

Informal Aspects of Uncertainty Evaluation

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Definitional Uncertainty: A Definitionally Uncertain (or Vague) Quantity?

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Abstract

Measurement results are interpreted as (distributions of) values of measurands, i.e., individual quantities intended to be measured. This reference to intentions is critical, since it emphasises the unavoidable presence of a non-empirical element of the process, and then of the possible difference between the model and the modelled entity, which is a source of so-called definitional uncertainty.

The way definitional uncertainty is operatively handled – from “practical minimum measurement uncertainty achievable in any measurement” (VIM) to the assumption that the measurand “can be characterized by an essentially unique value” (GUM) – provides a fundamental demarcation in the epistemology of measurement.

Context: JCGM

Joint Committee for Guides in Metrology:

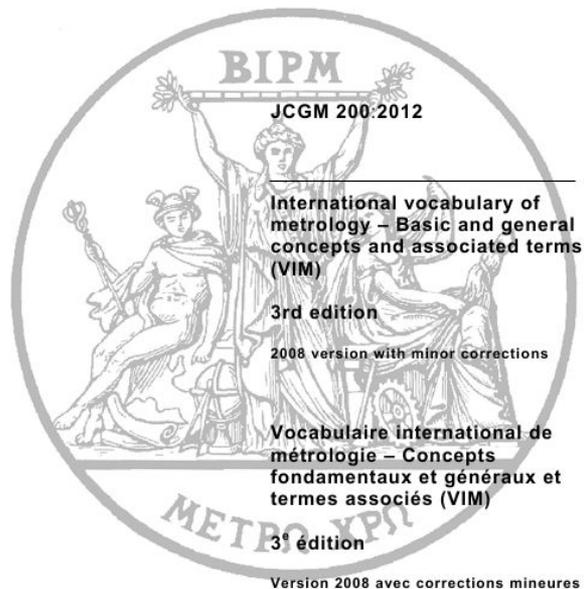
- (BIPM) Int.I Bureau of Weights and Measures
- (IEC) Int.I Electrotechnical Commission
- (IFCC) Int.I Federation of Clinical Chemistry and Laboratory Medicine
- (ILAC) Int.I Laboratory Accreditation Cooperation
- (ISO) Int.I Organization for Standardization
- (IUPAC) Int.I Union of Pure and Applied Chemistry
- (IUPAP) Int.I Union of Pure and Applied Physics
- (OIML) Int.I Organization of Legal Metrology

«to develop and maintain, at the international level, guidance documents addressing the **general metrological needs of science and technology**, and to consider arrangements for their dissemination»



JCGM documents

International Vocabulary of Metrology (VIM)



www.bipm.org/en/publications/guides/#vim

Guide to the Expression of Uncertainty in Measurement (GUM)



www.bipm.org/en/publications/guides/#gum

'Definitional uncertainty' in the VIM

«component of measurement uncertainty
resulting from the finite amount of detail
in the definition of a measurand»

Background: “Error” vs “Uncertainty” Approaches

[VIM, Introduction]

«... **change in the treatment of measurement uncertainty**

from an Error Approach (sometimes called Traditional Approach or True Value Approach)
to an Uncertainty Approach ...»

«The objective of measurement in the Error Approach is to determine an estimate of the true value that is as close as possible to that single true value»

«The objective of measurement in the Uncertainty Approach is [... the] assignment of an interval of reasonable values to the measurand»

JCGM documents in a diachronic perspective

(VIM1, 1984)



(GUM, 1993)



(VIM3, 2007)



witnesses (or actors?) of the «change in the treatment of measurement uncertainty»

from the EA

(our concept is not mentioned)

via the GUM

(it is introduced, termed “intrinsic uncertainty”)

to the UA

(it is defined)

«the measurand cannot be specified by a value
but only by a description of a quantity»

[GUM, D.1.1]

My thesis

Even more fundamentally than in the ontologic and epistemic status of true values, the two “Approaches” differ in their **interpretation of the measurand definition** (or specification, or identification, or description, or ...)

