

Paper for Consideration by S-101PT

Options for Modelling of Quality of Bathymetric Data and Spatial Quality

Submitted by:	IHO Secretariat
Executive Summary:	There have been two alternate modellings included in the S-101 DCEG since Edition 1.0.1. Action S-101PT10-25 requires further investigation of the modelling of the metadata features in S-101; and as part of this Action modelling options for the features QualityOfBathymetricData and SpatialQuality have been developed for the S-101PT.
Related Documents:	S-101PT Action S-101PT10-25; S-101 DCEG; S-101 DCEG Sub-Group 4 meeting Notes; S-65 Annexes B and C.
Related Projects:	S-101; S-100 ECDIS portrayal and performance; ENC data conversion

Introduction / Background

1. Since the two encoding options for the QualityOfBathymetricData and SpatialQuality features were included in S-101 Edition 1.0.1, there has been very little feedback on the preferred option to be included in the Edition 2.0.0 Operational Edition of S-101. Prompted by discussions at the S-101PT10 meeting (June 2023), consolidated modelling of these two options has been developed for discussion at S-101PT11, for inclusion of the preferred option in S-101 Edition 1.2.0 for testing.

Analysis/Discussion

2. The modelling and accompanying encoding guidance for the two options is included in Annexes A (redline changes from S-101 Edition 1.1.0) and B (clean versions for inclusion of the preferred option in S-101 Edition 1.2.0), with each option included in Scenario's 1 and 2 of the Annexes. The key characteristics of each scenario are described in the following paragraphs.
3. Scenario 1: Splits out the horizontalPositionAccuracy and verticalAccuracy out from the QualityOfBathymetricData meta feature and requires an associated instance of the Information type SpatialQuality for all QualityOfBathymetricData features. Key points to note include:
 - Effectively separates the horizontal position and vertical uncertainties from the feature intended to provide the overall indication of the quality of bathymetric data. Requires a mandatory feature/information association of instances of SpatialQuality with all instances of QualityOfBathymetricData using the association QualityOfBathymetricDataComposition.
 - For the requirement to provide horizontal position and vertical accuracy on all features of depth 30 metres or less, the same procedure is applied regardless of the quality of individual features. The same instance of SpatialQuality associated to the QualityOfBathymetricData can also be associated to all the features for which QualityOfBathymetricData applies; with additional instance(s) of SpatialQuality indicating different quality associated to the features having different horizontal position and vertical accuracies than the underlying QualityOfBathymetricData indicates. Lower quality depth information may be further indicated in the ECDIS by the population of the attribute qualityOfHorizontalPosition on SpatialQuality; however this must not be done for SpatialQuality associated to the QualityOfBathymetricData.
 - SpatialQuality can therefore play different roles, depending on the association used, with the spatial quality of the QualityOfBathymetricData feature itself being able to be encoded using the SpatialAssociation association, while the association to the features is done using QualityOfBathymetricDataComposition.
4. Scenario 2: Retains horizontalPositionAccuracy and verticalAccuracy on the QualityOfBathymetricData meta feature. Key points to note include:

- Encoding of all horizontal position and vertical accuracy remains on the QualityOfBathymetricData features, with no requirement for an association to SpatialQuality unless it is required to identify the accuracy of the QualityOfBathymetricData itself through a SpatialAssociation association.
 - For the requirement to provide horizontal position and vertical accuracy on all features of depth 30 metres or less, this is done by associating the QualityOfBathymetricData feature to all the features representative of the QualityOfBathymetricData; and through encoding an additional instance(s) of QualityOfBathymetricData having no geometry for other features whose quality does not correspond to the quality indicated in QualityOfBathymetricData surface feature. The QualityOfBathymetricData are associated to the features under 30 metres for which the data quality applies using the association QualityOfBathymetricDataAssociation. Optionally, SpatialQuality with attribute qualityOfHorizontalPosition may additionally be encoded and associated to the features using the SpatialAssociation association to indicate lower quality, however this must not be done for any feature having quality equivalent to the underlying QualityOfBathymetricData surface features.
 - Because the attributes horizontalPositionUncertainty and verticalUncertainty can be populated for both QualityOfBathymetricData and SpatialQuality, it is important therefore to note in the guidance that SpatialQuality having horizontalPositionUncertainty and verticalUncertainty must not be associated to features having an associated instance of QualityOfBathymetricData.
5. Other points to note in this revised modelling and guidance include:
- Noting the following statement that has been included in the DCEG on request of the DQWG:

“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.**”

the complex attributes horizontalPositionUncertainty and verticalUncertainty have been removed from their current (Edition 1.1.0) nesting as sub-complex attributes for the complex attributes zoneOfConfidence (for QualityOfBathymetricData) and spatialAccuracy (for SpatialQuality) so as to enable temporal changes to the uncertainties to be encoded. The guidance includes a recommendation that, if it is considered important to provide a temporal indication of changes in uncertainty, this is to be done by issuing an ENC Update.
 - S-101 Documentation and FC GitHub [Issue #91](#) has been raised to address ambiguity in encoding depth range values for overlapping QualityOfBathymetricData features. In order to (partially) address this, the guidance has been modified to require the depthRangeMinimum value for the QualityOfBathymetricData defining the next deepest depth range to be 0.1 metres deeper than the depthRangeMaximum value of the QualityOfBathymetricData above.
 - The revised guidance has been amended to include reference to all features carrying the attribute valueOfSounding (FoulGround, MarineFarmCulture, Obstruction, Sounding, UnderwaterAwashRock and Wreck).
6. It must be noted that the modelling proposed in this Paper has not been developed with any input/feedback from implementation/testing of the two options for the encoding of QualityOfBathymetricData and SpatialQuality included in S-101 since Edition 1.0.1 of the DCEG. As such, any decision made will require creation of test data and rigorous testing so as to apply any refinements as required prior to publication of S-101 Edition 2.0.0.
7. Additional changes throughout the DCEG (including required changes to Figure 3-2) will be made based on the preferred modelling/method of encoding chosen.

Conclusions and recommendations

8. The proposed options for encoding quality of bathymetry information in S-101 ENCs included in this Paper are an attempt to split out the optional methods included in S-101 since DCEG Edition 1.0.1. A preferred option must be included in S-101 Edition 1.2.0 so as to be included in corresponding test data; and rigorously tested to allow for refinement of the modelling and/or associated encoding guidance prior to publication of S-101 Edition 2.2.0.

9. It is recommended that S-101PT:

- Select one of the modelling options included as scenario's 1 and 2 in the included Annexes to this Paper, for inclusion in S-101 Edition 1.2.0; and
- Request the development of test data that implements the preferred option for testing and refinement of the modelling and/or guidance for inclusion in S-101 Edition 2.0.0.

Justification and Impacts

10. The inclusion of quality of bathymetry information in ENC is considered to be critical. The modelling of the QualityOfBathymetricData meta feature and the SpatialQuality Information type constitutes one of the greatest departures from the way that data is encoded in S-57 ENCs. As such, it is critical that a preferred model and corresponding encoding guidance is identified before the operational Edition 2.0.0 of S-101 is published.

11. This proposal will need to be carefully discussed in regard to its impact on all aspects of ENC production and ECDIS implementation.

Action Required of S-101PT

12. The S-101PT is invited to:

- **Discuss** this proposal.
- **Agree** the preferred modelling/encoding guidance for quality of bathymetry information in S-101, for inclusion in Edition 1.2.0.
- **Initiate** the development of associated test data.
- **Initiate** any further action as required.

