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PRACTICAL EXPERIENCE OF THE CIPM MRA - THE VIEW FROM AN NMI ”USER”

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Abstract: The mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes (NMIs) was signed in October 1999. Since then the NMIs have striven to develop and effectively implement the CIPM MRA. Following the completion of the transition period, this paper describes those activities from an NMI’s viewpoint, the lessons learnt and the challenges to be faced in the future, including ensuring that the benefits of the CIPM MRA are taken out into the wider international community and that the CIPM MRA can be developed and sustained in the long term.

Keywords: CIPM MRA, National Metrology Institutes, international cooperation.

1. INTRODUCTION

The mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes [1] (the CIPM Mutual Recognition Arrangement) was drawn up by the intergovernmental International Committee for Weights and Measures (CIPM). The CIPM MRA was signed in October 1999, by the directors of National Metrology Institutes (NMIs) from 38 countries and 2 international organisations, and by April 2006 this number had grown to 65 countries and 2 international organisations.

The objectives of the CIPM MRA are:

- 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.

The CIPM MRA is a response to the need for measurements and tests that are appropriate, reliable and trusted domestically and internationally in support of trade agreements, regulation and fair competition, and to underpin sustainable development. The CIPM MRA is certainly the most significant development in the structure of metrology since the adoption of the International System of Units (SI) [3] in the 1960’s and arguably the major development since the signing of the Metre Convention [3] in 1875 by representatives of seventeen nations. The CIPM MRA also formalised the structure of regional metrology for the first time through the establishment and transfer of defined responsibilities and roles to the Regional Metrology Organisations, such as EUROMET, SIM etc.

The CIPM MRA was subject to a transition period that finished at the end of 2004. Following the completion of the transition period, it seems appropriate to review those activities from an NMI’s viewpoint, consider the lessons learnt and identify the challenges to be faced in the future, including ensuring that the benefits of the CIPM MRA are taken out into the wider international community and that the CIPM MRA can be developed and sustained in the long term.

2. IMPLEMENTATION OF THE CIPM MRA

Unlike many agreements, the CIPM MRA is not just a paper arrangement and arguably the signing of the CIPM MRA could be considered as the beginning of the process. The CIPM MRA can be thought of as being supported by three pillars that require the participating NMIs and designated institutes (DIs) to:

- Take part in appropriate international comparisons of measurements - **the key and supplementary comparisons**;
- Declare and subject their **Calibration and Measurement Capabilities (CMCs)** to extensive peer review;
- Implement and demonstrate an appropriate **quality system**.

One of the main aspects of the CIPM MRA is the BIPM key comparisons database (KCDB) available for public consultation on the BIPM website [4]. The operational elements of the database are:

- A list of the signatories to the CIPM MRA;
- Results of key and supplementary comparisons;
- Listed key and supplementary comparisons;
- Calibration and measurement capabilities (CMCs).

2.1. Comparisons

Comparisons pre-date the CIPM MRA and have been an integral part of the activities of established NMIs for many decades, often driven by the need to validate the latest scientific developments. However, the establishment of the CIPM MRA meant that a much more structured and coordinated approach was possible and indeed required, with comparisons carried out at both CIPM level and regional level under the auspices of the Regional Metrology Organisations (RMOs). This has required identifying those comparisons required to underpin the CMCs and the CIPM MRA, developing schedules and protocols (enabling the results to be linked to those of other comparisons), selecting pilot laboratories and coordinating the participation of many (sometimes tens of) NMIs.

The KCDB lists more than 670 key and supplementary comparisons, of which more than 500 have been active since the beginning of 1999. Fig 1 shows the breakdown of the comparisons active since 1999 by region.

