Abstract: The development of metrology in the Caribbean has generally been adversely impacted by many of the specific social, economic and environmental vulnerabilities associated with their characterization as Small Island Developing States (SIDS). More specifically, in many countries of the Caribbean Community (CARICOM), whilst recognized by some of the major industries, metrology is often not high on the list of priorities for policy makers, and, is still more or less unknown to the majority of citizens, due in the main to the lack of awareness and appreciation of the impact of measurement science on their lives. Also, in addition to the limiting cross cutting theme of finance, many National Metrology Institutes (NMIs) are faced with the challenges of limited human and customer capital, weak regional transportation modalities, public misperception and the lack of suitable laboratory infrastructure. In order to address these challenges, the CARICOM NMIs have unified within the framework of CARIMET, the Caribbean sub-region of the Inter-American Metrology System (SIM) to pool assets and develop regional mechanisms to address the measurement demands across the region.

Keywords: Metrology, CARIMET, CROSQ, SIDS, SIM

1. INTRODUCTION

Currently, the United Nations (UN) has identified three geographic regions;
1. the Caribbean,
2. the Pacific and
3. AIMS (the Atlantic, Indian Ocean, Mediterranean and South China Sea) as the location of Small Island Developing States (SIDS).
This paper presents an overview of the challenges being faced by the Caribbean Community (CARICOM) in the development of metrology capabilities in its Member States, the strategies being employed and lessons learnt in addressing them.

2. THE HISTORICAL AND ECONOMIC CONTEXT OF CARICOM

The sustainable development of Small Island Developing States (SIDS) continues to be a challenge for political leaders and policy makers. In addition to the issues faced by developing nations, SIDS grapple with peculiar vulnerabilities arising mostly from the disproportionate impact of expansive globalisation and climate change, insularity, high per unit transportation costs, limited natural resources and high import levels. Faced with these challenges many SIDS began banding together long before the term SIDS was coined. Seeing the potential benefits of cooperation along with the lessons learned from the British West Indies Federation, the political leaders of Barbados, Guyana, Jamaica and Trinidad & Tobago created the Caribbean Community and Common Market with the signing of the Treaty of Chaguaramas in 1973. Over the following three (3) decades the total number of signatories to this Treaty grew to fifteen (15). During this time the CARICOM Single Market and Economy (CSME) was established with the Grand Anse Declaration in July 1989 and the need for a revised Treaty was recognised. As a result, the Revised Treaty of Chaguaramas was signed on 5 July 2001 establishing the Caribbean Community (CARICOM).

CARICOM is made up of fifteen (15) SIDS of which 12 are the smallest economies of the 35 economies in The Americas as measured by their Gross Domestic Products (GDPs). The largest economy within CARICOM is Trinidad and Tobago followed by Jamaica [1].
Table 1. Gross Domestic Product of the Countries of the Americas [1].
(Members of the Caribbean Community (CARICOM) are highlighted in red.)

<table>
<thead>
<tr>
<th>No.</th>
<th>State/Country</th>
<th>GDP (in '000,000,000 USD) (2014 est.)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>$17.420</td>
</tr>
<tr>
<td>2</td>
<td>Brazil</td>
<td>$2.244</td>
</tr>
<tr>
<td>3</td>
<td>Canada</td>
<td>$1.754</td>
</tr>
<tr>
<td>4</td>
<td>Mexico</td>
<td>$1.206</td>
</tr>
<tr>
<td>5</td>
<td>Argentina</td>
<td>$5.862</td>
</tr>
<tr>
<td>6</td>
<td>Colombia</td>
<td>$4.001</td>
</tr>
<tr>
<td>7</td>
<td>Chile</td>
<td>$2.641</td>
</tr>
<tr>
<td>8</td>
<td>Venezuela</td>
<td>$2.062</td>
</tr>
<tr>
<td>9</td>
<td>Peru</td>
<td>$2.062</td>
</tr>
<tr>
<td>10</td>
<td>Ecuador</td>
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</tr>
<tr>
<td>11</td>
<td>Cuba</td>
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</tr>
<tr>
<td>12</td>
<td>Dominican Republic</td>
<td>$5.428</td>
</tr>
<tr>
<td>13</td>
<td>Guatemala</td>
<td>$5.380</td>
</tr>
<tr>
<td>14</td>
<td>Uruguay</td>
<td>$5.560</td>
</tr>
<tr>
<td>15</td>
<td>Costa Rica</td>
<td>$5.048</td>
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<tr>
<td>16</td>
<td>Panama</td>
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</tr>
<tr>
<td>17</td>
<td>Bolivia</td>
<td>$3.086</td>
</tr>
<tr>
<td>18</td>
<td>Paraguay</td>
<td>$3.301</td>
</tr>
<tr>
<td>19</td>
<td>Trinidad &amp; Tobago</td>
<td>$2.063</td>
</tr>
<tr>
<td>20</td>
<td>El Salvador</td>
<td>$2.544</td>
</tr>
<tr>
<td>21</td>
<td>Honduras</td>
<td>$1.937</td>
</tr>
<tr>
<td>22</td>
<td>Jamaica</td>
<td>$1.937</td>
</tr>
<tr>
<td>23</td>
<td>Nicaragua</td>
<td>$1.185</td>
</tr>
<tr>
<td>24</td>
<td>Haiti</td>
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<tr>
<td>25</td>
<td>Bahamas, The</td>
<td>$0.849</td>
</tr>
<tr>
<td>26</td>
<td>Surinam</td>
<td>$0.573</td>
</tr>
<tr>
<td>27</td>
<td>Barbados</td>
<td>$0.277</td>
</tr>
<tr>
<td>28</td>
<td>Guyana</td>
<td>$0.142</td>
</tr>
<tr>
<td>29</td>
<td>Belize</td>
<td>$0.665</td>
</tr>
<tr>
<td>30</td>
<td>Antigua &amp; Barbuda</td>
<td>$1.236</td>
</tr>
<tr>
<td>31</td>
<td>Grenada</td>
<td>$0.839</td>
</tr>
<tr>
<td>32</td>
<td>Saint Kitts &amp; Nevis</td>
<td>$0.812</td>
</tr>
<tr>
<td>33</td>
<td>Saint Vincent &amp; the Grenadines</td>
<td>$0.745</td>
</tr>
<tr>
<td>34</td>
<td>Saint Lucia</td>
<td>$0.662</td>
</tr>
<tr>
<td>35</td>
<td>Dominica</td>
<td>$0.514</td>
</tr>
<tr>
<td>36</td>
<td>Montserrat</td>
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</tbody>
</table>