ANNEXES: A: Draft revised modelling and encoding guidance (redline)
 B: Draft revised modelling and encoding guidance (clean)

DCEG Draft Redline Changes

SCENARIO 1

3.7 Quality of bathymetric data

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	1,1
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
survey date range		See clause 2.4.8	C	1,1
date end	(SUREND)		(S) TD	1,1
date start	(SURSTA)		(S) TD	0,1
zone of confidence			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	EN	1,1
fixed date range		See clause 2.4.8	(S) C	0,1

date end	(DATEND)		(S) TD	0,1 †
date start	(DATSTA)		(S) TD	0,1 †
—horizontal position uncertainty			(S) G	0,1
——uncertainty fixed	(POSACC)		(S) RE	1,1
——uncertainty variable factor			(S) RE	0,1
—vertical uncertainty			G	0,1
——uncertainty fixed	(SQUACC)		(S) RE	1,1
——uncertainty variable factor			(S) RE	0,1
information		See clause 2.4.6	C	0,*
file locator			(S) TE	0,1
file reference	(TXTDSC) (NXTDSC)		(S) TE	0,1 †
headline			(S) TE	0,1
language		ISO 639-2/T	(S) TE	0,1
text	(INFORM) (NINFOM)		(S) TE	0,1 †

† For each instance of fixed date range, at least one of the sub-attributes **date end** or **date start** must be populated.

For each instance of **information**, at least one of the sub-attributes **file reference** or **text** must be populated.

INT 1 Reference:

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

~~[NOTE: The modelling of the complex attribute **zone of confidence** and accompanying encoding guidance in this Edition of S-101 Annex A is intended to allow for 2 options for the encoding of degrading bathymetric data quality over time for testing purposes. One of the options described must be used when encoding the quality of bathymetric data for an area. This modelling will be consolidated when the preferred option has been determined. See also clause 24.5.]~~

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

- the meta feature **Quality of Bathymetric Data** and the Information type **Spatial Quality** (see clause 24.5) for an **overall** 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 clauses 2.4.7 and 24.5).

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.

~~In order to provide an indication of the horizontal position and vertical accuracies of the features to which it applies, each instance of **Quality of Bathymetric Data** must be associated to an instance of the information type **Spatial Quality** (see clause 24.5), using the association **Quality of Bathymetric Data Composition**~~

(see clause 25.12).

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 **individual**/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.

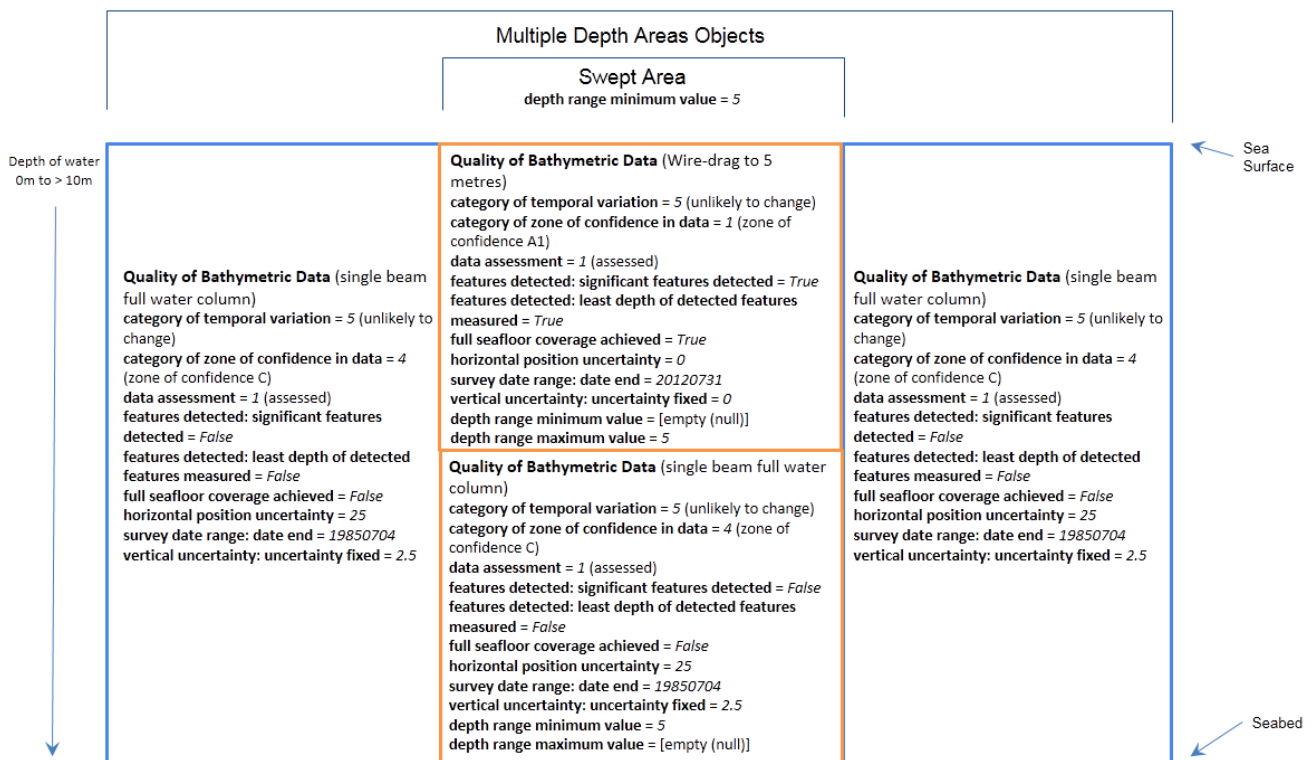


Figure 3-2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a mechanically 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 above 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*; and **category of zone of confidence in data** = 6 (zone of confidence U); ~~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*; complex attribute **features detected**, Boolean sub-attributes **least depth of detected features measured** and **significant features detected** set to *False*; the **zone of confidence** sub-attribute **category of zone of confidence in data** reclassified to 5 (zone of confidence D); and ~~the **zone of confidence** sub-attributes **horizontal position accuracy (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** on the associated **Spatial Quality** populated with an empty (null) value (however see bullet for **zone of confidence** below)~~ 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 seafloor, 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 **zone of confidence** 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 **zone of confidence** 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)) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.71) in accordance with the values populated for the attribute **full seafloor coverage achieved**; the complex attribute **features detected**; and ~~the **spatial accuracy** sub-complex attributes **horizontal position uncertainty** and **vertical uncertainty** on the associated **Spatial Quality**.~~
 - 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 on the associated **Spatial Quality****~~ 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 ~~on **Quality of Bathymetric Data**~~, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
- The ~~sub-complex attribute **horizontal position uncertainty on the associated **Spatial Quality****~~ is used to specify the positional uncertainty of the depths covered by the surface ~~within a specified date range (where encoded)~~.
- ~~The indication of the horizontal position and vertical uncertainties described in the above bullet and in Figure 3-2 may alternatively be encoded using an associated instance of the information type **Spatial Quality**, complex attribute **spatial accuracy** (see clause 24.5), and using the association **Quality of Bathymetric Data Composition**. Where the horizontal position and vertical uncertainties are encoded using this method, the **horizontal position uncertainty** and **vertical uncertainty** sub-complex attributes for **zone of confidence** must not be populated on **Quality of Bathymetric Data**. However, where populated, the values for the sub-attributes of the sub-complex attribute **fixed date range** must be identical~~