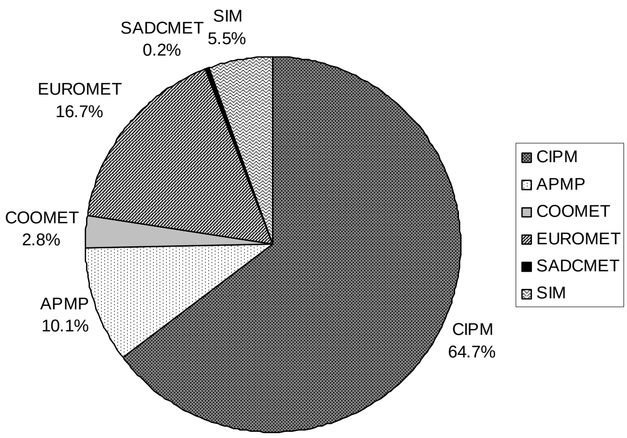

Fig 1. - Breakdown by region of comparisons active since the start of 1999

CIPM comparisons involve a selection of NMIs from across the regions. Comparisons under the auspices of CIPM fall into two categories, firstly the top level Consultative Committee comparisons and secondly the on-going comparisons, such as those in ionising radiation, run by BIPM. Around 70 comparisons included in the CIPM sector in Fig 1 fall into this second category.

The number of members within each RMO varies, as does the size and range of their economies. Some of the differences between the regions apparent in Fig 1 are perhaps also not surprising, as Europe has a long track record of comparisons, a significant number of established NMIs and a large number of active laboratories. In contrast COOMET and SIM have fewer members and include a significant number of recently established NMIs. Within EUROMET during the last seven years there have been over 100 comparisons which have been or still are active, of which the National Physical Laboratory, UK has participated in around two thirds.

2.2. Declaration and review of the CMCs

Calibration and measurement capabilities (CMCs) describe the best capabilities for services routinely offered by an NMI to its customers. Essentially CMCs comprise three main components - a description of the service (from the vocabulary), the range of the measurand and the associated uncertainty.

Prior to developing and declaring CMCs, it was necessary for the international NMI community to develop an internationally agreed terminology, known colloquially as the ‘vocabulary’, to describe the measurement services offered by the NMIs. In many technical areas this proved more challenging and time consuming than originally anticipated, with initial work complicated by the need to reach a consensus on which services would be entered into the KCDB. With hindsight this is perhaps not surprising as the process involved many NMIs around the world with diverse expertise and capabilities. In addition, not all countries had an established network of accredited calibration and test laboratories and hence in order to meet national needs a number of NMIs undertake measurements and tests that would, in a more established arena, either be carried out by accredited laboratories or a legal metrology laboratory.

After an internal review within the NMI, all CMCs undergo peer review by other NMIs within the local Regional Metrology Organisation (RMO), followed by a sample peer review by all other RMOs. CMCs are then submitted for review to the Joint Committee of the RMOs and the BIPM (JCRB). Once agreed by the JCRB they then populate the BIPM key comparison database (KCDB) on the BIPM web site. The CMCs are described using a common format that has been agreed internationally, categorised under the following nine technical areas and then further divided into a larger number of sub-fields:

- Acoustics, Ultrasound and Vibration
- Amount of Substance
- Electricity and Magnetism
- Ionising Radiation
- Length
- Mass and Related Quantities (including Flow)
- Photometry and Radiometry
- Thermometry
- Time and Frequency

CMCs have now been published within all the nine areas described above, but not yet for all sub-fields. By April 2006 there were around 18,000 CMCs published in the KCDB, of which around half were from the European RMO EUROMET.

2.3. Implementation and demonstration of an appropriate quality system

In 1999 only a minority of NMIs had formal quality systems, with a much smaller number, including NPL, having operated some accredited calibration services for a while. Many NMIs have therefore had to develop and implement quality systems (QS) which comply with the requirements of ISO/IEC 17025 [5], [6]. Whilst a number of laboratories chose to be formally accredited for all or a selection of their services, many chose to self declare their QS and mechanisms therefore had to be developed to ensure that compliance with the CIPM MRA could be demonstrated. The RMOs have developed a range of approaches, suited to their particular regional needs, in order to assess the quality systems of their member NMIs and DIs.

