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**SI, BIPM, RMOs, NMIs. What next?**

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**Abstract:** The organizations responsible for the maintenance of the measuring standards according to the SI at international, regional and national levels are facing new challenges. A worldwide efficient and transparent metrology requires a new model of organization. The authors give an overview of the actual challenges and explain their thinking about where to go and how to built up it in the future.

**Keywords:** SI, BIPM, metrology

## 1. INTRODUCTION

In the developed world, the different countries have a measurement infrastructure supported by national standards traceable directly to the SI units<sup>1</sup> or get their traceability through other National Measurement Institute (NMI).

The NMIs are the top layer of national measurement infrastructures and its traceability to SI units is their main purpose. They carry out a range of activities from high science metrology to maintenance of reference materials as primary or national standards [1]. Most NMIs also play a key role in measurement networks for knowledge and technology dissemination and transfer.

In order to realize the quantities in a consistent way, it is essential that the NMIs compare their standards with other countries. An inter-laboratory comparison at a similar level can't give direct traceability to the SI units, but it is an important way of accessing the reproducibility of the realizations.

The signatories countries of the Meter Convention met at the 21<sup>st</sup> CGPM<sup>2</sup>, held in October 1999, reached a consensus and signed an important document, known as the MRA<sup>3</sup>, bringing a challenge to the metrology world. The main objectives (CIPM<sup>4</sup>, [2] pg. 28) are: ...“to establish the degree of equivalence of national measurement standards maintained by NMIs; to provide 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 with international trade, commerce and regulatory affairs.”...

The mutual recognition is supported by the results of international inter-laboratory measurement comparisons –

the so-called *key and supplementary comparisons* organized by the CIPM CCs<sup>5</sup>, of the BIPM, the RMOs<sup>6</sup> and NMIs, and by the recognition of their quality systems and demonstration of competence by their peer NMIs. The greater number and broader scope of those participations in the comparisons of the institutes the larger traceability guarantee of the measurements realized in their country.

The quantitative measure of the difference between the national standards is one of the tasks emerging from this arrangement and the CIPM and the RMO's are in charge for.

## 2. THE MRA COMPARISONS

There are different rings of comparisons (otherwise a worldwide comparison would last several years or decades), the CCs rings, the Regional rings and are allowed bilateral comparisons, as MRA was planned.

The key comparisons (KC) are chosen by the CCs, followed by the RMOs, and they are the technical basis for international equivalence, testing the principal techniques in each field of metrology, checking the estimated accuracy of independent primary realizations of the units of the SI.

They are carried out according to a set of technical guidelines [3] drawn up to ensure the main objectives of the MRA, so the obtained results must be clear and unequivocal; robust and easy to compare with those of corresponding comparisons carried out by the RMOs.

A key comparison reference value (KV) and its uncertainty are obtained and the deviation from this reference value and the uncertainty of the deviation is deduced for each of the inter-laboratory comparison participants.

The proper evaluation of the standards uncertainties is critical and must be credible in order that the KV is a *Consensus Value*.

## 3. THE INTERNATIONAL MEASUREMENT SYSTEM

There is a wide range of RMOs concerned with the BIPM/MRA. These include EUROMET (European Fundamental Metrology), SIM (Inter-American Metrology System), that co-ordinates NORAMET (North America), CAMET (Central America), ANDIMET (Northern South America), SURAMET (Southern South America) and

<sup>1</sup> SI units – The International System of Units (CIPM, 1998)

<sup>2</sup> CGPM – General Conference of Weights and Measures

<sup>3</sup> MRA – Mutual Recognition Arrangement

<sup>4</sup> CIPM – International Committee of Weights and Measures

<sup>5</sup> CCs – Consultative Committees

<sup>6</sup> RMO – Regional Metrology Organisation

CARIMET (Caribbean). COOMET (Eastern Europe), APMP (Asia Pacific) and SADC MET (Southern Africa). Recently an agreement in the African region laid down the first principles to establish an AFRIMETS to be in charge for the regional role in fundamental metrology.

As an example of the regional metrology organization we will refer the European example so as the present challenges we are facing.