~~on both the Quality of Bathymetric Data and the associated Spatial Quality feature.~~

- **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 **set to a value 0.1 metres deeper than equal to** the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see 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 shoaler 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 **0.1 metres shoaler than equal to** the **depth range minimum value** for the **Quality of Bathymetric Data** feature defining the quality for the level below (see Figure 3-2 above).
- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area features** 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 **zone of confidence sub-attributes** (**category of zone of confidence in data**) = 5 (zone of confidence D). ~~and~~–The attributes **vertical uncertainty** (**uncertainty fixed**) and **horizontal position uncertainty** (**uncertainty fixed**) ~~=~~– for the associated **Spatial Quality** should be populated with an {empty (null)} value.
- For **Unsurveyed Area features** 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.
- ~~zone of confidence~~ (~~horizontal position uncertainty~~) ~~on~~ **Spatial Quality** (**horizontal position uncertainty**) associated to the **Quality of Bathymetric Data** using the association **Quality of Bathymetric Data Composition** (see clause 25.12) applies to bathymetric data situated within the surface, while **Spatial Quality** (**quality of horizontal measurement**) or (**horizontal position uncertainty**) on the associated spatial types using the association **Spatial Association** (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 seafloor, 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 **zone of confidence**, sub-complex attribute **vertical uncertainty** on **Quality of Bathymetric Data**, or alternatively using~~ an associated instance of the information type **Spatial Quality**, complex attribute **vertical uncertainty spatial accuracy** (see clause 24.5) and using the association **Quality of Bathymetric Data Composition** (see clause 25.12). If it is required to encode additional sounding uncertainty information, it must be done using the attributes **quality of vertical measurement** and **technique of vertical measurement** on groups of soundings or individual features ~~the complex attribute **vertical uncertainty** on individual features where available;~~ or by associating another instance of the information type **Spatial Quality** ~~(see clause 24.5)~~ to the spatial type associated with the individual geo features. Note that this is a mandatory requirement for the features **Sounding** and **Obstruction Underwater/Awash Rock**; and **Foul Ground, Marine Farm/Culture, Obstruction** and **Wreck** of type point, ~~and~~ of depth 30 metres or less.

The vertical and horizontal position uncertainty values populated on ~~the instance of **Spatial Quality** associated to the **Quality of Bathymetric Data**~~ must reflect the most commonly associated values for the **Foul Ground, Marine Farm/Culture, Obstruction, Sounding, Underwater/Awash Rock** and **Wreck** features within the area.

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

Feature/Information associations: **Quality of Bathymetric Data Composition**

Spatial/Information association: **Spatial Association**

24.5 Spatial quality

IHO Definition: **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>
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S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1
spatial accuracy			C	0,*
— fixed date range		See clause 2.4.8	(S)C	0,1
—— date end	(DATEND)		(S)TD	0,1 †
—— date start	(DATSTA)		(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
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1 †
— vertical uncertainty			C	0,1 †
— uncertainty fixed	(SOUACC)		(S) RE	1,1
— uncertainty variable factor			(S) RE	0,1

† For each instance of ~~fixed date range~~, at least one of the sub-attributes ~~date end~~ or ~~date start~~ must be populated. At least one of the attributes **horizontal position uncertainty**, **quality of horizontal measurement** or **vertical uncertainty** must be populated.

INT 1 Reference:

24.1 Spatial quality

~~[NOTE: The modelling of the complex attribute **spatial accuracy** and accompanying encoding guidance in this Edition of S-101 Annex A is intended to allow for 2 options for the encoding of degrading bathymetric data quality over time for testing purposes. This modelling will be consolidated when the preferred option has been determined. See also clause 3.7.]~~

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.

Spatial quality attributes are carried in the information type **Spatial Quality**. Only point, multipoint and curve geometry and the meta feature **Quality of Bathymetric Data** can be associated with spatial quality. Currently no use case for associating surface 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.

Each instance of **Spatial Quality** must be associated to the geometry to which the information applies using the association **Spatial Association** (see clause 25.14); or in the case of **Spatial Quality** associated with **Quality of Bathymetric Data**, using the association **Quality of Bathymetric Data Composition** (see clause 25.12).

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.

Remarks:

- The complex attributes **horizontal position accuracy** and **vertical accuracy** ~~spatial accuracy~~ are used to specify the ~~vertical and~~ horizontal position and vertical 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** ~~may~~ **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 25.12). ~~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 data 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** must be used to specify the vertical uncertainty of the depths covered by the associated **Quality of Bathymetric Data** ~~feature within a specified date range (where encoded)~~. When **depth range minimum value** is specified for the associated **Quality of Bathymetric Data** feature, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
 - The ~~sub-complex~~ attribute **horizontal position uncertainty** must be used to specify the positional uncertainty of the depths covered by the associated **Quality of Bathymetric Data** ~~feature within a specified date range (where encoded)~~.
 - The sub-attribute **quality of horizontal measurement** must not be populated.
 - Uncertainty due to temporal variation should not be included where the spatial accuracy is degraded over time. However, where it is considered that the uncertainty has increased sufficiently over time that it is required to indicate this to the Mariner, this must be done by amending the complex attributes **vertical uncertainty** and **horizontal position uncertainty** through issuance of an ENC Update.
- ~~The indication of the horizontal position and vertical uncertainties for providing an indication of the overall quality of the bathymetric data in an area described in the above bullet may alternatively be encoded using the complex attribute zone of confidence on a Quality of Bathymetric Data feature (see clause 3.7). Where the horizontal position and vertical uncertainties are encoded using this method, Spatial Quality should not be associated to Quality of Bathymetric Data using the association Quality of Bathymetric Data Composition. However, where Spatial Quality is used, the values for the sub-attributes of the sub-complex attribute fixed date range, where populated, must be identical on both the Quality of Bathymetric Data and the associated Spatial Quality feature.~~
- For the geometry associated with all **Sounding** and **Underwater/Awash Rock** features; and **Foul Ground, Marine Farm/Culture, 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~~ **Quality of Bathymetric Data Composition**. For the majority of, if not all, these features this should be done by using the instance of **Spatial Quality** associated with the underlying **Quality of Bathymetric Data** representing the overall indication of the quality of bathymetric data for the area.
- The attribute **quality of horizontal measurement** may be used on **Spatial Quality** to provide an indication of lower accuracy quality of depth features, in addition to population of **horizontal position accuracy**, than the underlying **Quality of Bathymetric Data** indicates, however where this is done the **Spatial Quality** feature must not be associated to a **Quality of Bathymetric Data** feature.