In Europe a EUROMET working group (QSForum) was established to undertake the peer review of the quality systems of all participating European NMIs and designated laboratories (DI). QSForum was headed by a steering committee comprising NMI representatives (including NPL) with significant experience of quality systems. As the transition period for the CIPM MRA drew to a close, EUROMET formalised the role of QSForum with the establishment of a separate technical committee (TC-Q). Each NMI and DI is required to make a formal presentation, to implement any corrective actions that are identified and to provide evidence of this. Within APMP the quality systems are assessed through a process of on-site peer review visits in cooperation with the accreditation bodies, whilst COOMET combine a review forum and on-site peer review visits.

Since the beginning of 2005 the requirement has been introduced for NMIs and DIs also to comply with the quality requirements of ISO Guide34 for reference material CMCs submitted through the Consultative Committee for the Amount of Substance.

3 LESSONS LEARNT AND CHALLENGES FOR THE NMIs IN THE FUTURE

The CIPM MRA was subject to a transition period that finished at the end of 2004. It is therefore appropriate to view the transition period (1999–2004) as the time during which the main elements of the CIPM were established and put into effect. Much progress has been made since the CIPM MRA was signed in 1999 and a number of lessons learnt.

One of the major issues facing the NMIs is that of resourcing the work of the CIPM MRA. Developing and reviewing the CMCs and coordinating and participating in comparisons has understandably proved very labour intensive, but that level of activity is not sustainable in the long term for the NMIs, particularly as the number of participants in the CIPM MRA continues to grow. Processes and approaches must therefore be developed to ensure that the CIPM MRA can be maintained, developed and benefited from in the future.

3.1 Comparisons

There are various aspects related to comparisons that require consideration, including:

- the number of comparisons undertaken (how to address issues such as the scope, range, ‘how far does the light shine’, frequency – how long is a comparison valid for?),
- linkage between comparisons (analysis of comparisons, scheduling between CC and RMO comparisons, incorporating additional members and supplementary comparisons),
- levelling out the work load between NMIs (in ‘popular’ technical areas it may be necessary to accommodate 20+ participants)

Comparisons are now primarily, but not solely, undertaken to establish the degrees of equivalence between participating NMIs and DIs, rather than purely to validate scientific results. This has led to a subtle, but crucial shift in both the composition and number of participants in a comparison. All NMIs and DIs participating in the CIPM MRA are now obliged to take part in appropriate comparisons either at CIPM or regional level. It is therefore necessary to ensure that appropriate comparisons are run to encompass all NMIs with their diverse range of capabilities and expertise. To incorporate these requirements in some areas it has already proved necessary to operate comparisons based on differing technological capabilities eg mise en practique and gauge blocks in the technical area of length.

The increase, both in number of comparisons and in participants has placed a heavy load on those NMIs able to undertake the role of pilot laboratory, and for many comparisons there are a limited number of NMIs with the resources and capability to take on this role. Additionally, an increase in the number of participants will naturally increase the length of time taken to complete the comparison. One challenge to NMIs is to ensure that mechanisms are developed enabling comparisons to be completed in a sufficiently short timescale that the results are still valid by the end of the comparison and that there is a gap between the completion of one comparison and the start of its replacement. Some technical areas have already taken steps to address the large number of participants by splitting the comparison into a number of sub-comparisons. In the case of one of the EUROMET high pressure gas comparison this was achieved by splitting the comparison into two sub comparisons, EUROMET.M.P-K3.a and EUROMET.M.P-K3.b, with two different pilot laboratories utilising different types of transfer standards.