In most of these countries the service based industries are the major contributor to GDP being the number one income earner for most countries with tourism, others such as banking and remittances also contributing significantly to GDP. Being former colonies, CARICOM SIDS have a long history of supplying natural resources such as sugar and spices to their respective metropolis and this tradition continues with industry in CARICOM being mostly focused on the supply of natural resources and raw materials, mostly agricultural and mining based, to developed nations. Manufacturing within CARICOM is mostly limited to five (5) countries, Belize, Guyana, Jamaica, Suriname and Trinidad & Tobago. Of these countries Trinidad & Tobago enjoys the largest share due to its indigenous source of fossil fuels. It is important to note that the Dominican Republic is not yet a member of CARICOM, although they have made a formal application to join which is under review. The Dominican Republic nonetheless is a part of CARIMET, the Caribbean sub-region of SIM.

The small size of the region’s economies and limited demand for Quality Infrastructure (QI) has meant that in most CARICOM countries the National Standards Bureaus (NSBs) have responsibility for the four main pillars of QI (i.e. Standardisation, Metrology, Accreditation and Conformity Assessment). In most CARICOM Member States, both regulatory (legal) and non-regulatory (industrial) metrology services fall within the mandate of the NSB and there are different degrees of development between member states. In respect of scientific/research metrology, standards are adopted from the more advanced economies.

The variation seen in economic size and level of development of each country can also be seen in the maturity of the respective national metrology infrastructure. Jamaica has the longest history in developing metrology and the largest National Metrology Institute (NMI) within CARICOM, with over twenty-five (25) years of cooperation with the German NMI, PTB and assistance from other institutions such as the World Bank. Trinidad & Tobago, having the strongest manufacturing sector within CARICOM has been developing its NMI using national funds.

In all CARICOM SIDS the evolution of metrology has followed the historical pattern of the development of metrology as a service required to support the verification of conformance to regulations by the way of...
harmonized measurements in trade. In addition to the two aforementioned countries; other countries such as Grenada, Guyana and Saint Lucia have well-developed legal metrology programmes and growing industrial metrology services to support these legal metrology programmes. The remaining countries are at varied stages of development with The Bahamas and Suriname now working to establish their NMI within their respective National Standards Bureau.

2. CHALLENGES

Though there are unique challenges in each country which rules out the possibility of a “one size fits all” approach, many of the NMIs in CARICOM share similar challenges which can be resolved using regional initiatives. These common challenges are considered herein.

2.1 The Socio-Political Environment

As Developing States, the Governments of CARICOM SIDS have been mostly focused on grappling with economic shocks from the rapid expansion of globalisation, addressing energy demands and burgeoning public debt. As a result, the development of Quality Infrastructure including metrology has not yet become a high political priority. Conversely, many of the Governments in advanced economies have seen the vital link between metrology and the manufacturing sector and as such most of the advanced economies support the metrology programmes developed by their NMIs. These programmes are typically expensive to establish and maintain yet they support breakthroughs in other fields of science and spur innovation in manufacturing thereby justifying the investment in the NMI.

The social environment within which CARICOM NMIs operate also contributes to weak support for the development of metrology. This is due to the fact that the majority of citizens in CARICOM have low incomes and as a result are price conscious versus quality conscious. With this weak push from policy makers coupled with a weak pull from the public, Quality Infrastructure is usually forgotten until there is a crisis. However, there has been an increase in demand for calibrations and other QI services over the past five to ten years due to the increase in the number of companies in CARICOM that are implementing the ISO 9001 Quality Management System (QMS). These companies have recognised the role a functioning QMS plays in being more competitive in the international market and also in overcoming the technical barriers to trade (TBTs) that are silently working against them. This need for traceable measurements has been mostly driven by companies which are part of an international conglomerate, requirements from a franchisor or due to trade requirements with developed nations. It has been noted that the calibrations conducted for many of these companies are arguable more used to satisfy auditors rather than to improve the production process or quality of the final product.

