Meeting future needs for Metrological Traceability – A physicist's view

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IUPAP 'SUNAMCO' Commission

C2: Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants

http://www.physics.umanitoba.ca/IUPAP/C2.html

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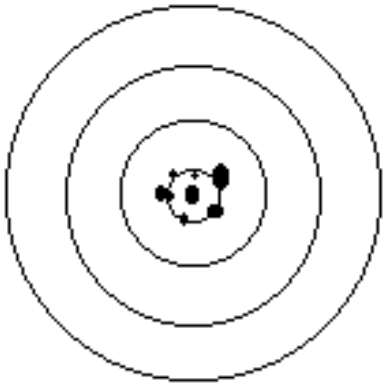
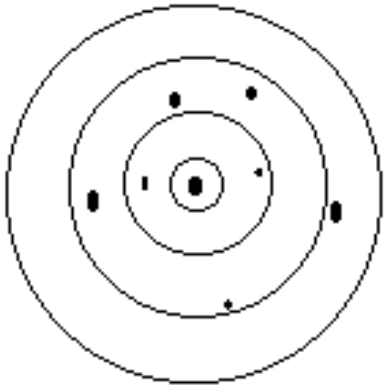
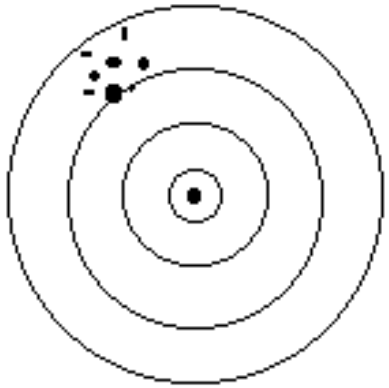


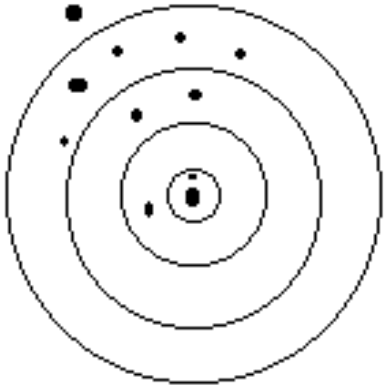
High trueness
High precision



High trueness
Low precision



Low trueness
High precision



Low trueness
Low precision

Accuracy

[ISO 5725]

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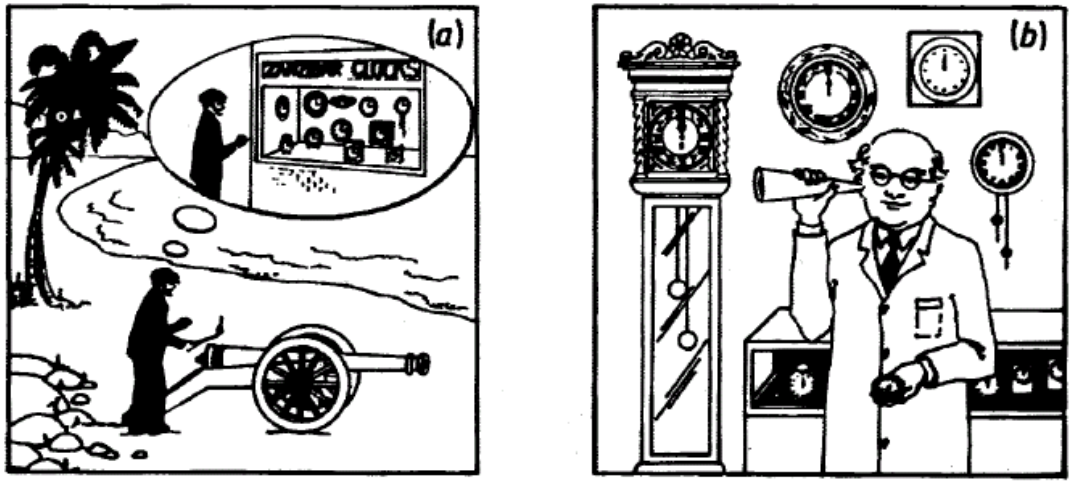
Traceability and calibration give <u>trueness</u>

