty values populated on **Quality of Bathymetric Data** must reflect the most commonly associated values for the **Obstruction, Sounding, Underwater/Awash Rock** and **Wreck** features within the area.

~~The uncertainty of sounding must not be encoded using **sounding uncertainty** on the depth geo feature, unless it is different from the value of **vertical uncertainty** encoded on **Quality of Bathymetric Data**.~~

Distinction: Quality of Non-Bathymetric Data; Quality of Survey; **Spatial Quality**.

3.7 Quality of bathymetric data (Option 2)

IHO Definition: **QUALITY OF BATHYMETRIC DATA.** An area within which a uniform assessment of the quality of the bathymetric data exists. (S-57 Edition 3.1, Appendix A – Chapter 1, Page 1.216, November 2000).

S-101 Metadata Feature: Quality of Bathymetric Data (M_QUAL)

Primitives: Surface

Real World	Paper Chart Symbol	ECDIS Symbol		
S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
category of temporal variation		1 : extreme event 2 : likely to change and significant shoaling expected 3 : likely to change but significant shoaling not expected 5 : unlikely to change 6 : unassessed	EN	0,1
data assessment		1 : assessed 2 : assessed (oceanic) 3 : unassessed	EN	1,1
depth range maximum value	(DRVAL2)		RE	0,1
depth range minimum value	(DRVAL1)		RE	0,1
features detected			C	1,1
least depth of detected features measured			(S) BO	1,1
significant features detected			(S) BO	1,1
size of features detected			(S) RE	0,1
full seafloor coverage achieved			BO	1,1
horizontal position uncertainty			C	1,1
—uncertainty fixed	(POSACC)		(S) RE	1,1
—uncertainty variable factor			(S) RE	0,1
survey date range			C	1,1
date end	(SUREND)	ISO 8601:2004	(S) TD	1,1
date start	(SURSTA)	ISO 8601:2004	(S) TD	0,1
vertical uncertainty			C	1,1
—uncertainty fixed	(SQUACC)		(S) RE	1,1
—uncertainty variable factor			(S) RE	0,1
zone of confidence				1,*
category of zone of confidence in data	CATZOC	1 : zone of confidence A1 2 : zone of confidence A2 3 : zone of confidence B 4 : zone of confidence C 5 : zone of confidence D 6 : zone of confidence U (data not assessed)	EN	1,1
fixed date range			(S) C	0,1
date end	(DATEND)	ISO 8601: 2004	(S) TD	0,1
date start	(DATSTA)	ISO 8601: 2004	(S) TD	0,1

INT 1 Reference:

3.7.1 Quality, reliability and uncertainty of bathymetric data (see S-4 – B-297)

Information about quality, reliability and uncertainty of bathymetric data is given using:

- the meta feature **Quality of Bathymetric Data** for an assessment of the quality of bathymetric data;
- the meta feature **Quality of Survey** for additional information about individual surveys (see clause 3.10);
- the attributes **quality of vertical measurement** and **technique of vertical measurement** on groups of soundings or individual features;
- the attributes **horizontal position uncertainty**, **quality of horizontal measurement** and **vertical uncertainty** on the spatial types (see clause 2.4.7).

Bathymetric data quality comprises the following:

- completeness of data (for example, seafloor coverage);
- currency of data (for example, temporal degradation);
- uncertainty of data;
- source of data.

All horizontal positional (2D), vertical (1D), horizontal distance (1D) and orientation (1D) uncertainty attributes concern the 95% confidence level of the variation associated with all sources of measurement, processing and visualization error. Uncertainty due to temporal variation should not be included in these attributes.

For the mariner, **Quality of Bathymetric Data** provides the most useful information. Therefore, the use of **Quality of Bathymetric Data** is mandatory for areas containing depth data or bathymetry on ENC datasets at maximum display scale 1:700000 and larger.

More detailed information about a survey may be given using **Quality of Survey** (see clause 3.10). For example, in incompletely surveyed areas, lines of passage soundings may be indicated as such using a curve **Quality of Survey** feature. This information is more difficult for the mariner to interpret, therefore the use of **Quality of Survey** is optional.

For individual features (wrecks, obstructions etc), or small groups of soundings, **quality of vertical measurement**, **technique of vertical measurement**, **horizontal position uncertainty** and **vertical uncertainty** may be used to provide additional information about quality and uncertainty.

The meta feature **Quality of Bathymetric Data** defines areas within which uniform assessment exists for the quality of bathymetric data, and must be used to provide an assessment of the overall quality of bathymetric data to the mariner. Areas of a dataset containing depth data or bathymetry must be covered by one or more **Quality of Bathymetric Data**, which may overlap vertically in order to define the quality of bathymetric data at varying depths in the water column.

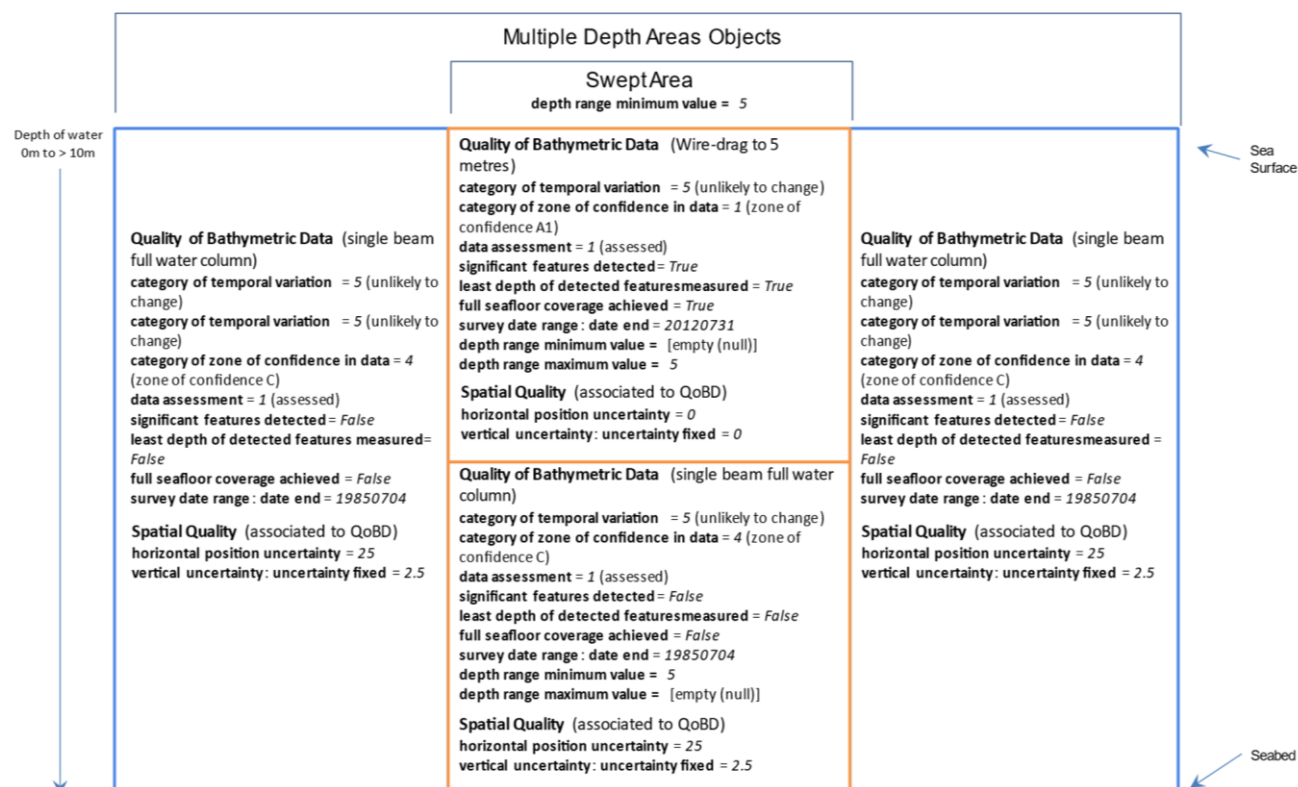


Figure 3.2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a wire swept area to a depth of 5 metres that has also been previously surveyed using single beam echo sounder to the seabed. For the **Quality of Bathymetric Data** and associated **Spatial Quality** feature that defines the data quality for the swept area, it is important to note that the recommended attribution shown below is intended to provide the highest (best) quality indicator for vessels navigating at a safety depth of less than 5 metres in the area.

