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Metrology in Developing Economies – Jamaican Experience in Publishing Mass CMCs in Appendix C of MRA of CIPM.

M. Sanz [1], L. O. Becerra [2]

[1] Formerly Bureau of Standards Jamaica (BSJ), Jamaica. Richmond Hill, Canada. E-mail: msanz@vecollective.com.
[2] CENAM, Querétaro, Mexico. E-mail: lbecerra@cenam.mx.

Abstract

This paper presents the strategy followed to restore Jamaica's Mass laboratory's development aiming towards the expansion of its Calibration and Measurement Capabilities (CMCs). The work will present a set of key steps taken to improve the current status of the Bureau of Standards Jamaica (BSJ) Mass laboratory in order to bring the laboratory closer to a level of a recognized National Metrology Institution (NMI). The factors considered for the improvement strategy of the laboratory were: i) the laboratory's quality system, ii) expertise and exposure of the staff, iii) work with peers NMIs, iv) publication of the laboratory CMCs.

Keywords: Mass Metrology, CMCs recognition.

1. Introduction

Metrology in Jamaica was fostered by the PTB more than a decade ago. One of the quantities best developed was Mass. After its accreditation by DKD, the laboratory's growth gradually came to a halt. Its operation was confined to the calibration of OIML F1 masses (1 mg - 10 kg) under DKD accreditation and up to 500 kg outside the scope of the accreditation. Although the laboratory is a pioneer facility in the Caribbean, the improvement of its accuracy, staff exposure and reputation among peers overseas, were in urgent need of attention. This paper will present the strategy implemented to restore the Mass laboratory's development aiming towards its CMCs expansion

2. Strategies towards Improvement of the BSJ Mass Laboratory Capabilities

In order to improve the level of accuracy and recognition of the mass laboratory, a simple strategy was designed and implemented. The strategy was based on participation in inter comparisons, upgrading of the laboratory, CMCs publication and exposure of junior officers of the laboratory to overseas training. The laboratory serves the local Jamaican industry, of which the main demand is for

the calibration of masses belonging to OIML class F1 and lower. The laboratory at this time has been upgraded to acquire OIML class E1 (1 mg – 20 kg) standards not only with the purpose of serving the local industry but also taking into consideration future demands of the Caribbean region. A program for the sensitization of the local industry is being planned, the aim of which is to increase the demand for calibration at the E2 level. One of the advantages of having the laboratory accredited was the requirement of having a Quality System (QS) implemented that could support this accreditation. The existence of this Quality System gave the Mass Laboratory a competitive advantage that allow it to be one of the first laboratories in the SIM region (Regional Metrology Organization RMO for Jamaica) that could present its Quality System to the SIM's Quality System Task Force (QSTF). The Mass laboratory's Quality System was approved in early 2005. As suggested by Jamaica, a SIM inter comparison (piloted by CENAM) was organized and took place with different representatives of each SIM sub region during the same year (2005). This was seen by the BSJ as a strategy for the recognition of its capabilities among its peers. This inter comparison was a key factor that helped to achieve the publication of the Mass CMCs in the BIPM data base. Although the capabilities of the laboratory are at a lower level than some important peers in the SIM and other regions, it achieved the publication of its CMCs. The laboratory's technical capabilities were also recognized by the technical working group (MWG7) of SIM. Jamaica has been one of the first countries in the region to be able to publish CMCs. This has been the result of the hard work of the laboratory staff, their level of expertise, the implementation of its quality system and the on time participation in very important inter comparisons.

3. Importance of CMCs Publication in Appendix C of MRA of CIPM

The International Committee of Weights and Measures (CIPM) prepared a Mutual Recognition Arrangement (MRA) entitled "Mutual recognition of National Measurement Standards and of Calibration and Measurement Certificates issued by National Metrology Institutes", which was signed in 1999 by thirty eight Member States of the Meter Convention and by two international organizations. The Member States of the Meter Convention signed through the directors of their respective NMIs.