The development of metrology is very resource-intensive and it has been accepted that the creation of a NMI requires significant monetary investment. The economic situation facing many CARICOM SIDS, due to decreases in their sources of income and increasing debt, has resulted in some countries finding it difficult to establish the industrial calibration services that are needed for national development. Additionally, some CARICOM NMIs are struggling to maintain the services that already exist. What makes the development of metrology even more challenging for SIDS is the fact that there is a limited or even declining amount of the other necessary domestic resources.

2.2 Human Resource Management

Critical to the success of any NMI is the hiring and retention of the scientists that are trained as metrologists. Within CARICOM there are not any dedicated metrology programmes or training courses available at any of the region’s colleges or universities. As a result graduates with a natural science or engineering background are hired and trained on the job as metrologists. This training comes at considerable cost to the NMI, as training must be obtained either through programs available outside of the country or by contracting external metrology experts to conduct training in country.
Notwithstanding these interventions and the increasing access to capacity building interventions from external sources such as the Inter-American Metrology System (SIM) and other NMIs, many CARICOM NMIs are challenged to retain the services of the professionals that they have trained. In the more industrialised CARICOM States, the small pool of scientists and engineers with a metrology background are highly prized by the manufacturing sector. This demand combined with the higher compensation packages available in industry has translated to a high rate of staff attrition at some NMIs. For example, one department in one CARICOM NMI that normally has twelve (12) metrologists on staff has lost seven (7) metrologists over the last five (5) years through normal means. This high staff attrition rate in many NMIs has restricted the development of certain metrology quantities as persons are continuously being replaced.

In addition to the financial cost of repeatedly training new scientists, these NMIs do not have the opportunity to build a strong technical reputation within SIM because of the changing representation at Metrology Working Group (MWG) activities. The risk of jeopardising the national and regional metrology development plans is further exacerbated when the NMI is small and has only two or three metrologists on staff. This limited number of metrologists forces each to be proficient in a wide number of metrology quantities and when one of these metrologists leaves this strikes a severe blow to the national and regional development plans. This was the case at one of the smaller CARICOM NMIs where there was one (1) senior metrologist and one (1) junior metrologist who both resigned within the span of two (2) years to fulfil personal and family obligations. At the time of his departure the competence of the junior metrologist was being developed using regional funds with the hope that he would one day become a regional resource in mass metrology.

2.3 Limited Client Base

From the establishment of the first NMIs in the late 19th century and throughout much of the 20th century, the NMIs of develop industrialised nations directly conducted calibrations for their industry clients. This changed in the 1970’s when the number of calibrations being conducted overextended the NMIs. This gave way for the creation of private calibration laboratories that would serve the industry directly and obtain their calibrations, measurement traceability, procedures and recognition from the NMI. Although the number of calibrations done by the NMI would now be lower, each calibration done for the growing number of private calibration laboratory would serve as the reference for a large number of industrial calibrations [2]. As the number of private laboratories grew, prices were impacted by market forces and as a result each laboratory was spurred to increase its efficiency and competitiveness.

Similar to the early development of NMIs in advanced economies; the relatively new NMIs in CARICOM are now directly conducting industrial calibrations. However, with a small manufacturing sector in most CARICOM States there is very little potential for the workload of the NMIs to increase to the point of spurring the creation of national calibrations laboratories. Without this bridge between the NMI and the industry client, the cost of establishing and maintaining the metrological references, the national measurement standards for each quantity must be spread across the limited industrial clients. This limited client base makes the calibration costs comparatively higher than that offered by private calibration laboratories in developed countries. Even in the case where industrial clients in CARICOM are forced to use calibration services from outside the region they must bear either the freight costs to transport the artefacts or the travel and accommodation costs for the foreign metrologists to conduct in situ calibrations. This higher cost to the manufacturing sector in CARICOM contributes to the already high costs of production and operation potentially making Caribbean products less competitive.

2.4 Availability of Suitable Laboratory Infrastructure

The expansion of NMIs within the Caribbean sub-region of SIM (CARIMET) from legal metrology into industrial metrology means that metrology laboratories need to be
established. These laboratories must be equipped with the requisite measurement standards and maintained within specific climatic requirements. The majority of CARIMET NMIs are presently housed in older buildings that were not designed with metrology in mind. These NMIs are currently in need of a significant capital investment in order to construct a new building or carry out significant retrofitting on the existing buildings.

Efforts to establish mass and length metrology laboratories within CARIMET have highlighted a lack of the necessary heating, ventilating and air-conditioning (HVAC) expertise in the Caribbean. Most Caribbean companies offering HVAC services have experience providing solutions for offices but not for laboratories requiring such precise temperature and humidity controls.

The maintenance of these laboratories has also been a challenge to the NMIs mostly due to the unavailability of local technicians to service the equipment. Most metrology equipment is very intricate in nature involving technologies that are the proprietary right of the manufacturer. This usually means that maintenance and repairs must be done by specialist technicians located outside of the Caribbean. This significantly increases the cost to CARIMET NMIs as they must either ship the equipment to the manufacturer or pay for the technicians to travel to the NMI.