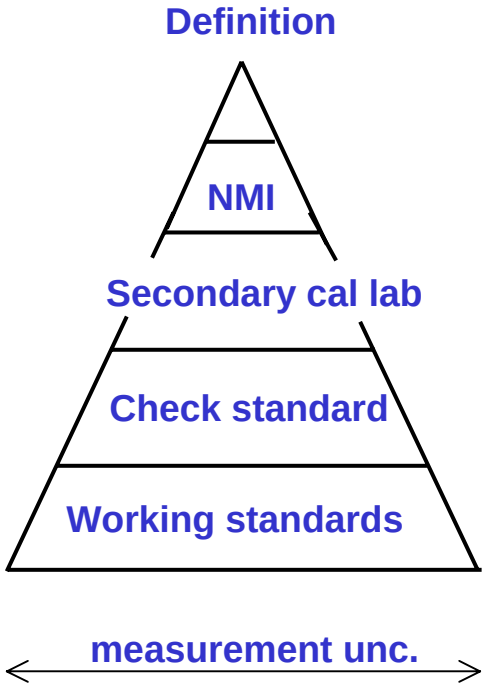


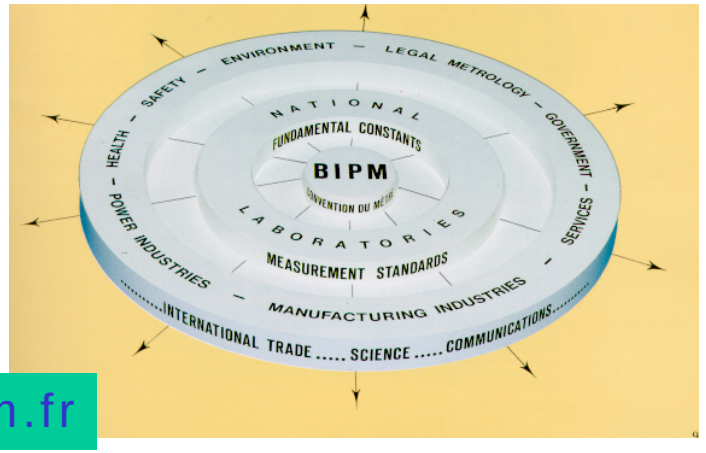
"Zanzibar effect" [Harrison, MIT]

National & International Metrology

Only measurement results where metrological traceability is clearly established

- can be compared
- independent of time and place





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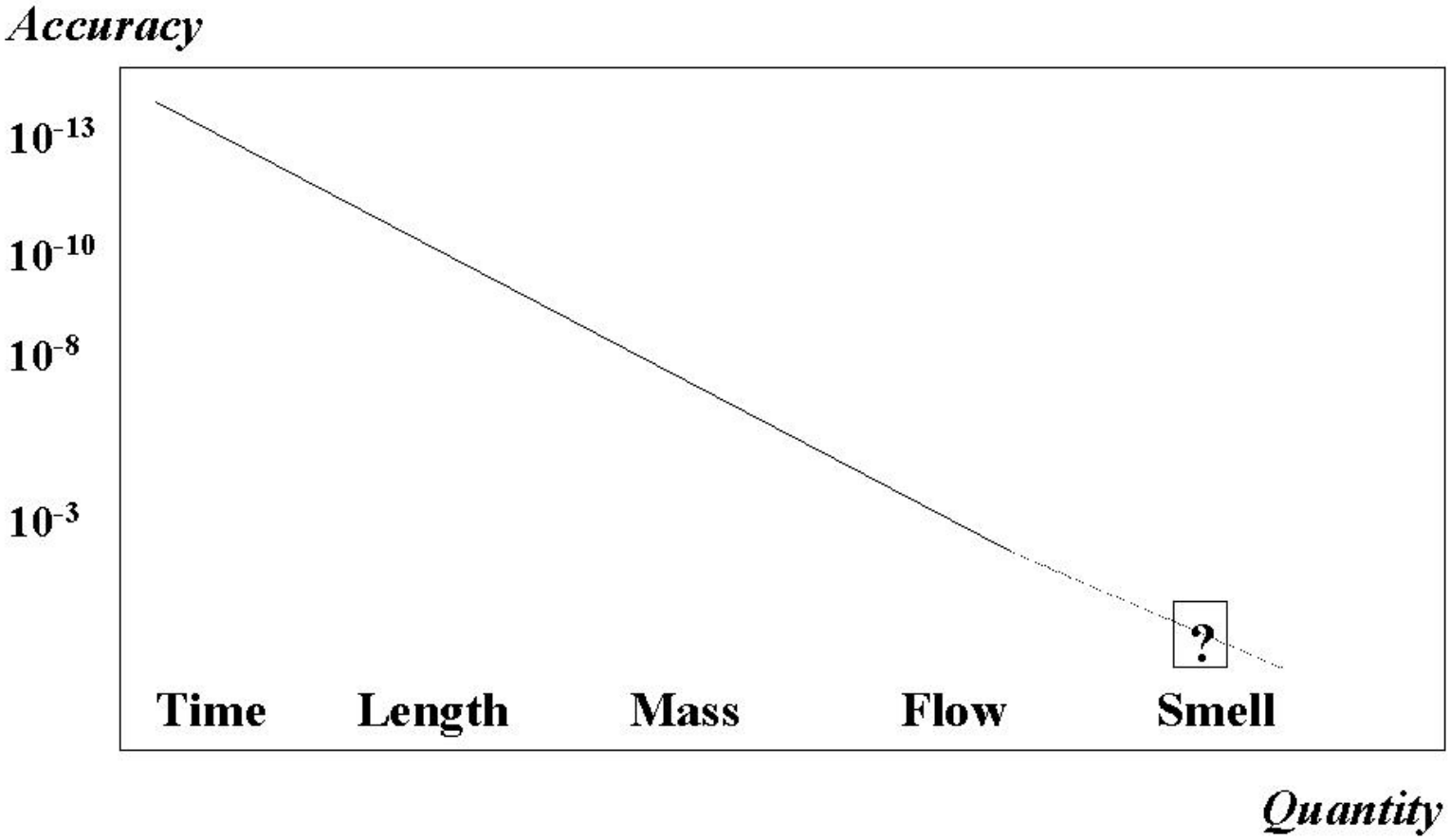
Meeting future needs for Metrological Traceability

