MINET - Measuring the Impossible Network
(FP6-NEST-MtI-project-043297)

THINK TANK EVENT C
Rome, Italy, October 9th – 10th, 2008

Measurement uncertainty when measuring the impossible

OUTLINE FOR DISCUSSION

1. Foreword

This paper, prepared by LSC, highlights some issues for discussion at MINET Think Tank C on "Uncertainty in measurement when measuring the impossible" which will be held in Rome on October 9th-10th, 2008. The Think Tank has as starting point the achievement of current metrology that **no measure is acceptable if it does not report uncertainty**, which therefore has to be dealt with in any kind of measurement.

Metrology like all modern science **rejects the idea that it is possible to reach truth as perfect correspondence between thought and reality.** It is not by chance that it increasingly prefers the notion of compatibility to that of truth and that of uncertainty to that of error (although error and uncertainty are distinct concepts which are both still in use).

In a certain sense, the identification and explicit mention of uncertainty is a sort of **regime** which transforms the danger of an inexact measurement in a controllable, yet unavoidable **risk**.

However the concept of uncertainty is not merely technical, since it also has **philosophical, theoretical and methodological implications**.

Uncertainty concerns all disciplines, both in the so called causal sciences and in the systemic sciences (a distinction which is perhaps more appropriate than that between natural and social sciences). Systemic sciences undoubtedly show some specificities that must be adequately taken into account. Yet, even physics, which is the archetypal "causal" science, at least in its quantum mechanical developments, is subject to the principle of indeterminacy and to an uncertainty which also affects the "intrinsic" (though still detected by means of a theory) characteristics of the measurand and not only the capability of the observer, as in the notorius case of the dual nature of particle and wave of the elements of matter [1].

Metrology distinguishes between type A uncertainty evaluation – with statistical methods – and type B uncertainty evaluation –with non-statistical methods. A link can be made to this regard between uncertainty and **the notion of validity and reliability** (items initially raised in the breakout seession at the latest MINET Think Tank event B[2] last September 2007 in Portoroz). We know that the uncertainty concept is heir of that of error margin, and that casual error is detected by assessing reliability, while systematic error is sometimes associated with validity. The outputs of these assessments are different though: validity and reliability are expressed as coefficients, while uncertainty is expressed as an interval; validity and reliability are referred to a test, uncertainty is referred to a measure; and so on. Moreover, while reliability is an observative, pre-theoretical concept, validity calls for a theory which establishes a relationship between the indicator (or the measure) and the measured phenomenon (or its concept, or construct). We might therefore ask ourselves whether a merely statistical approach to measuring validity is sufficient or, on the contrary, **a broader, theory-oriented concept of validity - and thus of uncertainty -** is necessary.

The **distinction between the type A and B measurement uncertainty evaluations does not say much on the possible causes or sources of uncertainty**[3]. In the context of systemic disciplines or interdisciplines like those involved in measuring the impossible, sources of uncertainty might include, besides systematic and casual error, also other sources like **natural variation** and the **intrinsic casuality** of certain systems, **model uncertainty**, and other specificities related to the use of **subjective judgements**. To this which has been termed "epistemic" uncertainty some authors add **"linguistic" uncertainty** provoked by **vagueness, ambiguity, underspecification, theoretical indeterminacy and context dependency of scientific terms** used to designate the phenomena to be measured[4].

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[1] Hanson N.R., "Uncertainty", *The Philosophical Review*, Vol. 63, No. 1, (Jan., 1954), pp. 65-73

2 http://lesliependrill.wordpress.com/minet-wp3-think-tanks/minet-think-tank-event-2-introduction-welcome/Password: "wp3"

[3] *International vocabulary of metrology – Basic and general concepts and associated terms (VIM),* JCGM 2008; JCGM WG1, *GUM - Guide for the expression of uncertainty in measurement,* www.bipm.org/en/commitees/jc/jcgm/wg1.html

[4] Regan H. M., Colyvan M., Burgman M. A., "A Taxonomy and Treatment of Uncertainty for Ecology and Conservation Biology", *Ecological Applications*, Vol. 12, No. 2, (Apr., 2002), pp. 618-628

In measurements with persons there is also a number of **psychological issues** which have to be taken into account. Progresses of cognitive sciences on the way in which **human beings make evaluations and estimates in uncertainty situations** should also be considered in this context: the various "cognitive illusions", the tendency to use criteria that are different from mathematical probability theory, etc.[5]. Of course, one should also consider that measurement with persons can be performed by using methods which reduce the influence of such cognitive bias (e.g. by asking to report facts rather than to make evaluations, providing objective indicators and criteria to base upon, etc.).

2. Questions for discussion

Based upon what has been exposed so far and further considerations, the following issues for discussion are suggested.

a) Would it be useful and appropriate to define **a typology of sources of uncertainty in measuring the impossible**? What could be the main sources to be included?

b) What is the **relationship between the concept of uncertainty** in measurement (especially developed in metrology) **and those of reliability and validity** (especially developed in social and psychological sciences)? Is an interdisciplinary dialogue in this field useful or possible?

c) In measuring multidimensional and complex phenomena the **number of uncertainty contributions** increases because more variables are measured. What to do when the "laws" which establish the relationship between quantities are not known, differently from what happens in physics when propagation of uncertainty is calculated? Does the widespread practice of some scientists in the MtI field of using **several different indicators** to increase the validity of the measurement of an individual phenomenon **reduce or increase uncertainty**?

d) How should we take into account the specific **difficulties and complexities of the first attempts of measurement in a certain field**? Can we think of a diversified "timing" for introducing the requisite of uncertainty assessment on the basis of the novelty and complexity of

[5] Tversky A., "Assessing Uncertainty", *Journal of the Royal Statistical Society*. Series B (Methodological), Vol. 36, No. 2,(1974), pp. 148-159; Kahneman D., Tversky A., *Variants of uncertainty*, paper, May 15, 1981.

the performed measurement? In the impossibility of quantifying uncertainty, could alternative, non-numerical ways to declare it be used? (e.g. by qualitatively describing the various sources of uncertainty). Are there "good practices" in assessing uncertainty in MtI projects, even if uncertainty is not explicitly declared?