

*Update After Paper Distribution*

# ~~Maximum Allowable Total Vertical Uncertainty Discrepancies in IHO Standards~~

February 2024

# Executive Summary

- Since the paper was written the HSWG team has received further input and discussed this issue further.
- S-44 and S-57/S-101 have different mechanisms for classifying data quality (*e.g. TVU & THU thresholds, coverage terminology*), CATZOC is internally inconsistent (*position accuracy only varies with depth for A1*), and there is no CATZOC above A1 for Exclusive and Special Survey Orders.
- HSWG Chair Team proposes to define a harmonized method to classify survey and data accuracy on navigational products taking into account all of the criteria (*uncertainty (TVU & THU), coverage, feature detection*) to ensure standard categorization. MODEL DEVELOPMENT
- HSWG proposes the creation of a Project Team which includes members from S-44, S-101, S-102, S-68, S-57, etc. to identify this unified method.
- It is critical that we make this change now before the operational version of S-101 is implemented. ***These changes should only apply to products going forward.***

# Executive Summary

- This change is critical because:
  - CATZOC classification may be inconsistent across hydrographic offices
  - IHO Survey Order classification cannot be used as an input to determine the CATZOC classification
  - IHO Survey Order is insufficient when identifying requirements for a new survey intended to support a specific CATZOC product
  - It is problematic to have inconsistent standards for a similar parameter within an international standards organization
- This harmonized method will improve data throughput, eliminate confusion across standards and ensure the data on the edges of classification boundaries are consistently categorized correctly. As such, **the benefits in procedures are large and the changes to classifications will be small.**

MODEL  
DEVELOPMENT

# Background: TVU

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

Differences:

- thresholds are calculated from different equations
- variables are rounded to different precision

The thresholds were developed independently of each other.

Over the years this inconsistency was raised but an appropriate solution has not been identified due to:

- CATZOC was to be abolished with the initiation of independent data quality attributes
- potential consequences of using one equation over the other for both standards

MODEL  
DEVELOPMENT

# Analysis: TVU

Main implication:

Inability to determine the CATZOC classification from the Survey Order Classification with respect to vertical uncertainty.

Update After Paper Distribution:  
New graph shows all Survey Orders  
and all CATZOCs