– A physicist's view



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Metrological traceability concept

Basic differences??

between the metrological infrastructure for
-'physical' and

- '(bio-)chemical', measurements.

Metrological traceability – different for the chemist?

"…*in chemical measurement the issue is to compare amount of analyte* …" [Taylor *et al.* 2003]

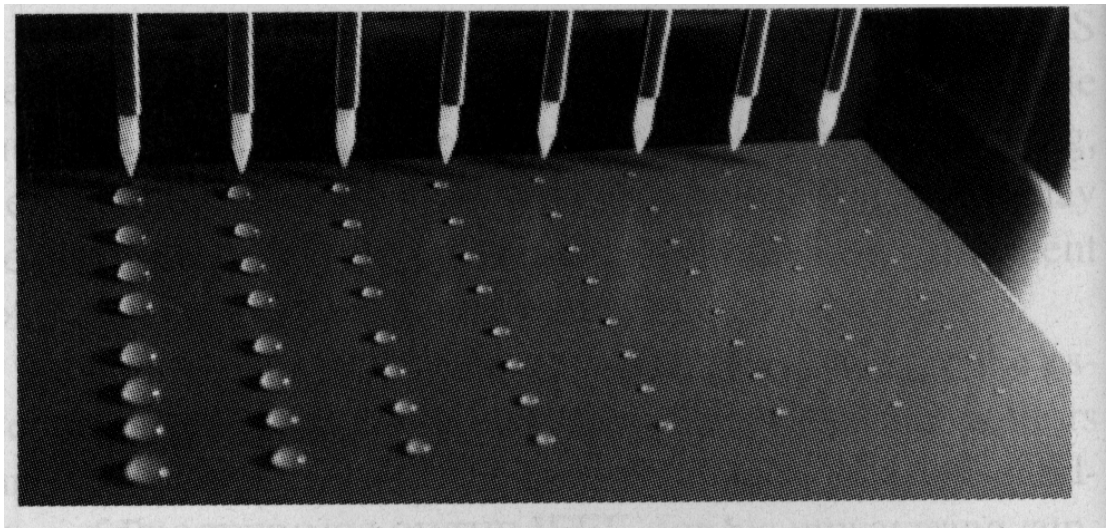
"*Chemical measurements …are made indirectly … measuring other quantities (…sample weight, volume, … signal response …) …and calculating the result…*" [King 2003]

Meeting future needs for Metrological Traceability – A physicist's view

"L'unité la plus employée en chimie est sans conteste le litre …" [Perdijon 1998]

?

