Revision of the *Guide to the expression of uncertainty in measurement*

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Evolution of the GUM so far

- First edition published in 1993
- 1st edition, 2nd print (1995)
- 1st edition, 3rd print (2008), as JCGM100:2008

- Document still largely unchanged
- Vast investments in various sectors to implement the concepts
  - Guides, written standards
  - Papers, quality documents

GUM Supplements

- Extensions to the GUM, to be used in conjunction with JCGM100
- Supplements foreseen/published
  - JCGM 101: Supplement 1 to the GUM – Propagation of distributions using a Monte Carlo method (2008);
  - JCGM 102: Supplement 2 to the GUM – Models with any number of output quantities,
  - JCGM 103: Supplement 3 to the GUM – Developing and using measurement models

GUM Supplement 1

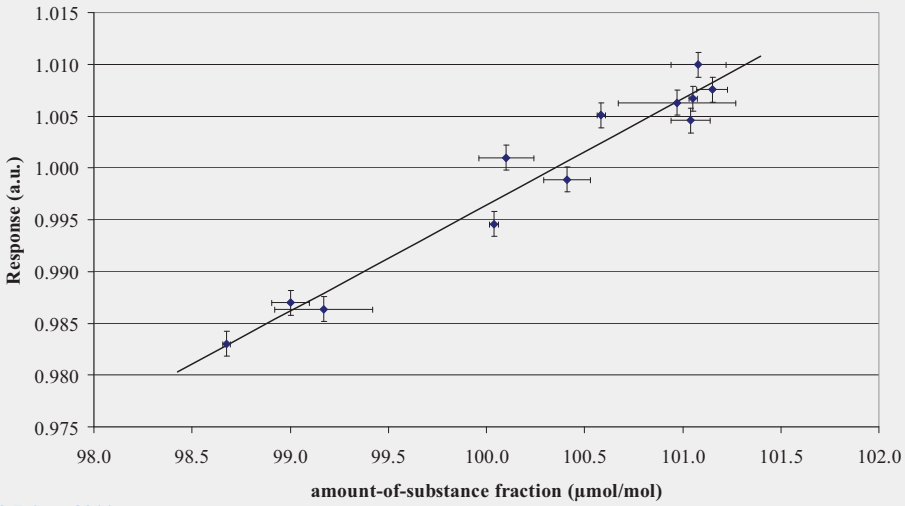
- Propagation of pdfs by means of Monte Carlo
- Versatile propagation method, capable of dealing with
  - Non-linear models
  - Models with constraints
- From output pdf, desired output can be calculated, e.g.,
  - Coverage interval
  - Standard uncertainty

GUM Supplement 2

- Agreed in May ’11 meeting to be ready for publication
- Extension to models with any number of output quantities
  - Uncertainty propagation (GUF)
  - Propagation of pdfs (GUM-S1)
- Use of complex numbers
- Validation of GUF using Monte Carlo

Multivariate models in chemistry

- All multipoint calibration curves fitted to a model with more than one coefficient



GUM Supplement 3

- Describes measurement modelling and use of models
- Document in an early stage of development
- 'Fishbone' diagrams as modelling aid to be included ('cause and effect' modelling)

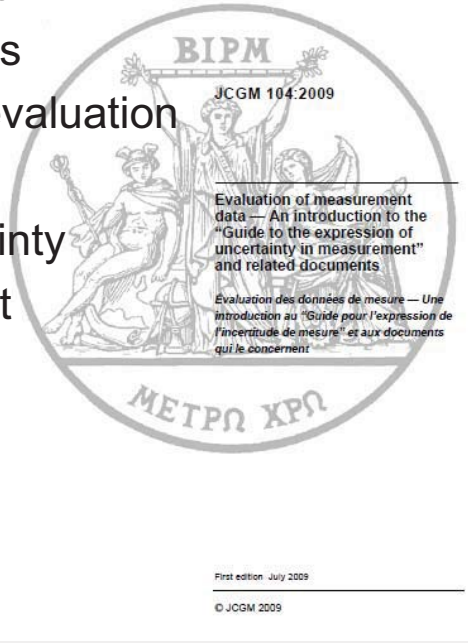
Complementary documents to the GUM

- Giving background, introduction, further guidance to aspects dealt with in the GUM

- Documents foreseen/published
  - JCGM 104: Evaluation of measurement data – An introduction to the "Guide to the expression of uncertainty in measurement" and related documents (2009),
  - JCGM 105: Evaluation of measurement data – Concepts and basic principles,
  - JCGM 106: Evaluation of measurement data – The role of measurement uncertainty in conformity assessment,
  - JCGM 107: Evaluation of measurement data – Applications of the least-squares method

JCGM 104:2009

- Introduction to the GUM
- Explanatory document
  - Concepts and principles
  - Stages of uncertainty evaluation
  - Formulation stage
  - Propagation of uncertainty
  - Conformity assessment
  - Least squares



JCGM 105

- Concepts, principles underlying the GUM
- Document in an early stage of development
- Support to choices made in GUM and its supplements