Remarks:

- In order to encode vertical and horizontal spatial accuracy information, each **Quality of Bathymetric Data** feature must be associated to an instance of the information type **Spatial Quality** (see clause 24.5) using the association **Quality of Bathymetric Data Composition**. The mandatory complex attribute **spatial accuracy** for **Spatial Quality** is used to specify the vertical and horizontal position uncertainty of the depths covered by the surface. Where **category of temporal variation** for **Quality of Bathymetric Data** is set to values 2 (likely to change and significant shoaling expected) or 3 (likely to change but significant shoaling not expected), multiple instances of **spatial accuracy** for **Spatial Quality** should be encoded to provide an indication of the degradation of the vertical and horizontal position accuracy of the charted bathymetric information over time.
 - The sub-complex attribute **fixed date range** is used to define the date range(s) where the spatial accuracy is degraded over time. Where multiple date ranges are specified, the **date start** of an instance must be equal to the **date end** of the previous instance. Within the sequence, the **date start** of the first instance and the **date end** of the last instance should not be populated.
 - The sub-complex attribute **vertical uncertainty** ~~is must be used on a Quality of Bathymetric Data feature~~ to specify the vertical uncertainty of the depths covered by the surface ~~within a specified date range (where encoded)~~. When **depth range minimum value** is specified, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
 - The sub-complex attribute **horizontal position uncertainty** ~~is must be used on a Quality of Bathymetric Data feature~~ to specify the positional uncertainty of the depths covered by the surface ~~within a specified date range (where encoded)~~.
- Wherever possible, meaningful and useful values of the mandatory attribute **zone of confidence (category of zone of confidence in data)** should be used (that is, values other than **category of zone of confidence in data = 6** (zone of confidence U (data not assessed))) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.XX) in accordance with the values populated for the attribute **full seafloor coverage achieved** and the complex attributes **features detected**; and the associated instance of **Spatial Quality** complex attribute **spatial accuracy**.
- Where multiple instances of **spatial accuracy** have been encoded on the associated instance of **Spatial Quality** to indicate degrading quality of bathymetric data over time, corresponding values of the complex attribute **zone of confidence** must also be encoded, having the appropriate values for the sub-attribute **category of zone of confidence in data** and identical corresponding values for the complex attribute **fixed date range**.
- The mandatory attribute **data assessment** provides an overall indicative level of assessment of bathymetric data from which further attribution is derived, and assists with portrayal of bathymetric data quality information in ECDIS:
 - Where the value for **data assessment** is set to 1 (assessed), all additional attribution for the **Quality of Bathymetric Data** feature must be indicative of the quality of bathymetric data for the area.
 - Where the value for **data assessment** is set to 2 (assessed (oceanic)), all additional attribution for the **Quality of Bathymetric Data** feature should be indicative of the quality of bathymetric data for the area for a mariner's ECDIS pick report, however no portrayal of the quality information will display on the ECDIS. This value should only be used to cover open ocean (oceanic) depths in waters deeper than 200 metres.
 - Where the value for **data assessment** is set to 3 (unassessed), the mandatory attributes **category of temporal variation = 6** (unassessed); **features detected (least depth of detected features measured and significant features detected) = False**; **full seafloor coverage achieved = False**; and **zone of confidence (category of zone of confidence in data) = 6** (zone of confidence U (data not assessed)) must be populated. For the associated **Spatial Quality** feature, the attributes **horizontal position uncertainty (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed) = [empty (null)]** must be populated.
- Wherever possible, meaningful and useful values for the attributes **category of temporal variation**, **full seafloor coverage achieved**, and the complex attribute **features detected** must be used for areas of bathymetry. For areas of unstable seafloors, the complex attribute **survey date range (date end)** must be used to indicate the date of the survey of the underlying bathymetric data.
- As a result of some disasters, for example earthquakes, tsunamis, hurricanes, it is possible that large areas of seafloor have moved and/or become cluttered with dangerous obstructions. Emergency surveys may subsequently be conducted over essential shipping routes and inside harbours. Outside these surveys, all existing detail is now suspect, whatever the quality of the previous surveys. In such cases, the attribute **zone of confidence (category of zone of confidence in data)** should be reclassified to 5 (zone of confidence D); the attribute **category of temporal variation** should be reclassified to value 1 (extreme event); the Boolean

attribute **full seafloor coverage achieved** set to *False*; complex attribute **features detected**, Boolean sub-attributes **least depth of detected features measured** and **significant features detected** set to *False*; and the associated **Spatial Quality** sub attributes **horizontal position uncertainty (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** = [empty (null)] in the affected areas outside the area covered by emergency surveys.

- To express completeness of bathymetric data, the complex attribute **features detected** must be encoded. **features detected** indicates that a systematic method of exploring the sea floor, or the water column to the depth indicated by population of the attribute **depth range maximum value**, was undertaken to detect significant features. The sub-attributes **size of features detected** and **least depth of detected features measured** must not be encoded unless the sub-attribute **significant features detected** is set to *True*.
- **depth range minimum value** must only be used on a **Quality of Bathymetric Data** feature where a swept area occupies the entire **Quality of Bathymetric Data** surface, or **Quality of Bathymetric Data** features overlap. Where these features overlap such that varying bathymetric data qualities exist at different depths in the water column, the **depth range minimum value** for a **Quality of Bathymetric Data** must be equal to the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see ~~diagram~~ Figure 3.2 above).
- **depth range maximum value** must only be used on a **Quality of Bathymetric Data** feature to specify the maximum depth to which all other attributes for the **Quality of Bathymetric Data** feature applies. When **depth range maximum value** is specified, values populated for all other attributes apply only to depths equal to or shallower than **depth range maximum value**. No quality information is provided for depths deeper than **depth range maximum value**. Where **Quality of Bathymetric Data** features overlap such that varying bathymetric data qualities exist at different depths in the water column, the **depth range maximum value** for a **Quality of Bathymetric Data** must be equal to the **depth range minimum value** for the **Quality of Bathymetric Data** feature defining the quality for the level below (see ~~diagram~~ Figure 3.2 above).
- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area** that contains any depth data or bathymetry (depth contours, obstructions, soundings, underwater rocks, wrecks); and must have mandatory attributes **data assessment** = 1 (assessed) **category of temporal variation** = 6 (unassessed); **category of zone of confidence in data** = 5 (zone of confidence D); **features detected** (**least depth of detected features measured** and **significant features detected**) = *False*; **full seafloor coverage achieved** = *False*; and **spatial accuracy** sub-complexes **vertical uncertainty (uncertainty fixed)** and **horizontal position uncertainty (uncertainty fixed)** = [empty (null)] for the associated **Spatial Quality** feature.
- For **Unsurveyed Area** that does not contain any depth data or bathymetry, it is not required to encode a **Quality of Bathymetric Data** feature that covers the area.
- If the attribute **technique of vertical measurement** is required, it must be encoded on either the meta feature **Quality of Survey** (see clause 3.10) or on individual geo features (for example **Sounding**).
- When the **Quality of Bathymetric Data** surface contains data from only one survey, the date of survey must be specified using the complex attribute **survey date range**, sub-attribute **date end**. When the **Quality of Bathymetric Data** surface contains data from two or more surveys, the date of the most recent and the oldest survey must be specified using the complex attribute **survey date range**.
- **Quality of Bathymetric Data** areas must not be encoded over land.
- **Spatial Quality (horizontal position uncertainty)** associated to ~~on the~~ **Quality of Bathymetric Data** using the association **Quality of Bathymetric Data Composition** applies to bathymetric data situated within the surface, while **Spatial Quality (quality of horizontal measurement or horizontal position uncertainty)** associated to **Quality of Bathymetric Data** using the association **Spatial Association** ~~on the associated spatial types~~ qualifies the location of the **Quality of Bathymetric Data** feature itself. See clause 24.5.
- Meta features **Quality of Bathymetric Data** and **Quality of Non-Bathymetric Data** may overlap.
- Additional quality information may be given using the meta feature **Quality of Survey**.

3.7.1.1 Temporal variation

The changeability of the bathymetry must be encoded using **category of temporal variation**. In order for a time reference to be given for the expression of temporal variation, the relevant dates of the bathymetric data must be encoded using the complex attribute **survey date range** if **category of temporal variation** is set to 1 (extreme event), 2 (likely to change and significant shoaling expected) or 3 (likely to change but significant shoaling not expected).

