Metrology: Definition and challenges by Mr. Mourad Ben Hassine AFRIMETS Chair

---

What is Metrology?

Metrology can be defined as "the science of measurement associated with the evaluation of its uncertainty". It includes all theoretical and practical aspects of measurements, whatever the measurement uncertainty and field of application. Metrology activities may be divided into three basic subfields:

- Scientific or fundamental metrology: concerns the establishment of quantity and unit systems, units of measurement, the development of new measurement methods, the realization of measurement standards, and the process to determine the equivalence of national measurement standards to those of other nations and the transfer of traceability from these standards to users in society.
- Applied metrology for voluntary applications, namely Industrial metrology: concerns the application of scientific metrology to manufacturing and other technological processes and their use in society, ensuring the suitability of measurement instruments, their calibration and the quality control of measurements.
- Applied metrology for mandatory applications, namely Legal metrology: concerns measurements and measuring instruments for fair trade, the protection of health and environment, public safety, for enabling taxation and for the protection of consumers.

Metrology is structured at international, regional and national levels to handle the following missions:

- Definition of internationally accepted units of measurement.
- Realisation of these units of measurement in practice
- Application of chains of traceability linking measurements made in practice to reference standards.
- Establishment of legal requirements for measurements and measuring instruments.

How is Metrology structures at international and regional levels?

Measurement is fundamental to practically all the processes we carry out, both large and small, from commodity trading, manufacturing, environmental and energy monitoring, health diagnostics, medical treatment, global navigation, sport performance, public safety and law enforcement to just about every daily activity we perform.
To ensure the accuracy of measurement in all these fields and to guarantee that measurements can be used repeatedly in time and space, the international community has set up an ensemble of standards associated with the international system of units and an ensemble of rules and specifications related to measuring instruments.

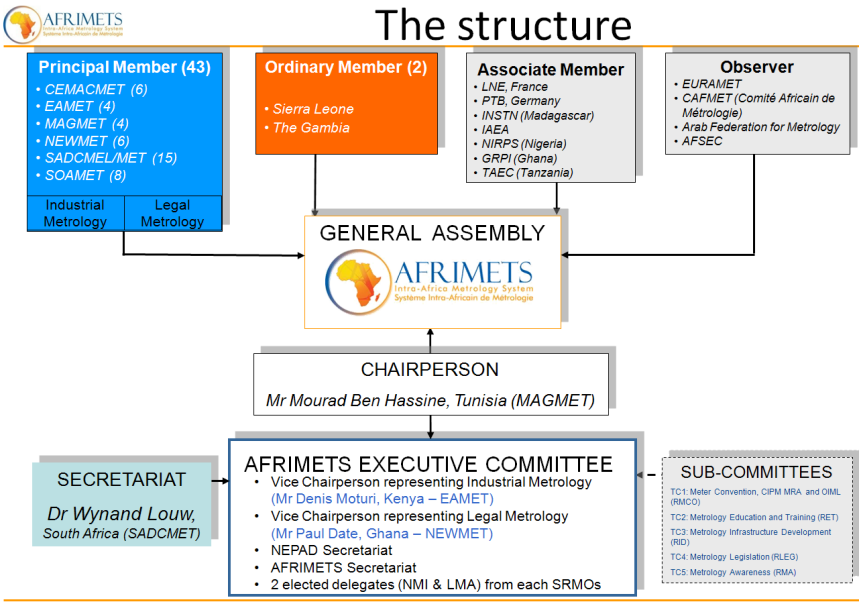
The organizations playing the main role at international level are respectively:

- The Bureau International des Poids et Mesures « BIPM » (www.bipm.org): set up by the Convention of the Mètre (treaty signed in Paris in 1875) and its mandate is to provide the basis for a single, coherent system of measurements throughout the world, traceable to the International System of Units (SI). The BIPM acts in matters of world metrology, particularly concerning the demand for measurement standards of ever

increasing accuracy, range and diversity, and the need to demonstrate equivalence between national measurement standards.