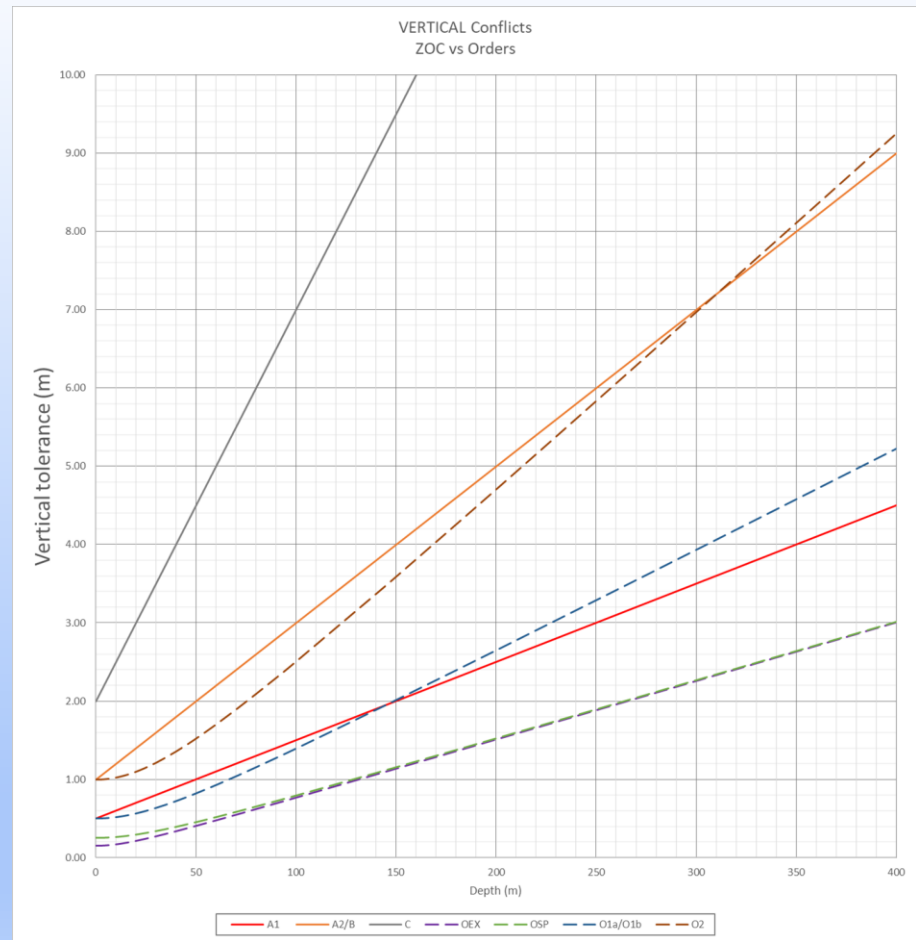


Figure 1: Comparison of maximum TVU for S-44 Orders compared to CATZOC.

# Analysis: TVU Example

Region A (<145 meters): A survey could not be classified as Order 1a or 1b but can be classified as supporting a CATZOC A1 product.

Region B (>145 meters): A survey can be classified as Order 1a or 1b but cannot be classified as supporting a CATZOC A1 product.

