DQWG13-10B Rev1

Paper for Consideration by Data Quality Working Group

Mismatch between S-44 and CATZOC

Submitted by:	HSPT
Executive Summary:	Suggestion to resolve the mismatch between S-44 and CATZOC.
Related Documents:	S-44 5th Edition February 2008, S-57 Supplement No.3 June 2014, S101_Data Classification and Encoding Guide Final, INSPIRE Data Specification on Elevation – Technical Guidelines
Related Projects:	S-101

Introduction / Background

IHO Standard for Hydrographic Surveys (S-44) is designed to provide a set of standards for the execution of hydrographic surveys for the collection of data which will primarily be used to compile navigational charts to be used for the safety of surface navigation and the protection of the marine environment. The publication "S-57—IHO Transfer Standard for Digital Hydrographic Data" describes the standard to be used for the exchange of digital hydrographic data between national hydrographic offices and for its distribution to manufacturers, mariners and other data users. The computation of Vertical Uncertainty present in both standards is computed in a different manner and with different coefficients.

Analysis/Discussion

S-44 Table 1lists the minimum standards for hydrographic surveying. The following criteria are used:

- Maximum allowable THU 95% confidence level
- Maximum allowable TVU 95% confidence level
- Full Sea Floor Search (YES/NO)
- Feature Detection
- Recommended Maximum Line Spacing
- Position of fixed aids to navigation and topography significant to navigation 95% confidence level
- Positioning of the coastline and topography less significant to navigation 95% confidence level
- Mean position of floating aids to navigation 95% confidence level

Total propagated uncertainty (TPU): the result of uncertainty propagation, when all contributing measurement uncertainties, both random and systematic, have been included in the propagation. Uncertainty propagation combines the effects of measurement uncertainties from several sources upon the uncertainties of derived or calculated parameters.
Total vertical uncertainty (TVU): The component of total propagated uncertainty (TPU) calculated in the vertical dimension. TVU is a 1 Dimensional quantity.

Recognising that there are both constant and depth dependent uncertainties that affect the uncertainty of the depths, the formula below is to be used to compute, at the 95% confidence level, the maximum allowable TVU. The parameters "a" and "b" for each Order, as given in the Table, together with the depth "d" have to be introduced into the formula in order to calculate the maximum allowable TVU for a specific depth:

$\sqrt{(a^2 + (b*d))^2}$

Where:

a represents that portion of the uncertainty that does not vary with depth;
b is a coefficient which represents that portion of the uncertainty that varies with depth;
d is the depth;
b x d represents that portion of the uncertainty that varies with depth;

For Special Order: a = 0.25 metre, b = 0.0075;
For Order 1a and 1b: a = 0.5 metre, b = 0.013;
For Order 2: a = 1.0 metre, b = 0.023;

S-44 describes the difference between Uncertainty and Uncertainty Surface:
Uncertainty: The interval (about a given value) that will contain the true value of the measurement at a specific confidence level. The confidence level of the interval and the assumed statistical distribution of errors must also be quoted. In the context of this standard the terms uncertainty and confidence interval are equivalent.
Uncertainty Surface: A model, typically grid based, which describes the depth uncertainty of the product of a survey over a contiguous area of the skin of the earth. The uncertainty surface should retain sufficient metadata to describe unambiguously the nature of the uncertainty being described.

S-57 defines Quality of data in the Object Class M_QUAL. It defines an area within which a uniform assessment of the quality of the data exists. One of its attributes is CATZOC: category of zone of confidence in data. They can hold the following values:

- Zone of confidence A1
- Zone of confidence A2
- Zone of confidence B
- Zone of confidence C
- Zone of confidence D
- Zone of confidence U

The ZOC Table contains the following criteria regarding the survey:

- Position accuracy
- Depth accuracy
- Seafloor coverage
- Typical survey characteristcs

Depth accuracy of depicted soundings = a + (b*d)/100 at 95% CI (2.00 sigma), where d = depth in metres at the critical depth.

For A1 depth accuracy: a = 0.50, b = 0.01 (1/100)
For A2 depth accuracy: a = 1.00, b = 0.02 (2/100)
For B depth accuracy: a = 1.00, b = 0.02 (2/100)
For C depth accuracy: a = 2.00, b = 0.05 (5/100)
For D worse than C
For U unassessed, the quality of the bathymetric data has yet to be assessed.

Result: with the current system, any survey performed at S-44 Order 1a or 1b, the uncertainty of individual measured points on the seafloor is better than the assigned CATZOC value of A1 or lower quality levels. A survey performed at S-44 Order 2, the uncertainty of individual points on the seafloor is better than the assigned CATZOC value of A2 or lower quality levels.

HSPT suggests DQWG to change the CATZOC coefficients a en b to match S-44.
HSPT suggests to apply the S-44 formula for CATZOC depth accuracy.

Considerations:

1. Horizontal and vertical uncertainty of a surface is different from horizontal and vertical uncertainty of single measurements. The uncertainty of a surface is also effected by the method the surface is build from single measurements. The horizontal and vertical uncertainty of a surface is always lower then the accuracy of a single point due to the gridding process, assuming the dataset is coming from a unique sensor.
2. A change of parameters can influence already existing assigned values of CATZOC in published ENCs.
3. The computation methodology for calculating uncertainty is different between the two standards, probably historically grown. In S-101 DCEG, CATZOC is replaced by Quality of Bathymetric Data. The table and computation for computing horizontal and vertical uncertainty is not yet published. This should be addressed by the DQWG.
4. ISO standard 19157published the standards on Geographic Information – Data Quality. The part on Positional Accuracy lists the possible measures:

Definition	Measure	Description
Positional Accuracy		
Vertical Position Accuracy	LinearMapAccuracy2Sigma	Half length of the interval defined by an upper and lower limit in which the true value lies with probability 95%.
Horizontal Position Accuracy	CircularError95	Radius describing a circle, in which the true point location lies with the probability of 95%.
Gridded Data Position Accuracy	CircularError95	Radius describing a circle, in which the true point location lies with the probability of 95%.

INSPIRE Data Specification on Elevation – Technical Guidelines p.92 makes a recommendation this subject:

Recommendation 29: Absolute or external accuracy of the vertical component of vector objects within vector data sets and within TIN structures and of values composing the range of grid elevation coverages, should be evaluated and documented using Root mean square error as specified below:

The true value of an observable Z is known as Z_t. From this, the estimator:

$$\sigma_z = \sqrt{((1/N)\sum_{i=1}^{N} (Z_{mi} - z_t)^2)}$$

yields to the linear root mean square error RMSE = σ_Z.

Conclusions

Alignment of parameters between online survey uncertainty and charted uncertainty is not necessarily desired as the number of remote sensing techniques develop at a fast pace whereas charted uncertainty is user driven and should remain constant unless user requirements change.

Recommendations

DQWG to investigate the guidelines how horizontal and vertical uncertainty for quality of bathymetric data should be calculated in S-101 DCEG.

Justification and Impacts

Change of CATZOC in S-57 has an impact on already published ENCs and should be avoided. Quality of measurement and quality in user context is also described in S-121 product specification. Harmonization on this item is required.

Action Required of Data Quality Working Group

The DQWG is invited to:

a. note this paper

b. discuss this paper

c. advise HSPT and S-121