3.7.1.2 Feature detection

In the context of bathymetry, a feature is any object, whether manmade or not, projecting above the sea floor, which may be considered to be a danger to surface navigation. Refer to IHO Publication S-44.

The ability to detect bathymetric features must be encoded using the complex attribute **features detected**. The sub-attribute **significant features detected** indicates whether the survey was capable of detecting features of a size indicated by the sub-attribute **size of features detected**. The sub-attribute **least depth of detected features measured** indicates whether the least depth of detected features was found. For instance, if a wreck was found, but it is not certain that the least depth of that wreck was measured, **least depth of detected features measured** must be set to *False*.

3.7.1.3 Sounding uncertainty

Sounding uncertainty is encoded using the complex attribute **spatial accuracy**, sub-complex attribute **vertical uncertainty** on the associated instance of **Spatial Quality** for **Quality of Bathymetric Data**. If it is required to encode additional sounding uncertainty information, it must be done using the complex attribute **vertical uncertainty** on individual features where available; or by associating an instance of the information type **Spatial Quality** (see clause 24.5) to the spatial type associated with the ~~on~~ individual geo features ~~(for example Sounding)~~. Note that this is a mandatory requirement for the features **Sounding** and **Obstruction**, **Underwater/Awash Rock** and **Wreck** of type point of depth 30 metres or less.

The vertical and horizontal position uncertainty values associated with **Quality of Bathymetric Data** must reflect the most commonly associated values for the **Obstruction**, **Sounding**, **Underwater/Awash Rock** and **Wreck** features within the area.

~~The uncertainty of sounding must not be encoded using **sounding uncertainty** on the depth geo feature, unless it is different from the value of **vertical uncertainty** encoded on **Quality of Bathymetric Data**.~~

Distinction: Quality of Non-Bathymetric Data; Quality of Survey; **Spatial Quality**.

Feature/Information associations

Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Asso	Quality of Bathymetric Data Composition	Quality of Bathymetric Data	Defines	1,1	Spatial Quality	Defined for	1,1

24.5 Spatial Quality (Option 2)

<u>IHO Definition:</u> SPATIAL QUALITY . The indication of the quality of the locational information for features in a dataset.				
S-101 Information Type: Spatial Quality				
Primitives: None				
<i>Real World</i>	<i>Paper Chart Symbol</i>		<i>ECDIS Symbol</i>	
S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
horizontal position uncertainty			C	0,1
— uncertainty fixed	(POSACC)		(S) RE	1,1
— uncertainty variable factor			(S) RE	0,1
quality of horizontal measurement	(QUAPOS)	1 : surveyed 2 : unsurveyed 3 : inadequately surveyed 4 : approximate 5 : position doubtful 6 : unreliable 9 : estimated 10 : precisely known 11 : calculated	EN	0,1
spatial accuracy			C	1,*
fixed date range			(S) C	0,1
date end	(DATEND)	ISO 8601: 2004	(S) TD	0,1
date start	(DATSTA)	ISO 8601: 2004	(S) TD	0,1
horizontal position uncertainty			(S) C	0,1
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
vertical uncertainty			C	0,1
uncertainty fixed	(SOUACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
vertical uncertainty			C	0,1
— uncertainty fixed	(VERACC)		(S) RE	1,1
— uncertainty variable factor			(S) RE	0,1
<p><u>INT 1 Reference:</u></p> <p>24.5.1 Spatial quality</p> <p>Spatial attribute types must contain a referenced geometry and may be associated with spatial quality attributes. Each spatial attribute instance must be referenced by a feature instance or another spatial attribute instance.</p> <p>Spatial quality attributes are carried in the information type Spatial Quality. Only points, multipoints and curves geometry and the meta feature Quality of Bathymetric Data can be associated with spatial quality. Currently no use case for associating surfaces geometry with spatial quality attributes is known, therefore this is prohibited. Vertical uncertainty is prohibited for curves as this dimension is not supported by curves.</p> <p>Each instance of Spatial Quality must be associated to the geometry to which the information applies using the association Spatial Association (see clause 25.13).</p> <p><u>Remarks:</u></p> <ul style="list-style-type: none"> The mandatory complex attribute spatial accuracy is used to specify the vertical and horizontal position uncertainty, which may degrade in changeable areas over time. In order to provide the spatial accuracy components for provision of an overall indication of the quality of bathymetric data for an area, an instance 				

of **Spatial Quality** must be associated with each instance of the meta feature **Quality of Bathymetric Data** using the association **Quality of Bathymetric Data Composition** (see clauses 3.7 and 25.XX). Where the attribute **category of temporal variation** for **Quality of Bathymetric Data** is set to values 2 (likely to change and significant shoaling expected) or 3 (likely to change but significant shoaling not expected), multiple instances of **spatial accuracy** should be encoded to provide an indication of the degradation of the vertical and horizontal position accuracy of the charted bathymetric information over time.

- The sub-complex attribute **fixed date range** is used to define the date range(s) where the spatial accuracy is degraded over time. Where multiple date ranges are specified, the **date start** of an instance must be equal to the **date end** of the previous instance. Within the sequence, the **date start** of the first instance and the **date end** of the last instance should not be populated.
- The sub-complex attribute **vertical uncertainty** is used to specify the vertical uncertainty of the depths covered by the surface within a specified date range (where encoded). When **depth range minimum value** is specified, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
- The sub-complex attribute **horizontal position uncertainty** is used to specify the positional uncertainty of the depths covered by the surface within a specified date range (where encoded).
- For the geometry associated with all **Sounding** features and **Obstruction**, **Underwater/Awash Rock** and **Wreck** features of type point and of depth 30 metres or less, it is mandatory to associate an instance of **Spatial Quality** using the association **Spatial Association**.

Distinction: Quality of Bathymetric Data; Quality of Non-Bathymetric Data; Quality of Survey.

Feature/Information associations

Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Asso	Quality of Bathymetric Data Composition	Spatial Quality	Defined for	1,1	Quality of Bathymetric Data	Defines	1,1
Asso	Spatial Association	Spatial Quality	Defined for	1,1	Spatial Types	Defines	0,*

11.3 Sounding

IHO Definition: **SOUNDING**. Measured or charted depth of water (may be a drying height), or the measurement of such a depth, which has been reduced to a vertical datum. (Adapted from IHO Dictionary – S-32).

S-101 Geo Feature: Sounding (SOUNDG)

Primitives: Pointset

Real World

Paper Chart Symbol

ECDIS Symbol

S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
display uncertainties			BO	0,1
feature name			C	0,*
display name			(S) BO	0,1
language		ISO 639-2/T	(S) TE	0,1
name	(OBJNAM) (NOBJNM)		(S) TE	1,1
quality of vertical measurement	(QUASOU)	1 : depth known 3 : doubtful sounding 4 : unreliable sounding 8 : value reported (not surveyed) 9 : value reported (not confirmed)	EN	0,*
reported date	(SORDAT)	ISO 8601: 2004	TD	0,1
status	(STATUS)	18 : existence doubtful	EN	0,1
technique of vertical measurement	(TECSOU)	1 : found by echo sounder 2 : found by side scan sonar 3 : found by multi beam 4 : found by diver 5 : found by lead line 6 : swept by wire-drag 8 : swept by vertical acoustic system 9 : found by electromagnetic sensor 10 : photogrammetry 11 : satellite imagery 12 : found by levelling 13 : swept by side scan sonar 15 : found by LIDAR 16 : synthetic aperture radar 17 : hyperspectral imagery	EN	0,*
vertical uncertainty			€	0,1
—uncertainty fixed	(SQUACC)		(S)-RE	1,1
—uncertainty variable factor			(S)-RE	0,1
scale minimum	(SCAMIN)	See clause 2.5.9	IN	0,1

INT 1 Reference: I 10, 14, 15

11.3.1 Soundings (see S-4 – B-412 and B-413.1)

A sounding associated with a rock or coral pinnacle which is an obstruction to navigation must be encoded using the feature **Underwater/Awash Rock** (INT1 – K14, see clause 13.4) with attribute **value of sounding** populated with the value of the sounding.

The geometry of soundings and no bottom found depths (see clause 11.8) is held in a 3 dimensional array (latitude, longitude, depth). In the interests of efficiency, multiple soundings should be encoded in one spatial type, provided that all the spatial and geo feature attributes are common to the group.