Claude Émile Jean-Baptiste LITRE 1763
"Etudes volumetriques"



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"Weighed in the Balance – A history of the Laboratory of the Government Chemist"

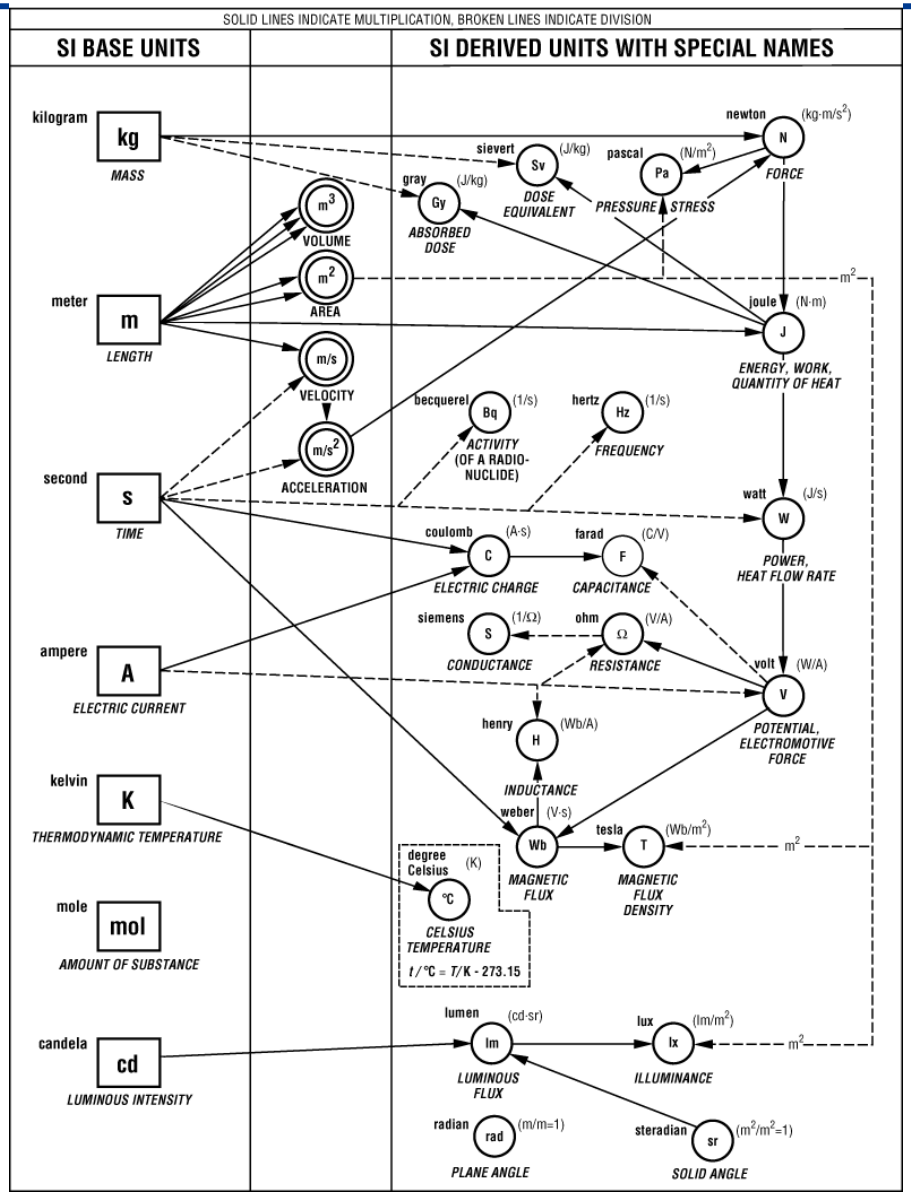
[Hammond and Egan 1992]

Meeting future needs for Metrological Traceability – A physicist's view

"Chemical measurements …are made indirectly … measuring other quantities (…sample weight, volume, … signal response …) …and calculating the result…" [King 2003]

Direct and indirect measurements

- laws (eg $F = m \cdot a$)
- "recipes"