#### 4. THE RMO EUROMET

The top-level role of the European NMIs is similar but their activity varies across Europe. Some are more research-oriented, others more customer-oriented disseminating the units by the calibration of measurement instruments, by producing reference materials and legal metrology activity.

As referred at the final report of European Measurement Project "The Assessment of The Economic Role of Measurements and Testing in Modern Society [1], ...Building a Europe-wide measurement infrastructure is a task that is properly taken on by the European Commission, ...Measurement infra-technologies are essential in supporting EU aims for the ERA<sup>7</sup>, for enlargement, for the further development of the single market and for its continuing efforts in health, safety, the protection of the environment and the fight against fraud.....

##### 3.1 The iMERA Project

To face the need of huge financial and personnel needs for the next generation measurement standards, Europe is building up a new metrology network. In this network the countries put their own national effort together with others to develop new measuring standards and new measuring methods. From this common effort a new formal institution will supersede EUROMET and change the way of governing the resources each country will put on board of the project. New generation primary standards will come out from this common effort and a new concept of international and national traceability overall Europe will be implanted. Details of this iMERA project will not be referred in this communication, as others will provide them.

Anyway we can imagine in a near future a first level of the European measurement standards in a number of decentralized NMIs, providing traceability to all others. This more efficient way of investing in future developments and of realization of the SI units together with the provision of traceability in the region. The expected result of this effort will allow not only a better use of limited resources but also a deeper collaboration between experts in the same field from different countries. This project will have a variable geometry considering the different measurement fields: some more centralized others more decentralized.

At the same time new generation measurement standards require more and more interdisciplinary metrology, demanding an extensive collaboration between experts of different technologies and fields. This approach of sharing facilities and experts will facilitate the required ambiance for the materialization of the new standards.

#### 5. THE BIPM OF THE FUTURE

At the international level we must look on what is happening to the BIPM. With a very limited budget and increasing demands to provide international traceability and international guidance and leadership in metrology needs all over human activities the BIPM faces a large uncertainty in its future. The amount of work to deal with the MRA and the KCDB tends to increase more and more especially to deal with the new fields absorbing the limited resources of the organization and the members are not intending to overcharge their contributions.

If these tendencies go on, most of the international standards according to the metrological science state of the art will be kept in the next future outside the BIPM, in national or regional institutions of excellence and the role of governance of the BIPM will be symbolical and administrative. So a new conceptual idea for the BIPM of the future is needed.

Established in Sèvres in the third quarter of the nineteenth century the BIPM plays a role in the international arena with a high standard of metrological quality. There is no way to increase in the present to all the fields requiring metrology attention the ideal concept behind its creation.

In 130 years time the technologies had a huge evolution and the metrological traceability requirements cover today all aspects of human life, tangible or intangible. Sèvres, France or any other country at the top of metrological knowledge has no more conditions to host such a broader and future organization. However the model to keep traceability coherent and spreaded around must be kept: it is essential to provide credibility to trade and society in general.

At the same time the SI is still far of being completely disseminated and in some large and influent countries there are still difficulties in its application in daily life. So the XIX century goals are not yet accomplished and there is an important path to be fulfilled by the BIPM.

In recent years to face the needs to provide international traceability in some new arising fields some of the BIPM historical and traditional fields had to close their work to concentrate in the new fields some more budgetary resources. This reallocation of resources has no return and more resources should be allocated in new areas in the future like materials science, food and drugs, environment, biotechnologies and life sciences, etc. And no one can think nowadays about an immense BIPM taking over of the research in all the fields requiring scientific metrology at the international level. So, a new approach is required.

With such circumstances there is only one way to face the future. The BIPM infrastructure should be disseminated itself. The role of keeping and developing measuring standards should be pursued in centers of metrological Excellency all over the globe in particular laboratories working on behalf of the BIPM, using multilateral expertise and collaboration, accessible to all BIPM members.

The new European infrastructures under construction in the frame of iMERA together with some others around the globe could be in the future the seeds of those metrological Excellency centers where international traceability could be assured for a longer time life period.

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<sup>7</sup> European Research Area

The BIPM should keep the same role of governing scientific metrology, organizing equivalence of regional and national metrology systems as the focal point for the international work to provide metrological credibility and equivalence to support world society.

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