As the sounding multiplication factor (CMFZ) for ENC is 100, soundings may be encoded to two decimal places of a metre. Drying soundings must be indicated by a negative value.

For soundings surrounded by a danger line, see clauses 13.1 and 13.2.

Population of the attributes **quality of vertical measurement**, **source date** and the spatial attribute **quality of horizontal measurement** are described in the Table below:

Sounding	S-4	INT 1	quality of horizontal measurement	quality of vertical measurement	Remarks
In true position	B-412.1	I10		1or <undefined>	May be encoded using quality of horizontal measurement = 10
Out of position on paper chart	B-412.2	I11 I12		1or <undefined>	Spatial type must be encoded at the true position. There is no "sounding, out of position" in an ENC.
Lower reliability	B-412.4	I14	4	4	
Drying	B-413	I15		1or <undefined>	Negative value
Doubtful	B-424.4	I2		3	Existence doubtful should be encoded using status = 18
Reported but not confirmed		I3 I4	8	9	If available, the year of report must be encoded using the attribute reported date

Table 11.1 - Soundings - Attribute encoding

Remarks:

- Encoders are advised to use caution when considering encoding soundings that are shoaler than the range of depth of the surrounding depth area, as **Sounding** features will not be displayed when utilising some ECDIS display settings. Where it is considered that a sounding that is shoaler than the range of depth of the surrounding depth area may be a hazard to navigation, encoders should preferably conduct further investigation of source material in order to encode additional depth contour and depth area information more relevant to the sounding. Alternatively, encoders may consider using an alternate feature (for example **Obstruction**) to encode the depth.
- The attribute **technique of vertical measurement** must only be populated for **Sounding** features if it is different from the value of **technique of vertical measurement** encoded on an overlapping **Quality of Survey** feature (see clause 3.10); and the information is considered to be important to navigation.
- Where **Sounding** features are covered by the meta feature **Quality of Survey**, the attribute **quality of vertical measurement** must not be populated unless different from the value of **quality of vertical measurement** populated for the **Quality of Survey**.
- For all **Sounding** features of depth 30 metres or less, an instance of the information type **Spatial Quality** (see clause 25.4) must be associated to the associated geometry, using the association **Spatial Association**. See also clause 3.7.1.3 (**Quality of Bathymetric Data**).
- The attribute **display uncertainties** is a cartographic attribute intended to reduce screen clutter in some ECDIS display settings by limiting the display of the horizontal position accuracies of a sounding to those considered by the encoder to be important to the mariner, and is mandatory for all **Sounding** of depth 30 metres or less. Factors to be considered in populating this attribute include depth in relation to the general nature of the seabed, proximity to other dangers, intention of the ENC, proximity to routes taken by vessels, and the types of vessels intended to utilise the ENC.
- For depths indicated as no bottom found, see clause 11.8.

Distinction: Depth Area; Depth – No Bottom Found; Obstruction; Underwater/Awash Rock; Wreck.

<u>Feature/Information associations</u>							
Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Asso	Additional Information	Sounding	Provides information	0,*	Nautical Information	Information provided for	0,1
Comp	Text Association	Sounding	Positions	0,1	Text Placement	Identifies	0,1
Asso	Updated Information	Sounding	Updates	0,*	Update Information	Identifies	0,1
Asso	Spatial Association	Spatial type	Defines	1,*	Spatial Quality	Defined for	1,1

13.4 Rocks (intertidal/awash/submerged)

IHO Definition: **UNDERWATER/AWASH ROCK.** A concreted mass of stony material or coral which dries, is awash or is below the water surface. (S-57 Edition 3.1, Appendix A – Chapter 1, Page 1.194, November 2000).

S-101 Geo Feature: Underwater/Awash Rock (UWTROC)

Primitives: Point

<i>Real World</i>	<i>Paper Chart Symbol</i>	<i>ECDIS Symbol</i>		
S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
display uncertainties			BO	0,1
exposition of sounding	(EXPSOU)	1 : within the range of depth of the surrounding depth area 2 : shoaler than the range of depth of the surrounding depth area	EN	0,1
feature name			C	0,*
display name			(S) BO	0,1
language		ISO 639-2/T	(S) TE	0,1
name	(OBJNAM) (NOBJNM)		(S) TE	1,1
nature of surface	(NATSUR)	14 : coral	EN	0,1
quality of vertical measurement	(QUASOU)	1 : depth known 2 : depth or least depth unknown 3 : doubtful sounding 4 : unreliable sounding 6 : least depth known 7 : least depth unknown, safe clearance at value shown 8 : value reported (not surveyed) 9 : value reported (not confirmed)	EN	0,*
reported date	(SORDAT)	ISO 8601: 2004	TD	0,1
status	(STATUS)	18 : existence doubtful	EN	0,1
technique of vertical measurement	(TECSOU)	1 : found by echo sounder 2 : found by side scan sonar 3 : found by multi beam 4 : found by diver 5 : found by lead line 6 : swept by wire-drag 8 : swept by vertical acoustic system 9 : found by electromagnetic sensor 10 : photogrammetry 11 : satellite imagery 12 : found by leveling 13 : swept by side scan sonar 15 : found by LIDAR 16 : synthetic aperture radar 17 : hyperspectral imagery	EN	0,*
value of sounding	(VALSOU)		RE	1,1

vertical uncertainty			C	0,1
—uncertainty fixed	(SQUACC)		(S)RE	1,1
—uncertainty variable factor			(S)RE	0,1
water level effect	(WATLEV)	3 : always under water/ submerged 4 : covers and uncovers 5 : awash	EN	1,1
scale minimum	(SCAMIN)	See clause 2.5.9	IN	0,1
default clearance depth			RE	0,1
surrounding depth			RE	0,1

INT 1 Reference: K 11-15

13.4.1 Rocks which may cover (see S-4 – B-421.2 to B-421.4)

Full details of all dangers to navigation must be encoded except in those areas for which the ENC is clearly inappropriate for navigation (see S-4 – B-401 and B-402). The fullest possible information on clearance depths must be given irrespective of their depths, where known, in preference to making any arbitrary distinction between “dangerous” and “non-dangerous” depths. This will allow navigators of all classes of vessels, including deep-draught ships and submarines, to make their own assessments of what is dangerous to them.

Underwater rocks may cover and uncover, may be awash, or may be always underwater.

Population of the attributes **quality of vertical measurement**, **water level effect**, **reported date** and the spatial attribute **quality of horizontal measurement** are described in the Table below:

Rock or coral reef	INT 1	water level effect	quality of vertical measurement	Comment
Covers and uncovers, depth unknown	K11	4	2 or <undefined>	See Remarks below for population of the attribute exposition of sounding .
Covers and uncovers, depth known	K11	4	any value except 2; or <undefined>	Negative value for value of sounding
Awash	K12	5		
Always submerged, depth unknown	K13	3	2 or <undefined>	See Remarks below for population of the attribute exposition of sounding .
Always submerged, depth known	K14	3	any value except 2; or <undefined>	
Reported, not confirmed	I3.1,3.2	3,4 or 5	9	If available, the year reported should be encoded in reported date . The attribute quality of horizontal measurement should be set to 8 (reported (not confirmed)).

Table 13.2 - Underwater rocks - Attribute encoding

Remarks:

- For rocks which do not cover (islets), see clause 5.4.2.
- All **Underwater/Awash Rock** features should be encoded using one of the above combinations of attributes.
- For ~~guidance regarding the population of the complex attribute vertical uncertainty~~, all **Underwater/Awash Rock** features of depth 30 metres or less an instance of the information type **Spatial Quality** (see clause 25.4) must be associated to the associated point geometry, using the association **Spatial Association**. Where **value of sounding** is populated with an empty (null) value, the value for the attribute **vertical uncertainty (uncertainty fixed)** on the associated **Spatial Quality** feature must also be populated as empty (null). See also clause 3.7.1.3 (**Quality of Bathymetric Data**).
- The attribute **display uncertainties** is a cartographic attribute intended to reduce screen clutter in some ECDIS display settings by limiting the display of the horizontal position accuracies of a sounding to those considered by the encoder to be important to the mariner, and is mandatory for all **Underwater/Awash Rock** of depth 30 metres or less. Factors to be considered in populating this attribute include depth in relation to

the general nature of the seabed, proximity to other dangers, intention of the ENC, proximity to routes taken by vessels, and the types of vessels intended to utilise the ENC.

