Financial sustainability of metrology research for smaller countries and developing economies

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- What is metrology research?
- Does it differ from other research areas?
- Is it different from country to country?
- What affects financial sustainability of metrology research?
- Do we need metrology research, CMCs, MRA?
EMRP - EXECUTIVE SUMMARY

What is metrology research?

With the overall goal of accelerating innovation and competitiveness, generating data and knowledge necessary to improve quality of life, and providing better tools for the scientific community the European Metrology Research Programme aims, through European integration, to develop new measurement capabilities which have strategic impact for Europe.

Does it differ from other research areas?

- The programme objective is to accelerate the development of new measurement capabilities and to significantly improve dissemination and application of the knowledge generated throughout the stakeholder community.

YES! It is a demand driven scientific disciplines and infrastructure, inherently related to applications and consequently to objective quality.
Is it different from country to country??

In principle NOT! (with the respect to global markets)
It has to provide traceability to SI units, develop new techniques, assure quality…

Dilemma
How to solve comparable objectives? Compromise on scientific excellence, quality, scope?

ACTIVITY AREAS (EMRP)

• Metrology is a horizontal scientific-technical field which underpins almost all subject fields in natural sciences and engineering. It is a technically wide and multidisciplinary field under a common methodology – characterized by the scientific treatment of measurement uncertainties, mathematical methods and principles of traceability.

• Consequently, the activity areas of the EMRP are structured in
  – Grand challenges for multidiscipline metrology (health, energy, environment, new technologies).
  – Grand challenges on fundamental metrology.
  – Focussed single-discipline and applied metrology.
NEED FOR THE DEVELOPMENT OF NATIONAL MEASUREMENTS STANDARDS
Evolution of national measurement standards’ accuracy with time

Reference to:
Dneviček et al, Establishing appropriate metrological infrastructures in a small country with important industrial production, OIML Bulletin, Oct1998

METROLOGY RESEARCH ➔ BASIC OPERATIONS

Realization of the internationally agreed abstract definition of the unit.

Maintenance of the results of realization of the unit by means of a primary measurement standard.

Dissemination of the unit to the user.

Reference to:
High Level Expert Group for Measurements and Testing, Measurement and testing needs in the candidate member states, Measurement and Testing Newsletter, vol 10, no 1, June 2002
**Experimental realisation**

**Metrological application of basic science and technology**

Enabling science and technology

**Future needs in transport**

**Global climate change, earth radiation budget**

**Global trade, interoperability**

**Improved realisations and dissemination of SI unit K**

**Thermal properties from first principles**

**Modeling of thermal systems**

**Anchoring the kelvin to Boltzmann constant kB**

**Thermodynamic bases of the "mise en pratique" of the kelvin**

**New definition of ITS-XX**

**Acoustic, dielectric, radiometric, and spectroscopic determination of k with an uncertainty of ±10^-8**

**Radiometric thermometry to 3500 K, Gas thermometry 3 K - 800 K, Spectroscopic thermometry, Noise thermometry, Melting pressure thermometry**

**Reference materials, supercond. ref. devices**

**Specific development for pressure, volume and capacitance**

**Impurity and isotopic analyses**

**Improved techniques for fabrication of fixed points**

**Traceable analytical chemistry, material science**

**Ultra-pure isotopically controlled substances**

**Calorimetry and other thermal analysis methods**

**Modeling by fundamental thermodynamics and quantum mechanics**

**Improvement in dimensional, optical, and electrical metrology**

**IT and mathematics**

Enabling thermal metrology to serve future needs

**Triggers**

**Targets**

**Experimental realisation**

**Metrological application of basic science and technology**

**Enabling science and technology**

**2005**

**2010**

**2015**

**2020**

FROM HORIZONTAL TO VERTICAL

Grand challenges on fundamental metrology

**Participation in metrology research for smaller countries and developing economies**

Grand challenges on fundamental metrology

(new ITS, redefinition of Boltzmann constant)
FINANCIAL IMPLICATIONS OF METROLOGY RESEARCH
(Implementation of MRA, rationale for CMCs...)