Through this MRA it was established that the institutes signing the arrangement would recognize the validity of calibration and measurement certificates issued by other signatory institutes for the quantities and ranges specified in Appendix C. The CMCs to which the MRA makes reference are those sometimes referred to as best measurement capabilities. These CMCs are those ordinarily available to the customers of an institute through its calibration and measurement services.

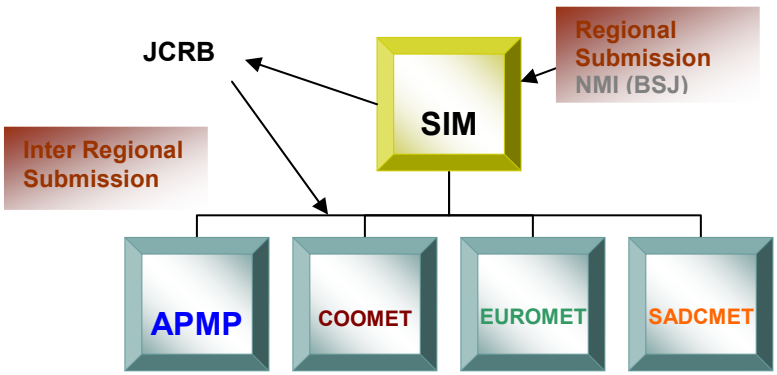
Jamaica was one of the first countries in the America Region that in recent years signed the Meter convention and is the only one in the Caribbean region to have done so independently. Other signatory countries in the America region of the meter convention are: Argentina, Brazil, Canada, Panama, Chile, Mexico, Paraguay, Uruguay, United States, CARICOM (Caribbean Community and Common Market). As a signatory member of the Meter Convention, Jamaica

realized the importance of the recognition of the Bureau Standard Jamaica (BSJ) capabilities among its peers. The BSJ therefore embraced the challenge of publishing its Mass Laboratory CMCs, as this laboratory was among those in the country with the best capabilities and organization. In addition, the services offered by the Mass laboratory were not only for the local industry but for other National and Secondary Laboratories in Jamaica and the Caribbean Region, for which traceability to the mass unit and calibration services originated. The need then for having the Mass laboratory CMCs published was well justified. The capabilities and calibration and measurement certificates issued by the laboratory needed to be recognized by its peers.

4. Procedure for CMCs entry into Appendix C

There are two main steps that must be followed for the publication of the CMCs. The First Step: the Regional Assessment (internal to the NMI region) of the laboratory capabilities. The Second Step: the Inter-regional Assessment (external to the NMI region) of the laboratory capabilities. The Regional Assessment is coordinated by the Regional Metrology Organization (RMO) to which the NMI is a member, SIM for this case. The Inter-regional Assessment is coordinated by the Joint Committee of the Regional Metrology Organizations (JCRB).

The JCRB is a Joint Committee of the RMOs and the BIPM created by the CIPM. The responsibility of the JCRB is the coordination of data provided by the RMOs, as well as other actions they may embrace to promote confidence in calibration and measurement certificates.



In order to publish its Mass CMCs the BSJ's Mass Laboratory therefore complied with:

1. The requirements established by the JCRB for NMI's calibration and measurement capabilities to be entered into Appendix C [1]. Criteria for acceptance of data for Appendix C included in the "JCRB Rules of Procedure for CMC entry into Appendix C".

These are not simply requirements, as they entail:

- International comparisons of measurements to be known as key comparisons; supplementary international comparisons of measurements;
- Quality systems and demonstrations of competence by NMIs.

2. SIM Regional Procedure for the Review of Calibration and Measurement Capabilities, consisting of three parts: a Technical Review, a Quality System Review, and a Final Coordinating Review by the Technical Committee (TC).

5. BSJ Mass Laboratory - SIM Requirements

The capabilities of the BSJ Mass laboratory at the time of the submission of its CMCs were not at the level of a Mass Laboratory keeper of 1 kg prototype of platinum iridium. Notwithstanding the lack of the 1 kg prototype and not having the same experience as others NMIs, the BSJ recognized the need of having the Laboratory Calibration and Measurement Capabilities recognized. The laboratory despite its size and developmental level could meet all the stringent requirements set by its RMO (SIM) for submission of its CMCs to the JCRB.