NIST

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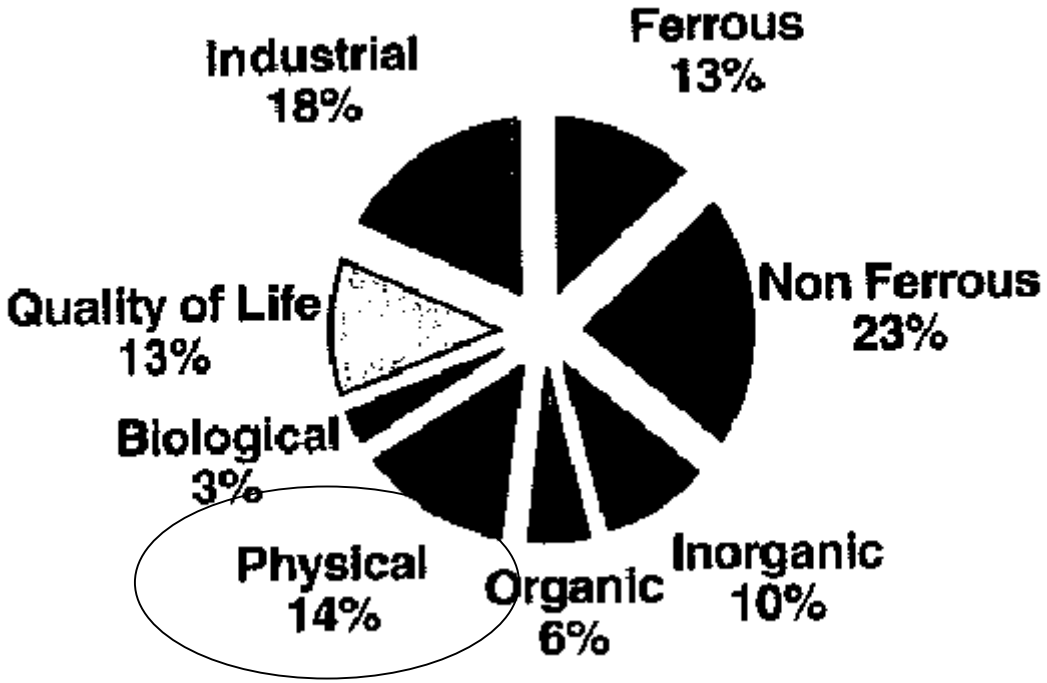
Distribution of certified reference materials (CRM) by field of application



Not always full traceability to the SI

Pradel, Steiger and Klich 2003 *ACQUAL* **8** , 317 -8

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Not always full traceability to the SI

Brightness of paper = a quality paid for

Impediment: Differences in measurement standards for diffuse optical reflectance according to ISO standards
Observed difference for 100% brightness point: 0.5% -1%

Canada is the largest producer world wide

- North America traceable to NRC
- Europe traceable to PTB

Consequences:

- Extra bleaching
- Whiteness 79 to 80:
- 2,5 USD/tonne
- 65M USD/yr for Canadian producers

Not included are costs of:

- New equipment
- Process changes
- Less recycling of paper
- Environmental impact

If traceable to SI, then measurement results even of <u>different</u> quantities become comparable in framework of physical theory

- laws (eg $F = m \cdot a$)
- ”recipes”

Metrological traceability – different for the chemist?

"…*end-user chemists … no philosophical interest in knowing 'if a bias must always be corrected'…*" [Charlet and Marschal 2003]

"…*where traceability …to SI …is not possible and/or irrelevant …*" [ISO 17025 and Mittmann *et al.* 2003]

"*Essential requirement is that … traceability is … established at a level of uncertainty appropriate to the final test result*" [King 2003]

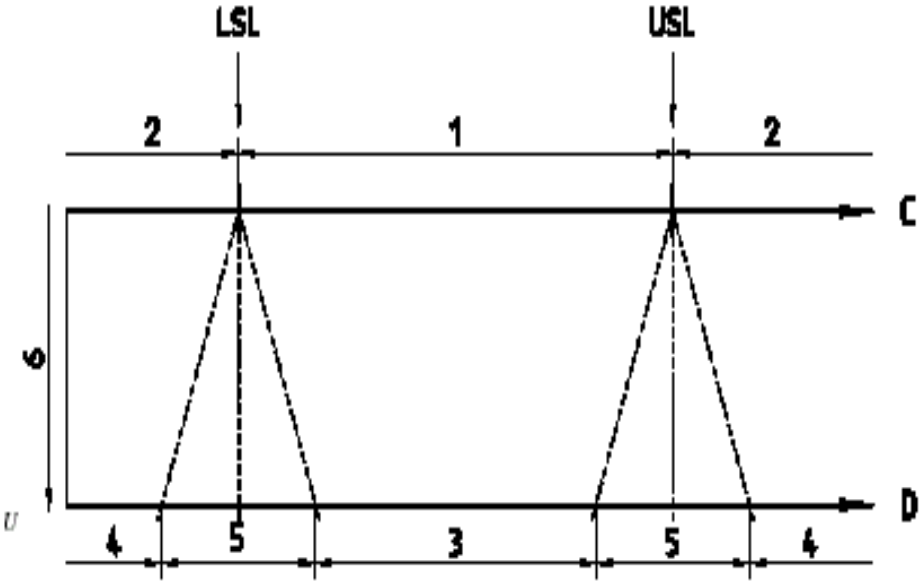
Conformity assessment and measurement uncertainty