- The International Organization of Legal Metrology « OIML » (www.oiml.org): an intergovernmental treaty organization established in 1955 and having a mission to enable economies to put in place effective legal metrology infrastructures that are mutually compatible and internationally recognized, for all areas for which governments take responsibility, such as those which facilitate trade, establish mutual confidence and harmonize the level of consumer protection worldwide.

At regional and continental level, the Regional Metrology Organization (RMO) are coordinating the cooperation of National Metrology Institutes (NMIs).



The Intra-Africa Metrology System "AFRIMETS" (www.afrimets.org) is the RMO of Africa. Its mission is to "Promote metrology and related activities in Africa with the view of facilitating intra-African and international trade and to ensur the safety, health, and consumer and environmental protection of its citizens".

AFRIMETS objectives are to:

1. Create awareness in Metrology in Africa at all levels of society and government;
2. Assist in the development and/or strengthening of the metrology infrastructure in each country/sub-region on the continent;
3. Contribute to the development of a conformity assessment and regulatory infrastructure as required and to promote equity in trade;
4. Foster competitiveness and quality in the manufacturing sector in order to promote trade and commerce;
5. Contribute to the development of the metrological infrastructure required to protect the environment and to promote the general well-being of the population, including its health, safety and the protection of consumers from fraudulent dealings where measurements are used as the basis for the transaction;
6. Develop a closer collaboration between Members;
7. Improve the level of metrology, and to assist members in gaining international recognition;
8. Improve the traceability of measurement standards within Africa to international standards as defined in the international system of units (SI), and to generally promote the International Committee of Weights and Measure's Mutual recognition Arrangement (CIPM MRA) and the objectives of the Metre Convention;

9. Encourage measurement traceability in Africa through recognised calibration services;
10. Promote the adoption of International Organisation of Legal Metrology (OIML) technical recommendations or other relevant international standards as technical regulations wherever possible and harmonize technical regulations in Africain order to minimise technical barriers to trade.

What are the main challenges of Metrology in Africa?

For many decades, Africa has been at a disadvantage with its trading partners and one of the reasons is the lack of a proper Quality Infrastructure. Without such an infrastructure, it is difficult to manufacture to international specifications and tolerances, to ensure the integrity of export commodities, to apply quality control for the acceptance of fresh produce at the port of arrival, to lock out unsafe imports, to ensure the health and safety of the population and for effective crime prevention and law enforcement.

The lack or inadequateness of any of the pillars of a Quality infrastructure (QI), namely Standards, Accreditation, Metrology, Conformance testing and Quality, but especially metrology as the cornerstone of a QI, can lead to an uncompetitive manufacturing industry and limited access to export markets, the inability to protect against unsafe local or imported products, ineffective environmental monitoring and the failure of a national health or law enforcement system.

Accurate measurement and the acceptance of measurement results internationally can only be achieved through a proper, benchmarked national measurement system. A strategic roadmap for the years 2012-2016 was developed by AFRIMETS to achieve such goals.

AFRIMETS also cooperate through the Pan-African Quality Infrastructure Forum “PAQI” (www.paqi.org) with the other African organizations dealing with accreditation and standardization.

Contact details :

AFRIMETS CHAIR
Mr Mourad Ben Hassine
E-mail (1): mourad.benhassine@anm.nat.tn
E-mail (2): mourad_benhassine@yahoo.fr

Tunisian National Metrology Institute / Agence National de Métrologie (ANM-TUNISIA)
Tel: +216 71 12 50 00
Fax: +216 71 12 50 01

Legal Metrology: Definition and applications by Mr. Ian Dunmill, OIML Deputy Director

---

What is legal metrology?

Simply put, legal metrology is about applying legislation to measurements and measuring instruments.

Legislation on measurements and measuring instruments is required, for example when there is a need to protect both the buyer and the seller in a commercial transaction, when measurements are used to apply a sanction, when public health or safety depend on a measurement. Virtually all countries provide such protection by including metrology in their legislation – hence the term "legal metrology". Legal metrology legislation is one of the oldest forms of legislation, having existed in some European countries since at least medieval times.