- A rock represented on paper charts by a spot sounding and an associated nature of seabed (underwater rock not dangerous to surface navigation) should be encoded using a single **Underwater/Awash Rock** feature, with the sounding value encoded using the attribute **value of sounding**. Where **Underwater/Awash Rock** is encoded, there must be no **Sounding** feature encoded coincident.
- For area rock and coral reef features, see clause 12.1.1.
- When a group of rocks is surrounded by a danger line, each rock should be encoded as a separate **Underwater/Awash Rock** feature covered by an obstruction area feature (**Obstruction** – see clause 13.6).
- If it is required to encode an **Underwater/Awash Rock** feature where the attribute **value of sounding** is populated with an empty (null) value, but the source information indicates the depth of the feature is within the range of the surrounding depth area, the value **exposition of sounding** = 1 (within the range of the surrounding depth area) must be populated in order to avoid the unnecessary display of isolated danger symbols in ECDIS.

Distinction: Obstruction; Seabed Area; Sounding; Wreck.

Feature/Information associations

Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Asso	Additional Information	Underwater/Awash Rock	Provides information	0,*	Nautical Information	Information provided for	0,1
Comp	Text Association	Underwater/Awash Rock	Positions	0,1	Text Placement	Identifies	0,1
Asso	Updated Information	Underwater/Awash Rock	Updates	0,*	Update Information	Identifies	0,1
Asso	Spatial Association	Spatial type	Defines	1,*	Spatial Quality	Defined for	1,1

13.5 Wrecks

IHO Definition: **WRECK.** The ruined remains of a stranded or sunken vessel which has been rendered useless. (IHO Dictionary – S-32).

S-101 Geo Feature: Wreck (WRECKS)

Primitives: Point, Surface

Real World		Paper Chart Symbol		ECDIS Symbol	
S-101 Attribute		S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
category of wreck		(CATWRK)	1 : non-dangerous wreck 2 : dangerous wreck 3 : distributed remains of wreck 4 : wreck showing mast/masts 5 : wreck showing any portion of hull or superstructure	EN	0,1
display uncertainties				BO	0,1
exposition of sounding		(EXPSOU)	1 : within the range of depth of the surrounding depth area 2 : shoaler than the range of depth of the surrounding depth area 3 : deeper than the range of depth of the surrounding depth area	EN	0,1
feature name				C	0,*
display name				(S) BO	0,1
language			ISO 639-2/T	(S) TE	0,1
name		(OBJNAM) (NOBJNM)		(S) TE	1,1
height		(HEIGHT)		RE	0,1
quality of vertical measurement		(QUASOU)	1 : depth known 2 : depth or least depth unknown 3 : doubtful sounding 4 : unreliable sounding 6 : least depth known 7 : least depth unknown, safe clearance at value shown 8 : value reported (not surveyed) 9 : value reported (not confirmed)	EN	0,*
radar conspicuous		(CONRAD)		BO	0,1
reported date		(SORDAT)	ISO 8601: 2004	TD	0,1
status		(STATUS)	7 : temporary 13 : historic 18 : existence doubtful	EN	0,*
technique of vertical measurement		(TECSOU)	1 : found by echo sounder 2 : found by side scan sonar 3 : found by multi beam 4 : found by diver 5 : found by lead line	EN	0,*

		6 : swept by wire-drag 8 : swept by vertical acoustic system 9 : found by electromagnetic sensor 10 : photogrammetry 11 : satellite imagery 12 : found by levelling 13 : swept by side scan sonar 15 : found by LIDAR 16 : synthetic aperture radar 17 : hyperspectral imagery		
value of sounding	(VALSOU)		RE	0,1
vertical uncertainty			C	0,1
—uncertainty fixed	(SQUACC)		(S)-RE	1,1
—uncertainty variable factor			(S)-RE	0,1
visual prominence	(CONVIS)	1 : visually conspicuous 2 : not visually conspicuous 3 : prominent	EN	0,1
water level effect	(WATLEV)	1 : partly submerged at high water 2 : always dry 3 : always under water/ submerged 4 : covers and uncovers 5 : awash	EN	1,1
scale minimum	(SCAMIN)	See clause 2.5.9	IN	0,1
default clearance depth			RE	0,1
surrounding depth			RE	0,1

INT 1 Reference: K 20-31

13.5.1 Wrecks (see S-4 – B-422, B-422.1 to B-422.8)

Wrecks must be encoded to whatever depth they are considered to be of interest, also taking account of the needs of submarines and fishing vessels where appropriate, but not generally in water deeper than 2000m. (Trawling regularly takes place in depths of 400m and occasionally in depths as great as 2000m).

Population of the attributes **category of wreck**, **quality of vertical measurement**, **technique of vertical measurement** and **water level effect** are described in Table 13.3 below.

In the following Table, the symbol '/' indicates that this attribute is not relevant for the wreck instance and therefore must not be encoded. A blank indicates that the encoder may choose a relevant value for the attribute.

Wrecks...	S-4	INT 1	category of wreck	water level effect	quality of vertical measurement	technique of vertical measurement
Showing any part of hull or superstructure (visible at high water)	B-422.2	K24 K20	5	1 or 2	/	/
Showing any part of hull or superstructure (visible at low water)	B-422.2	K24 K21	5	4		
Covers and uncovers	B-422.2	K24 K21	4 or 5	4		
Awash				5		
Only the mast is visible at high water	B-422.2	K25	4 or 5	1	/	/
Only the mast is visible at low water	B-422.2	K25	4	4		
Measured depth	B-422.4	K26		3	1, 6 or <undefined>	
Depth measured and swept by wire drag	B-422.3	K27		3	6	6
Depth measured by diver	B-422.3	K27		3	1 or 6	4

Depth unknown, considered dangerous by the responsible producing authority	B-422.6	K28	2	3	2* or <undefined>	/
Depth unknown, not considered dangerous by the responsible producing authority	B-422.6	K29	1	3	2* or <undefined>	/
Depth unknown, with a safe clearance	B-422.5	K30		3	7	/
Distributed remains of wreck	B-422.8	K31	3			
Reported, not confirmed	B-424.5	I3.1 I3.2			9	

Table 13.3 - Wrecks - Attribute encoding

All wrecks should be encoded using one of the above combinations of attributes.

* For a wreck where the least depth is unknown, the attribute value 2 (depth or least depth unknown) for **quality of vertical measurement** does not apply to the depth of the seabed near the wreck.

The provision of more quantitative information for wrecks where possible is particularly important in terms of the portrayal of wrecks in ECDIS, as the classification of wrecks as “dangerous” or “non-dangerous” is not taken into account in ECDIS when symbolizing **Wreck** features outside **Unsurveyed Area**. This often results in wrecks located in **Depth Area** or **Dredged Area** being symbolized as an obstruction to navigation where they are actually non-dangerous. Where the depth of the wreck is unknown, compilers should consider determining an estimated safe clearance value (see S-4 – B-422.5) and populating **quality of vertical measurement** = 7 (least depth unknown, safe clearance at value shown).

Remarks:

- At least one of the attributes **category of wreck** or **value of sounding** must be populated.
- The attribute **height** is only relevant for wrecks having attribute **water level effect** = 1 (partly submerged at high water) or 2 (always dry).
- For ~~guidance regarding the population of the complex attribute vertical uncertainty~~, all **Wreck** features of type point and of depth 30 metres or less, an instance of the information type **Spatial Quality** (see clause 25.4) must be associated to the associated point geometry, using the association **Spatial Association**. Where **height** (when **water level effect** = 1 (partly submerged at high water) or 2 (always dry)) or **value of sounding** is populated with an empty (null) value, the value for the complex attribute **vertical uncertainty (uncertainty fixed)** on the associated **Spatial Quality** feature must also be populated as empty (null). See also clause 3.7.1.3 (**Quality of Bathymetric Data**).
- The attribute **display uncertainties** is a cartographic attribute intended to reduce screen clutter in some ECDIS display settings by limiting the display of the horizontal position accuracies of a sounding to those considered by the encoder to be important to the mariner, and is mandatory for all **Wreck** of depth 30 metres or less. Factors to be considered in populating this attribute include depth in relation to the general nature of the seabed, proximity to other dangers, intention of the ENC, proximity to routes taken by vessels, and the types of vessels intended to utilise the ENC. For **Wreck** of type surface, **display uncertainties** must be set to “no”.
- For reported, not confirmed wrecks, the date of the report must be populated, where known, using the attribute **reported date**.
- The distributed remains of a wreck must be encoded, where required, as a **Wreck** feature with attribute **category of wreck** = 3 (distributed remains of wreck). Even though the wreck may be safe for surface vessels to navigate over the wreck, it must not be encoded as foul ground (see clause 13.7).
- When encoding a **Wreck** feature, the attributes populated should adhere to the guidance in S-4 clause B-422. Where possible, this includes the population of the attributes **value of sounding** and **quality of vertical measurement** where the depth of a wreck is known, or the depth is unknown but an estimated safe clearance can be determined. Where the depth is known, or the depth is unknown but an estimated safe clearance has been determined, it is not required to populate the attribute **category of wreck** = 1 (non-dangerous wreck) or 2 (dangerous wreck), as the mariner has the quantitative information in order to determine whether the wreck may be dangerous to their type of vessel.
- If it is required to encode a **Wreck** feature where the attribute **value of sounding** is not populated or is populated with an empty (null) value, but the source information indicates the depth of the feature is within the range of the surrounding depth area, the value **exposition of sounding** = 1 (within the range of the surrounding depth area) must be populated in order to avoid the unnecessary display of isolated danger symbols in ECDIS.
- For wrecks visible or partly visible at sounding datum, the height or drying height should be encoded, if known. This helps to distinguish wrecks which are always visible from wrecks which are only visible at low tide.

