

Measurement uncertainty

A proposed new definition

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 Webinar 2 July 2025

Why a new definition?

The current definition (non-negative parameter...) is ambiguously close to that of standard uncertainty

Need for disambiguation

In modern metrology, many measurements involve implicit and (or) multivariate models, inverse problems, perhaps with algorithmic solution, Bayesian inference, AI and so on

Need for generalisation



Measurement uncertainty

doubt about the value of the measurand that remains after making a measurement

MU as *doubt*

From the Oxford Advanced Learner's Dictionary of Current English, thirteenth impression, 1961

Doubt: *uncertainty* of mind; not feeling sure; a state of uncertainty

Uncertainty: *doubt*; the state of not being sure

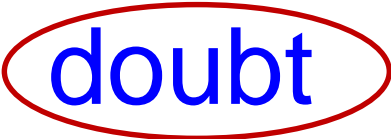
From JCGM 100:2008 (the legacy GUM)

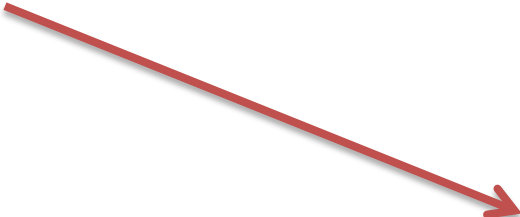

The word “uncertainty” means *doubt*, ...

In this Guide, the word “uncertainty” without adjectives refers both to the *general concept of uncertainty* and to any or all quantitative measures of that concept

MU as *doubt*

MU is a (subjective) state of mind

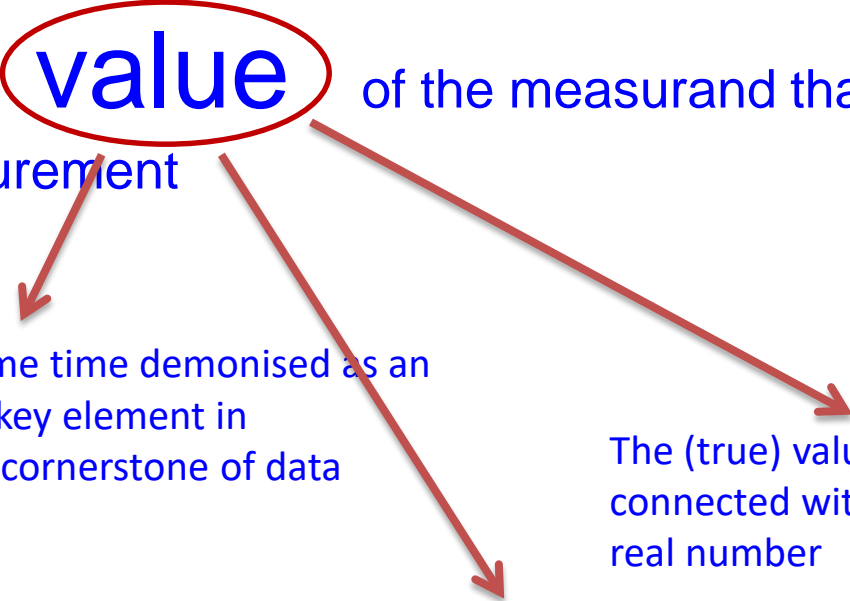
 **doubt** about the value of the measurand that remains after making a measurement



MU is the concept, not its quantitative expression (a *parameter*)