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

Feature/Information association: Quality of Bathymetric Data Composition

Spatial/Information association: Spatial Association

SCENARIO 2

3.7 Quality of bathymetric data

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, 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	
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	1,1	
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			(S) C	1,1	
uncertainty fixed	(POSACC)		(S) RE	1,1	
uncertainty variable factor			(S) RE	0,1	
survey date range		See clause 2.4.8	C	1,1	
date end	(SUREND)		(S) TD	1,1	
date start	(SURSTA)		(S) TD	0,1	
vertical uncertainty			C	1,1	
uncertainty fixed	(SOUACC)		(S) RE	1,1	
uncertainty variable factor			(S) RE	0,1	
zone of confidence			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	EN	1,1	

		4 : zone of confidence C 5 : zone of confidence D 6 : zone of confidence U		
fixed date range		See clause 2.4.8	(S) C	0,1
date end	(DATEND)		(S) TD	0,1 †
date start	(DATSTA)		(S) TD	0,1 †
—horizontal position uncertainty			(S) C	0,4
—uncertainty fixed	(POSACC)		(S) RE	1,4
—uncertainty variable factor			(S) RE	0,4
—vertical uncertainty			C	0,4
—uncertainty fixed	(SOUACC)		(S) RE	1,4
—uncertainty variable factor			(S) RE	0,4
information		See clause 2.4.6	C	0,*
file locator			(S) TE	0,1
file reference	(TXTDSC) (NTXTDS)		(S) TE	0,1 †
headline			(S) TE	0,1
language		ISO 639-2/T	(S) TE	0,1
text	(INFORM) (NINFOM)		(S) TE	0,1 †

† For each instance of fixed date range, at least one of the sub-attributes **date end** or **date start** must be populated.

For each instance of **information**, at least one of the sub-attributes **file reference** or **text** must be populated.

INT 1 Reference:

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

~~[NOTE: The modelling of the complex attribute **zone of confidence** and accompanying encoding guidance in this Edition of S-101 Annex A is intended to allow for 2 options for the encoding of degrading bathymetric data quality over time for testing purposes. One of the options described must be used when encoding the quality of bathymetric data for an area. This modelling will be consolidated when the preferred option has been determined. See also clause 24.5.]~~

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 **individual**/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.

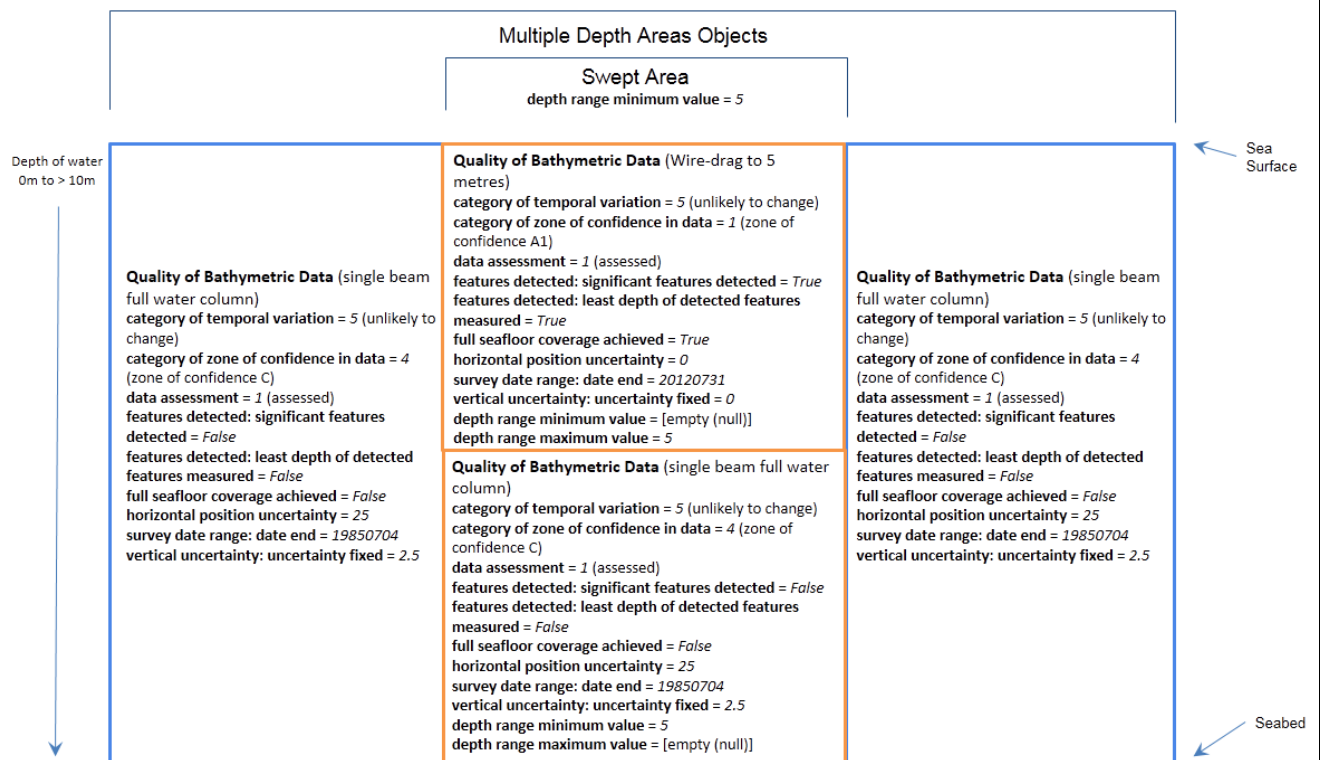


Figure 3-2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a mechanically 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 above is intended to provide the highest (best) quality indicator for vessels navigating at a safety depth of less than 5 metres in the area.

In order to provide an indication of the horizontal position and vertical accuracies of the features to which it applies, each instance of **Quality of Bathymetric Data** must be associated to the features to which the **Quality of Bathymetric Data** applies (**Sounding** and **Underwater/Awash Rock** features; and **Foul Ground, Marine Farm/Culture, Obstruction** and **Wreck** features of type point) of depth 30 metres or less, using the association **Quality of Bathymetric Data Association** (see clause 25.12). Where some features within the area have a different horizontal and vertical accuracy, an additional instance(s) of **Quality of Bathymetric Data**, having no geometry, may be associated to these features (see clause 3.7.1.3).