13.5.1.1 Where a wreck is shown with its true shape (large scale ENC's) (see S-4 – B-422.1)

Soundings and heights are often given inside a wreck to show the highest points of the hull or superstructure (for example mast, funnel). If it is required to encode such features, they must be done using:

- A **Wreck** feature of type surface with all populated attributes applying to the highest point of the wreck.
- **Land Elevation** features of type point to encode the features of the wreck that are always dry; the type of each feature (for example mast, funnel) may be encoded using an associated instance of the information type **Nautical Information** (see clause 24.4), complex attribute **information**.
- **Sounding** features to encode the features of wrecks which are always submerged, or cover and uncover; the type of each feature (for example mast, funnel) may be encoded using an associated instance of the information type **Nautical Information** (see clause 24.4), complex attribute **information**, which means that these soundings must be encoded individually.

13.5.1.2 Changing criteria for wrecks

Historically the criteria used for differentiating between “dangerous” and “non-dangerous” wrecks were often based on a threshold value for the estimated depth over the wreck (for example 20m, 28m). Criteria have varied between nations and over time (due to the increasing draught of large vessels). The term “non-dangerous wreck” may be applied even though a wreck may be dangerous to some vessels capable of navigating in the vicinity. Unfortunately, the mariner is not necessarily aware of that fact or that, due to the changing criteria, wrecks encoded as “non-dangerous” may have different meanings. Ideally, therefore, all encoded “dangerous” and “non-dangerous” wrecks having no known depth should be re-assessed to conform to the guidance provided in S-4 – B-422.

13.5.2 Historic wrecks (see S-4 – B-422)

Many nations have designated areas around certain wrecks of historical or cultural (for example sea graves) importance to protect the wrecks from unauthorised interference (for example by diving, salvage or anchoring). Such areas should be encoded on the largest maximum display scale ENC data covering the wreck.

If it is required to encode a restricted area around a historic wreck, it must be done using a **Restricted Area Navigational** feature (see clause 17.8) or **Restricted Area Regulatory** feature (see clause 17.9), with attribute **category of restricted area** = 10 (historic wreck area).

In addition, the wreck itself should be encoded as a **Wreck** feature, with attribute **status** = 13 (historic).

Distinction: Depth Area; Hulk; Obstruction; Sounding; Underwater/Awash Rock.

Feature/Information associations

Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Asso	Additional Information	Wreck	Provides information	0,*	Nautical Information	Information provided for	0,1
Comp	Text Association	Wreck	Positions	0,1	Text Placement	Identifies	0,1
Asso	Updated Information	Wreck	Updates	0,*	Update Information	Identifies	0,1
Asso	Spatial Association	Spatial type	Defines	0,*	Spatial Quality	Defined for	0,1

13.6 Obstructions

IHO Definition: **OBSTRUCTION.** In marine navigation, anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel. The term is usually used to refer to an isolated danger to navigation, such as a sunken rock or pinnacle. (IHO Dictionary – S-32).

S-101 Geo Feature: Obstruction (OBSTRN)

Primitives: Point, Curve, Surface

<i>Real World</i>	<i>Paper Chart Symbol</i>	<i>ECDIS Symbol</i>		
S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
category of obstruction	(CATOBS)	1 : snag/stump 2 : wellhead 3 : diffuser 4 : crib 5 : fish haven 6 : foul area 8 : ice boom 9 : ground tackle 10 : boom 12 : wave energy device 13 : subsurface ocean data acquisition system (ODAS) 14 : artificial reef 15 : template 16 : manifold 17 : submerged pingo 18 : remains of platform 19 : scientific instrument 20 : underwater turbine 21 : active submarine volcano	EN	0,1
condition	(COND TN)	1 : under construction 2 : ruined 5 : planned construction	EN	0,1
display uncertainties			BO	0,1
exposition of sounding	(EXPSOU)	1 : within the range of depth of the surrounding depth area 2 : shoaler than the range of depth of the surrounding depth area 3 : deeper than the range of depth of the surrounding depth area	EN	0,1
feature name			C	0,*
display name			(S) BO	0,1
language		ISO 639-2/T	(S) TE	0,1
name	(OBJNAM) (NOBJNM)		(S) TE	1,1
height	(HEIGHT)		RE	0,1
maximum permitted draught			RE	0,1
nature of surface	(NATSUR)	1 : mud 2 : clay 3 : silt 4 : sand 5 : stone 6 : gravel	EN	0,*

		7 : pebbles 8 : cobbles 9 : rock 11 : lava 14 : coral 17 : shells 18 : boulder		
product	(PRODCT)	1 : oil 2 : gas 3 : water 8 : drinking water 23 : electricity	EN	0,*
quality of vertical measurement	(QUASOU)	1 : depth known 2 : depth or least depth unknown 3 : doubtful sounding 4 : unreliable sounding 6 : least depth known 7 : least depth unknown, safe clearance at value shown 8 : value reported (not surveyed) 9 : value reported (not confirmed)	EN	0,*
reported date	(SORDAT)	ISO 8601: 2004	TD	0,1
status	(STATUS)	1 : permanent 4 : not in use 5 : periodic/intermittent 7 : temporary 8 : private 13 : historic 18 : existence doubtful 28 : buoyed	EN	0,*
technique of vertical measurement	(TECSOU)	1 : found by echo sounder 2 : found by side scan sonar 3 : found by multi beam 4 : found by diver 5 : found by lead line 6 : swept by wire-drag 8 : swept by vertical acoustic system 9 : found by electromagnetic sensor 10 : photogrammetry 11 : satellite imagery 12 : found by levelling 13 : swept by side scan sonar 15 : found by LIDAR 16 : synthetic aperture radar 17 : hyperspectral imagery	EN	0,*
value of sounding	(VALSOU)		RE	0,1
vertical length	(VERLEN)		RE	0,1
vertical uncertainty			G	0,1
—uncertainty fixed	(SQUACC)		(S)-RE	1,1
—uncertainty variable factor			(S)-RE	0,1
water level effect	(WATLEV)	1 : partly submerged at high water 2 : always dry 3 : always under water/ submerged 4 : covers and uncovers 5 : awash 7 : floating	EN	1,1
scale minimum	(SCAMIN)	See clause 2.5.9	IN	0,1

default clearance depth			RE	0,1
surrounding depth			RE	0,1

INT 1 Reference: K 1, 31, 40-43, 46; L 21, 23; Q 42

13.6.1 Obstructions and foul areas (see S-4 – B-327.5, B-420.1, B-422.8-9, B-431.6, B-445.1, B-447.5 and B-447.7)

If it is required to encode snags, stumps, wellheads, diffusers, cribs, fish havens, foul areas, booms, ice booms, sites of cleared platforms, ground tackle, wave energy devices, underwater turbines, subsurface ocean data acquisition systems, or artificial reefs, it must be done using the feature **Obstruction**.

Population of the attributes **quality of vertical measurement**, **technique of vertical measurement** and **water level effect** are described in Table 13.4 below.