The very first step taken by the BSJ Mass Laboratory in order to achieve the publication of its CMCs was to comply with SIM_05 Procedure for Review of Calibration and Measurement Capabilities Submitted for Appendix C of the CIPM MRA [2]. The steps followed by the BSJ were as follows:

5.1 Submission for Technical Review

The BSJ Mass laboratory submitted its calibration and measurement capability (CMC) to the SIM Mass & Related Quantities Metrology Working Group (MWG7) through its chairman. The CMCs were declared following the JCRB Procedure for specifying the scope of CMCs [3], where three unambiguous characteristics, must be declared, that of, Measurand, Range and Uncertainty. The Mass laboratory in addition to the CMCs needed to submit the following information for the MWG7 reviewing process:

a) Key and supplementary comparisons listed in Appendix B; and/or

b) Other multilateral or bilateral comparisons; and/or

c) A history of peer-reviewed measurement activities; and/or

d) Discussions between members of the SIM MWG and the responsible scientists within the NMI; and/or

e) Personal knowledge of MWG members obtained by visits or other means; and/or

f) Performance of currently used equipment, etc.

5.2 Submission of Quality System for review

The BSJ Mass laboratory's submitted and presented its Quality System (QS) to SIM's Quality System Task Force (QSTF). There were two alternatives established by SIM that could be used to provide evidence of quality and competence: accreditation or peer review. The first alternative (Accreditation) could be in the form of an ISO/IEC 17025 or equivalent system accredited by a body fulfilling the requirements of ISO/IEC Guide 58.

The second alternative (Peer review) is*:

- *"A statement by peers from other NMIs that they have examined the procedures and visited the NMI in question and have confidence that the NMI is capable of performing the calibrations/measurements within the uncertainties stated in their calibration and measurement certificates"*; and
- "*A statement from an expert or experts acceptable to SIM that the system to assure quality implemented at the NMI in question meets basic criteria and documents the quality and capabilities of the NMI"*.

Note*: The use of italics indicates a direct quotation from the SIM Reference Document Nº 05)

The basic criteria that must be met by the NMI QS includes:

i. Technical descriptions of the measurement facility, measurement procedures, uncertainty analysis and procedures for statistical control of the measurement process.
ii. Competent staff
iii. Procedures for dealing with discrepant results
iv. Management system and internal audit:

5.3. Coordinating Review

The final step was the TC's review of the recommendations made by the MWG7 to ensure reasonable uniformity between them.

6. BSJ Mass Laboratory Strategy and Alternatives followed to meet Sim Requirements

From the requirements and alternatives established by SIM to comply with the review process of CMCs the following strategy was followed:

1. For the Technical review the BSJ decided to submit:

a) Key and supplementary comparisons listed in Appendix B;

b) Other multilateral or bilateral comparisons;

BSJ strategy: Although the BSJ had not taking part directly on key or supplementary comparisons, its participation in SIM.7.31, had the objective of linking the Mass Laboratory to key comparisons of CCM. In addition, the Mass Laboratory participation in other comparisons, such as DKD 2000/01 PTB 2002 and PTB-ARSO, were submitted and accepted as relevant inter comparison experience.

c) A history of peer-reviewed measurement activities; and/or

d) Discussions between members of the SIM MWG and the responsible scientists within the NMI; and/or

e) Personal knowledge of MWG members obtained by visits or other means; and/or

BSJ strategy: For items c), d) and e) the BSJ submitted its presentations to the SIM MWG7 in group meetings and reports regarding its involvement as technical coordinator on CARIMET activities. The technical capabilities of the

laboratory were also seen by experts from other NMIs such as PTB and CENAM and accreditation bodies such as DKD.

f) Performance of currently used equipment, etc.

