5th Meeting of the Hydrographic Surveys Working Group (HSWG)

Report on the 2nd meeting of the HSWG Uncertainty sub Working Group (U subWG)

Agenda Item 11.4.3

HSWG5, 2 – 5 Oct 2023

INTRODUCTION

International Hydrographic Organization

- **Origin: HSWG3 Action 06:** Set a sub-group “Hydrographic Uncertainty Sub-Group” to discuss uncertainty concept.

- **Mandate**: formalize the concept of measurement uncertainty as applied to the hydrographic survey context.

- **Constitution**: 8 HSWG members (open for more).

- **Achievements**:
  - Virtual meeting on 15th Feb 2023
  - Several e-mail exchanges with Dr. Brian Calder
  - Technical document exchanges
  - Virtual meeting on 18th Sept 2023

REVIEW OF SOURCES DESCRIBING "UNCERTAINTY" IN IHO PUBLICATIONS

International Hydrographic Organization

Recommendation #1:
U subWG agrees that measurement uncertainty should be described in detail in a single IHO source, most likely C-13.

Table 1: Review of the use of the term "Uncertainty" in several IHO publications

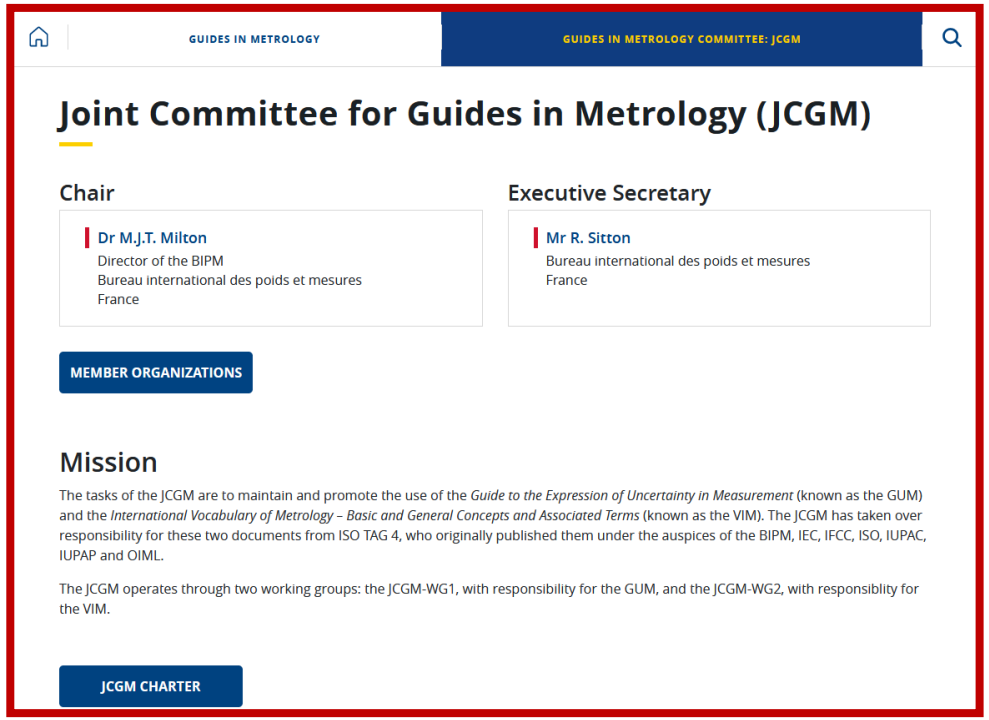
IHO Publication		Reference
B-11 IHO-IOC GEBCO Cook Book	*"The following has been extracted from 5th Edition, S-44 (2008) Annex A, section A.4 by Rob Hare and editing for context"*	p. 198, *Sources of Uncertainty*
	Monte Carlo Technique, Bayesian Network Technique, Windowed Regression with Kriging Corrections, Error Growth Model and Split-Sample Approach	pp. 199 – 221, *Measuring Uncertainty*
B-12 Guidance to Crowdsourced Bathymetry	"The topic of uncertainty can become quite involved. This document provides an overview of the topic, but IHO Special Publication S-44 (Standards for Hydrographic Surveys, 6th ed., 2020, IHO Publication C-13 (Manual on Hydrography, 2010), and the ISO Guide to Uncertainty in Measurements (ISO, 1995) contain additional background material, and may be consulted for further details."	p. 33, *Uncertainty Evaluation*
B-13 Satellite-Derived Bathymetry Best Practice guide	"The topic of uncertainty can become quite involved. This document provides an overview of the topic, but IHO Special Publication S-44 (Standards for Hydrographic Surveys, 6ed, 2020), IHO Publication C-13 (Manual on Hydrography, 2010), and the ISO Guide to Uncertainty in Measurements (ISO, 1995) contain additional background material, and may be consulted for further details."	p. 35, *Uncertainty*
C-13 Manual on Hydrography	"Further details on multibeam uncertainty can be found in Hare [1995] and Lurton [2002]."	p. 175, *Multibeam systems*
S-32 Hydrographic Dictionary	"**Uncertainty**: Estimate characterising the range of values within which the true value of a measurement is expected to lie as defined within a particular confidence level. It is expressed as a positive value."	
S-44 IHO Standards for Hydrographic Surveys	"**TPU**: Three dimensional uncertainty with all contributing measurement uncertainties included"	p. ix, *Glossary*
	"A statistical method, combining all uncertainty sources for determining both the horizontal and the vertical positioning uncertainty should be adopted to obtain THU and TVU respectively."	p. 4, *Uncertainties*
S-101	**Uncertainty fixed:** IHO Definition: The best estimate of the fixed horizontal or vertical accuracy component for positions, depths, heights, vertical distances and vertical clearances	*p. 687, Meta Feature and Spatial Attribute*