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*; **horizontal position uncertainty (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** = [empty (null)]; and **category of zone of confidence in data** = 6 (zone of confidence U); ~~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*; complex attribute **features detected**, Boolean sub-attributes **least depth of detected features measured** and **significant features detected** set to *False*; **horizontal position accuracy (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** populated with an empty (null) value; and the ~~zone of confidence~~ sub-attribute **category of zone of confidence in data** reclassified to 5 (zone of confidence D); ~~and zone of confidence sub-attributes **horizontal position accuracy (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** populated with an empty (null) value (however see bullet for zone of confidence below)~~ 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 seafloor, 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 complex attribute **vertical uncertainty** is used to specify the vertical uncertainty of the depths covered by the surface. 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 complex attribute **horizontal position uncertainty** is used to specify the positional uncertainty of the depths covered by the surface.
- Uncertainty due to temporal variation should not be included where the spatial accuracy is degraded over time. However, where it is considered that the uncertainty has increased sufficiently over time that it is required to indicate this to the Mariner, this must be done by amending the complex attributes **vertical uncertainty** and **horizontal position uncertainty** through issuance of an ENC Update.
- The mandatory complex attribute **zone of confidence** 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 **zone of confidence** 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)) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.71) in accordance with the values populated for the attribute **full seafloor coverage achieved**; ~~and the complex attributes **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 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).~~
- ~~The indication of the horizontal position and vertical uncertainties described in the above bullet and in Figure 3-2 may alternatively be encoded using an associated instance of the information type **Spatial Quality**, complex attribute **spatial accuracy** (see clause 24.5), and using the association **Quality of Bathymetric Data Composition**. Where the horizontal position and vertical uncertainties are encoded using this method, the **horizontal position uncertainty** and **vertical uncertainty** sub-complex attributes for **zone of confidence** must not be populated on **Quality of Bathymetric Data**. However, where populated, the values for the sub-attributes of the sub-complex attribute **fixed date range** must be identical on both the **Quality of Bathymetric Data** and the associated **Spatial Quality** feature.~~
- **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 **set to a value 0.1 metres deeper than equal to** the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see 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 **0.1 metres shallower than equal to** the **depth range minimum value** for the **Quality of Bathymetric Data** feature defining the quality for the level below (see Figure 3-2 above).
- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area** features 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*; **vertical uncertainty (uncertainty fixed)** and **horizontal position uncertainty (uncertainty fixed)** = [empty (null)]; and **zone of confidence 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** features 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.
- ~~**zone of confidence (horizontal position uncertainty)** on the **Quality of Bathymetric Data** applies to bathymetric data situated within the surface, while **Spatial Quality (quality of horizontal measurement)** or **(horizontal position uncertainty)** on the associated spatial types using the association **Spatial Association** (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 seafloor, 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 **zone of confidence**, sub-complex attribute **vertical uncertainty** on **Quality of Bathymetric Data**, or alternatively using an associated instance of the information type **Spatial Quality**, complex attribute **spatial accuracy** (see clause 24.5) and using the association **Quality of Bathymetric Data Composition**. 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 individual geo features. 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 sounding uncertainty information **vertical and horizontal position uncertainty values** populated on the **Quality of Bathymetric Data** surface features covering the area of bathymetry for the dataset must reflect the most commonly associated values for the **Foul Ground**, **Marine Farm/Culture**, **Obstruction**, **Sounding**, **Underwater/Awash Rock** and **Wreck** features within the areas. Where there are individual features located within an area having quality information that is different from the underlying **Quality of Bathymetric Data** feature, this should be indicated using the attributes **quality of vertical measurement** and **technique of vertical measurement** on groups of soundings or individual features; or, where the horizontal accuracy is lower than the underlying **Quality of Bathymetric Data** indicates, using the attribute **quality of horizontal measurement** on an associated instance of the Information type **Spatial Quality** (see clause 24.5).~~

~~Alternatively, an additional **Quality of Bathymetric Data** feature having no geometry may be encoded; and associated to the relevant feature(s) using the association **Quality of Bathymetric Data Association** (see clause 25.12). Note that this is a requirement where the feature(s) are of depth 30 metres or less (see clause 3.7.1).~~

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

Feature/Information associations: **Quality of Bathymetric Data Association-Composition**

Spatial/Information association: **Spatial Association**

24.5 Spatial quality

IHO Definition: **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>
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S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1
spatial accuracy			C	0,*
— fixed date range		See clause 2.4.8	(S)C	0,1
—— date end	(DATEND)		(S)TD	0,1 †
—— date start	(DATSTA)		(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
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1 †
— vertical uncertainty			C	0,1 †
— uncertainty fixed	(SOUACC)		(S) RE	1,1
— uncertainty variable factor			(S) RE	0,1

† For each instance of ~~fixed date range~~, at least one of the sub-attributes ~~date end~~ or ~~date start~~ must be populated. At least one of the attributes **horizontal position uncertainty**, **quality of horizontal measurement** or **vertical uncertainty** must be populated.

INT 1 Reference:

24.5.1 Spatial quality

~~[NOTE: The modelling of the complex attribute **spatial accuracy** and accompanying encoding guidance in this Edition of S-101 Annex A is intended to allow for 2 options for the encoding of degrading bathymetric data quality over time for testing purposes. This modelling will be consolidated when the preferred option has been determined. See also clause 3.7.]~~

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.

Spatial quality attributes are carried in the information type **Spatial Quality**. Only point, multipoint and curve geometry ~~and the meta feature **Quality of Bathymetric Data**~~ can be associated with spatial quality. Currently no use case for associating surface 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.

Each instance of **Spatial Quality** must be associated to the geometry to which the information applies using the association **Spatial Association** (see clause 25.14); ~~or in the case of **Spatial Quality** associated with **Quality of Bathymetric Data**, using the association **Quality of Bathymetric Data Composition** (see clause 25.12).~~

Remarks:

- The complex attributes **horizontal position accuracy** and **vertical accuracy** ~~spatial accuracy~~ is are used to specify the ~~vertical and~~ horizontal position and vertical 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** may 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 25.12). 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 **data 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** must be used to specify the vertical uncertainty of the depths covered by the associated **Quality of Bathymetric Data** feature within a specified date range (where encoded). When **depth range minimum value** is specified for the associated **Quality of Bathymetric Data** feature, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
 - The sub-complex attribute **horizontal position uncertainty** must be used to specify the positional uncertainty of the depths covered by the associated **Quality of Bathymetric Data** feature within a specified date range (where encoded).~~
- The indication of the horizontal position and vertical uncertainties for providing an indication of the overall quality of the bathymetric data for bathymetric features (**Sounding** and **Underwater/Awash Rock** features; and **Foul Ground**, **Marine Farm/Culture**, **Obstruction** and **Wreck** features of type point), of depth 30 metres or less, must be in an area described in the above bullet may alternatively be encoded using the meta feature complex attribute **zone of confidence** on a **Quality of Bathymetric Data** feature (see clause 3.7), associated to the relevant geo features using the association **Quality of Bathymetric Data Association** (see clause 25.12). Where this occurs and it is considered important to provide the Mariner with an indication that an associated feature is of lower quality than the quality indicated by the underlying **Quality of Bathymetric Data** feature, this may be done by encoding an associated instance of **Spatial Quality** having the attribute **quality of horizontal measurement** populated. There must be no **Spatial Quality** having attributes **horizontal position uncertainty** and **vertical uncertainty** associated with **Sounding**, **Underwater/Awash Rock**, **Foul Ground** (point), **Marine Farm/Culture** (point), **Obstruction** (point) and **Wreck** (point) features of depth 30 metres or less. Where the horizontal position and vertical uncertainties are encoded using this method, **Spatial Quality** should not be associated to **Quality of Bathymetric Data** using the association **Quality of Bathymetric Data Composition**. However, where **Spatial Quality** is used, the values for the sub-attributes of the sub-complex attribute **fixed date range**, where populated, must be identical on both the **Quality of Bathymetric Data** and the associated **Spatial Quality** feature.
- 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 association: ~~Quality of Bathymetric Data Composition~~

Spatial/Information association: **Spatial Association**

25.12 Quality of bathymetric data ~~composition-association~~

IHO Definition: **QUALITY OF BATHYMETRIC DATA COMPOSITION-ASSOCIATION**. The ~~mandatory~~ association between the quality-related characteristics of bathymetric data and the ~~horizontal-position-and vertical-uncertainties-of-the-data~~ bathymetric features themselves.

Remarks:

- No remarks.