The measurand is a defined, not a given, quantity

An example

[GUM, D.3]

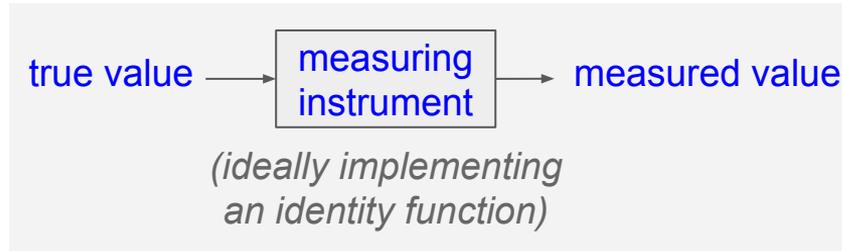
«Suppose that the measurand is the thickness of a given sheet of material...»

The measurand is described as a general quantity specified by reference to an object

and let us assume the traditional position on true values, e.g.:

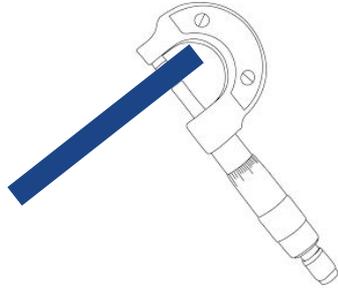
«in an ideal measurement system, the measured value would be equal to the true value»

[Bentley, 2005, p.3]



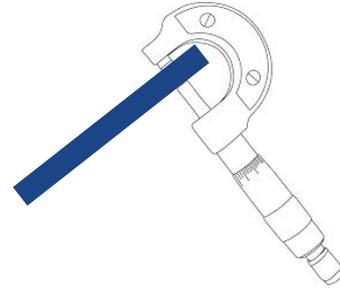
the thickness of a given sheet of material has a true value, right?

An example /2



supplier:

thickness(S) = x m



customer:

thickness(S) = y m

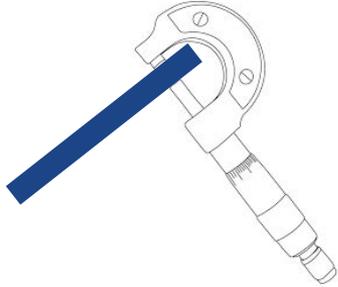
$y \neq x$

under the assumption that both micrometers are ideal (no “measurement errors”)

First explanation: **the sheet S changed its state**

i.e., $\text{thickness}(S(t_1)) \neq \text{thickness}(S(t_2))$ and both are true values (?)

An example /3



by acknowledging that
the delimiting surfaces of S
cannot be perfectly planar...



... we could add one more specification:

thickness of S in given conditions of temperature, etc, **and in a given position of S**

Second explanation of $\text{thickness}(S(t_1)) \neq \text{thickness}(S(t_2))$:

the sheet S was measured in different positions

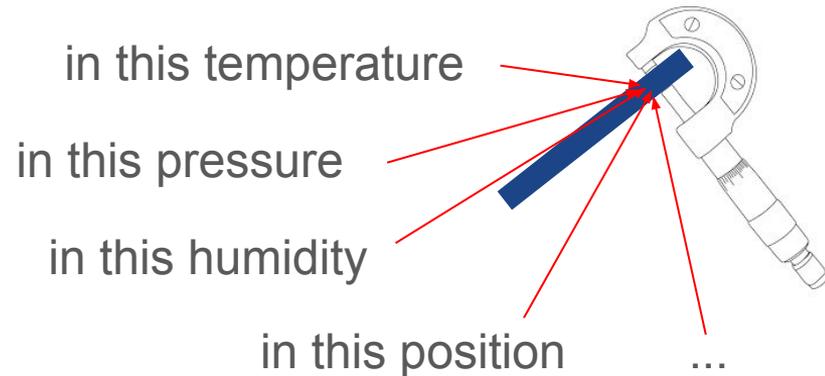
Interpretation in the EA (VIM1)

true value: «the value which characterizes a quantity perfectly defined, in the conditions which exist when that quantity is considered»

The thickness of a given sheet S, thickness(S), **is not a perfectly defined quantity**

The definition could be improved by **specifying some influence quantities** and **better specifying the object itself**

**This would lead to
a “more perfectly defined” quantity**



Interpretation in the EA (VIM1) /2

We might conclude that a less-than-perfectly defined measurand does not have a true value...