Physical metrology: Tolerances and uncertainties for measuring devices

EN ISO 14253-1:1998

Key

C Design/specification phase
D Verification phase
1 Specification zone (in specification)
2 Out of specification
3 Conformance zone
4 Non-conformance zone
5 Uncertainty range
6 Increasing measurement uncertainty, *U*



When is traceability important? $\frac{MPE}{U_{cal}} > 6?$

[Källgren *et al.* 2003]

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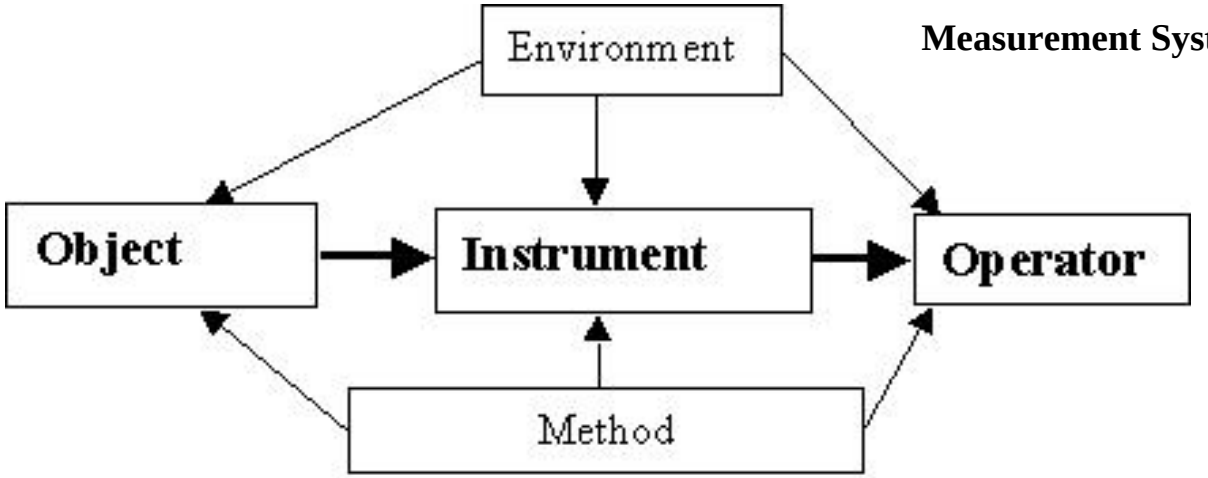