- Uncertainty is described in several IHO publication, but most cite S-44 and/or C-13 as the definitive sources on the matter.
- Uncertainty is not well described in C-13.

ALIGNMENT OF IHO WITH JCGM

International Hydrographic Organization

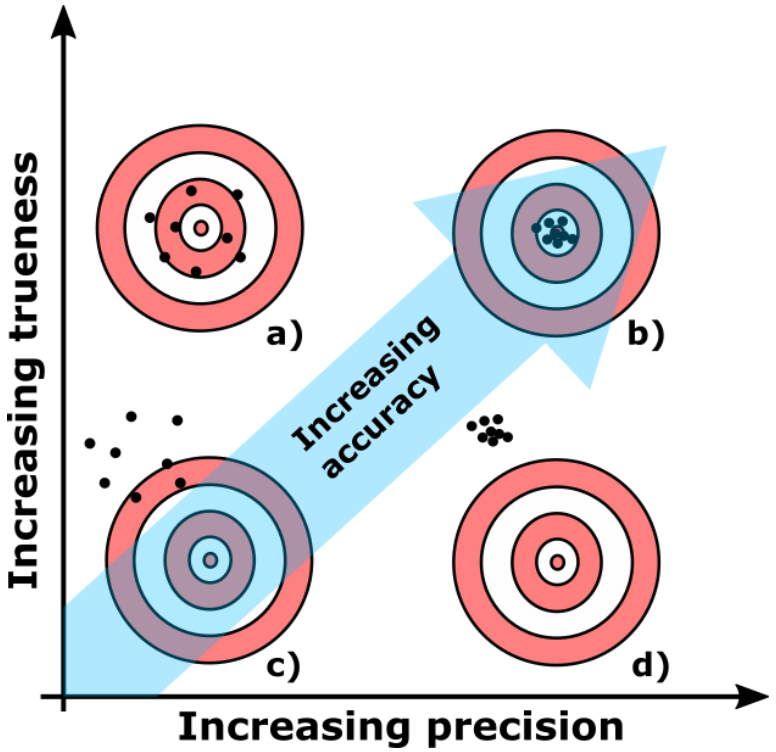
Recommendation #2:
U subWG recommends keeping S-44 aligned with JCGM.