Slovenian GDP = 33 000 MEUR

Reference to:
- Evolving Needs for Metrology in Trade, Industry and Society and the Role of the BIPM, BIPM, April 2004
- Potential Economic Impact of the CIPM Mutual Recognition Arrangement, BIPM, April 2002
- Knut Blind, The impacts of innovations and standards on trade of measurement and testing products: empirical results of Switzerland’s bilateral trade flows with Germany, France and the UK, Information Economics and Policy 13 (2001), 439-460
- Paul Temple, Geoffrey Williams, Infra-technology and economic performance: Evidence from the UK measurement infrastructure, study, Pembroke College, Oxford, HLEG 2002

- Measurement and measurement related operations (from 3 % to 6 % of GDP (up to 15 %) )
- Investments in infrastructure by governments in industrial countries (from 20×10^-6 of GDP to 70×10^-6 of GDP)
- from 990 M EUR to 1980 M EUR
- from 0.7 M EUR to 2.3 M EUR
- ratio 1:1500

BASIC PROBLEMS AND DILEMMAS
Metrology research as scientific discipline and infrastructure

Implementation of MRA does not depend only on the ability of a NMI, but is influenced by several other elements:
- resources
  - human
  - financial
  - time
- infrastructure (technical and scientific)
  - metrology NMI (M&T)
  - accreditation
  - standardization
  - certification
  - conformity assessment
- socio-economic
  - scientific environment
  - industrial requirement
  - service requirement

CMCs, maintenance and development of measurement standards, key and supplementary comparisons in relation to CIPM MRA, metrology research
RESEARCH IN METROLOGY – PRIORITISATION
(Solving the dilemma of resources)

MRA, benchmarking and national metrology development plans

- prioritisation of national needs
- comparison with other NMI’s CMCs
- new CMCs
- extension of dynamic range
- improvement of uncertainty
- maintenance of existing CMCs
- abandonment of CMCs

Reference to:

Metre Convention/ILAC joint working group, CIPM 2004-14

EUROMET Position Paper on European Laboratory Accreditation, version V5, 13.5.2004

Relationship between National Metrology Institutes and National Accreditation Bodies, draft resolution N, 22nd General Conference
### BENCHMARKING AND PRIORITISATION

CMC comparison Slovenia and European countries – thermodynamic temperature

<table>
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<th>EU MIN</th>
<th>BI</th>
<th>EU AVG</th>
<th>EU MAX</th>
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<td>LSPRT (Sn)</td>
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<td>LSPRT (Zn)</td>
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**FP of Indium (156.5985 °C)**

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### What affects financial sustainability of metrology research?

**ANALYSIS – COSTS OF CMCs**

\[
\text{uncertainty of } CMC_x = \sqrt{\text{contribution}_1^2 + \text{contribution}_2^2 + \ldots}
\]

\[
\text{uncertainty of } CMC_x = \sqrt{\text{instrument} + \text{procedure} + \text{environment} + \ldots}
\]

\[
\text{improvement of } CMC_x = \text{cost}_1 + \text{cost}_2 + \text{cost}_3 + \ldots = ???
\]

**COST = COST OF ESTABLISHMENT + COST OF MAINTENANCE (SCIENCE + QUALITY)**

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**Implementation of MRA**

**Identification of needs, weighting, prioritisation, provision of resources**

**Sharing of resources**

**IMERA**
**STEPS IN PRIORITISATION PROCESS**

- What do we need?
- What already exists?
- How many CMCs and their quality?
- What is the reference point?
- History of scientific excellence
- Do we have resources; expertise, money, time?
- Is an NMI able to provide resources?
- Do we need wider public consensus/support?

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**METROLOGY RESEARCH**
(from Metre convention to Mutual Recognition Arrangement)

**Objectives**
- to establish the degree of equivalence of national measurement standards maintained by NMIs;
- to provide for the mutual recognition of calibration and measurement certificates issued by NMIs;
- thereby to provide governments and other parties with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs.

**Process**
- international comparisons of measurements, to be known as key comparisons;
- supplementary international comparisons of measurements;
- quality systems and demonstrations of competence by NMIs.
CONCLUSIONS

• Financial sustainability → Sustainable use of resources (finances, material, human, premises, time…)

• Clear identification of required resources (research, maintenance, dissemination…)

• From horizontal to vertical

• Metrology is scientific discipline and infrastructure and as such is of public interest

• Metrology research as a support to MRA