BSJ strategy: For this item BSJ Mass laboratory presented its List of procedures, equipment, staff qualification and DKD accreditation certificate.

2. Quality system submission: The BSJ presented to the SIM QSTF its Quality System (QS) that under the requirements for accreditation must be implemented in the Mass Laboratory. The QS followed the guidelines established under ISO/IEC 17025. SIM QSTF accepted the QS and the acceptance was forwarded to the Chairman of MWG7 when submitting the CMCs.

BSJ Strategy: The BSJ decided to take advantage of its accreditation process with the DKD from Germany. The accreditation with DKD had required the implementation of a Quality System (QS) in the Mass Laboratory under the guidelines of ISO/IEC 17025.

3. Coordinating review: After the MWG7 had reviewed the BSJ Mass laboratory submission (steps 1 and 2 above) and made their comments the TC chairman of the group recommended for the BSJ Mass laboratory CMCs to be forwarded to the JCRB. The code **Okay**, as indicating in SIM_05 Procedures documents, was assigned to the laboratory's submission. The code Okay means that the claimed CMC is judged to be consistent with relevant information.

7. BSJ Mass Laboratory - JCRB Requirements

Before submitting its CMCs to its RMO (SIM) for review, the BSJ Mass Laboratory became more acquainted with the **Criteria for acceptance of data for Appendix C** established by the JCRB. Once the BSJ's Mass Laboratory understood the JCRB criteria it compared them with SIM_05 Procedures for Reviewing CMCs. After comparing both sets of requirements the laboratory made sure to comply with JCRB criteria when submitting its CMCs to SIM for reviewing. Meeting JCRB criteria would have made easier to achieve the publication of the CMCs from the time of their submission to SIM.

These are the points that the JCRB takes into account when evaluating CMC submissions:

a) Results of key and supplementary comparisons.

b) Documented results of past CCs, RMO or other comparisons (including bilateral comparisons).

c) Knowledge of technical activities by other NMIs.

d) Active participation in RMO projects.

e) Appropriate measurement procedures and equipment.

f) Scientific and technical qualifications of staff.

g) Other available knowledge and experience.

h) Quality system existing or in preparation, brief description.

i) Any peer assessment, third party accreditation or self declaration, including the name of the accreditation body; membership of a multilateral agreement/arrangement; scope of accreditation; names of peer reviewers.

8. BSJ Mass Laboratory Strategy followed to meet JCRB Requirements

The BSJ Mass Laboratory ensured it complied with the JCRB criteria or requirements for CMCs submission at the time the CMCs were submitted to SIM. The Mass Laboratory used the JCRB criteria as its guide when submitting the CMCs to SIM MWG7.

The information and documentation were submitted to SIM in such a way that the requirement of the JCRB (indicated in section 7. above) was already met when complying with its equivalent SIM requirement, as shown on the following table:

JCRB criteria equivalent to	SIM requirements
1 and 2	a) and b) of SIM Technical review requirements.
3 and 4	c), d) and e) of SIM Technical review requirements
5, 6 and 7	e) and f) of SIM Technical review requirements.
8 and 9	step 2 of SIM review Process: Quality System Review

9. BSJ Mass Laboratory towards the final step on its CMCs Publication

Following the Rules of Procedure of the JCRB, which specify the requirements for an NMI's Calibration and Measurement Capabilities to be entered into Appendix C, the BSJ achieved the publication of its Mass CMCs.

All steps of the JCBR procedure were met:

(a) The BSJ sent its draft CMCs to SIM (local RMO) for review and approval according to the JCRB and SIM criteria.

(b) SIM (MWG7 chairman) sent the approved CMCs to the Chairman of JCRB with appropriate formal statement on behalf of SIM representative to the JCRB.

(c) Chairman of JCRB forwarded received CMCs to all other RMOs (EUROMET, SADCMET, APMP, COOMET) through their representative on the JCRB.

(d) Inter-regional review took place.

(e) Reports of reviews were sent through JCRB representatives to the Chairman of JCRB with an official accompanying statement. The JCRB chairman then sent these reports of reviews on to chairmen of other RMOs.