Role Type	Role	Associated With	Multiplicity
Composition Association	Defines	Spatial Quality of Bathymetric Data	1,1
	Defined for	Quality of Bathymetric Data—Foul Ground, Marine Farm/Culture, Obstruction, Sounding, Underwater/Awash Rock, Wreck	0,* {1,* [C]}

DCEG Draft Changes (Clean)

SCENARIO 1

3.7 Quality of bathymetric data

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	1,1
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
survey date range		See clause 2.4.8	C	1,1
date end	(SUREND)		(S) TD	1,1
date start	(SURSTA)		(S) TD	0,1
zone of confidence			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	EN	1,1
fixed date range		See clause 2.4.8	(S) C	0,1

date end	(DATEND)		(S) TD	0,1 †
date start	(DATSTA)		(S) TD	0,1 †
information		See clause 2.4.6	C	0,*
file locator			(S) TE	0,1
file reference	(TXTDSC) (NXTDTS)		(S) TE	0,1 †
headline			(S) TE	0,1
language		ISO 639-2/T	(S) TE	0,1
text	(INFORM) (NINFOM)		(S) TE	0,1 †

† For each instance of fixed date range, at least one of the sub-attributes **date end** or **date start** must be populated.

For each instance of **information**, at least one of the sub-attributes **file reference** or **text** must be populated.

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** and the Information type **Spatial Quality** (see clause 24.5) for an overall 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 clauses 2.4.7 and 24.5).

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.

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.

In order to provide an indication of the horizontal position and vertical accuracies of the features to which it applies, each instance of **Quality of Bathymetric Data** must be associated to an instance of the information type **Spatial Quality** (see clause 24.5), using the association **Quality of Bathymetric Data Composition** (see clause 25.12).

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 individual/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.

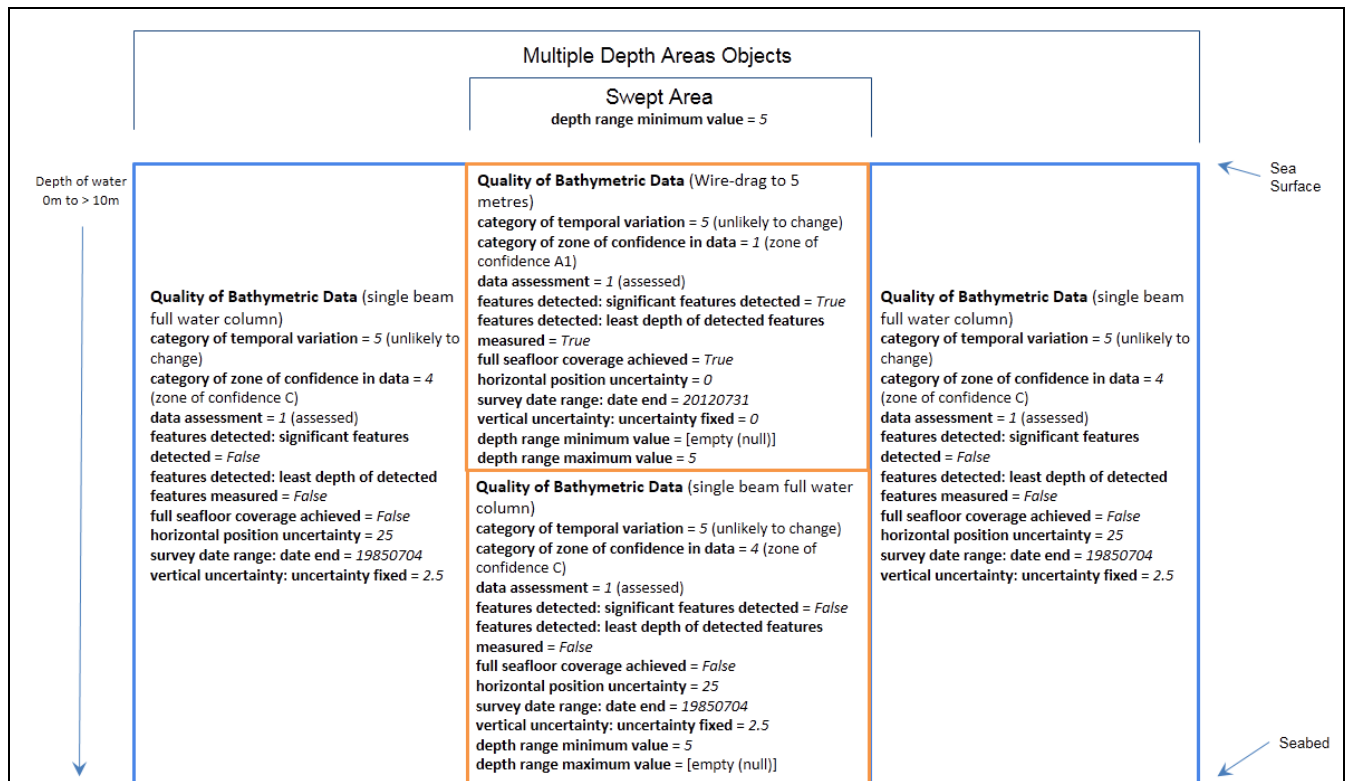


Figure 3-2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a mechanically 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 above 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; and **category of zone of confidence in data** = 6 (zone of confidence U) 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; complex attribute **features detected**, Boolean sub-attributes

least depth of detected features measured and **significant features detected** set to *False*; the **zone of confidence** sub-attribute **category of zone of confidence in data** reclassified to 5 (zone of confidence D); and the attributes **horizontal position accuracy (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** on the associated **Spatial Quality** 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 seafloor, 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 **zone of confidence** is used on a **Quality of Bathymetric Data** feature to 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 **zone of confidence** should be encoded to provide an indication of the degradation of the overall 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)) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.71) in accordance with the values populated for the attribute **full seafloor coverage achieved**; the complex attribute **features detected**; and the complex attributes **horizontal position uncertainty** and **vertical uncertainty** on the associated **Spatial Quality**.
 - 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 complex attribute **vertical uncertainty** on the associated **Spatial Quality** is used to specify the vertical uncertainty of the depths covered by the surface. When **depth range minimum value** is specified on **Quality of Bathymetric Data**, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.
 - The complex attribute **horizontal position uncertainty** on the associated **Spatial Quality** is used to specify the positional uncertainty of the depths covered by the surface.
- **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 set to a value 0.1 metres deeper than the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see 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 0.1 metres shallower than the **depth range minimum value** for the **Quality of Bathymetric Data** feature defining the quality for the level below (see Figure 3-2 above).
- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area** features that contain 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 **zone of confidence (category of zone of confidence in data)** = 5 (zone of confidence D). The attributes **vertical uncertainty (uncertainty fixed)** and **horizontal position uncertainty (uncertainty fixed)** for the associated **Spatial Quality** should be populated with an empty (null) value.
- For **Unsurveyed Area** features that do 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 the **Quality of Bathymetric Data** using the association **Quality of Bathymetric Data Composition** (see clause 25.12) applies to bathymetric data situated within the surface, while **Spatial Quality (quality of horizontal measurement)** or **(horizontal position uncertainty)** on the associated spatial types using the association **Spatial Association** (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 seafloor, which may be considered 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 an associated instance of the information type **Spatial Quality**, complex attribute **vertical uncertainty** (see clause 24.5) and using the association **Quality of Bathymetric Data Composition** (see clause 25.12). If it is required to encode additional sounding uncertainty information, it must be done using the attributes **quality of vertical measurement** and **technique of vertical measurement** on groups of soundings or individual features; or—by associating another instance of the information type **Spatial Quality** to the spatial type associated with the individual geo features. Note that this is a mandatory requirement for the features **Sounding** and **Underwater/Awash Rock**; and **Foul Ground**, **Marine Farm/Culture**, **Obstruction** and **Wreck** of type point, of depth 30 metres or less.