Another factor affecting the maintenance of the laboratories is the geography of CARICOM SIDS especially those in the Eastern Caribbean. Many of these NMIs are situated within low-lying coastal towns affected by the negative impacts of climate change. The increasing occurrence of natural disasters in some of these countries has significantly impacted national debt leaving the NMIs with diminished budgets. Even without this threat, the harsh salt air from the nearby sea reduces the usable life of equipment such as the condensers for the air-conditioning units.

2.5 Weak Regional Transportation Infrastructure
Development of metrology within CARICOM has also been affected by the limited transportation infrastructure in the region. Land based travel between CARICOM Member States is only limited to Guyana and Suriname, sea travel is limited to small ferries between certain countries mostly in the Eastern Caribbean and the cost of air travel is high. In some cases it is cheaper to travel to developed nations such as the United States, Canada, England and Germany rather than to other CARICOM countries. In the past this issue was a major obstacle to information sharing between NMIs and even with the advent of modern communication technology this high cost of travel increases the cost of technical cooperation between CARICOM NMIs.

In recent years this lack of suitable inter-island transportation has resulted in significant damage to measurement artefacts being transported for calibration. With limited available commercial couriers, a number of CARIMET NMIs use international couriers only to find that their artefacts are destroyed during inspection at the couriers’ logistics hubs. This issue almost ended the first CARIMET Inter-Laboratory Comparison in Mass Metrology in 2010 and later was the reason for Guyana having to replace one of its national mass sets, see Figure 1.

![Figure 1. Damage sustained by a 2 kg mass piece shipped outside the region.](image)

2.6 The Public Perception of the NMI as a Regulator
At independence most Caribbean SIDS inherited a system of weights and measures that was regulated by the Police. Post-independence Member States transferred these powers to the National Standards Bureaus and pursued a course of economic
development which including preferential trade agreements and protectionist measures to promote the growth of their fledging manufacturing sectors. This national focus meant that the processes that were developed though similar still have elements that vary from Member State to Member State. From that time until the late 1990’s the National Standards Bureaus built a strong reputation as regulators through their active role in standards development and enforcement, legal metrology inspections and conformity assessment of products. This reputation of policing has however presented some drawbacks which have impacted the effectiveness of the development of metrology. Because of this reputation there is reluctance from private companies to share information about their operations or cooperate with the NMI which in the CARICOM context is the NSB. This has resulted in metrology services being developed that are underutilised in many countries because of reluctance on the part of the private sector to utilise the services of the NMI or due to limited market demand data.

2.7 Public Sector Culture
The culture of any organisation has a significant impact on its performance and on its employees [3]. Organisational culture in this sense refers “to the climate and practices that organisations develop around the handling of people, or to the espoused values and credo of an organization” [3]. According to the classification of organisational culture proposed in Bradley and Parker’s (2001) Competing Values Framework (CVF) most CARICOM NMIs have a hierarchical culture emanating from being a part of the public service, see Figure 2. This culture creates an internal focus and coupled with being regulators, the NMIs have inherited a culture of clients be required to come to them instead of them having to focus on their client’s demands. As a result, many NMIs do not have a good understanding of the actual demands of the market and many programmes are developed based on instructions from the political directorate, perceived demands or areas of interest to the NMI.

Additionally, the controlled structure of this organisational culture at many CARICOM NMIs coupled with the expensive artefacts and standards has created a fear of failure on the part of the metrologists. This is seen in
reluctance on the part of some regional metrologists to experiment with the equipment, try new methods on their own, research or carry out operations outside of the established routine.

3. STRATEGIES
Considering the afore mentioned challenges the CARIMET NMIs have taken a position to strengthen metrology by using the following strategies.

3.1 Regional Support Mechanisms
As a response from CARICOM to promote sustainable production and trade of goods and services in the CSME, the CARICOM Regional Organisation for Standards and Quality (CROSQ) was created in February 2002 and given the mandate under Article 67 of the Revised Treaty of Chaguaramas to facilitate the development of regional standards, promote the harmonization of metrology systems and through that support the sustainable production and trade of goods and services in the CSME. The CROSQ Secretariat is located in Warrens, Barbados and is managed by a Chief Executive Officer (CEO) and governed by a Council made up of the fifteen (15) Directors of the region’s NSBs/NMIs.

3.1.1 The Signing of the International Committee on Weights and Measures Mutual Recognition Agreement (CIPM-MRA) as a Bloc of Nations
As the regional pioneer in establishing a NMI it was understandable that Jamaica would actively pursue becoming a signatory to the CIPM-MRA and this was done on 21 July 2004. In the following year, on 12 October 2005, CROSQ signed the CIPM-MRA on behalf of the remaining eleven (11) established NMIs. This arrangement as a bloc of nations is unique to CARICOM and affords the Member States the benefit of sharing the financial obligations of being a signatory. Unfortunately, the region has not been able to fully utilise all the benefits afforded as signatories.

3.1.2 Adoption of CARIMET as a Special Committee of CROSQ
The region’s next strategic move to support the development of metrology on a harmonised regional level was the adoption of CARIMET, the Caribbean sub-region of the Inter-American Metrology System (SIM), as a special committee of CROSQ. This was done at the twelfth (12th) meeting of the CROSQ Council held in Bridgetown, Barbados on 9-10 April 2008. Through this mechanism, CARIMET is able to access financial and administrative support from the CROSQ Secretariat. With this development CARIMET has been able to link the national goals of individual member states within the framework of a harmonised regional metrology system utilising SIM as the link to the international metrology system.