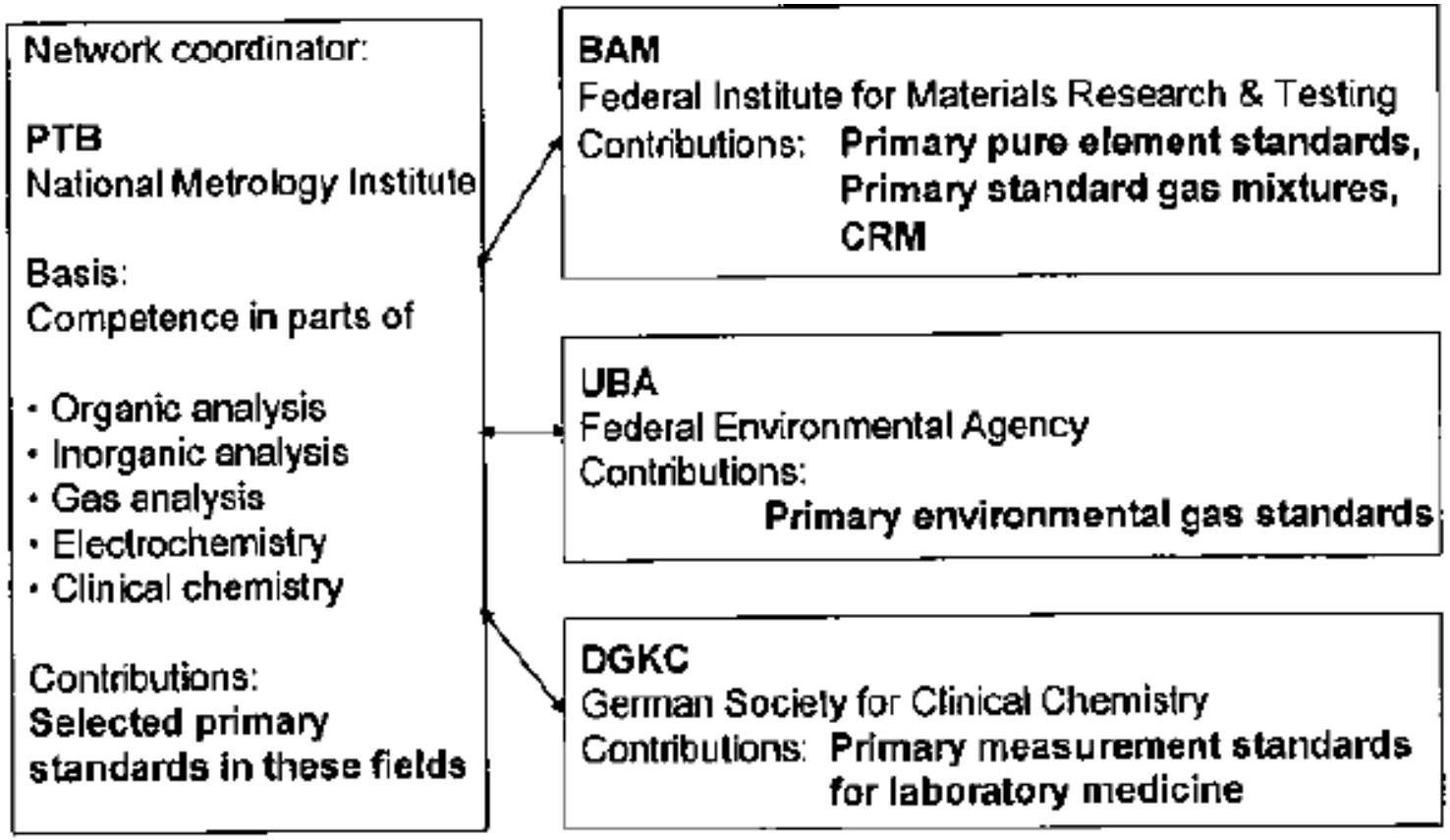
Measurement System Analysis [QS9000]