Creating global standards (called International Recommendations) for use in legal metrology legislation is the role of the International Organisation of Legal Metrology (OIML). The OIML is an inter-governmental organisation, established in 1955, which has its headquarters in Paris, France. It develops these International Recommendations through project groups consisting of experts drawn from its Member States. As of July 2014, the OIML has 60 Member States and 67 Corresponding Members

A more complete definition of legal metrology can be found in International Document D 1 *Considerations for a law on metrology* published by the (OIML):

> *"Legal metrology is the practice and the process of applying regulatory structure and enforcement to metrology. It comprises all activities for which legal requirements are prescribed on measurement, units of measurement, measuring instruments or systems and methods of measurement, these activities being performed by or on behalf of governmental authorities, in order to ensure an appropriate level of confidence in measurement results in the national regulatory environment."*

How does legal metrology affect daily life?

Measurements are so much a part of our daily lives that we often take them for granted and possibly don't even notice them. For example

- we buy meat, fish, fruit and vegetables by weight,
- we fill our cars with fuel by volume,
- we consume electricity, gas and water which are billed based on meters in our homes,
- we monitor the speed at which we drive to ensure we travel safely and thus reduce road casualties,
- we undergo medical checks to make sure we remain healthy,
- we receive medical treatments with precisely measured doses, such as radiation treatment for cancer,

- we use time to be punctual for appointments, and satellite positioning systems to pinpoint our location,
- we have our vehicles checked to monitor the exhaust emission levels and so on.

These examples, along with countless other activities in our daily lives, involve some sort of measurement. We are so used to this that we take many measurements for granted. We know that "someone" takes care of ensuring that these measurements are correct. This is true if we live in an industrialised country with an operational legal metrology infrastructure, but many in many developing countries, this is not the case, leading to possibility of severe financial or health- & safety-related consequences for individual members of the public, for companies (from the family-run to the large), and even for states themselves.

Legal metrology legislation ensures that the accuracy of measurements and measuring instruments is appropriate to the measurement in question. This legislation is then founded on there being traceability, an unbroken chain of measurements, provided by each national measurement institute which connects individual measurements made in the market or doctor's surgery to the national standards for that unit and then on to the International System of Units (the SI).

How does legal metrology affect trade?

The trade of goods and services around the world is vital for economic growth, for the wellbeing of the population, and to maintain worldwide financial stability.

Measurements are involved in most trade transactions and in order to ensure fairness to all parties, they must be able to be considered as "acceptable".

Very large amounts of money may be involved in a transaction based on, say, the measurement of the volume of oil that flows through a pipeline, where a measurement error of a fraction of a percent could lead to a huge difference in the amount invoiced. Without the capability to perform accurate measurements, one of the parties would be disadvantaged and the state may also lose out on tax revenue.

Technical regulations and standards are adopted in legislation by governments to protect both producers and consumers at national and international levels. The Organisation for Economic Co-operation and Development (OECD) estimates that about 80 % of global trade is affected by standards or regulations. However if no sound measurement system is in place, these regulations and standards may become technical barriers to trade (TBT) which may increase costs, inhibit the free flow of goods, or require repeated testing.

Even in the non-regulated areas of trade, the need for compatibility of components and systems requires consistency and uniformity in the way we measure. Components are frequently manufactured in one country and then assembled with parts or systems manufactured in another country. In addition, there is a growing trend to partially manufacture components in one country, and complete their manufacture in another. This is only possible if a uniform global system of measurement is in place ensuring traceability to the SI, and confidence in testing and measurement results by means of certification, standardization, accreditation and calibration.
To help industry to demonstrate international consistency of measurement and testing, two international metrology Agreements exist:

- The International Committee for Weights and Measures (CIPM) has created a Mutual Recognition Arrangement (CIPM MRA) which ensures equivalence of the national measurement standards and calibration and measurement certificates issued by National Metrology Institutes);
- The International Organization of Legal Metrology (OIML) has created a Mutual Acceptance Arrangement (MAA) facilitates international acceptance of declarations of conformity of regulated measuring instruments with OIML Recommendations.

As a result, the aim of *"measured once, accepted everywhere"* can be achieved and trade regulators and industry can rely on measurements as evidence of compliance with national and international regulations and standards.