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

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

Feature/Information associations: Quality of Bathymetric Data Composition

Spatial/Information association: Spatial Association

24.5 Spatial quality

IHO Definition: 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>
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S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
horizontal position uncertainty			(S) C	0,1 †
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1 †
vertical uncertainty			C	0,1 †
uncertainty fixed	(SOUACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1

† At least one of the attributes **horizontal position uncertainty**, **quality of horizontal measurement** or **vertical uncertainty** must be populated.

INT 1 Reference:

24.1 Spatial quality

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.

Spatial quality attributes are carried in the information type **Spatial Quality**. Only point, multipoint and curve geometry and the meta feature **Quality of Bathymetric Data** can be associated with spatial quality. Currently no use case for associating surface 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.

Each instance of **Spatial Quality** must be associated to the geometry to which the information applies using the association **Spatial Association** (see clause 25.14); or in the case of **Spatial Quality** associated with **Quality of Bathymetric Data**, using the association **Quality of Bathymetric Data Composition** (see clause 25.12).

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.

Remarks:

- The complex attributes **horizontal position accuracy** and **vertical accuracy** are used to specify horizontal position and vertical uncertainty. 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 25.12).
 - The complex attribute **vertical uncertainty** must be used to specify the vertical uncertainty of the depths covered by the associated **Quality of Bathymetric Data**. When **depth range minimum value** is specified for the associated **Quality of Bathymetric Data** feature, **vertical uncertainty** refers only to the uncertainty of the swept depth defined by **depth range minimum value**.

- The complex attribute **horizontal position uncertainty** must be used to specify the positional uncertainty of the depths covered by the associated **Quality of Bathymetric Data** feature.
- The sub-attribute **quality of horizontal measurement** must not be populated.
- Uncertainty due to temporal variation should not be included where the spatial accuracy is degraded over time. However, where it is considered that the uncertainty has increased sufficiently over time that it is required to indicate this to the Mariner, this must be done by amending the complex attributes **vertical uncertainty** and **horizontal position uncertainty** through issuance of an ENC Update.
- For the geometry associated with all **Sounding** and **Underwater/Awash Rock** features; and **Foul Ground, Marine Farm/Culture, Obstruction** 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 **Quality of Bathymetric Data Composition**. For the majority of, if not all, these features this should be done by using the instance of **Spatial Quality** associated with the underlying **Quality of Bathymetric Data** representing the overall indication of the quality of bathymetric data for the area.
- The attribute **quality of horizontal measurement** may be used on **Spatial Quality** to provide an indication of lower accuracy quality of depth features, in addition to population of **horizontal position accuracy**, than the underlying **Quality of Bathymetric Data** indicates, however where this is done the **Spatial Quality** feature must not be associated to a **Quality of Bathymetric Data** feature.

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

Feature/Information association: Quality of Bathymetric Data Composition

Spatial/Information association: Spatial Association

SCENARIO 2

3.7 Quality of bathymetric data

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, 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
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	1,1
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			(S) C	1,1
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
survey date range		See clause 2.4.8	C	1,1
date end	(SUREND)		(S) TD	1,1
date start	(SURSTA)		(S) TD	0,1
vertical uncertainty			C	1,1
uncertainty fixed	(SOUACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
zone of confidence			C	1,*
category of zone of confidence in data	CATZOC	1 : zone of confidence A1	EN	1,1

		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		
fixed date range		See clause 2.4.8	(S) C	0,1
date end	(DATEND)		(S) TD	0,1 †
date start	(DATSTA)		(S) TD	0,1 †
information		See clause 2.4.6	C	0,*
file locator			(S) TE	0,1
file reference	(TXTDSC) (NXTDSC)		(S) TE	0,1 †
headline			(S) TE	0,1
language		ISO 639-2/T	(S) TE	0,1
text	(INFORM) (NINFOM)		(S) TE	0,1 †

† For each instance of fixed date range, at least one of the sub-attributes **date end** or **date start** must be populated.

For each instance of **information**, at least one of the sub-attributes **file reference** or **text** must be populated.

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 individual/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.

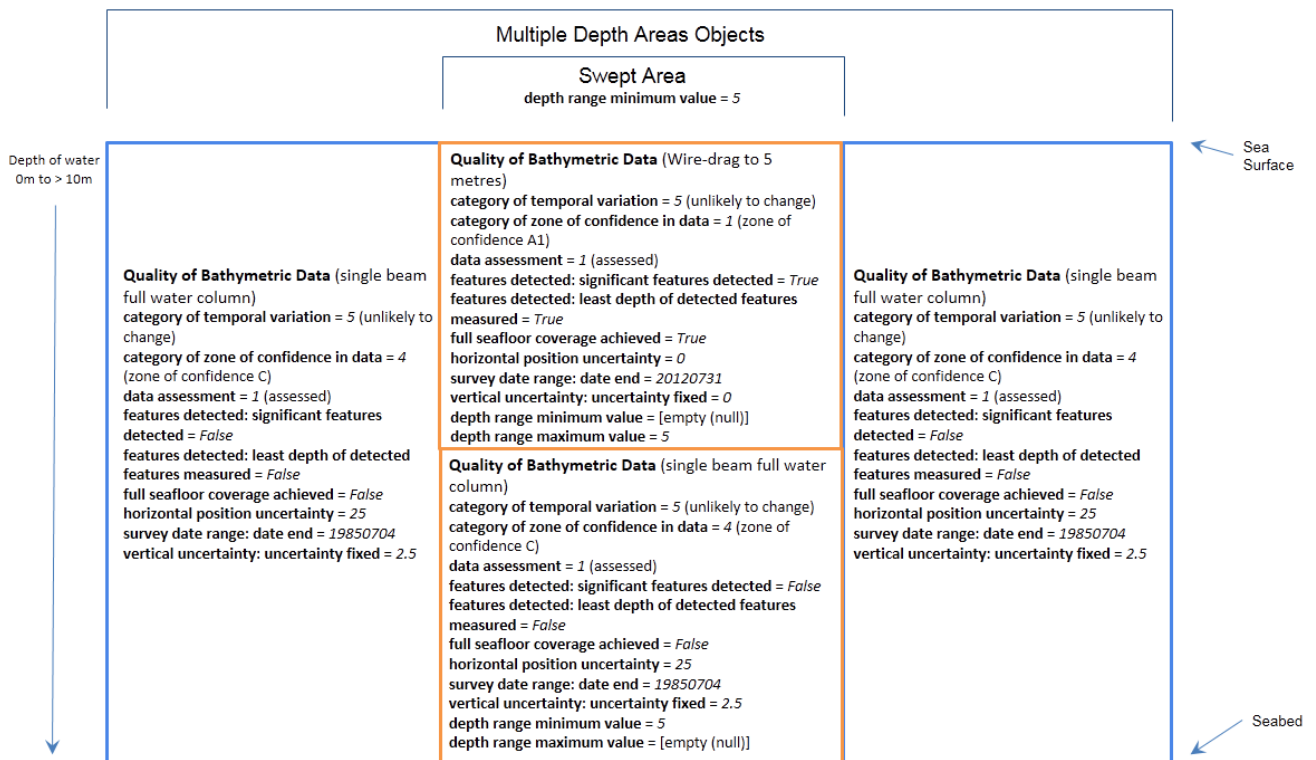


Figure 3-2 – Adjoining and overlapping Quality of Bathymetric Data features

The Figure above demonstrates the encoding for varying quality of bathymetric data in the water column, in this example a mechanically 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 above is intended to provide the highest (best) quality indicator for vessels navigating at a safety depth of less than 5 metres in the area.