(f) BSJ revised their CMCs as necessary and re-submitted to SIM.

(g) SIM sent their revised CMCs to the Chairman of the JCRB with the appropriate formal statement stating that all issues raised in inter-regional review have been resolved.

(h) Chairman of the JCRB published revised CMCs on the JCRB website setting a date not more than one month ahead for approval by RMOs.

(i) All RMOs indicated their approval on the website, the CMCs were entered into Appendix C.

10. Acquired Equipment for Laboratory Upgrade

During the publication of its CMCs and as a result of this said publication, the BSJ realized even more the importance of having its equipment and capabilities upgraded. The CMCs publication has added enormous value to the BSJ's Mass Laboratory, which made the publication of the CMCs a main tool or strategy towards the improvement and expansion of its capabilities.
The following equipment was therefore acquired to ensure higher accuracy levels in the laboratory's calibration and measurement capabilities (lower levels of uncertainties):

Set of Weights	***Mass Comparator***
Brand: Häfner	Brand: Mettler-Toledo
Range: 1 mg- 20 kg	Model: UMX5
Accuracy class: OIML E1	Capacity: 5,1 g Resolution: 0,1 µg
Mass Comparator	***Mass Comparator***
Brand: Sartorius	Brand: Mettler-Toledo
Model: CC1000S-L	Model: AX10005
Capacity: 1 002g Resolution: 1 µg	Capacity: 10 011g Resolution: 10 µg
Mass Comparator	***Mass Comparator***
Brand: Mettler-Toledo	Brand: Mettler-Toledo
Model: XP26003L	Model: XP64003L
Capacity: 26,1 kg Resolution: 1 mg	Capacity: 64,1 kg Resolution: 5 mg

11. Results of Strategy Implementation and future developments

As a result of the implementation of its Quality System, Accreditation, Participation in SIM and other inter comparisons, Jamaica through its Mass Laboratory has been the first Caribbean country publishing CMCs. The Mass Laboratory has been upgraded to increase its level of accuracy (lower uncertainties), therefore upgrading of the scope of the Mass CMCs is now a more obtainable goal. The Mass Laboratory is now under expansion to add the quantity of Density. Density can now be easily added since the new equipment acquired for the Mass Laboratory will also allow the implementation of the hydrostatic weighing system for density measurements (density of solids and liquids, hydrometers calibration, etc.). In the future Density could be therefore the next CMCs to be published and the ultimate goal now for the BSJ Mass Laboratory is to be the keeper of 1 kg prototype of Pt-Ir for Jamaica and to be able to offer traceability with the prototype to the local and regional industries and laboratories. This traceability could be to the new definition of the mass unit (i.e. Watt balance experiment).

Upgrading of the scope of the Mass Laboratory CMCs may or may not require the accreditation of the BSJ Mass Laboratory. Peer review of the Mass Laboratory's CMCs and Quality System is another option that could now be easier to explore by the Laboratory. Peer reviews may assist the BSJ in placing itself at the same level of other recognised NMI. Peer reviews will increase the Mass Laboratory interaction with other recognized Peers in the region and facilitate the assessment process of the Mass Laboratory's Capabilities.

12. Acknowledgments

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13. Conclusions

The Mass Laboratory has allowed Jamaica to be the first Caribbean country publishing CMCs. Key strategies for the laboratory development are the implementation of a recognized quality system and work in conjunction with more developed peers. Lack of vision and independence can be one of the major obstacles for small NMIs to achieve an appropriate development of their metrology capabilities.

References

[1] Document JCRB-7/1 - JCRB Rules of Procedure for CMC entry into Appendix C, Revised October 2001.

[2] SIM REFERENCE DOCUMENT Nº 05 - SIM Procedure for Review of Calibration and Measurement Capabilities Submitted for Appendix C of the CIPM MRA.

[3] DOCUMENT JCRB-12/06(2) Approved on 3-4 May, 2004 JCRB Procedure for specifying the scope of CMCs