Using its position as an inter-governmental organisation representing the region, CROSQ has been able to leverage regional and donor funds to make interventions aimed at developing metrology as the region expanded out of a heavy standardisation focus. In order to access funding and technical assistance, CROSQ formed strategic relationships with such regional institutions as the Caribbean Development Bank (CDB) and the Inter-American Development Bank (IDB) and international institutions such as the German NMI PTB and the European Union (EU). These relationships however have not solely been for accessing donor funding but also have allowed CROSQ to use regional metrology expertise to guide bilateral interventions being implemented by these development partners.

3.1.3 Creation of the Position of Technical Officer of Metrology
To assist in coordinating the metrology development activities of CROSQ and the harmonisation of metrology processes in the region’s NMIs, the CROSQ Secretariat created the position of Technical Officer of Metrology and hired a regional expert to fill this position in 2010. In addition to undertaking tasks assigned by the CEO of the CROSQ Secretariat, the Technical Officer of Metrology serves as a technical resource for the Member States providing them with guidance on technical topics or identifying suitable experts and resources that can assist with their national development plans. The Technical Officer of Metrology also serves as the Technical Secretary of CARIMET and is...
responsible for monitoring the progress of CARIMET activities, reporting on these activities to the CROSQ Council and providing the CARIMET Coordinator with administrative support as required.

3.1.4 Cooperation with the Dominican Republic
On 22 August 1998 the Dominican Republic and CARICOM signed an agreement establishing the free trade area between the two parties. Seven years later the Dominican Republic took action to strengthen this relationship by applying to become the 16th member of CARICOM. Although the Dominican Republic is not yet a member of CARICOM, the process of regional integration has continued within the framework of the Caribbean Forum (CARIFORUM) of the African, Caribbean and Pacific States (ACP). As a result, CROSQ began to collaborate with the Dominican Directorate General of Standards and Quality Systems (DIGENOR) which has since been replaced with the Dominican Institute for Quality (INDOCAL). This collaboration started with cooperation in the German Federal Government funded projects administered by the PTB and grew into INDOCAL being regular invitees to attend the Meeting of the CROSQ Council. In 2011, CROSQ, INDOCAL and PTB partnered to develop the 10th European Development Fund Caribbean Regional Indicative Programme (EDF-CRIP) Economic Partnership Programme Technical Barriers to Trade (EPA-TBT) Project which is now being jointly implemented by all three parties. In metrology, INDOCAL cooperates with CROSQ by actively participating in CARIMET. This has included assisting in shaping the CARIMET Strategic Plan for 2016-2020, participating in capacity building activities, hosting regional and international metrology fora and offering to host the Caribbean Reference Laboratory (CaRL) for Electrical Power Measurements. A system of reciprocating administrative support and mutual respect has fostered strong professional ties between CROSQ and INDOCAL.

3.1.5 Increased Participation in SIM
For many years, SIM has been and continues to be an important ally in the development of metrology in CARICOM. Not only because of the atmosphere of camaraderie and technical assistance that permeates the organisation. Through SIM, CARIMET NMIs has benefited from bilateral assistance rendered from other NMIs.

CARIMET NMIs have relied on funding from the Organisation of American States (OAS) administered through SIM to support their participation in SIM activities however as funding from the OAS decreased so did CARIMET participation. As CARIMET implements its strategic plan for 2016-2020 (see 3.1.6), SIM's role will be even more important than before. This plan includes more active representation at the SIM Quality Systems Task Force (QSTF) and MWGs and increasing the number of submissions from CARIMET NMIs to the SIM-QSTF. As a result, additional funding must be allocated from national and regional initiatives to ensure the increased participation of CARICOM NMIs in SIM. Seeing this need, the 10th EDF-CRIP EPA-TBT Project was conceptualised to use CARIMET as the Technical Implementation Group (TIG) for the metrology component. In return for CARIMET's assistance in planning the annual operating plan for the project, the project partially supports the NMI's attendance at the SIM General Assembly and other MWG activities that are considered to be of regional importance. In recent years this partial funding has been graciously met with counterpart funding from the US National Institute of Standards and Technology (NIST) for the SIM General Assembly and SIM counterpart funding for the MWG meetings and training interventions thus guaranteeing the participation of CARIMET NMIs.

3.1.6 CARIMET Strategic Plan 2016-2020
In 2010, CARIMET recognised the need for a structured approach to the regional development of metrology which led to the creation of the first CARIMET Strategic Plan in Frigate Bay, Saint Kitts & Nevis in 2011. With the expiration of this first plan in 2015, CARIMET took the lessons learned from this plan to develop a more pragmatic plan for 2016-2020. Using this 2016-2020 Strategic Plan CARIMET hopes to bring the benefits of metrology into the mainstream of Caribbean industry and society.
3.2 Development of Regional Metrologists

Over the years, CARIMET has pursued various options to develop the competence of the regions metrologists. Many have benefited from training interventions organised by CROSQ or by Regional Metrology Organisations (RMOs) such as SIM and EURAMET. In addition to bilateral assistance within SIM there has been regional training provided by other more developed NMIs such as the German National Metrology Institute (PTB), the Mexican National Metrology Centre (CENAM), the Brazilian National Institute of Metrology, Quality and Technology (INMETRO), the Argentinian National Institute of Industrial Technology (INTI), the Peruvian National Institute of Quality (INACAL) and the US National Institute for Standards and Technology (NIST).