In the following Table, the symbol ‘/’ indicates that this attribute is not relevant for the obstruction instance and therefore must not be encoded. A blank indicates that the encoder may choose a relevant value for the attribute.

Obstruction...	INT 1	water level effect	quality of vertical measurement	technique of vertical measurement
Depth unknown	K40	3 or 4	2* or <undefined>	/
Least depth known	K41	3 or 4	1 or 6	
Swept by wire to the depth shown	K42	3	6	6
Measured by diver	K42	3	1 or 6	4

Table 13.4 - Obstructions - Attribute encoding

All obstructions should be encoded using one of the above combinations of attributes.

* For an obstruction where the least depth is unknown, the attribute value 2 (depth or least depth unknown) for **quality of vertical measurement** does not apply to the depth of the seabed near the obstruction.

It is important when encoding obstructions to be aware of the distinction between attribute value **category of obstruction** = 6 (foul area) and foul ground:

Foul areas are defined as areas of numerous uncharted dangers to navigation. When encoded on ENC, **Obstruction** features of type surface with attribute **category of obstruction** = 6 (foul area) will display in the ECDIS “base display” as an obstruction to navigation, with all associated alarms to indicate that it is unsafe for vessels to enter or transit the area.

Foul ground is defined as an area over which it is safe to navigate but which should be avoided for anchoring, taking the ground or ground fishing. When encoded on ENC, **Foul Ground** features (see clause 13.7) of type surface will display in the ECDIS “other” display as a “foul area of seabed safe for navigation but not for anchoring”, indicating to the mariner that it is safe to enter or transit the area but hazardous to take the ground or undertake other subsurface activities.

In some cases areas on the source indicated to be foul ground have been misinterpreted as foul areas, which has resulted in encoding in ENC of **Obstruction** with **category of obstruction** = 6 (foul area). This encoding results in the incorrect indication in the ECDIS that the area is unsafe for navigation, which is potentially confusing to the mariner.

Foul ground, over which it is safe to navigate but which should be avoided for anchoring, taking the ground or ground fishing, should be encoded using a **Foul Ground** feature. Although the source may depict a “Foul Area”, it should be determined whether it is in fact “Foul Ground” before encoding the appropriate feature.

Remarks:

- At least one of the attributes **height** or **value of sounding** must be populated.
- The minimum depth, if known, over any obstruction, must be encoded using the attribute **value of sounding**. Where obstructions such as fish havens have a declared maximum authorised draught for vessels passing over the feature, this must be populated, where known, using the attribute **maximum permitted draught**.
- The attribute **height** must be populated for **Obstruction** features having attribute **water level effect** = 1 (partly submerged at high water) or 2 (always dry).
- The attribute **vertical length** is used to populate the distance of the obstruction above the seabed.

- For ~~guidance regarding the population of the complex attribute vertical uncertainty~~, all **Obstruction** features of type point and of depth 30 metres or less, an instance of the information type **Spatial Quality** (see clause 25.4) must be associated to the associated point geometry, using the association **Spatial Association**. Where **height** or **value of sounding** is populated with an empty (null) value, the value for the attribute **vertical uncertainty (uncertainty fixed)** on the associated **Spatial Quality** feature must also be populated as empty (null). See also clause 3.7.1.3 (**Quality of Bathymetric Data**).
- The attribute **display uncertainties** is a cartographic attribute intended to reduce screen clutter in some ECDIS display settings by limiting the display of the horizontal position accuracies of a sounding to those considered by the encoder to be important to the mariner, and is mandatory for all **Obstruction** of depth 30 metres or less. Factors to be considered in populating this attribute include depth in relation to the general nature of the seabed, proximity to other dangers, intention of the ENC, proximity to routes taken by vessels, and the types of vessels intended to utilise the ENC. For **Obstruction** of type curve or surface, **display uncertainties** must be set to "no".
- For reported, not confirmed obstructions, the date of the report must be populated, where known, using the attribute **reported date**.
- If the nature of a dangerous underwater feature, dangerous underwater area, or floating feature is not explicitly known, it must be encoded using **Obstruction**.
- An **Obstruction** feature of type surface must be covered by a surface feature from Skin of the Earth as appropriate.
- An area containing numerous dangers, through which navigation is not safe at the maximum display scale for the ENC data, should be encoded using an **Obstruction** feature of type surface, with attribute **category of obstruction** = 6 (foul area).
- If it is required to encode an **Obstruction** feature where the attribute **value of sounding** is populated with an empty (null) value, but the source information indicates the depth of the feature is within the range of the surrounding depth area, the value **exposition of sounding** = 1 (within the range of the surrounding depth area) must be populated in order to avoid the unnecessary display of isolated danger symbols in ECDIS.
- Active submarine volcanos can be a significant navigational hazard; and harmful concentrations of volcanic gases emanating from active submarine volcanos can cover an extensive area (see S-4 – clause B-428.4). If it is required to encode an active submarine volcano, it must be done using an **Obstruction** feature, with attributes **category of obstruction** = 21 (active submarine volcano), **exposition of sounding** = 2 (shoaler than the range of depth of the surrounding depth area) and **quality of vertical measurement** = 2 (depth or least depth unknown). To indicate the unpredictable nature of the volcano (it may be periodically submerged or extend above the surface), the mandatory attributes **value of sounding** and **water level effect** must be populated with an empty (null) value. In order to raise the level of indication of the hazard in the ECDIS to the mariner so as to generate an alarm, a small **Depth Area** feature having attribute **depth range minimum value** = 0 may also be encoded. The area that can be potentially covered by harmful volcanic gases, which may cover an area of up to 10 NM from the volcano, should be encoded using a **Caution Area** feature (see clause 16.10), having an instance of the information type **Nautical Information** (see clause 24.4) associated, with complex attribute **information**, sub-attributes **text** = *Volcanic activity* and **file reference** carrying a reference to an appropriate cautionary note similar to:
Active submarine volcanos exist in this area. Some volcanos have been reported to erupt breaking the surface of the sea and projecting ashes, other volcanic materials and harmful gases into the air. Changes to charted depths, uplifting of reefs and emerging of volcanic islets may occur throughout the area. Due to the unpredictable nature of these events mariners are strongly recommended to avoid the area.
 Inactive submarine volcanos must be encoded, if required, using a **Sea Area** feature (see clause 9.1).
- A danger circle on a paper chart that surrounds a single symbol or sounding (for example INT1 – K26, K27, K40(b) or K41 to K43.1) must not be encoded as a separate surface. However, when a danger line indicates the true shape of the feature, it should be encoded using **Wreck** or **Obstruction** features of type surface. A single sounding enclosed by a danger circle on medium and large scale paper charts must be encoded using an **Obstruction** feature of type point. The sounding value, in this case, must be encoded using the attribute **value of sounding**. Soundings enclosed by a danger circle on small scale paper charts may indicate a reported, not confirmed sounding, and such soundings should be evaluated to determine whether they should be encoded as **Obstruction** features, or **Sounding** features (see clause 11.3) with attribute **quality of vertical measurement** = 9 (value reported (not confirmed)).
- Platforms which have been cut-off above the seabed must be encoded as **Obstruction**, while platforms which have been cut-off to the level of the seabed should be encoded as **Foul Ground** (see clause 13.7).
- In certain circumstances where an obstruction is always dry (for example cribs), it must be covered by a **Land Area** feature.
- Features that are considered to be subsurface Fish Aggregating Devices (FAD) must be encoded as **Obstruction**, with **category of obstruction** = 5 (fish haven), unless the FAD is a vessel that has been deliberately sunk to form a fish haven, which should be encoded as a **Wreck** feature (see clause 13.5).
- If it is required to encode a subsurface ocean data acquisition system (ODAS), whether on the seabed or suspended in the water column by a subsurface float, it must be done using **Obstruction** with **category of obstruction** = 14 (subsurface ocean data acquisition system (ODAS)). An ODAS buoy must be encoded as a **Buoy Special Purpose/General** feature (see clause 20.5).

Distinction: Depth Area; Fishing Facility; Foul Ground; Marine Farm/Culture; Underwater/awash Rock; Water Turbulence; Wreck.

