Proposal: Standardization Between S-44 and S-100 Maximum Allowable Total Vertical Uncertainty

August 28, 2023

Subject:

There are differences between the maximum allowable Total Vertical Uncertainty (TVU) thresholds of S-44 Standards for Hydrographic Surveys and S-57/S-101 ENC Product Specification. First, thresholds are calculated from different equations and second the variables are rounded to different precision.

Depending on a hydrographic office's implementation, this may cause problems because:

1. IHO Survey Order classification is insufficient to determine the CATZOC classification with respect to vertical uncertainty;
2. It is problematic to have inconsistent requirements within an international standards organization

	Equation	Fixed (a) Precision	Variable (b) Precision
S-44	$\sqrt{a^2 + (b \times d)^2}$	0.0 and 0.00	0.000 and 0.0000
S-57/S-101	$a + (b \times d)$	0.0	0.00

Figure 1: Equations for maximum allowable TVU and their associated precision.

Background:

The S-44 and S-57 maximum allowable TVU thresholds were developed independently of each other. Over the years this inconsistency was raised but an appropriate solution has not been identified due to the potential consequences of using one equation over the other for both standards.

Implication:

The main implication is the inability to realize the CATZOC classification from the Survey Order Classification with respect to vertical uncertainty. This is illustrated in the graph below which demonstrates the comparison of maximum TVU for S-44 Orders 1a & 1b compared to CATZOC A1. For depths <145 meters, the S-44 equation and rounding rules create a lower threshold (blue line) and for depths > 145 meters the S-57/S-101 equation creates a lower threshold (orange line). Following the math in the current standards, an IHO Order 1a or 1b survey in 200 meters of water with a TVU of 2.55m cannot be classified as a CATZOC A1.

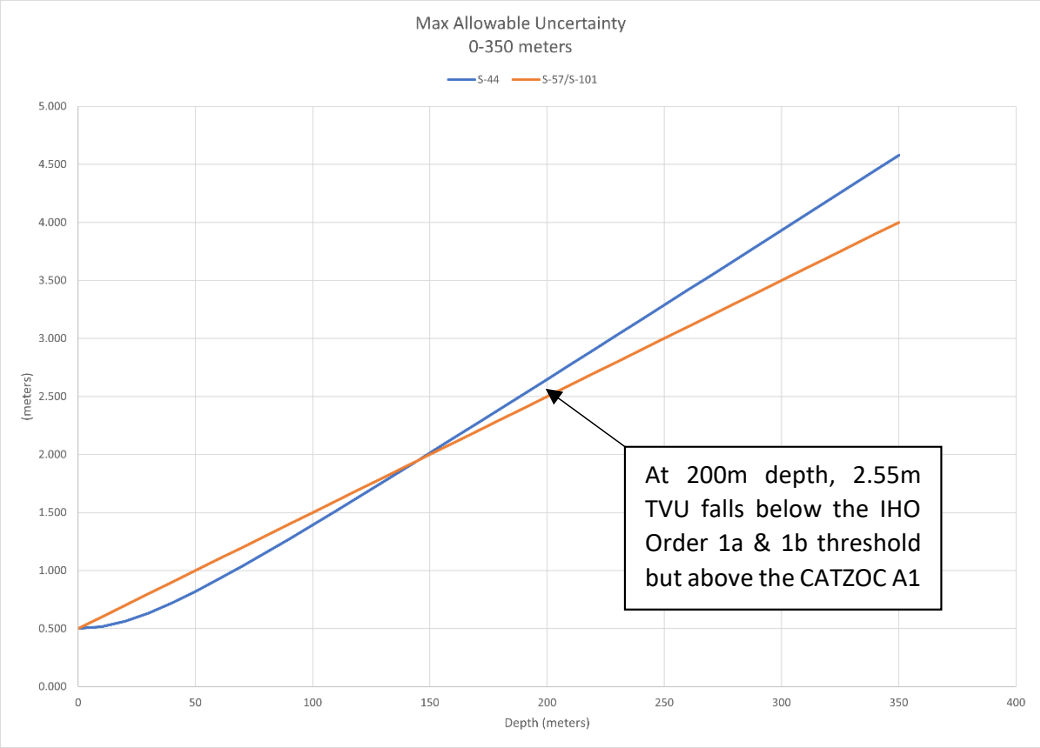


Figure 2: Maximum TVU for S-44 Orders 1a & 1b compared to CATZOC A1

This inconsistency is further clarified in the new "Guidelines and Recommendations for Hydrographic Offices for the Allocation of CATZOC/QOBD Values from Survey Data". The DQWG took this very complex issue and demonstrated the inconsistency very clearly in the depth accuracy table on page 7 (note the split cell).

7.5 Check 5: Depth accuracy

Table 7-5 – Valid CATZOC Capabilities for the Survey Orders based on depth accuracy

Vertical Accuracy	Survey Order tolerance	$\sqrt{((0.15^2 + (0.0075*d)^2)}$	$\sqrt{((0.25^2 + (0.0075*d)^2)}$	$\sqrt{((0.5^2 + (0.013*d)^2)}$		$\sqrt{((0.5^2 + (0.013*d)^2)}$		$\sqrt{((1.0^2 + (0.023*d)^2)}$
ZOC tolerance	Survey / Zoc/QoBD	Exclusive	Special	1a		1b		2
0.5m+0.01*d	A1/1			d≤145 m	d≥145 m	d≤145 m	d≥145 m	
1.0m+0.02*d	A2/2							
1.0m+0.02*d	B/3							
2.0m+0.05*d	C/4							
>2.0m+0.05*d	D/5							
N/A	U/6							
N/A	-/Oceanic							

d=depth

Figure 3: Extract of Depth Accuracy table from IHO S-68 document.