... but this is not what the EA says (of course...!):

1. the measurand is intended as «the quantity subject to measurement» and as such it has a (true) value
2. the fact that in principle the description of a measurand cannot be complete does not affect the existence of its (true) value, but only its knowability
3. measurement uncertainty is «the estimate characterizing the range of values within which the true value of a measurand lies»

Into pragmatics (let's ask mr. E)



The measurand could be defined as the quantity with which the measuring system interacts...



... in the given, completely unknown, state of the universe, whatever it is: yes...



... such a definition is super-simple but the information acquired by measurement almost useless !

Into pragmatics /2



If instead some information
on the state of the universe
is also acquired...



... this requires
more and more
measurements...

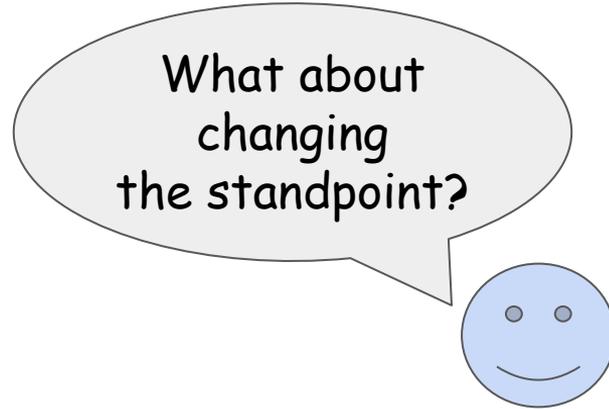


... measurement results
would be much more
useful: but...

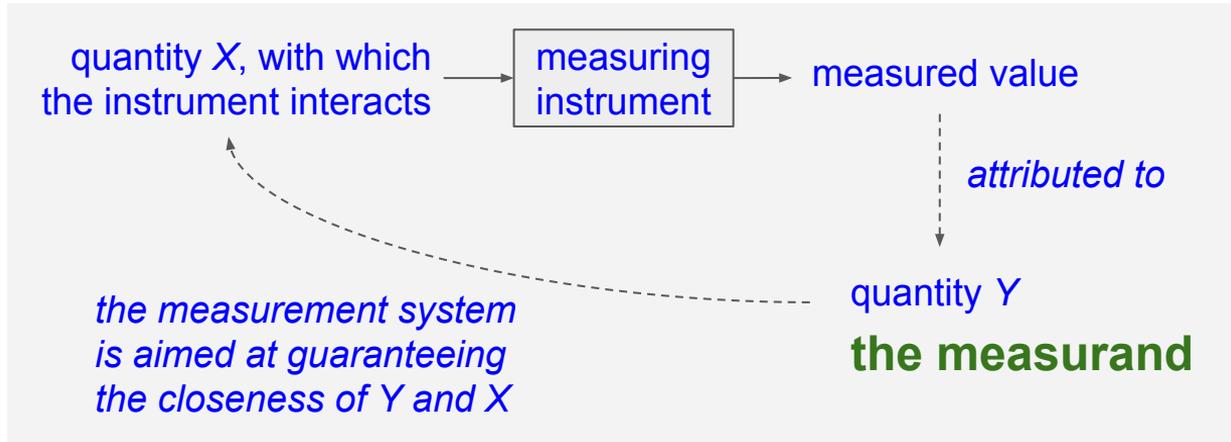


... and nevertheless
the true value
remains unknown...

Into pragmatics /3



Rethinking what the measurand is



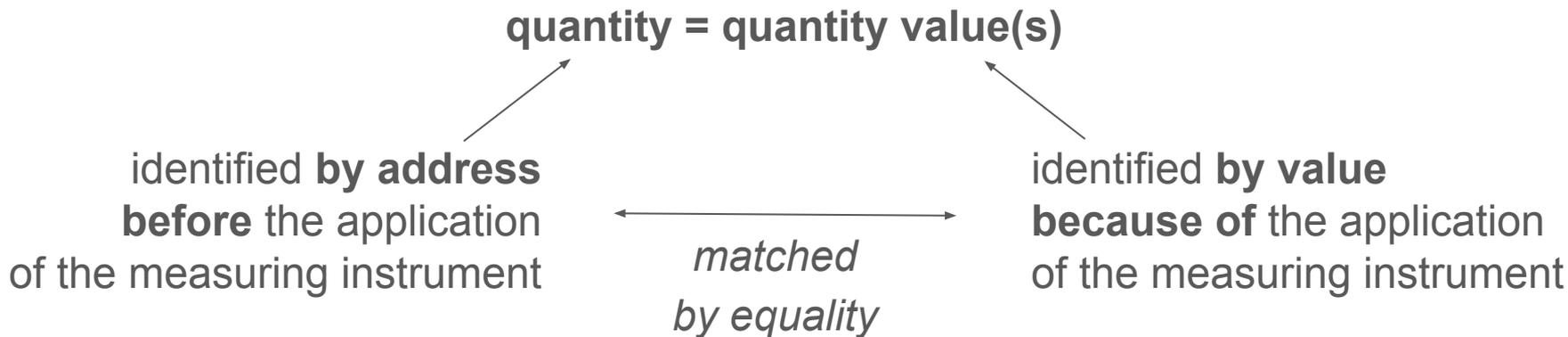
The measurand is the quantity to which the measured value is attributed