Contact details :

OIML Deputy Director
Mr. Ian Dunmill
Email: ian.dunmill@oiml.org

11, rue Turgot, 75009 Paris
Website : https://www.oiml.org

Metrology - for Quality Promotion, Competiveness, and Trade, by Dr. Bruno Doko, Technical expert of the ACP-EU-TBT Programme

---

Introduction

Metrology is the science of measurement that includes units of measurement and their standards, measuring instruments and their fields of application, and all theoretical and practical problems relating to measurement. Metrology is fundamental to trade yet as a concept it is not always well understood by policy makers from developed and developing economies. Most global trade is underpinned by physical and/or chemical measurements, to determine the quantity and quality of products and services (UNIDO, 2009). Metrology and physical standards provide the basis for accurate measurements, the accepted performance of which can then be written in international standards, which can in turn be used as the basis for conformity assessment (ISO, 2006; CIDI, 2011).

The world economy and the quality of everyday life depend on reliable measurements and tests which are trusted and accepted internationally and which do not form a barrier to trade. The role of measurement science is important in terms of international effort to eliminate technical barriers to trade (TBT) particularly in the area of conformity assessment. It is a prerequisite to ensure that relevant conformity assessment bodies (CABs) have adequate and enduring technical competence for the continued reliability of their conformity assessment results. Metrology[1,] standardization and conformity assessment are used by business and government to optimize production, health, consumer protection, environment, security and quality. Their effective implementation supports sustainable development and social welfare, and facilitates trade.

Metrological Impediments to Trade

Metrological technical barriers to trade arise for a variety of reasons, both real and perceived, including differences in regulations, legislation and mandated standards, differences in the implementation of existing legislation, de facto requirements for traceability to national standards in a specified country or institute, historical practices, differences between metrological standards in different countries, variations in technology between countries and the lack of harmonisation of test and calibration procedures. Metrology communities play an important role in CABs' obtaining technical competence in their activities.

A number of international agreements through the world trade organization (WTO) aim to promote free trade, primarily through the reduction or elimination of tariff barriers. In this context, it has become widely recognized that a lack of suitable technical infrastructures, or their absence, can create technical barriers to trade, causing free trade to remain hampered. Therefore, developing countries with absent or weak technical infrastructures are at a disadvantage and their ability to successfully enter into trade is potentially restricted (Streak, M., 2008). The role of metrology communities in the WTO's efforts to realize free trade system is essential, particularly with regard to the conformity assessment (Park and Bahng, 2009).

The European Commission, in partnership with metrological communities, is supporting the MetroTrade project,

[1] Metrology is classified in three main fields: scientific metrology, industrial metrology and legal metrology

which addresses direct measurement issues related to trade between the regions (EUROMET). The MetroTrade project (http://www.metrotrade.dk/) aims to identify and facilitate the removal of metrological impediments to international trade by addressing issues such as:

- Lack of knowledge of the degree of equivalence of national measurement capability
- Promotion of a framework for the mutual acceptance of calibration certificates
- De facto requirements to repeat traceable calibrations

Metrology in developing countries

An internationally recognized metrology infrastructure in developing countries and countries in transition is now recognized as a high priority. For these countries, the lack of such a structure is hindering development as it raises the vulnerability to non-tariff barriers to trade, that in turn delays market access and further industrial and economic development. Exchange of information and know-how, awareness stimulation and coordination of assistance to these countries in metrology, accreditation and standardization are now being attempted through a Joint Committee on Coordination of Assistance to Developing Countries in Metrology, Accreditation and Standardization (JCDCMAS) comprising the BIPM, the Regional Metrology Organizations (RMOs), ILAC, the International Organization for Legal Metrology (OIML), the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Accreditation Forum (IAF), the United Nations Industrial Development Organization (UNIDO), and the International Telecommunications Union (ITU). (BIPM; 2003). In addition, The UNIDO, BIPM, and the OIML agreed to establish a strategic partnership on metrology. The aim of the partnership is to enhance the impact of industrial development on economic growth and to minimize technical barriers to trade (TBT), which are still a major obstacle to exports from developing countries and countries with economies in transition (UNIDO; 2008). The EU Commission in partnership with UNIDO had funded the West Africa Quality Programme covering among others things, metrology, a key pillar of quality infrastructure. The contribution of this Programme in the implementation of technical provisions to assist economic operators in different countries to meet international standards, technical regulations and conformity assessment requirements, enabled notable changes.