Proposals:

Option 1:

Change the S-57/S-100 equation and rounding precision to the S-44 equation and rounding precision.

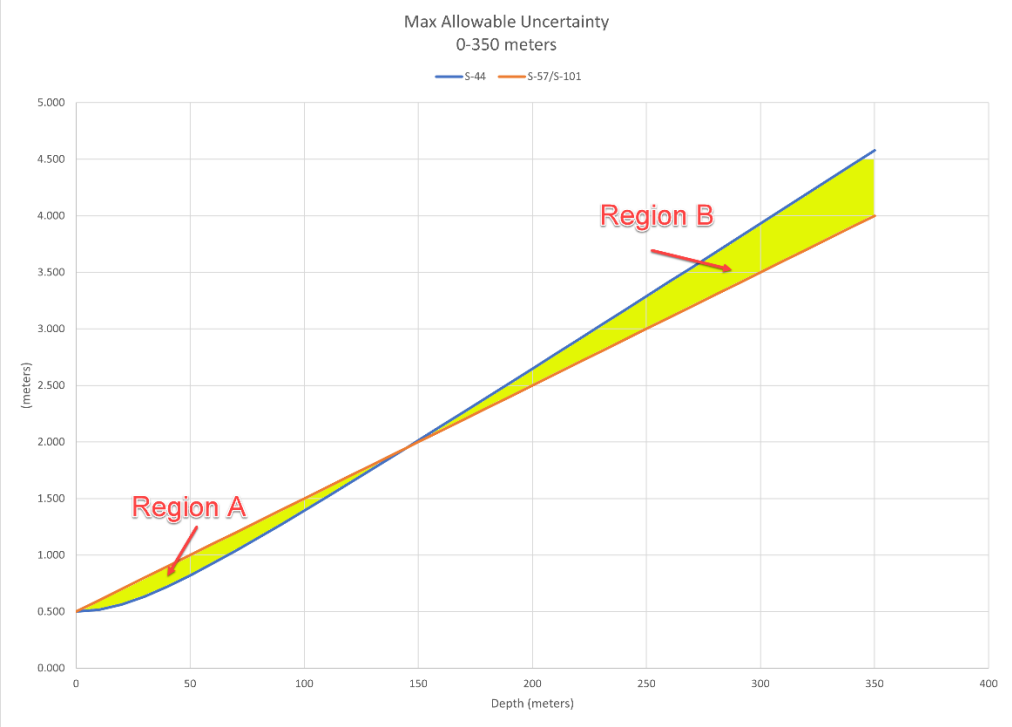
	Equation	Fixed (a) Precision	Variable (b) Precision
S-44	$\sqrt{a^2 + (b \times d)^2}$	0.0 and 0.00	0.000 and 0.0000
S-57/S-101	$\sqrt{a^2 + (b \times d)^2}$	0.0 and 0.00	0.000 and 0.0000

Implications:

A. Higher accuracy threshold in shallower waters (i.e. < 145 meters) resulting in surveys with lower vertical uncertainty to be classified as CATZOC A1.
B. The root sum square method is more appropriate mathematically because it is generally the appropriate way to combine independent variables.
C. If a hydrographic office evaluates the actual TVU to the CATZOC TVU threshold, then some surveys may require a re-evaluation to determine if the CATZOC is correct. However, if the hydrographic office uses survey Order to drive their CATZOC decision, then no change is required.

   Note, the areas of concern are small. Using the same example as above with Order 1a & 1b compared to CATZOC A1, the areas are highlighted in yellow in the figure below which have been labeled as "Region A" and "Region B". Either of these scenarios should have thrown a red flag as they would be out of the ordinary.

   - Region A (<145 meters): A survey was not classified as Order 1a or 1b but was classified as CATZOC A1
   - Region B (>145 meters): A survey was classified as Order 1a or 1b but was not classified as CATZOC A1



Option 2:

Change the S-44 equation and rounding precision to the S-57/S-100 equation and rounding precision.

	Equation	Fixed (a) Precision	Variable (b) Precision
S-44	$a + (b \times d)$	0.0	0.00
S-57/S-101	$a + (b \times d)$	0.0	0.00

Implications:

A. This is a more relaxed threshold in shallower waters (i.e. < 145 meters) resulting in surveys with higher vertical uncertainty to be classified as CATZOC A1.
B. A simplified method to calculate the uncertainty threshold.
C. In most cases this threshold calculation method would not follow the same calculation method (i.e. root sum squared) as standard error model calculations.

Option 3:

Make no change and continue with different equations and rounding rules between S-44 and S-57/S-101 standards.

Implications:

A. Hydrographic offices that use S-44 Orders to determine CATZOC should recognize the risk that surveys > 145 meters may have been mis-classified as CATZOC A1 if the actual TVU is greater than the S-57/S-100 TVU threshold.
B. Continued inability to realize CATZOC and/or QoBD classifications with regards to vertical uncertainty from S-44 Survey Orders.
C. Continued lack of standardization and discrepancies of standards within the IHO, leading to potential reputational impact.

References:

- IHO S-101 Edition 1.1.0
  - CATZOC Pages 607-609
  - Uncertainty fixed and uncertainty variable factor Page 676
- IHO S-44 Edition 6.1.0
  - Table 1 Page 18