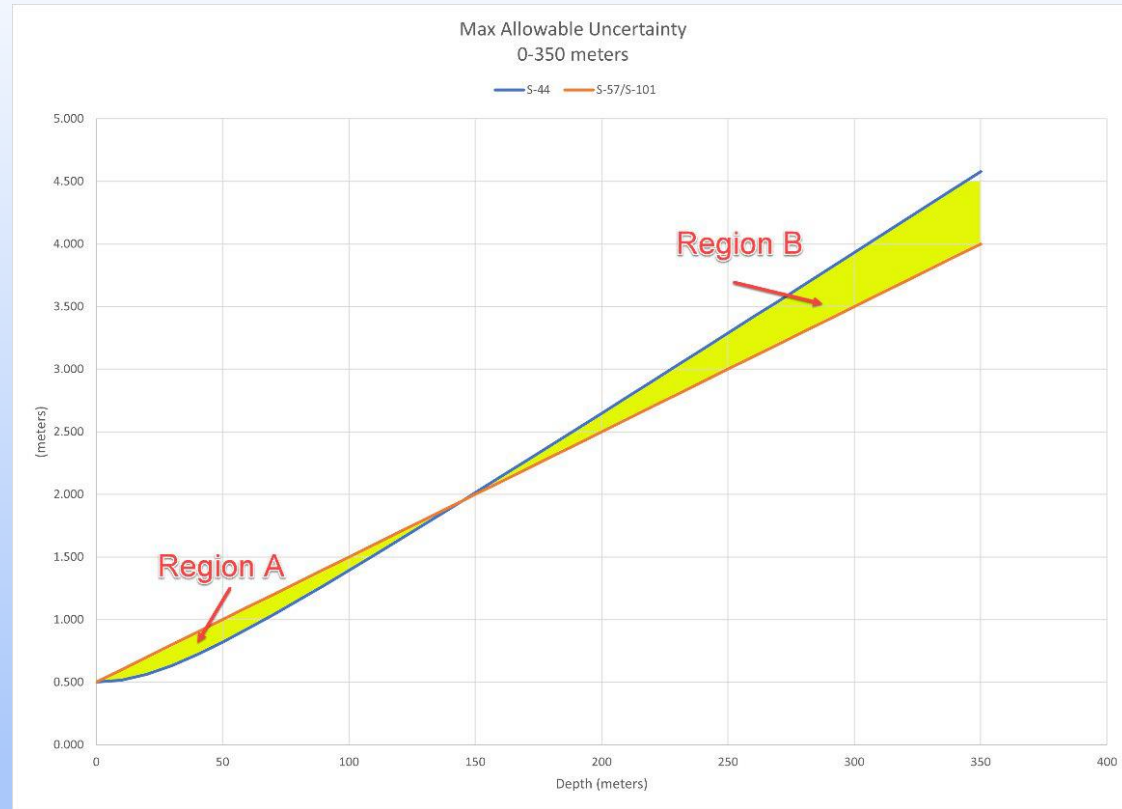


Figure 2: Comparison of maximum TVU for S-44 Orders 1a & 1b compared to CATZOC A1. The areas are highlighted in yellow and labeled as “Region A” and “Region B”. Either of these scenarios should have thrown a red flag as they would be out of the ordinary.

# Analysis:TVU

The inconsistency is further illustrated in S-68 table 7.5.

Note the split cells which demonstrate the misalignment between the standards.

## 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 Zoc/QoBD	$\sqrt{((0.15^2 + (0.0075^2 \cdot d^2))}$	$\sqrt{((0.25^2 + (0.0075^2 \cdot d^2))}$	$\sqrt{((0.5^2 + (0.013^2 \cdot d^2))}$	$\sqrt{((0.5^2 + (0.013^2 \cdot d^2))}$	$\sqrt{((1.0^2 + (0.023^2 \cdot d^2))}$		
		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: S-68 “Guidelines and Recommendations for Hydrographic Offices for the Allocation of CATZOC/QOBD Values from Survey Data”

# Additional Discrepancies Besides TVU Threshold

(discussed after paper distribution)

## Total Horizontal Uncertainty Threshold

- S-44 remains constant for the strict Special and Exclusive Orders but varies with depth for Orders 1 and 2
- S-57/S101 varies with depth for CATZOC 1A but remains constant for CATZOC A2, B & C

ZOC Table:

1	2
ZOC <sup>1</sup>	Position Accuracy <sup>2</sup>
A1	± 5 m + 5% depth
A2	± 20 m
B	± 50 m
C	± 500 m

Reference	Criteria	Order 2	Order 1b	Order 1a	Special Order	Exclusive Order
<a href="#">Chapter 1</a>	Area description (Generally)	Areas where a general description of the sea floor is considered adequate.	Areas where underkeel clearance is not considered to be an issue for the type of surface shipping expected to transit the area	Areas where underkeel clearance is considered not to be critical but features of concern to surface shipping may exist	Areas where underkeel clearance is critical	Areas where there is strict minimum underkeel clearance and manoeuvrability criteria
<a href="#">Section 2.6</a>	Depth THU [m] + [% of Depth]	20 m + 10% of depth	5 m + 5% of depth	5 m + 5% of depth	2 m	1 m

Figure 4: S-44 Table 1 (above) and ZOC Table (right)