Feature/Information associations

Type	Association Name	Association Ends					
		Class	Role	Mult	Class	Role	Mult
Aggr	Mooring Trot Aggregation	Obstruction	Consists of	0,*	Mooring Trot	Component of	0,1
Asso	Additional Information	Obstruction	Provides information	0,*	Nautical Information	Information provided for	0,1
Comp	Text Association	Obstruction	Positions	0,1	Text Placement	Identifies	0,1
Asso	Updated Information	Obstruction	Updates	0,*	Update Information	Identifies	0,1
Asso	Spatial Association	Spatial type	Defines	0,*	Spatial Quality	Defined for	0,1

25.XX Quality of bathymetric data composition (Option 2 only)

Quality of Bathymetric Data Composition: IHO Definition: The mandatory association between the quality-related characteristics of bathymetric data and the horizontal position and vertical uncertainties of the data.

Remarks:

- No remarks.

Role Type	Role	Associated With	Multiplicity
Association	Defined for	Quality of Bathymetric Data	1,1
	Defines	Spatial Quality	1,1

27.XX category of zone of confidence in data

Category of zone of confidence in data: IHO Definition: Classification of the zone of confidence in data within an area based on the positional accuracy, survey equipment and coverage.

Attribute Type: Enumeration

1) zone of confidence A1

IHO Definition: Positional Accuracy +/- 5 metres; Depth Accuracy 0.5 metre +1% depth; Full area search undertaken. Significant seafloor features detected and depths measured; Controlled, systematic survey, high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

2) zone of confidence A2

IHO Definition: Positional Accuracy +/- 20 metres; Depth Accuracy 1.0 metre + 2% depth; Full area search undertaken. Significant seafloor features detected and depths measured; Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder and a sonar or mechanical sweep system. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

3) zone of confidence B

IHO Definition: Positional Accuracy +/- 50 metres; Depth Accuracy 1.0 metre + 2% depth; Full area search not achieved, uncharted features hazardous to surface navigation are not expected but may exist; Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echosounder, but no sonar or mechanical sweep system. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

4) zone of confidence C

IHO Definition: Positional Accuracy +/- 500 metres; Depth Accuracy 2.0 metre + 5% depth; Full area search not achieved, depth anomalies may be expected; Low accuracy survey or data collected on an opportunity basis such as soundings on passage. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

5) zone of confidence D

IHO Definition: Positional Accuracy worse than ZOC C; Depth Accuracy worse than ZOC C; Full area search not achieved, large depth anomalies may be expected; Poor quality data or data that cannot be quality assessed due to lack of information. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

6) zone of confidence U (data not assessed)

IHO Definition: The quality of the bathymetric data has yet to be assessed. (Adapted from S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.107, November 2000).

Remarks:

- The full categorisation of each category is as follows:

1	2	3		4	5
ZOC ¹	Position Accuracy ²	Depth Accuracy ³		Seafloor Coverage	Typical Survey Characteristics ⁵
A1	± 5 m + 5% depth	=0.50 + 1%d		Full area search undertaken. Significant seafloor features detected ⁴ and depths measured.	Controlled, systematic survey ⁶ high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multi beam, channel or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 0.6		
		30	± 0.8		
		100	± 1.5		
		1000	± 10.5		
		= 1.00 + 2%d		Full area search undertaken. Significant seafloor features	Controlled, systematic survey ⁶ achieving position and depth accuracy less than zone of
		Depth (m)	Accuracy (m)		

A2	± 20 m	10 30 100 1000	± 1.2 ± 1.6 ± 3.0 ± 21.0	detected ⁴ and depths measured.	confidence A1 and using a modern survey echo sounder ⁷ and a sonar or mechanical sweep system.
B	± 50 m	= 1.00 + 2%d		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than zone of confidence A2 , using a modern survey echo sounder ⁷ , but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
C	± 500 m	= 2.00 + 5%d		Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
		Depth (m)	Accuracy (m)		
		10	± 2.5		
		30	± 3.5		
		100	± 7.0		
		1000	± 52.0		
D	Worse than zone of confidence C	Worse than zone of confidence C		Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	Unassessed - The quality of the bathymetric data has yet to be assessed				

To decide on a ZOC Category, all conditions outlined in columns 2 to 4 of the table must be met.

Explanatory notes quoted in the table:

¹ The allocation of a Zone of Confidence (ZOC) indicates that particular data meets minimum criteria for position and depth accuracy and seafloor coverage defined in this Table. ZOC categories reflect a charting standard and not just a hydrographic survey standard. Depth and position accuracies specified for each ZOC category refer to the errors of the final depicted soundings and include not only survey errors but also other errors introduced in the chart production process. Data is further qualified in Feature Class **Quality of Bathymetric Data** (see clause 3.7) attributes as follows:

a) Positional Accuracy (**horizontal position uncertainty**) and Sounding Accuracy (**vertical uncertainty**) may be used to indicate that a higher position or depth accuracy has been achieved than defined in this Table (for example a survey where full seafloor coverage was not achieved could not be classified higher than ZOC B; however, if the position accuracy was, for instance, ± 15 metres, the attribute **horizontal position uncertainty** could be used to indicate this).

b) Swept areas where the clearance depth is accurately known but the actual seabed depth is not accurately known may be accorded a 'higher' ZOC (i.e. A1 or A2) providing positional and depth accuracies of the swept depth meets the criteria in this Table. In this instance, the attribute **depth range minimum value** may be used to specify the swept depth. The position accuracy criteria apply to the boundaries of swept areas.

c) The complex attribute **survey date range** is used to indicate the start and end dates of the survey(s) covering the area.

² Position Accuracy of depicted soundings at 95% CI (2.45 sigma) with respect to the given datum. It is the cumulative error and includes survey, transformation and digitizing errors etc. Position accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

³ Depth accuracy of depicted soundings = $a + (b \cdot d)/100$ at 95% CI (2.00 sigma), where d = depth in metres at the critical depth. Depth accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

⁴ Significant seafloor features are defined as those rising above depicted depths by more than:

	<u>Depth</u>	<u>Significant Feature</u>
a.	<40 m	2 m
b.	>40 m	10% depth

A full seafloor search indicates that a systematic survey was conducted using detection systems, depth measurement systems, procedures, and trained personnel designed to detect and measure depths on significant seafloor features. Significant features are included on the chart as scale allows. It is impossible to guarantee

that no significant feature could remain undetected, and significant features may have become present in the area since the time of the survey.

⁵ Typical Survey Characteristics - These descriptions should be seen as indicative examples only.

⁶ Controlled, systematic surveys (ZOC A1, A2 and B) - surveys comprising planned survey lines, on a geodetic datum that can be transformed to WGS 84.

⁷ Modern survey echo sounder - a high precision single beam depth measuring equipment, generally including all survey echo sounders designed post 1970.

27.XX display uncertainties

Display uncertainties: IHO Definition: A statement defining whether an encoded feature is to have its horizontal position and vertical accuracies displayed or not.

Attribute Type: Boolean

Indication: A True value is an indication that the uncertainties are to be displayed in some ECDIS settings.

Remarks:

- The attribute **display uncertainties** uses the values encoded for an associated instance of the information type **Spatial Quality** to determine the accuracy values to be displayed for a geo feature.

29.XX spatial accuracy (Option 1)

Spatial accuracy: IHO Definition: Provides an indication of the vertical and horizontal positional uncertainty of bathymetric data, optionally within a specified date range.

Indication: The complex attribute defines the horizontal and vertical position accuracy of bathymetric features, which may optionally be degraded over time.

<u>Sub-attributes:</u>	category of zone of confidence in data	see clause 27.X
	fixed date range	see clause 29.4
	horizontal position uncertainty	see clause 29.8
	vertical uncertainty	see clause 29.41

Remarks:

- No remarks.

29.XX spatial accuracy (Option 2)

Spatial accuracy: IHO Definition: Provides an indication of the vertical and horizontal positional uncertainty of bathymetric data, optionally within a specified date range.

Indication: The complex attribute defines the horizontal and vertical position accuracy of bathymetric features, which may optionally be degraded over time.

<u>Sub-attributes:</u>	fixed date range	see clause 29.4
	horizontal position uncertainty	see clause 29.8
	vertical uncertainty	see clause 29.41

Remarks:

- No remarks.

29.XX zone of confidence (Option 2)

Spatial accuracy: IHO Definition: The overall indication of the quality of bathymetric data within an area based on the positional accuracy, survey equipment and coverage; optionally within a specified data range.

Indication: The complex attribute defines the horizontal and vertical position accuracy of bathymetric features, which may optionally be degraded over time.

<u>Sub-attributes:</u>	category of zone of confidence in data	see clause 27.X
	fixed date range	see clause 29.4

Remarks:

- No remarks.