In order to provide an indication of the horizontal position and vertical accuracies of the features to which it applies, each instance of **Quality of Bathymetric Data** must be associated to the features to which the **Quality of Bathymetric Data** applies (**Sounding** and **Underwater/Awash Rock** features; and **Foul Ground**, **Marine Farm/Culture**, **Obstruction** and **Wreck** features of type point) of depth 30 metres or less, using the association **Quality of Bathymetric Data Association** (see clause 25.12). Where some features within the area have a different horizontal and vertical accuracy, an additional instance(s) of **Quality of Bathymetric Data**, having no geometry, may be associated to these features (see clause 3.7.1.3).

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; **horizontal position uncertainty** (**uncertainty fixed**) and **vertical uncertainty** (**uncertainty fixed**) = [empty (null)]; and **category of zone of confidence in data** = 6 (zone of confidence U) 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*; complex attribute **features detected**, Boolean sub-attributes **least depth of detected features measured** and **significant features detected** set to *False*; **horizontal position accuracy (uncertainty fixed)** and **vertical uncertainty (uncertainty fixed)** populated with an empty (null) value; and **zone of confidence** sub-attribute **category of zone of confidence in data** reclassified to 5 (zone of confidence D) 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 seafloor, 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 complex attribute **vertical uncertainty** is used to specify the vertical uncertainty of the depths covered by the surface. 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 complex attribute **horizontal position uncertainty** is used to specify the positional uncertainty of the depths covered by the surface.
- Uncertainty due to temporal variation should not be included where the spatial accuracy is degraded over time. However, where it is considered that the uncertainty has increased sufficiently over time that it is required to indicate this to the Mariner, this must be done by amending the complex attributes **vertical uncertainty** and **horizontal position uncertainty** through issuance of an ENC Update.
- The mandatory complex attribute **zone of confidence** is used on a **Quality of Bathymetric Data** feature to 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 **zone of confidence** should be encoded to provide an indication of the degradation of the overall 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)) for areas of bathymetry. These values must be determined from the **category of zone of confidence in data** definition table (see clause 27.71) in accordance with the values populated for the attribute **full seafloor coverage achieved** and the complex attributes **features detected**, **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.
- **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 set to a value 0.1 metres deeper than the **depth range maximum value** for the **Quality of Bathymetric Data** feature defining the quality for the level above (see 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 shoaler 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 0.1 metres shoaler than the **depth range minimum**

value for the **Quality of Bathymetric Data** feature defining the quality for the level below (see Figure 3-2 above).

- **Quality of Bathymetric Data** must be encoded over **Unsurveyed Area** features that contain 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*; **vertical uncertainty (uncertainty fixed)** and **horizontal position uncertainty (uncertainty fixed)** = [empty (null)]; and **zone of confidence (category of zone of confidence in data)** = 5 (zone of confidence D).
- For **Unsurveyed Area** features that do 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.
- **horizontal position uncertainty** on the **Quality of Bathymetric Data** applies to bathymetric data situated within the surface, while **Spatial Quality (quality of horizontal measurement)** or (**horizontal position uncertainty**) on the associated spatial types using the association **Spatial Association** (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 seafloor, 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

The sounding uncertainty information populated on the **Quality of Bathymetric Data** surface features covering the area of bathymetry for the dataset must reflect the most commonly associated values for the **Foul Ground, Marine Farm/Culture, Obstruction, Sounding, Underwater/Awash Rock** and **Wreck** features within the areas. Where there are individual features located within an area having quality information that is different from the underlying **Quality of Bathymetric Data** feature, this should be indicated using the attributes **quality of vertical measurement** and **technique of vertical measurement** on groups of soundings or individual features; or, where the horizontal accuracy is lower than the underlying **Quality of Bathymetric Data** indicates, using the attribute **quality of horizontal measurement** on an associated instance of the Information type **Spatial Quality** (see clause 24.5).

Alternatively, an additional **Quality of Bathymetric Data** feature having no geometry may be encoded; and associated to the relevant feature(s) using the association **Quality of Bathymetric Data Association** (see clause 25.12). Note that this is a requirement where the feature(s) are of depth 30 metres or less (see clause 3.7.1).

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

Feature/Information associations: Quality of Bathymetric Data Association

Spatial/Information association: Spatial Association

24.5 Spatial quality

IHO Definition: **SPATIAL QUALITY**. The indication of the quality of the locational information for features in a dataset.

S-101 Information Type: Spatial Quality

Primitives: None

Real World

Paper Chart Symbol

ECDIS Symbol

S-101 Attribute	S-57 Acronym	Allowable Encoding Value	Type	Multiplicity
horizontal position uncertainty			(S) C	0,1 †
uncertainty fixed	(POSACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1
quality of horizontal measurement	(QUAPOS)	4 : approximate 5 : position doubtful	EN	0,1 †
vertical uncertainty			C	0,1 †
uncertainty fixed	(SOUACC)		(S) RE	1,1
uncertainty variable factor			(S) RE	0,1

† At least one of the attributes **horizontal position uncertainty**, **quality of horizontal measurement** or **vertical uncertainty** must be populated.

INT 1 Reference:

24.5.1 Spatial quality

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.

Spatial quality attributes are carried in the information type **Spatial Quality**. Only point, multipoint and curve geometry can be associated with spatial quality. Currently no use case for associating surface 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.

Each instance of **Spatial Quality** must be associated to the geometry to which the information applies using the association **Spatial Association** (see clause 25.14).

Remarks:

- The complex attributes **horizontal position accuracy** and **vertical accuracy** are used to specify the horizontal position and vertical uncertainty.
- The indication of the overall quality of the bathymetric data for bathymetric features (**Sounding** and **Underwater/Awash Rock** features; and **Foul Ground**, **Marine Farm/Culture**, **Obstruction** and **Wreck** features of type point), of depth 30 metres or less, must be encoded using the meta feature **Quality of Bathymetric Data** (see clause 3.7), associated to the relevant geo features using the association **Quality of Bathymetric Data Association** (see clause 25.12). Where this occurs and it is considered important to provide the Mariner with an indication that an associated feature is of lower quality than the quality indicated by the underlying **Quality of Bathymetric Data** feature, this may be done by encoding an associated instance of **Spatial Quality** having the attribute **quality of horizontal measurement** populated. There must be no **Spatial Quality** having attributes **horizontal position uncertainty** and **vertical uncertainty** associated with **Sounding**, **Underwater/Awash Rock**, **Foul Ground** (point), **Marine Farm/Culture** (point), **Obstruction** (point) and **Wreck** (point) features of depth 30 metres or less.

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

Spatial/Information association: Spatial Association

25.12 Quality of bathymetric data association

IHO Definition: **QUALITY OF BATHYMETRIC DATA ASSOCIATION.** The association between the quality-related characteristics of bathymetric data and the bathymetric features themselves.

Remarks:

- No remarks.

Role Type	Role	Associated With	Multiplicity
Composition Association	Defines	Quality of Bathymetric Data	1,1
	Defined for	Foul Ground, Marine Farm/Culture, Obstruction, Sounding, Underwater/Awash Rock, Wreck	0,* {1,* [C]}