Interpretation in the UA (VIM3)

measurand: «quantity intended to be measured»

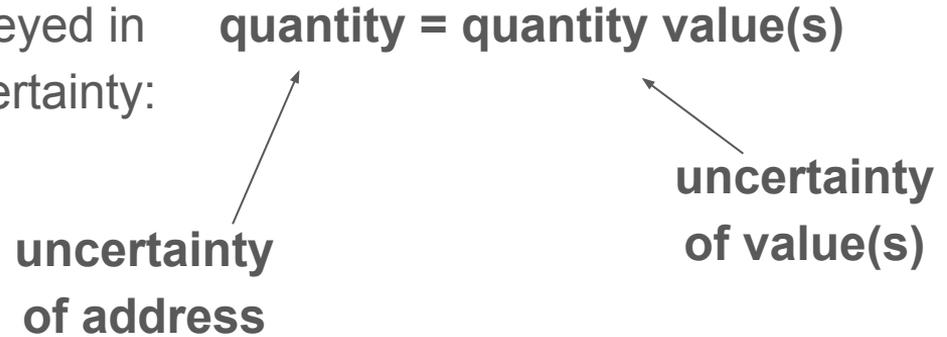
This reference to intentions embeds our subject in pragmatics:
measurement is a designed-on-purpose process, aimed at producing information

with the structure:



Interpretation in the UA (VIM3) /2

The quality of the information conveyed in should be reported in terms of uncertainty:



definitional uncertainty: «component of measurement uncertainty resulting from the finite amount of detail in the definition of a measurand»

Uncertainty of address, uncertainty of value

uncertainty		
in address	in value	
small	small	Eran's heights is 1.80 m
big	small	The height of someone in this room is 1.80 m
small	big	Eran's heights is between 1.75 and 1.85 m
big	big	The height of someone in this room is between 1.75 and 1.85 m

Synthesis: EA vs UA again

EA (VIM1, 1984):

objective of measurement

to determine an estimate
of the single true value

measurand

quantity subject to measurement

measurement uncertainty

estimate characterizing
the range of values within which
the true value of a measurand lies

UA (VIM3, 2007):

to assign an interval of reasonable values
to the measurand

quantity intended to be measured

non-negative parameter characterizing
the dispersion of the quantity values
being attributed to a measurand,
based on the information used

Some questions for the discussion

Definitional uncertainty is expected to be quantified (plausibly by means of non-statistical -- “type B” -- techniques):

*given that definitional uncertainty is related to missing information on the measurand, is its reliable quantification really possible?
is it a case of uncertain uncertainty?*

Some questions for the discussion /2

«In the GUM, the definitional uncertainty is considered to be negligible with respect to the other components of measurement uncertainty. The objective of measurement is then to establish a probability that this essentially unique value lies within an interval of measured quantity values, based on the information available from measurement.» [VIM3, Introduction]:

has the negligibility of the definitional uncertainty with respect to the other components of measurement uncertainty really something to do with the assumption that the measurand has an “essentially unique value”?

Some questions for the discussion /3

The relation between definitional uncertainty (uncertainty in address) and the other components of measurement uncertainty (uncertainty in value) is not obvious:

should uncertainty in address be included in the uncertainty budget, and therefore propagated to compute the combined standard uncertainty? or is it the minimum limit to any measurement uncertainty and not a component of measurement uncertainty?