As the regional competence in metrology is improved by external interventions there has been an increase in the number of capacity building activities planned and implemented within CARIMET. In addition to planning workshops on topics of regional interest there has been an increase in the number of NMIs sending their experts to train other NMIs and also, the attachment of metrologists within CARIMET NMIs.

3.2.1 CARIMET Capacity Building Programme in Metrology

Metrology is a multifaceted science starting from the scientific theory and research that forms the basis for the realisation of measurements, to the application of these measurement standards to real world situations, the maintenance of adequate laboratory facilities and equipment, the statistical calculations that are required to instil confidence in the quality of the measurement taken and all the records and documentation that must be created and maintained. Appropriately then, the development of competence in metrology requires a varied approach to knowledge transfer. As a result, the CARIMET Capacity Building Programme in Metrology was conceptualised to combine workshops, work attachments and short term consultancies with the aim of stimulating the most professional growth within the shortest possible time.

The aim of this programme is to simultaneously develop a cadre of regional experts in three (3) areas. In the first instance the areas of Mass Metrology, Thermometry and Volumetry will be developed within a period of one (1) year. Fifteen (15) metrologists will be selected from all CARIFORUM States, through a competitive application process to form three (3) groups of five (5) metrologists each focusing on one area.

3.2.2 Inter-Laboratory Comparisons

Inter-Laboratory Comparisons are important tools in demonstrating the equivalence and competence of measurement capabilities of different NMIs. By comparing their results with other NMIs, this allows the laboratories to identify any deficiencies or areas for improvement after which they can take the required action. For the metrologist this is also an important for demonstrating his/her competence in comparison with his peers and can be an important learning and confidence building tool. This demonstration of the technical and professional competences of metrologists is critical for their development to the point of being considered “experts” in their respective areas of focus. Within CARIMET the largest two (2) NMIs, the Bureau of Standards Jamaica (BSJ) and the Trinidad & Tobago Bureau of Standards (TTBS) have been actively participating in comparisons planned by SIM and other RMOs in areas of national importance. CARIMET knowing the value of these comparisons and recognising the need for other CARIMET NMIs to participate in comparisons began to plan its own.

The first CARIMET comparison, SIM-M.M-S7: Interlaboratory Mass Comparison between Laboratories Belonging to CARIMET [4] was conducted between 2009 and 2010 and involved seven (7) CARIMET NMIs. For five (5) of these NMIs it was their first time participating in a comparison published on the International Bureau of Weights and Measures (BIPM) Key Comparison Database (KCDB). The pilot laboratory was the BSJ and since this was their first time in this role as pilot laboratory the then Chair of the SIM Mass & Related Quantities Working Group (MWG 7), Mr. Francisco Garcia of Chile’s Centre of Measurement Studies and Quality
Certification (CESMEC) served as coach. The results are shown in the Figure 3.

The second CARIMET comparison that is now being implemented is the CARIMET Comparison at 20 Litre Volume. This comparison has a total of nine (9) CARIMET NMIs and CENAM will be providing the link to the BIPM KCDB. Additionally, invitations have been extended to the Kenya Bureau of Standards (KEBS) and the Cuban National Research Institute of Metrology (INIMET). The BSJ is also the pilot laboratory for this comparison and they are being coached by Mr. Roberto Arias of CENAM.

The 2 kg results of SIM.M.M-S7 supplementary mass comparison

3.3 Regional Cooperation Schemes
The individual markets of most Caribbean countries are too small to sustain all the calibration services required to support trade. As a result, private investors have no interest in establishing calibration laboratories in many of these islands leaving the manufacturing sector looking to the Government for support. In order to ease the burden on individual states and assist in accelerating their access to metrology services two (2) regional cooperation schemes have been conceptualised and are now being implemented.

3.3.1 Caribbean Reference Laboratory (CaRL) Scheme
In order to ensure the traceability of their national reference standards to the International System of Units (SI), each CARICOM NMI would independently try to identify the most cost effective calibration service provider. This could either be another NMI or a private calibration laboratory. In an attempt to ensure that the national reference standards in all NMIs are calibrated by another NMI and at the same time reduce the cost of these high level calibrations the concept of the Caribbean Reference Laboratory (CaRL) was developed in 2010.

A Caribbean Reference Laboratory, (CaRL), is a metrology laboratory within a National Metrology Institute (NMI) or Designated Institute (DI) in CARIMET recognized by the CROSQ Council as a regional reference laboratory providing traceability for a measurement quantity within a defined scope. This capability must be demonstrated by either internationally recognized accreditation and/or the publication of the laboratory’s Calibration and Measurement Capabilities (CMCs) on the BIPM KCDB.

The development of CaRLs first starts with the identification of areas of demand based on the requests for support from all the NMIs within CARICOM. Once a metrology quantity is identified as requiring a regional reference, expressions of interest are then made to CARIMET from those who have the capability or potential to serve as the CaRL for this measurement quantity. An NMI or NMIs (depending on the interest and demand for this service) are then selected by CARIMET for development and ratified by the CROSQ Council based on the technical competence.
of the metrologists working in each laboratory, the level of development of the existing service, and the sustainability of that service based on the NMI’s own national demand. Regional funds are then allocated to complement the national development plans for each laboratory. After receiving international recognition for their measurement capability each laboratory would then be official recognised as a CaRL by the signing of a Memorandum of Understanding (MOU) between the parent NMI and the CROSQ Council.