# Additional Discrepancies Besides TVU Threshold

## Total Horizontal Uncertainty Threshold

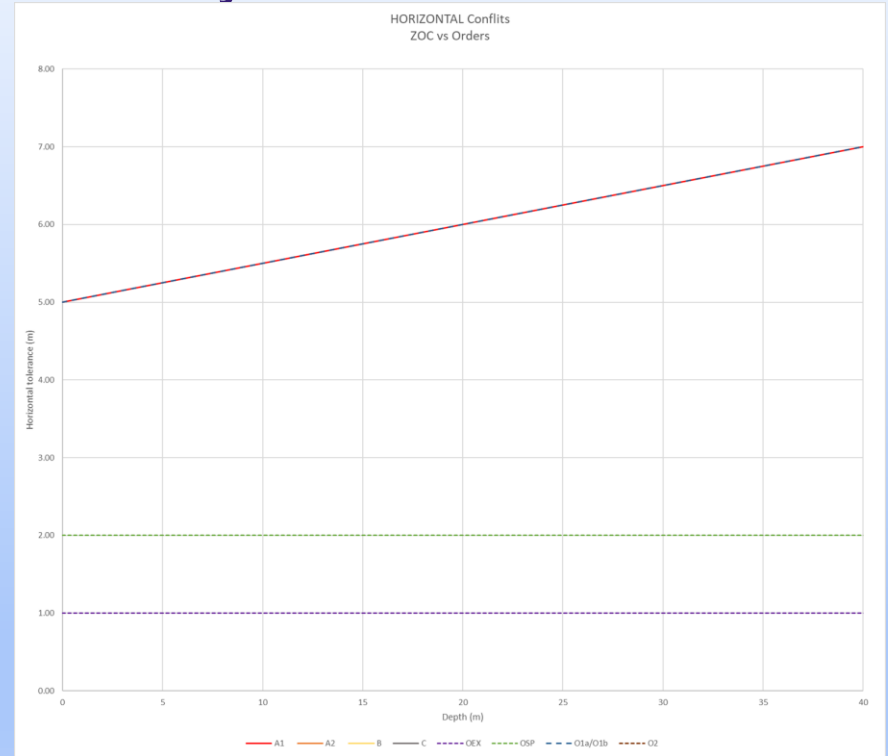
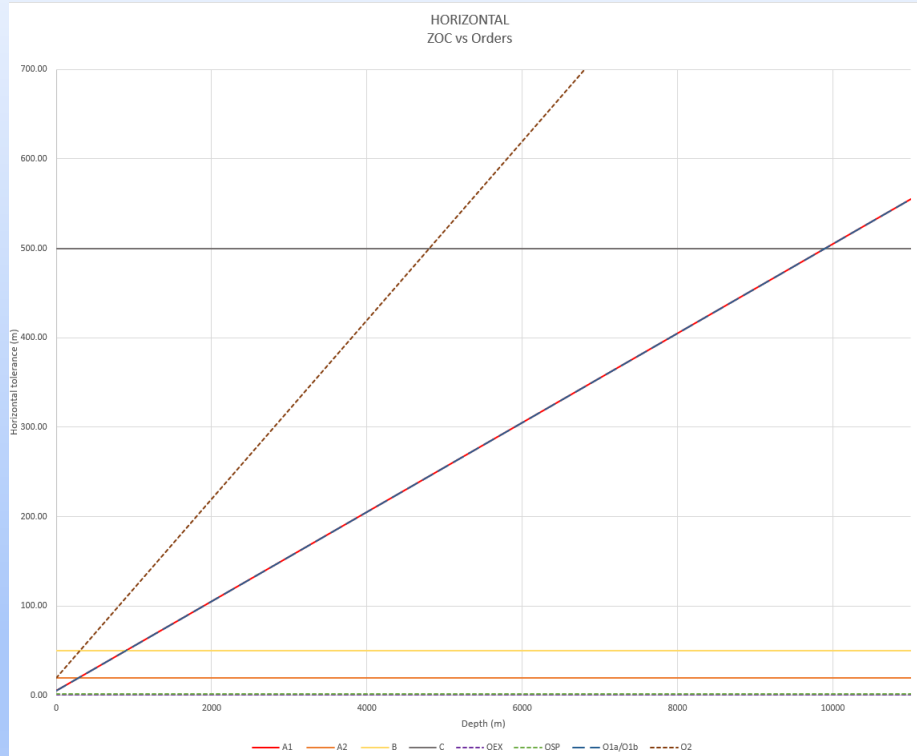


Figure 5: Comparison of maximum THU for S-44 Orders compared to CATZOC. Depths 0-11,000 m (left) and 0-40 m (right)

# Additional Discrepancies Besides TVU Threshold Coverage Terminology

- S-44 has moved to a percent coverage metric to maintain system agnostic terminology
- S-57/S101 has maintained the terms “Seafloor Coverage” and “Full Area Search”

Reference	Criteria	Order 2	Order 1b	Order 1a	Special Order	Exclusive Order
<a href="#">Section 3.5</a>	<a href="#">Bathymetric Coverage</a> [%]	5% <i>*Bh3</i>	5% <i>*Bh3</i>	≤ 100% <i>*≤ Bh9</i>	100% <i>*Bh9</i>	200% <i>*Bh12</i>

Figure 6: S-44 Table 1 (above) and ZOC Table (right)

4
Seafloor Coverage
Full area search undertaken. Significant seafloor features detected <sup>4</sup> and depths measured.
Full area search undertaken. Significant seafloor features detected <sup>4</sup> and depths measured.
Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.
Full area search not achieved, depth anomalies may be expected.
Full area search not achieved, large depth anomalies may be expected.