The ACP-EU-TBT Programme

The ACP EU TBT Programme is a 15 million euro trade-related technical assistance programme funded by the 10th European Development Fund and implemented, on behalf of the ACP Secretariat, by the Brussels-based TBT Programme Management Unit. The Programme was launched in March 2013 and will run until July 2017. The ACP-EU TBT Programme main objective is to contribute to improved competitiveness in local, regional and export markets by enhancing the export capacity of economic operators in ACP countries.

The ACP-EU TBT Programme's intervention

Capacity building activities provided under the Programme covered training and education of technical competencies of the personnel, and provision of equipment in metrology fields. The ACP-EU-TBT Programme's actions in the support to trade facilitation encompass building/strengthening the competencies of technical personnel resources through training, advisory services, preparedness towards accreditation, and academic upgrading and international exchange of experiences, in order to enable the establishment of an efficient national metrological framework, to help remedy impediments to the successful development and implementation of international trade agreements.

The ACP-EU-TBT Programme tackles the metrology issues through three Programme lines[2] including:

- Upgrading and strengthening Quality Infrastructure (QI) and related institutions
- Empowering economic operators and export sectors to comply with international market requirements
- Dissemination results and experiences

Support to Upgrading/strengthening QI and related institutions

The ACP-EU-TBT Programme supports the QI institutions. Most of the technical assistance requests recorded so far encompass capacity building assistance through training of personnel resources on metrological technical requirements, laboratory good practices, readiness for accreditation purposes in a number of countries, including, Benin, Mauritius, Mauritania, Côte d'Ivoire, Rwanda. In Benin and Mauritania the cooperation projects with both ABMCQ[3], and DNPQ[4], consisted in:

- In-house training the trainers on metrological technical requirements, uncertainty of measurements, etc.
- Organisation of advanced training courses on metrological dimensions (Mass, Temperature, Volume, and Pressure) in international training in Paris (France), within an advanced reference training centre, the LNE (http://www.lne.eu/en/training/intro-en.asp) for 10 and 5 engineers/technicians originated from ABMCQ (Benin), and DNPQ (Mauritania), respectively.
- Organisation of specific programmes intended to executives of ABMCQ (Benin) and DNPQM (Mauritania) to enable better overview on the areas of activity related to metrology at international level.

Support ACP-Members participation to AFRIMETS Legal Metrology School[5]

The ACP-EU-TBT Programme is supporting the participation of 60 ACP-Members candidates originating from Benin (1), Botswana (2), Burkina Faso (2), Burundi (2), Chad (2), Comoros (2), Djibouti (2), Democratic Republic of Congo (2), Ethiopia (2), Gabon (2), Gambia (1), Ghana (2), Guinea Bissau (2), Haiti (2), Cote d'Ivoire (2), Kenya (2), Lesotho (2), Liberia (1), Mali (2), Mauritania (2), Mauritius (2), Mozambique (1), Namibia (2), Niger (2), Rwanda (2) Senegal (2), Sierra Leone (2), Seychelles (2), Swaziland (1), Tanzania (2), Togo (2), Uganda (2), Zambia (2), Zimbabwe (2). The AFRIMETS Legal Metrology School is a ten day training event on the foundations of legal metrology and quality for participants from developing economies and members of the Intra-Africa Metrology System (AFRIMETS), will take place in Hammamet (Tunisia) from 8 to 17 October 2014. The event will be organized by AFRIMETS under a UNIDO project with funding from the NORAD. It will be held in cooperation with the ANM; OIML; PTB, and the ACP-EU TBT Programme.

The main objective of the project is to initiate ACP-Members executives to the quality Infrastructure (metrology, standardization, quality and Accreditation) with the aim of (i) form a nucleus of trainers technically related to metrology, and (ii) contribute to the emergence of potential managers of legal metrology services.