JCGM 106

- Use of measurement uncertainty in conformity assessment
- Methodologies for decision taking on the basis of results including uncertainty
- Document close to completion

Revision of the GUM

- Preservation of vast investments made so far in implementing it
- Inconsistencies
  - Internally (frequentist and Bayesian approaches; terminology)
  - Externally (GUM Supplements; VIM3)
- Inadequacies
  - Measurement uncertainty evaluation in new fields
  - Concept of a unique true value
- Ambiguities
  - Notational and terminology

Objectives revision GUM

- Clarity of presentation
- Structure as close as possible to that of the present GUM
- Level of presentation comparable to that of the present GUM
- Better specification of the conditions of applicability

Outcome of revision

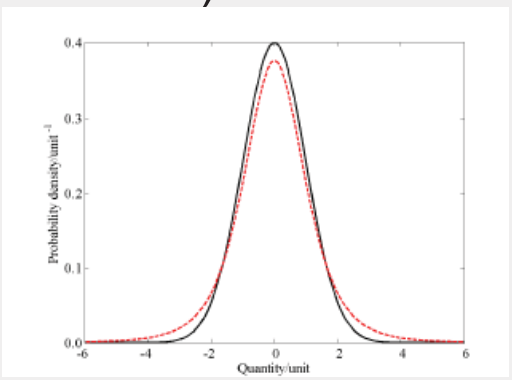
- Unification of the concepts of Type A and Type B evaluations of uncertainty
- Increased guidance in the evaluation of standard uncertainty for input estimates
- Less emphasis given to effective degrees of freedom
- Improved treatment of coverage intervals
- Increased number of examples, with applications taken from chemistry etc

Bayesian or not Bayesian?

- Some aspects of the present GUM are not Bayesian
- In the new edition, everything will be "Bayesian"
- Implication for type A uncertainty evaluation (using *t*-distribution)

$$u^2(x) = \frac{n-1}{n-3} s^2(x)$$

Requires additional guidance when $n < 4$



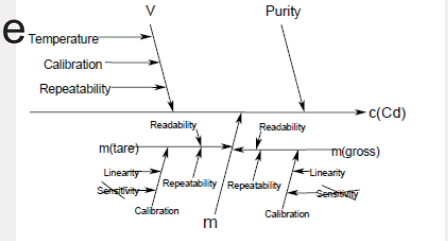
Contents of new JCGM100

VIM3:2008

- To be incorporated in JCGM 100
- Already used in JCGM 101, 104 and draft documents
- Some concepts are modified in order to fit in the GUM setting
  - Measurand has a unique true value
- Feedback is given to JCGM WG2 (VIM)

Modelling the measurement

- Current contents in JCGM 100 largely unchanged
- JCGM 103 deals with the matter in great detail
- Fishbone-diagram aided modelling to be added (JCGM 103?!)
- Incorporation of 'top-down approach'
  - Appreciable hesitations
  - Use of precision data to be accommodated



Top-down “versus” bottom-up

- Not really different methods
- No real uncertainty evaluation is truly one or the other: usually a hybrid is used

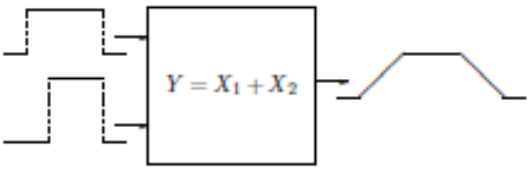
- De-emphasising differences aids to
  - Explain that the input variables can be chosen
  - Uncertainties can be evaluated using the method of choice

Use of PT-data

- Controversial, because
  - Proper randomisation of effects hard to achieve
  - Inhomogeneity of the performance of the labs
  - Even satisfactory performance does not prove that the lab can derive its uncertainty from the PT-data
  - Guidance is needed (connection with ISO 21748 and similar documents)

Output uncertainty

- Emphasis on propagating pdfs rather than uncertainties
  - Application of Bayes' theorem
  - Monte Carlo (GUM S1)
- In 'special cases': law of propagation of uncertainty
- Established ('easy to use') criteria on what to use when



Examples

- Examples to be added from
  - Analytical chemistry
  - Physical chemistry (thermodynamics)
  - Clinical chemistry
  - Microbiology
  - (etc.)
- Further examples to be added illustrating methodology
  - Bayesian theorem
  - Matrix calculus

Outstanding issues

- Uncertainty evaluation of results containing bias
  - Quite common in ‘testing’
  - Legislative requirements
  - Parameters used in ‘engineering’
- Measurement methods with little or nothing to model
  - Components: precision, trueness
- GUM for testing or calibration?

Conclusions

- GUM revision aims at serving other fields than solely physical calibration
- Approach will become more versatile, without loosing connection with the past
- Document structure largely unchanged
- Smooth transitions between GUM and its supplements

Acknowledgement

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The author is a member of the Joint Committee on Guides in Metrology (JCGM) Working Group 1 (GUM). The opinion expressed in this paper does not necessarily represent the view of this Working Group.