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FROM THE INTERNATIONAL SYSTEM OF UNITS TO A GLOBAL METROLOGY SYSTEM

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Abstract – The paper describes recent developments towards a global metrology system. The driving forces behind this development are globalization and the liberalization of trade. The World Trade Organization, WTO, with more than 140 member states sets the rules for international trade. Other international organizations must take into account these rules and especially, the Technical Barriers to Trade Agreement. The organs of the Metre Convention developed a system to ensure worldwide traceability and mutual recognition of measurements and calibrations. Details of the system and measures to establish confidence in the competence of National Metrology Institutes are described. Furthermore, laboratory accreditation procedures and the role of regional and international accreditation organizations with regard to ensure confidence in competence are explained. The International Organization of Legal Metrology, OIML, contributes to the global metrology system by recommendations for measuring instruments and a certificate system indicating that a given instrument pattern complies with the requirements of the relevant OIML recommendation. Suggestions for possible IMEKO contributions are given.

Keywords: metrological infrastructure, metrology system

1. INTRODUCTION

I would like to draw your attention to new developments in metrology, and especially to developments which could lead to a global metrology system. By global system I mean a system which ensures reliable measurement results owing to the use of internationally recognized procedures.

These procedures include

- the use of the International System of Units, the SI,
- measuring instruments which are traceable to the SI,
- the calculation of the measurement uncertainty according to internationally accepted rules,
- the operation of a quality management system,
- the participation in activities to demonstrate competence.

Only if all these procedures and requirements are fulfilled will measurement results be qualified for acceptance on the international level.

This acceptance on the international level is not a problem in science and research but it is a problem in international trade, environmental protection, health care and perhaps also

other sectors in which decisions or financial transactions are based on measurements.

I will show that international trade is one major driving force for the development of metrology. I will then describe efforts and achievements of the Metre Convention, the International Organization of Legal Metrology, OIML, and the International Laboratory Accreditation Corporation, ILAC, in responding to the international requirements and to rules of the World Trade Organization. The procedures developed by the above-mentioned organizations are elements of a global metrology system. In the concept of a global metrology system, regional metrology organizations play an important part. Using the European Union as an example, I will explain the interdependence between a regional trading system and a regional metrology system. I will conclude with some remarks on IMEKO's role in international metrology.

2. TRADE AND METROLOGY

The International System of Units, SI, which is applied worldwide facilitates international trade. The absence of such an international system hampered international trade in the second half of the 19th century so seriously that the Metre Convention was devised and founded in 1875. This international convention ensures the propagation and improvement of the International System of Units, the SI, the modern embodiment of the metric system.

Nevertheless, there is still a lack of confidence in the results of measurements and tests, especially in cross-border trading transactions. Multiple measurements are therefore carried out by the parties involved. These double, triple and even multiple measurements and tests are costly, time-consuming and a waste of resources. The growing demand for measurements and tests due to conformity assessments makes the situation even worse.

Conformity assessment is any activity concerned with determining directly by measurements or test or indirectly that relevant requirements of standards or technical regulations are fulfilled.

Estimates show that up to 80% of trade is subject to standards or technical regulations and that conformity assessments may be required. The acceptance of conformity certificates on the international level is not yet realized so that multiple tests are necessary. This is not in line with the efforts of the World Trade Organization, WTO, nor with the expectations of the manufacturers who strive for: one

standard, one test, accepted everywhere. International organizations reacted to these requirements and worked out procedures to ensure confidence in the competence of calibration and testing laboratories, which I will describe below.

3. THE CONTRIBUTION OF THE METRE CONVENTION

Since conformity assessment usually requires measurements and tests, the procedures must be in agreement with the Technical Barriers to Trade Rules of the WTO which means: they must be transparent, justified, non-discriminatory, based on international standards and acceptable on the international level [1].

New ideas and concepts have been developed on the international level to fulfill these requirements.

Under the umbrella of the Metre Convention, a quite extensive program was set up to build confidence in the competence of National Metrology Institutes (NMIs). To reach this objective, interested NMIs are invited to state their measurement capabilities, to take part in international comparison measurements and to establish and maintain quality management systems. Based on these principles, a mutual recognition agreement was drawn up by the International Committee of Weights and Measures (CIPM), which was signed by the directors of 38 NMIs and two international organizations in October 1999 as the Mutual Recognition Arrangement for National Measurement Standards and for Calibration and Measurement Certificates issued by National Metrology Institutes (CIPM-MRA). Subsequently another 14 NMIs signed the CIPM-MRA so that the total number of signatories is 52 + 2 as of January 2003 [2].