If we treated the unified CARICOM region as one nation then in this model, the CaRL would be operating as the NMI for the region. This would therefore allow each NMI to operate like a national calibration laboratory and focus on fulfilling only the sustainable demand within their country. Any demand outside of this scope could then be cared for directly by the CaRL.

On 1 February 2013, the Mass Laboratory of the BSJ was recognised as the region’s first CaRL. This was to provide mass calibrations for the range 1mg to 20 kg according to OIML Class E2. Since that time the BSJ has been having challenges with the environmental climate control in the laboratory and the scope has been downgraded to OIML Class F1. However, the BSJ is taking corrective action and with a national project funded by the World Bank they plan to have the service restored to OIML Class E2 within two (2) years.

Two (2) more CaRLs are currently being developed and there are plans for the development of three (3) more CaRLs in the short to medium term. The two (2) laboratories currently being developed with funding from the 10th EDF-CRIP EPA-TBT Project are the thermometry laboratory at the TTBS and the Volumetry laboratory at the BSJ. Technical Assistance for the development of these two (2) CaRLs is being kindly provided by fellow SIM NMIs. The SNM–INDECOPI has kindly provided their thermometry expert; Mr. Edwin Guillen to guide the TTBS in the development of the Thermometry CaRL and NIST has provided Dr. John Wright as a resource for the Volumetry CaRL at the BSJ. The development of a CaRL for Electrical Power Measurements at INDOCAL and the Pressure and Humidity CaRLs at the TTBS are in the early planning phase.
3.3.2 Mobile Calibration Service

The first indication of the need for a regional mobile calibration service was that most CARIMET NMIs own a large number of 20 kg and higher weights procured using their own national funds or through support from development partners. For example in 2012, twenty (20) 20 kg weights along with two (2) 50 kg weight baskets totalling 500 kg were delivered to the CARIMET NMIs through support from the German Government funded project entitled “Establishment of a demand-oriented and regionally harmonized quality infrastructure in the Caribbean” which was being implemented by PTB. In addition to these 20 kg and 50 kg weights, most NMIs already owned a number of metric and in some cases imperial weights. These weights all require regular calibration in order to maintain their traceability to the SI. Without this traceability, the use of these weights is almost pointless as there is no documented means of proving the acceptability of the values. In many cases these weights go uncalibrated due to the undeveloped national mass metrology service and the economic infeasibility of shipping a large number of 20 kg weights to Jamaica, Trinidad & Tobago or elsewhere for calibration.

In an attempt to ensure the traceability of these weights, a mobile calibration service for 20 kg and 50 kg masses up to OIML Class M1 will be developed at the Saint Lucia Bureau of Standards (SLBS). This service will have international recognition through either accreditation from a recognised Accreditation Body or through the CMCs being published on the BIPM KCDB. The preferred route will be to utilise the systems within SIM to support the publishing of CMCs.

Two (2) mass metrologists from the SLBS who fulfil pre-established criteria will be further trained in the performance of this service; it will be preferable to support this infrastructure with attaches’ from other NMIs in due course. These technicians must already possess a strong competence in handling mass metrology weights and equipment and must be available to travel to other regional NMIs to conduct the calibrations.

In addition to this mass metrology service other calibration services will be developed as a regional need is identified.

3.4 Technical Assistance with Laboratory Climate Control Specifications

In order to establish the required laboratories within CARIMET NMIs it will be necessary to either construct new buildings or retrofit the existing building. To support all NMIs with this process technical assistance is being provided through CROSQ to NMIs that are now being built or retrofitted. The lessons learned, specifications developed and contacts made in assisting these NMIs would then be compiled and made available to all the other NMIs.

3.5 Engagement of Regional Customs Agencies and Airlines

In an attempt to ensure the safe transportation of national standards sent overseas for calibration CROSQ has made direct representation on behalf of CARIMET to both major regional airlines and also to the grouping of CARICOM Customs Agencies. Although the two previously mentioned incidents of damage were experienced when the artefacts were outside of the region, the representation to the Customs Agencies was only a formal action meant to reinforce the delicate nature of the national standards. However, there is already a strong relationship that exists throughout the region between each Customs Agency and their respective NSB/NMI and the risk of damage at this stage is low.

As the CaRL and other regional work sharing schemes grow and as the number of CARIMET comparisons increase, it is anticipated that there will be an increase in the number of measurement artefacts that need to be transported within the region. In order to reduce the need for artefacts to be transhipped through the United States, CARIMET has decided that it will use the cargo services of both regional airlines as much as is possible to transport measurement artefacts. The intention behind the representation made to both major airlines was to educate them on the sensitive nature of the measurement artefacts and the
importance of their safe transportation. This system has since been tested with one (1) of the airlines and there has been positive feedback from the three (3) NMIs who safely received artefacts.