Fig 2 (courtesy of BIPM) shows the proposed linkage between Consultative Committee and RMO comparisons. In an ideal world, the Consultative Committee comparisons would be undertaken first followed by the matching RMO comparisons, which would then be linked to the Consultative Committee comparisons enabling the degrees of equivalence to be calculated. In practice this has proved difficult to achieve in many instances as the RMO comparisons may have commenced before the CC comparison was initiated and some RMOs have been able to initiate and complete their comparisons in a shorter timeframe than some other RMOs or the CC. One technical area is already considering a more radical approach to key comparisons whereby only RMO comparisons are undertaken, but each including a number of participants from other regions thus enabling interlinking of the regions and calculation of the degrees of equivalence. An approach such as this certainly requires further investigation. Some NMIs already participate in other RMO comparisons, particularly where there are no appropriate comparisons in their own region, with South Africa a particular case in point.

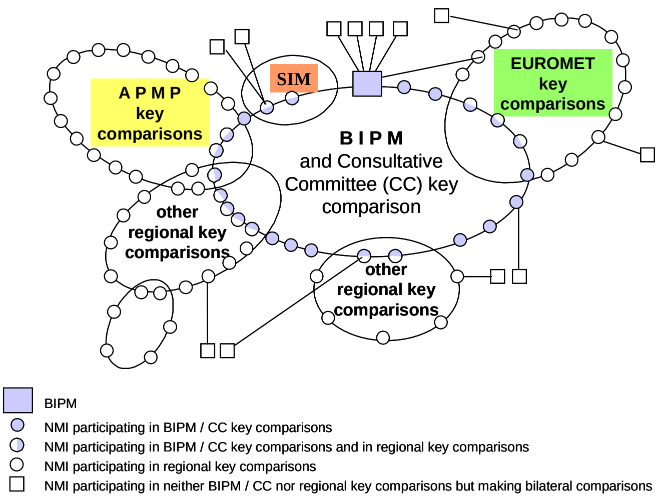

Fig 2. – Schematic of the linking between CIPM and RMO comparisons (courtesy of BIPM)

3.2 CMCs

The development and review of CMCs has proved a mammoth task for both the individual experts within the NMIs and also the RMO technical committees (as evidenced by the 8000+ CMCs already published for EUROMET alone), and the process is not yet complete. For example there are currently no published CMCs for humidity and CMCs for viscosity have only been published for NMIs within EUROMET and COOMET. Whilst the bulk of the CMC development work has now been completed, the process is an on-going one with new and revised CMCs being developed and submitted for review all the time as laboratories introduce new services and revise the scope and uncertainty of existing services.

The review process for CMCs has on occasions proved exceedingly lengthy with CMCs taking a number of years to be published. Whilst the review process has improved with time, but there is still opportunity for improvements and a need to ensure that both CMCs for new services and technical fields and minor modifications (including updates arising from changes to accreditation schedules) can be accommodated promptly.

Some lessons learnt have already been implemented, for example improvements in presentation have been made to some previously published CMCs, most notably in the Electricity and Magnetism field, where the introduction of a matrix format enable the data to be presented in a much more compact format, significantly reducing the total number of CMCs, whilst still incorporating the same information.

For the first time, the CIPM MRA provides end users with validated data declared in a harmonised way (prior to the development of the international ‘vocabulary’ there was no consistent approach to describing NMI calibration services), by NMIs that are obliged to operate a quality system and take part in international comparisons. End users are now able to make a realistic comparison of the services and uncertainties offered by the various NMIs. There is a hidden challenge within these benefits, which is that NMIs need to ensure that the data and the review process remain robust and that the CMCs within in the KCDB do not inadvertently become an explicit marketing tool. Linked to this is the need to ensure that data related to ‘specials’ are either specifically excluded from the KCDB and the inherent implications of automatic international acceptability, or services are modified such that this capability becomes readily available to all customers on a routine basis. One challenge for NMIs, once the CIPM MRA logo is finalised, is to incorporate the logo and associated text on relevant calibration certificates so that all customers can readily see which certificates fall within the agreement. It is crucial that NMIs and DIs ensure that the logo is only applied to certificates covered by the agreement if the CIPM MRA is to continue to be robust and internationally accepted. This is not a trivial process considering the large number of services offered and certificates issued by some of the NMIs, and the fact that services are introduced/revised/removed on an on-going basis. Application of the logo and text to certificates will also require prior approval of the National Accreditation Bodies for those NMI services that are accredited.