With the approval of the authorities responsible, the NMI directors

- accept the process specified in the MRA for establishing the database,
- recognize the results of key and supplementary comparisons as stated in the database,
- recognize the calibration and measurement capabilities of other participating NMIs as stated in the database, and
- agree to implement and maintain a quality management system.

The BIPM is responsible for the overall coordination, while the Consultative Committees of the CIPM, the Regional Metrology Organizations and the BIPM are responsible for carrying out the key and supplementary comparisons and a Joint Committee of the Regional Metrology Organization (RMO) and the BIPM are charged with checking information for entry into the database for calibration and measurement capabilities as declared by the NMIs. The operation of a quality management system can be demonstrated either by accreditation or by self-declaration of the NMI. The NMIs must also state their measurement capabilities for a database to be checked by the Regional Metrology Organization and verified by the Joint Committee of the RMOs and the BIPM (JC).

The new and important role regional metrology organizations play in the concept of the CIPM-MRA is

worth mentioning. It is the task of the RMOs to organize metrology in the region, to ensure traceability and to cooperate closely with the BIPM in order to link-up with the international level. The RMOs will take over tasks which cannot be carried out by the BIPM because it has neither the capacity nor the intention to cooperate with every NMI. It will concentrate on NMIs performing measurements with the lowest uncertainties.

Another new feature of establishing confidence in measurement and calibration activities is the requirement to maintain a quality management system for its measurement and calibration services and to demonstrate its effectiveness. This may be done either by choosing a system in compliance with international Guidelines or standards and assessed by an accreditation body fulfilling the relevant international requirements or by self-declaration and an assessment by the local RMO and a review by the Joint Committee. The demonstration of competence and capability may require visits and examinations by an NMI and/or peers assigned by the local RMO.

Formally, the CIPM-MRA is a technical arrangement among the directors of NMIs having signed it with the approval of the appropriate governmental or other official authorities of their country. It is expected that participation in this arrangement will open the way and provide the technical basis for wider agreements on trade, commerce and regulatory affairs. It serves already as a technical basis for the accreditation of laboratories in accordance with the relevant international standards developed by the International Organization for Standardization, ISO, and the International Electrotechnical Commission, IEC.

The CIPM-MRA and all its procedures are in agreement with the WTO requirements. For the time being, only 52 Directors of National Metrology Institutes have signed the Arrangement. In reality, the requirements of the CIPM-MRA are technical barriers for many NMIs because they are not advanced enough to fulfill the requirements.

On the other hand, the fees of membership in the Metre Convention is a financial barrier for many countries. To reduce this problem and to enable more countries to participate in its programs and to sign the CIPM-MRA, a new member status has been introduced, the Associate to the General Conference.

The program of the Metre Convention aims at building confidence in the competence of National Metrology Institutes which are members or associates.

This program for National Metrology Institutes is one element of a global system. Contributions of other international organizations will be described in the next section.

4. CONTRIBUTIONS OF OTHER INTERNATIONAL ORGANIZATIONS

4.1 *The International Organization of Legal Metrology*

There is another intergovernmental organization in the field of metrology subject to legal control: the International Organization of Legal Metrology, OIML.

Its main task is to provide its Members with models for establishing harmonized legal metrology requirements and practices. For this purpose, OIML International

Recommendations and Documents are published, providing the legal, metrological and technical foundations necessary for establishing and operating uniform legal metrology structures. International Recommendations are intended for implementation by metrology services as national regulations to ensure the proper design, verification, and use of measuring instruments subject to legal requirements. International Documents provide guidelines and references for general aspects of legal metrology, including fundamental laws, units, metrological control, verification processes and personnel training. The OIML Technical Committees and Subcommittees are responsible for the development of International Recommendations and Documents which serve to exchange technical knowledge and develop harmonized metrological requirements and testing procedures. Harmonized requirements facilitate trade.

The OIML Certificate System for Measuring Instruments introduced in 1991 to facilitate administrative procedures and lower the costs associated with the international trade of measuring instruments subject to legal control serve the same purpose. The system provides the possibility for a manufacturer to obtain an OIML certificate and a test report stating that a particular instrument type complies with the requirements of the relevant OIML International Recommendations.

Certificates are delivered by OIML Member States. OIML certificates are accepted by national metrology services on a voluntary basis. As the climate for mutual confidence and recognition of test results is developing among the OIML Members, the OIML Certificate System promises to simplify the type approval process for manufacturers and metrology authorities by eliminating the costly duplication of application and test procedures and thereby contributing to a global metrology system, especially in the regulated area [3].