# Alternatives for Harmonizing TVU Thresholds

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

Option 1:

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

- A. Tighter S-57/S-101 accuracy threshold in shallower waters (i.e., < 145 meters) resulting in surveys with smaller vertical uncertainty to be classified as CATZOC A1, which better supports safety of navigation.
- B. The root sum square method is more appropriate mathematically because it is generally the appropriate way to combine independent variables.

# Alternatives for Harmonizing TVU Thresholds

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

Option 2:

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

- A. For S-44, this is a more relaxed threshold in shallower waters (i.e., < 145 meters) resulting in surveys with higher vertical uncertainty to be classified as Order 1, which increases risk for safety of navigation in shallower waters.
- B. A simplified method to calculate the uncertainty threshold and in most cases this approach would not follow the same calculation method (i.e., root sum squared) as standard error model calculations.
- C. This would diverge from the way uncertainty is typically calculated in sciences, mathematics, and statistics where measurements and their uncertainties are aggregated.

# Alternatives for Harmonizing TVU Thresholds

## Option 3:

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

- A. Under this scenario, hydrographic offices should recognize that an exact one-to-one mapping between IHO Survey Order and CATZOC is impossible. This implies either:
  - a. a re-thresholding of vertical uncertainty in the survey acceptance and product application phases of the chart compilation process, or
  - b. changing the vertical uncertainty standards of hydrographic survey specifications away from S-44, or
  - c. accepting potential mis-classification of CATZOC for some surveys.

# Alternative for Harmonized Method to Classify Data Accuracy on Navigational Products

Update After Paper Distribution:

New Recommendation from HSWG Chair Team

Option 4:

- Since the paper was written the HSWG team has received further input and discussed this issue further.
- S-44 and S-57/S-101 not only have different TVU threshold equations and variables but also have different THU thresholds and “coverage” has different metrics/terminology
- HSWG Chair Team proposes to define a harmonized method to classify survey and data accuracy on navigational products taking into account all of the criteria (*uncertainty (TVU & THU), coverage, feature detection*) to ensure standard categorization.
- HSWG proposes the creation of a Project Team which includes members from S-44, S-101, S-102, S-68, S-57, etc. to identify this unified method.
- It is critical that we make this change now before the operational version of S-101 is implemented.

# Conclusion

- The different mechanisms between S-44 and S-57/S-101 for classifying data quality have potentially already caused inconsistencies across hydrographic offices of the categorization of hydrographic data on the nautical chart (CATZOC and QoBD).
- Currently, IHO Survey Order classification cannot be used as an input to determine the CATZOC classification and IHO Survey Order is insufficient when identifying requirements for a new survey intended to support a specific CATZOC product.
- It is problematic to have inconsistent standards for a similar parameter within an international standards organization.
- Member states must identify a harmonized method to classify data quality in going forward which will result in improved data throughput, clarification across standards and ensure the data on the edges of classification boundaries are consistently categorized correctly. As such, **the benefits in procedures are large and the changes to classifications will be small.**
- It is critical that we make this change now before the operational version of S-101 is implemented. ***These changes should only apply to products going forward.***

# Action Requested of S-101 PT

The S-101 is invited to:

- A. endorse the HSWG's recommendation and work with appropriate IHO working groups (HSWG, DQWG) on a strategic implementation plan
- B. agree with the HSWG's recommendation, but make modifications to their recommendation
- C. note the HSWG's recommendation but make no changes to standards or procedures. Discuss any potential next steps with HSWG Chair Team.