In an attempt to address the issues outside the region, the CROSQ Secretariat sought guidance from NIST as to the methods they use to ensure the safe transportation of their artefacts. With guidance from the NIST Shipping Department, each CARIMET NMI was provided with a list of recommendations including a list of preferred couriers that are utilised by NIST. By implementing these recommendations provided by NIST it is envisaged that the incidents of damage will be reduced.

3.6 Development of Regional Marketing and Communications Strategy and Action Plan.

With the national perception that the CARICOM NMIs are a standards-setting regulator with the power to detain products and shut down manufacturers it has been difficult to accurately determine the true needs of the manufacturing sector and this makes it challenging for the NMIs to develop sustainable calibration services. To assist in changing this perception a regional Marketing and Communications Strategy and Action Plan was developed by the Marketing, Information, Knowledge and Education (MIKE) Committee of the CROSQ Council [5]. This plan entails two (2) fundamental strategies, the first one being a direct engagement of the national stakeholders by assigning at least one (1) dedicated person to the building and maintaining of the relationship between each stakeholder group. This person would also be responsible for building outreach to these groups in order to gain consensus, support and agreement on interventions being planned. Critical to this strategy’s success is a structured stakeholder management system. The second (2) strategy is a mass communication strategy focused at the end users of metrology services geared towards repositioning the CROSQ and national NMI brands in a favourable light. The effectiveness of this strategy hinges on the NMI’s ability to clearly connect real market needs with impactful metrology solutions combined with appropriate messaging and branding.

3.7 Collection of Demand Data

In order to ensure the sustainable development of metrology services it is critical that each NMI understands the demand for their services. Since most CARIMET NMIs had no data on the actual calibrations needs in their respective country there must be a concerted effort on their part to collate this data. Although it was possible from the beginning to gather this information using an external consultant it was thought that since this would have to be an activity that must be periodically repeated it would be best if it were undertaken at a national level by the NMI. In an attempt to stimulate the collection of this data the 10th EDF-CRIP EPA-TBT project began the procurement of equipment for those Member States who had completed and submitted this data to the CROSQ Secretariat. Through this process in combination with some assistance for a few Member States where resources were particularly low, the Project was able to get an understanding of the demand in all CARICOM countries.

4. LESSONS LEARNED

The following are the major lessons learned over the last five (5) years of developing a regional metrology system:

i. The strength of the regional metrology system is the national capabilities.

ii. Regional activities must be developed in such a way that they are not perceived by the NMIs as additional work but as beneficial steps leading to the success of national development plans.

iii. An inclusive approach at the planning stage regardless of the NMIs’ level of development creates greater buy-in and is educational for the lesser developed NMIs.

iv. The management of strong relationships at all levels within the NMIs is critical to the success of regional cooperation.
v. The administration of all benefits must have clear criteria and a transparent process.

5. CONCLUSION

Notwithstanding the fact that the global metrology community has over a century of history in the development of NMIs with empirical data demonstrating the contribution of metrology to economic and social sustainable development, the development of metrology in CARICOM SIDS continues to prove challenging to individual Member States and as a result a regional approach has been developed. This plan has at its core the identification of the demand for calibration services in each country and then developing sustainable calibration services in each country and using regional mechanisms to meet those needs that cannot be met nationally. In the case of CARICOM, the following summary of challenges and strategies to overcome these challenges can be made:

1) The Socio-political environment which places metrology low in the order of priorities at both a governmental and consumer level is being addressed by developing regional support mechanisms. These have included signing the CIPM-MRA as a bloc of nations, the adoption of CARIMET as the metrology special committee of the CROSQ Council, the creation of the regional position of Technical Officer of Metrology to coordinate the regional development of metrology and the increased participation in SIM.

2) The development and management of the metrologists in the region is being addressed by the implementation of regional capacity building initiatives to ensure that a pool of skilled metrologists is available for the region. Additionally, inter-laboratory comparisons are being used to strategically build competence and confidence and also to demonstrate the technical capability of CARIMET.

3) Developing sustainable calibration services has proved to be a challenge to many countries due to the limited number of industrial clients in each country. As a result NMIs are being developed to address those demands that are sustainable and to complement this CARIMET is developing regional resource sharing and cooperation schemes. These schemes are the Caribbean Reference Laboratory (CaRL) which establishes a cost-effective entry point for traceability into the CARICOM region and the mobile calibration services that will enable one (1) NMI to perform calibrations throughout the region on behalf of the home NMI where an international recognised service is not available.

4) The detached geographical nature of SIDS presents more transportation challenges than countries that share a land border. In the case of CARICOM there is a weak regional transportation infrastructure and this has made the calibration costs for national standards higher and also increases the risk of damage to these standards. As a result it has been important to ensure that the standards that are being shipped from one CARIMET NMI to another do not have to be transshipped outside of the CARICOM SIDS. To assist in this endeavour the two (2) major regional airlines have been directly engaged as the preferred means of shipping artefacts and the Customs Agencies have been engaged to ensure measurement artefacts are not damaged during inspection.

5) To address the negative image of the NMI as regulator intent of closing down manufacturers the region has developed a regional Marketing and Communications Strategy and Action Plan to guide the Member States.

6) The culture inherited from being a part of the public service can only be corrected by directly engaging the stakeholders at a national level. As a result considerable effort has been placed on encouraging each NMI to engage the manufacturers in order to determine the true needs and to continuously repeat this process.
5. REFERENCES