4.2 *The International Laboratory Accreditation Corporation*

Confidence in the competence of the actors in the system is the key to the success of the metrology system. Accreditation is a procedure by which an authoritative body formally recognizes that a body or person is competent to carry out specific tasks and is a means to create confidence. The development of laboratory accreditation practices and procedures, the promotion of laboratory accreditation as a trade facilitation tool and the recognition of competent calibration and test laboratories around the globe is the task of the International Laboratory Accreditation Cooperation, ILAC.

The work of ILAC is based on international standards and Guidelines laid down by the International Organization for Standardization, ISO, the International Electrotechnical Commission, IEC, and in some cases by working groups of specialist international organizations. This ensures a broad consensus on the procedures applied.

ILAC also encourages the development of regional accreditation cooperations and the establishment of multilateral mutual recognition arrangements among ILAC member bodies. The ILAC arrangement is based on regional arrangements. Each recognized Regional Accreditation

Body must abide by the procedures defined in ILAC requirements documents. Currently, the European Cooperation for Accreditation, EA, and the Asia Pacific Laboratory Accreditation Cooperation, APLAC, are the only regions recognized by ILAC with acceptable mutual recognition arrangements and evaluation procedures [4]. Such arrangements will further enhance and further facilitate the international acceptance of calibration data and contribute to the realization of a global metrology system and to “one- stop testing”, the wish of manufacturers and traders.

5. REGIONAL ORGANIZATION

Regional metrology and accreditation organizations are the building blocks for a global metrology system. The development of such regional organizations is supported by the creation of regional markets, regional associations or regional communities. The formation of regional markets requires regionally harmonized metrology systems. I will present examples from the European Union and the realization of the Single Market.

The value of products traded by mass, volume or length is enormous. Estimates are of the order of 10 percent of the gross domestic product. If the national legislations for measurements and measuring instruments are not compatible, they will be serious barriers to trade. This was the case in the EU member states. The harmonization of legislation commenced in 1971 and is still going on. According to the so-called “New Approach”, the Measuring Instruments Directive (MID)

- establishes essential requirements, performance requirements rather than design specifications (the so-called “New Approach”)
- requires conformity assessment procedures (according to the so-called “Global Approach”) and
- establishes mutual recognition of the results of conformity assessment among the member states.

After the MID’s entry into force no parallel national regimes of legal control of measuring instruments may exist in the Member States. Technical solutions satisfying the metrological requirements will be given in international normative documents such as the Recommendations of the International Organization of Legal Metrology, OIML. The application of such documents shall give presumption of conformity with the requirements of the Directive. But the manufacturer may also apply solutions which are not covered by such documents if he can demonstrate that the essential requirements are fulfilled [5].

Within the EU, these directives serve two purposes: They enable free movement of measuring instruments, and they ensure correct trading transactions by establishing legal requirements for their accuracies and other performance characteristics. This means that the directives are necessary to realize the Single Market and that they constitute the legal basis for consumer protection.

The enforcement of the directives after translation into national law is the task of the national legal metrology services of the EU member states. These check the

compliance of measuring instruments and prepacked products with the requirements of the directives.

To ensure good cooperation, 18 representative members from national legal metrology authorities in the European Union and EFTA member states signed a Memorandum of Understanding in 1990 to found the European Cooperation in Legal Metrology, WELMEC. At that time Europe was politically divided into East and West, and the acronym WELMEC stood for Western European Legal Metrology Cooperation. Today, however, WELMEC extends beyond Western Europe and includes representatives from Central and Eastern Europe. The acronym WELMEC has been retained. Among the objectives of WELMEC are:

- development of mutual confidence among legal metrology services and
- achievement of the harmonization of legal metrology activities [6].

These activities assure correct and consistent implementation and enforcement of the legislation.

Confidence in competence is further enhanced through the work within the former Western European Calibration Cooperation WECC, (established in 1974), subsequently by the European co-operation for Accreditation of Laboratories, EAL, (1994) and at present by the European co-operation for Accreditation, EA (since 1997).

The members of EA are accreditation bodies recognized on the national level of the member countries, the candidate countries of the European Union and the European Free Trade Area, EFTA, operating accreditation systems compatible with the European Standard EN 45003 or with ISO/IEC Guide 58.