Increased clarity in the traceability concept

- not only of benefit for the chemist

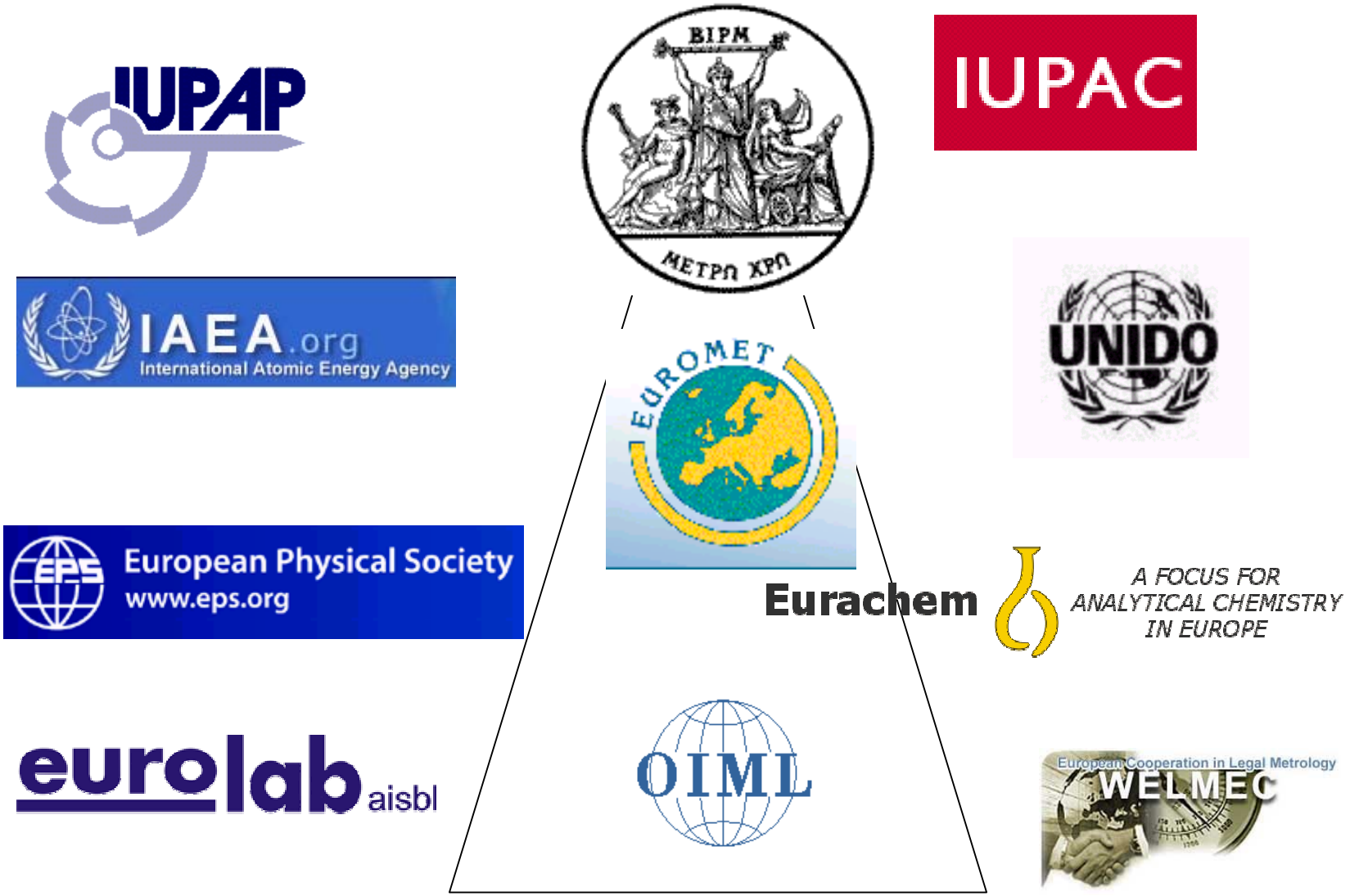
- but also provides new insight into this concept in physical measurements.

Structure of German national standards network for chemical measurements



Richter and Güttler 2003 *ACQUAL* **8**, 448 - 53

Stakeholders in Traceability



Pendrill L R 2003 "*European Metrology Stakeholders Consultation*", SP Report 2003:13

"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom."

SI base unit

- **Highest accuracy** (both precision and trueness)
- **Generic – not for a specific application**

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Needs / Resources	Science /strategic	Manufact-uring	Trade	Nano-technology	Regu-lation	Food
Mass		X		X		X
Length		X				
Time	X				X	
Electricity				X		
Amount of substance			X			

Matching needs and resources in metrology

Formulating benefit criteria for metrology projects

- Economic impact
- NMI science
- Science infrastructure
- Quality of life
- Standards & Technical Regulation
- Risk

DTI (UK) 2003

Particular concerns of developing countries in metrology

Metrological traceability in measurement of a wide range of physical and (bio-)chemical quantities

- plays a key role in ensuring sustainable development.

• increased efficiency and reduced waste in *industrial processes and production*

• monitoring and control of the *environment* and emissions

• *transport*

• international *trade*

Stakeholders in Traceability

IUPAP

IUPAC

IAEA.org
International Atomic Energy Agency

UNIDO

EUROMET

European Physical Society
www.eps.org

Eurachem
A FOCUS FOR ANALYTICAL CHEMISTRY IN EUROPE

eurolab aisbl

OIML

European Cooperation in Legal Metrology
WELMEC

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Pendrill L R 2003 "*European Metrology Stakeholders Consultation*", SP Report 2003:13, ISBN 91-7848-946-6 [http://www.sp.se/metrology/eng/documents/MERA_WP6_SP_Report2003_13.PDF]

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