Currently NMI calibration services are described in the KCDB in terms of CMCs, whilst accredited services are described as ‘Best measurement capability’ (BMCs) within the published scope of accreditation. From an NMI’s customer point of view, one of the most beneficial improvements would be if agreement could be reached between NMIs and National Accreditation Bodies/Regional Accreditation Bodies regarding the use of the terms ‘CMCs’ and ‘BMCs’, ie either compromising on one term or ensuring that the two terms have a consistent definition.

Over the last seven years most RMO technical committees have concentrated on the review of CMCs and the organisation and participation in comparisons. There is also a desire within some RMOs to reduce the workload on CIPM MRA related activities in order to enable the NMIs to undertake some collaborative projects as well.

3.3 NMI Quality systems

Quality systems within NMIs are not static and the number of designated institutes and indeed NMIs participating in the CIPM MRA continues to grow. By early 2005 in Europe there were over a 90 NMIs and designated institutes with quality systems subject to the peer review process and the review of these QS has been achieved within a six year period.

It is probably therefore timely to consider whether the review process should be developed to ensure that robust and effective reviews could take place more efficiently. It would definitely be beneficial to review the quality systems in a shorter timeframe and one option might be to hold more than one review forum a year, but there are other options. One possibility is to take more account of whether a laboratory is formally third party accredited for its services, and concentrate on those laboratories which do not undergo other third party assessment. There are still of course additional areas particularly related to NMI activities that would require review for accredited laboratories, for example:

- Maintenance of national standards, including details of standards held, participation in key comparisons and supplementary comparisons, qualifications and training of staff involved.
- Alignment of accredited scope with CMCs.
- Use of CIPM MRA logo and statement and associated control procedures.
- Results of recent assessments, non-conformances and corrective actions.
- Changes of scope.
- Improvement plans (4.10 of 17025).

Some NMIs have invested considerable time and effort in their accredited calibration services, involving in the case of NPL, many man weeks of peer review by international experts, however, at least at present in EUROMET no recognition or credit is given for this.

3.4 Ensuring real benefit from the CIPM MRA

Perhaps the greatest challenge for the metrology community is that of ensuring that the benefits of the CIPM MRA are taken out into the wider international community and it does not just remain a ‘metrology community initiative’.

Global trade, commerce and quality of life rely on measurements and tests that need to be accepted internationally and do not form barriers to trade. Measurements and tests are required during product manufacture, to assess compliance with standards and directives, to ensure food safety, to monitor the environment, to enable air transport to operate safely, to protect workers from adverse conditions and to optimise medical treatment, to name a few. The regulatory process relies on data, measurements and tests to underpin the rationale for legislation, the development of regulations and mandated standards, establishing technical limits and to ensure effective market surveillance.

The CIPM MRA was signed by the Directors of the NMIs and hence is not legally binding on governments and regulators. The metrology community therefore needs to work to ensure that the Arrangement is adopted by the regulatory and trade communities. Whilst many NMIs have promoted the CIPM MRA to their stakeholders, detailed activities and assistance have been limited during much of the transition period as the information within the KCDB was somewhat limited.

Now that the transition phase of the CIPM MRA has been completed, it is time to take steps towards ensuring that these challenges are met.

4. CONCLUSIONS

There has been much progress since the CIPM MRA was signed in October 1999. The CIPM MRA has brought an increased level of confidence and quality to the measurement service claims of the NMIs. Implementation of the CIPM MRA during the transition period has identified two key challenges for the future. Firstly developing processes to reduce the workload on the NMIs and ensure the long term sustainability of the CIPM MRA, and secondly ensuring that the benefits of the CIPM MRA are taken out into the wider international community.

5. ACKNOWLEDGEMENTS

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