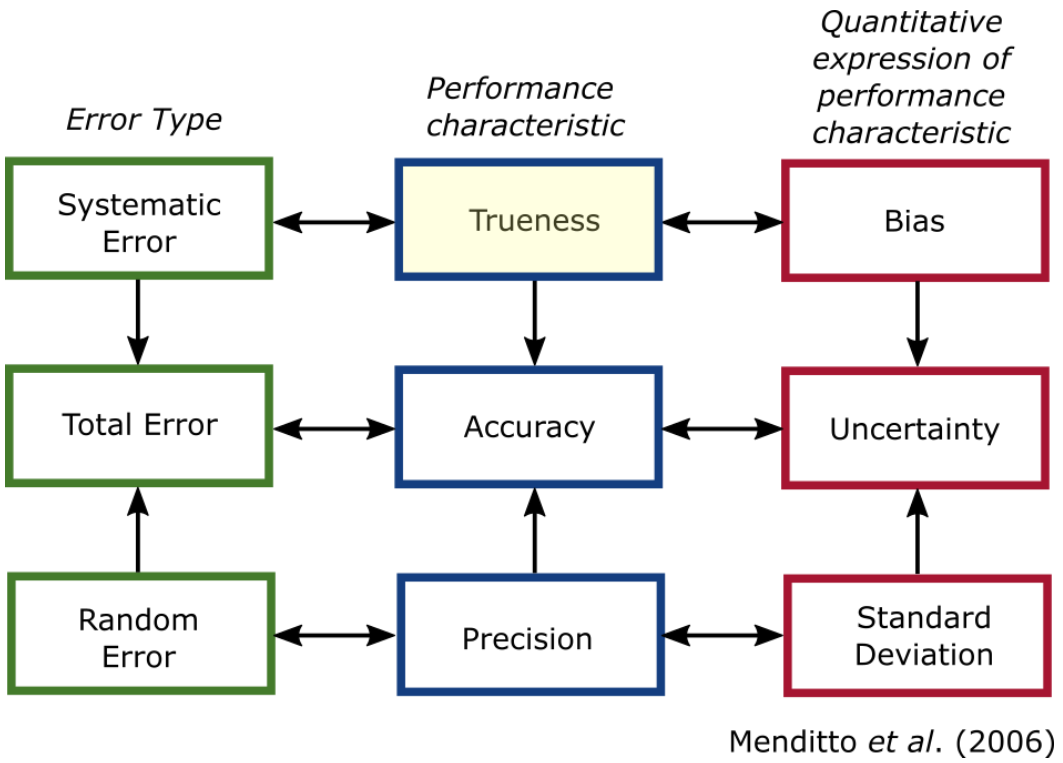


- Attention to proper definitions of terms as specified in the *Vocabulary of Metrology – Basic and General Concepts and Associated Terms* (known as the VIM)

ALIGNMENT OF IHO WITH JCGM

Recommendation #2-1:
U subWG agrees to evaluate the consequences of adopting the JCGM/ISO 5725-1:2023 viewpoint on *Accuracy (trueness and precision) of measurement methods and results* .





Menditto *et al*. (2006)

MEASUREMENT MODELS

Recommendation #3:
U subWG recommends adding the expression “in a measurement model” to the definition of TPU.

From the S-44 glossary:

Total propagated uncertainty (TPU): Three dimensional uncertainty with all contributing measurement uncertainties included.

From the VIM:

Combined Standard Measurement Uncertainty (CSMU): Standard measurement uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a **measurement model**.

MEASUREMENT MODELS

Recommendation #4:
U subWG recommends adding the information about dominant models to C-13 (no endorsement)

System Type	Dominant Model
Acoustic systems	HGM 1995
Laser scanning systems	cBLUE
Satellite-derived bathymetry systems	-

Calder (2023)

CLARIFYING A PRIORI AND A POSTERIORI UNCERTAINTY

International Hydrographic Organization

Recommendation #3:
U subWG recommends making a clear distinction between *a posteriori* Uncertainty and online/updated/*a posteriori* TVU

Definition #1

*"[..] in general practice, by analogy, the term "a priori" tends to mean "before the survey starts" and therefore is used to model what we think the uncertainty of the observations are going to be before they are made. This is generally useful for planning surveys, for example, because it gives you an idea of what the uncertainty levels are going to be. The term "**a posteriori**" is then taken to mean "estimated from the data that we actually observed", and is generally used for an estimate of the noise level in the point cloud observed (e.g., from cross-lines, although that's generally not a great estimate of the actual uncertainty)."* (Calder, 2023)

AND

Definition #2

*"I'd suggest that we might reserve the term "a priori" for pre-analysis, or a model that doesn't include any current observations (to allow for a model that's calibrated from previous observations), and use "**a posteriori**" to mean an estimate of the uncertainty of the data derived after all of the data is collected. This allows for the use case where you have the HGM tuned with real-time uncertainty estimates for the motion data as "a posteriori". It's a little bit of a stretch, but I think it'd work."* (Calder, 2023)

TPU VERSUS THU AND TVU

Recommendation #5:
U subWG wishes to inform HSWG of the following:

Following email exchanges with Dr. Brian Calder, it is clear that although it is deemed feasible to compute a 3D TPU, it is not worth the effort and it is acceptable to consider separate calculations for the horizontal and the vertical components of uncertainty.

PRODUCT/GRID UNCERTAINTY

Recommendation #6:
U subWG recommends to further investigate product/grid uncertainty

Problem affecting Grids:

- Discrepancies between S-44 and S-102
- Annex D to be moved into C-13