The specific objectives of the project are intended to:

- Allow future executives in charge of metrology to have a better overview on the areas of activity related to metrology;

2 The ACP-EU-TBT Programme. Accessed http://www.acp-eu-tbt.org/index.cfm
3 ABMCQ : Agence Béninoise de Métrologie et du Contrôle de la Qualité
4 DNPQ : Direction de la Normalisation et de la Promotion de la Qualité
5 http://www.unido.org/en/news-centre/events/afrimets-legal-metrology-school.html

- Establish inter-personal relationships essential to the development of their careers and strengthen networks relevant to their activities.
- Strengthen the knowledge of the international requirements of the BIPM and OIML;
- Provide training technique, adequate to the needs of African countries, relative to the requirements of legal metrology.

Conclusions

Metrology is a foundation of national quality infrastructure (NQI). Metrology and physical standards provide the basis for accurate measurements, the accepted performance of which can then be written in international standards, which can in turn be used as the basis for conformity assessment. A functioning national quality infrastructure (NQI) is a prerequisite for international trade (i.e., access to regional and global markets) and a key determinant of competitive advantage, and economic growth. It fosters innovation, competitiveness, consumer protection, promotes market transparency and the elimination of technical barriers to trade (TBT) which, in turn, promote access to new markets, job creation, encourage investment and a more careful use of natural resources. Today's global economy depends on reliable measurements and tests, which are trusted and accepted internationally. They should not create technical barriers to trade. Precondition for this is a widely utilised, sound metrological infrastructure.

REFERENCES

- *UNIDO (2009). UNIDO and BIPM: a complementary approach to measurement capabilities. – In TCB Brief; No. 8, November 2009.*
- *ISO (2006). Three pillars of sustainable development: Metrology, Standardization and Conformity assessment. ISO Central Secretariat; ISBN 92-67-10416-0: http://www.iso.org/iso/devt_3pillars_2006.pdf; consulted 09/2014.*
- *CIDI (2011). Towards a vision 20/25 in science, technology and innovation for the Americas: Hemispheric cooperation for competitiveness and prosperity in a knowledge economy. OEA/Ser.K/XVIII.3; CIDI/REMYT-III/doc.5/11 rev. 2; 17 November, 2011.*
- *Michael Streak (2008). Bringing down technical barriers to trade with metrology, accreditation and standardization. In The Way forward – Developing countries and emerging economies; ISO Focus; Volume 5, No. 9, September 2008, ISSN 1729-8709.*
- *J. Park and G. W. Bahng (2009). The Role of Metrology Communities under the WTO system: Measurement Science and Conformity Assessment Procedures. XIX IMEKO World Congress; Fundamental and Applied Metrology; September 6-11, 2009, Lisbon, Portugal: http://www.imeko2009.it.pt/Papers/FP_239.pdf consulted 09/2014.*
- *P. Howarth and F. Redgrave (2003). Metrology in Short. EUROMET project 673; December, 2003.*
- *BIPM (2003). Evolving Needs for Metrology in Trade, Industry and Society and the Role of the BIPM. CIPM. Source: http://www.bipm.org/utils/en/pdf/kaarls2003-EN.pdf ; consulted 9/2014.*
- *Ulrich Harmes-Liedtke (2010). The Relevance of Quality Infrastructure to Promote Innovation Systems in Developing Countries; PTB- April, 2010.*
- *UNIDO (2008). New Cooperation Agreement on Metrology to Combat Technical Barriers to Trade and Spur Economic Growth). Press releases - UNIS/INF/308; 4 December 2008.*
- *EUROMET. MetroTrade – Metrological Support for International Trade. http://forum.oiml.org/posters/offers/pdf/poster_offer_metrotrade.pdf consulted 09/2014.*

Contact details :

ACP EU TBT Programme
Dr Bruno Doko
Email : B.DOKO@acp-eu-tbt.org

Avenue de Tervuren 32 box 31
1040 Brussels Belgium
Tel : +32 2 739 0000
www.acp-eu-tbt.org