Part of the EA's work is the organization of interlaboratory comparisons. The work of these organizations over the years ensures the necessary confidence in the competence of their members on the basis of documented facts. It was driven by the economic and political development and oriented to the needs of the region. The result is a regional accreditation system providing mutual recognition of the certificates issued by its members. Another important fact to be mentioned here is that Memoranda of Understanding (MoUs) have been signed between the European Commission respectively EFTA and the EA. By this agreement, EA's important role in the area of conformity assessment, i.e. testing, calibration, certification and inspection to ensure the efficient operation of the Single Market has been officially recognized [7].

EUROMET is a cooperative voluntary organization among the NMIs. Since the EUROMET MoU was signed the metrological collaboration in Europe has significantly increased. More than ever before, contacts and exchange of know-how among metrology experts of the Member NMIs, the European Commission and NMIs from outside EUROMET were to be noted. At the same time the number of signatories rose from originally 18 to 25, including NMIs from Central and Eastern Europe. In addition, another 19 Corresponding Applicants are seeking full membership.

Although EUROMET has no funds of its own, hundreds of metrology projects have been proposed, launched and completed. A number of projects were supported by various EU programs. The many years of close cooperation have

created a high level of confidence in the competence of the member NMIs [8].

The European example clearly shows the interdependence between the realization of the Single Market and the development of regional structures in metrology, covering legal metrology, calibration services and national metrology institutes. Moreover, good working relations have been established between the relevant political bodies and the regional metrology organizations.

Good and intensive working relations have also been established with the relevant international organizations, the Metre Convention, OIML and ILAC. These interactions are reflected in the work of both, the international and the regional organizations. The European system is integrated into the international system and is the regional reflection of a global system. It can be assumed that the Europeans will expect equal efforts for the realization of regional cooperation in other parts of the world in order to create the same level of confidence in the competence of their regional members.

6. IMEKO'S CONTRIBUTIONS

I will conclude with some remarks on IMEKO with regard to the realization of the global metrology system and I will make some suggestions.

Although IMEKO is an international metrology organization, it is not involved in the development of the global metrology system. However, in my opinion there are possibilities of contributing to the realization of the system. My first suggestion relates to contributions at the level of the member organizations.

Since member organizations of IMEKO are national societies concerned with the advancement of measurement technology, they could pass on the idea and the working principles of the global system to their individual members within their societies. There is a lack of information about these new developments at the work bench level, especially in countries which are neither members of the Metre Convention nor of a regional or international laboratory accreditation organization. The national metrology societies with established communication links can fill this gap of information about the concept of traceability, the calculation of measurement uncertainties and the functioning of the system. This information is of special importance for industry in order to benefit from the global system and to enhance competitiveness.

The national metrology societies can also serve as focal points for criticism and problems encountered when applying the system at the work bench level. This feedback is important and should be treated by the national metrology society and passed on to the international level for corrective actions. These tasks should be included in the national working program of every IMEKO member organization.

The second suggestion is about the work of the Technical Committees. Their main objective is the exchange of scientific and technical information. Nevertheless, the development of formal procedures and technical requirements necessary for a global metrology system also deserves their attention. Questions of traceability,

measurement uncertainty, international and regional comparison measurements or accreditation have both scientific and formal aspects. Both are worth treating per se and in the context of a global metrology system.

The third suggestion concerns the use of information gathered in special committees. The scopes of work of TC 8 "Traceability in Metrology" and TC 11 "Metrological Infrastructures" are directly related to subjects of interest to the global system. As the chairman of TC 11, I will briefly describe our efforts in this regard.

The scope of TC 11 is defined as follows:

"To collect, discuss and disseminate know-how about development, establishment and operation of institutions and services concerned with measurement standards, measuring instruments, calibration, metrological assurance, certification and accreditation, taking into account the specific economic, social and educational needs of individual countries with special emphasis on developing countries."

TC 11 considers itself a forum for the discussion of topics of metrological infrastructures and new developments and offers support, especially to developing countries and to countries in transition to market economy, in the transfer of knowledge about the above-mentioned subjects. Information is provided through conferences, seminars, round table discussions and the homepage on the Internet [9].

Contacts to the relevant international and regional organizations have been established and their representatives

have contributed to round table discussions organized by TC 11 at IMEKO World Congresses since 1994. Another round table will be organized during this conference with the aim of raising the awareness and stimulating active support for the implementation of the global metrology system. It will become really a global system if all regions of the world will actively participate. This still is a long way to go, and there are ample possibilities for metrologists to contribute to the realization of the system. It was my intention to increase your interest in this subject.

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