Measurement uncertainty

doubt about the **value** of the measurand that remains after making a measurement



```
graph TD; Value((value)) --> Text1[The (true) value, at some time demonised as an idealised concept, is a key element in estimation theory, the cornerstone of data treatment]; Value --> Text2[The (true) value is strictly connected with the concept of real number]; Value --> Text3[In several cases, the true value not only exists, but can be known exactly];
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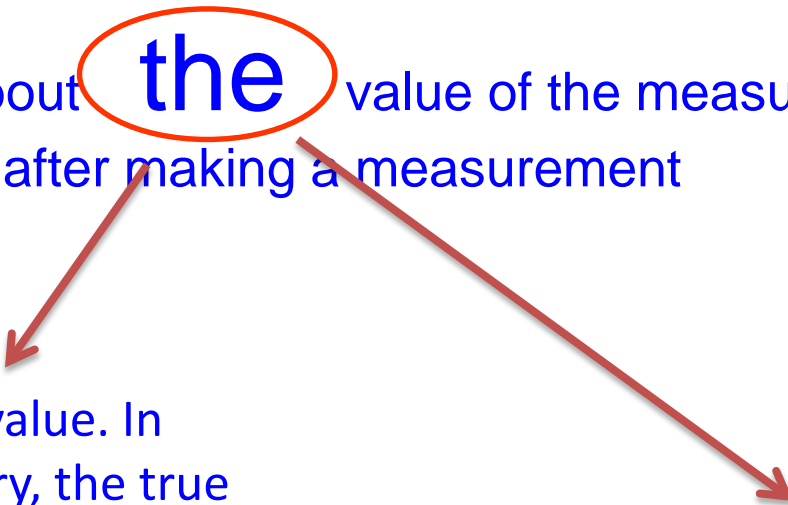
The (true) value, at some time demonised as an idealised concept, is a key element in estimation theory, the cornerstone of data treatment

The (true) value is strictly connected with the concept of real number

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MU as *doubt*

doubt about **the** value of the measurand that
remains after making a measurement



```
graph TD; A("the") --> B("The, not a true value. In estimation theory, the true value is unique"); A --> C("Uniqueness is controversial");
```

The, not **a** true value. In estimation theory, the true value is unique

Uniqueness is controversial

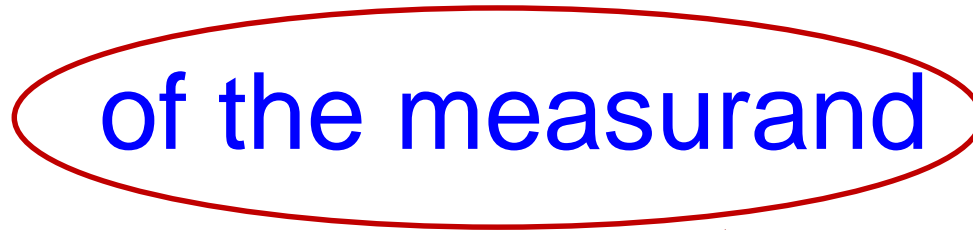
In any case

If the phenomenon of interest can be represented only as a distribution of values or is dependent on one or more parameters, such as time, then the measurands required for its description are the set of quantities describing that distribution or that dependence. (JCGM 100:2008, Scope, 1.2)

MU as *doubt*: about what?

doubt about the value

of the measurand




that remains after making a measurement

The doubt is **about the measurand**
(given its estimate), *not* about the
estimate

There is a divergence in this between the
frequentist and the subjective views of
probability

MU as *doubt*

doubt about the value of the measurand that remains
after making a **measurement**



«measurement» has a meaning broader than that intended in the VIM. «Experimentally» in the VIM definition should be dropped in order to encompass some Type B evaluations.

Notes to MU definition

Note 1 For the purpose of this definition, the term 'true value of the measurand' is not used because the word 'true' is viewed as redundant.

MU as *doubt*

NOTE 2 Measurement uncertainty can be described fully and quantitatively by a probability distribution on the set of possible values of the measurand.

MU as *doubt*

NOTE 3 For scalar measurands, measurement uncertainty can be summarised by, for example, the standard uncertainty, a coverage interval with specified coverage probability, or by selected quantiles of the probability distribution in Note 1. For multivariate measurands, measurement uncertainty can be described, for example, by the covariance matrix or by a coverage region, with specified coverage probability.

Key takeaways

- The concept is separate from its quantitative expressions (no longer ambiguity)
- Definition broader than the current one: MU is now a overarching concept that accommodated a variety of mathematical tools used to express it
- Easily transferable to categorical data (properties) as *examination uncertainty* (*classification uncertainty* in AI!)

How do we express doubt about the value of the measurand(s)?

- We use:
- standard uncertainties
- coverage intervals (including expanded uncertainties)
- covariance matrices
- Probability distribution (continuous or discrete)
- ... and possibly more

- EXACTLY as we already do

- The definitions of all these quantitative expressions for MU are unchanged, so that

No impact whatsoever on current laboratory practice

