

The new perspective of the Guide to the expression of uncertainty in measurement

Walter Bich (INRiM, Torino – JCGM-WG1)

w.bich@inrim.it

GUM - The undisputed reference in uncertainty evaluation since 1993



Joint Committee for Guides in Metrology – JCGM, 1997



JCGM Working Group on the Expression of Uncertainty in Measurement (GUM)

News	Mission	Members	GUM & Supplements	Bibliography	Forum Workspace	Members' area	JCGM
------	---------	---------	-------------------	--------------	-----------------	---------------	------

→ Working Group 1 (WG1) of the Joint Committee for Guides in Metrology (JCGM) has responsibility for maintaining the *Guide to the Expression of Uncertainty in Measurement* (GUM), which is now used worldwide at all levels of the measurement chain, from NMIs to industry.

An updated version of the GUM has been prepared under the name JCGM 100:2008 (GUM 1995 with minor corrections). In addition, the JCGM-WG1 has decided to produce a series of complementary documents to cover some topics of interest in more detail, whilst also directing them to groups of users with different levels of expertise. Please refer to the News from the JCGM-WG1 for information on the latest publications and the documents in preparation.

From the BIPM website

GUM, Scope, 1.1

This Guide establishes general rules for evaluating and expressing uncertainty in measurement that can be followed at various levels of accuracy and in many fields — from the shop floor to fundamental research.

...

A declared scope broader than the real coverage

GUM essentials

- A measurement model $Y = f(X_1, X_2, \dots, X_N)$, i.e, univariate (scalar) explicit
- A great idea: to deal with systematic errors as corrections, (i.e., input quantities in the measurement model) with associated uncertainties about the quality of each correction
- As a consequence, uncertainties $u(x_i)$ from random and systematic effects are treated in the same way as standard deviations of probability density functions
- Simple rules to assign standard uncertainties to the estimates x_i of the input quantities X_i (using both frequency and subjective distributions)
- Gauss rule of propagation to obtain $u(y)$
- Simple rule to obtain a coverage interval

GUM drawbacks

- **Insufficient guidance on the multivariate case**
- **Insufficient guidance on strongly non-linear problems**
- **Optimistic application of the Central Limit Theorem in the construction of a coverage interval**
- **Internal inconsistency due to the co-existence of contrasting views of probability**
- **Difficult or impossible application to a broad range of problems (where a model is difficult or impossible to write and (or) treat). This occurs in many fields beyond «classical» metrology: chemistry, biology, climate science...**

As already said:

Declared scope broader than content

Remedies

- **Ancillary documents developed either as Supplements**
 - **BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML Evaluation of measurement data - Supplement 1 to the "Guide to the expression of uncertainty in measurement" - Propagation of distributions using a Monte Carlo method, JCGM 101:2008**
 - **BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML Evaluation of measurement data - Supplement 2 to the "Guide to the expression of uncertainty in measurement" - Models with any number of output quantities, JCGM 102:2011**

Remedies

... or as supporting documents

- BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML Evaluation of measurement data - An introduction to the "Guide to the expression of uncertainty in measurement" and related documents, JCGM 104:2009

... or as application documents

- BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML Evaluation of measurement data - The role of measurement uncertainty in conformity assessment, JCGM 106:2012

All these documents were developed mostly in the framework of «classical» metrology

GUM revision

- The GUM and its Supplements are inconsistent (in Type A evaluation)
- The Supplements cover a broader scope than the GUM

Hence, the decision to revise the GUM (endorsed by the JCGM in 2008 and encouraged by an on-line survey^{1,2} in 2012)

After a long preparatory work, a Committee Draft (CD) was circulated in 2014 among the JCGM Member Organisations and National Metrology Institutes for comments.

1 https://www.bipm.org/wg/JCGM/JCGM-WG1/Allowed/sub-committee_5/WG1-SC5-N12-15_JCGM_GUM_Survey_Collated_responses.pdf

2 https://www.bipm.org/wg/JCGM/JCGM-WG1/Allowed/sub-committee_5/WG1-SC5-N12-14b_GUM_survey_report.pdf

GUM revision rejected

- The reactions were largely negative and the CD was withdrawn
- The reasons for the rejection were analyzed³ and it was realized that

a radical change of perspective was needed

- A reason relevant here is that the CD had the same declared scope and the same (if not narrower) real coverage as the GUM. In addition, procedural changes were introduced with insufficient motivation

³ [Bich W, Cox M and Michotte C 2016 Metrologia 53 S149](#)

GUM New Perspective (NP)

The GUM is little known, let alone adopted, beyond the circle of NMIs, calibration laboratories and perhaps legal metrology

One of the tasks of the NP is to broaden the adoption of the GUM and GUM-related documents within all the eight Member Organisations and possibly beyond them

To fulfill this task, a range of techniques broader than the existing ones should necessarily be included

Horses for courses, rather than a unique, universal rule

The GUM NP was elaborated by the JCGM-WG1 and submitted to the JCGM, which endorsed it in 2017

GUM New Perspective

Considering a wider spectrum of techniques implies that a whole suite of specific documents (including those already published and further to come) is needed

The whole suite would adequately cover the broad scope of the current GUM (JCGM 100:2008)

The portfolio will include the current JCGM 100:2008 (the so-called *grandfathering*, requested by some prominent NMIs)

JCGM 100:2008 will lose its current role of main reference document, which will be taken by the portfolio as a whole

Structure of the NP

The New GUM will be the entire portfolio of documents

All documents will be at the same level

Therefore, there will be no longer hierarchical dependence

Those documents currently considered Supplements to JCGM 100:2008 will become parts of the GUM

An Introduction will set the scene and give a general outline, guiding the reader to the document appropriate for the problem at hand

Advantages of the NP

A flexible structure made of largely stand-alone documents, each devoted to a specific purpose

New documents will be easily included

The request of grandfathering of JCGM 100:2008 is met

A document conveying some of the concepts which originally motivated the GUM revision will be proposed in due course, this time with the support of solid scientific arguments

Fully developed examples covering the whole range of different techniques will be given in a specific document. This will facilitate updates when new examples will be added (connection with the EMUE Project**)**

The new GUM

JCGM GUM-X:2020 Guide to the expression of uncertainty in measurement – Part X: Title

Part 1: **Introduction** (in preparation, based on JCGM 104:2009)

Part 2: **Principles and concepts** (in preparation)

Part 3: Legacy (the current JCGM 100:2008)

Part 4: Conformity assessment (the current JCGM 106:2012)

Part 5: **Examples** (in preparation)

Part 6: **Modelling** (at the Final Committee Draft stage)

Part 7: Monte Carlo (the current JCGM 101:2008)

Part 8: Multivariate (the current JCGM 102:2011)

Part 9: **Inter-Laboratory Studies** (in preparation)

Part 10: **Least-squared methods** (planned)

Part 11: **Bayesian methods** (planned)

...

This way of numbering will enable harmonisation with the ISO/IEC version of the documents (a source of confusion so far)

Lively debate

The debate is currently alive within the JCGM-WG1 on the evaluation of the standard uncertainty from a sample of n observations (Type A evaluation, in the GUM language), especially when n is small

A one-day workshop on this topic was held at the BIPM during the last JCGM-WG1 meeting (December 2019)

The outcome of the workshop is the subject of a talk later today

Thank you for your patience