

Measurement Processes in Conformity Assessment Systems

Roman Aleksander Tabisz

*Rzeszow University of Technology, Faculty of Electrical and Computer Engineering,
Department of Metrology and Measurement Systems. Wincentego Pola 2. 35-959 Rzeszów.
tel: +48 017 8651188, fax: +48 0178542088 Email: rtabisz@prz.rzeszow.pl*

Abstract- A key role of metrology in the realization of the concept of sustainable development of the regions and countries of the world, is underlined. In particular, are those developing regions/countries and those in the process of an economical transformation in their economic systems. The most important influence of the measurement process validation in all kinds of conformity assessment systems, is explained. The need for the creation of regional metrological centres and information systems to aid the measurement process validation for different testing and calibration laboratories, are pointed out. The research project which carries out designing and developing of the information systems, namely: Computer Aided Measurement Process Validation – CAMPV, is presented. This system can be used by regional metrological centres.

I. Introduction

Realization of the concept of sustainable development of the world [1],[2], in particular those countries or regions which are in the development or transformation phase of their economic systems, requires the creation of the right technical infrastructure. The three main pillars of this infrastructure are: metrology, standardization and conformity assessment systems. These three pillars should develop simultaneously, according to the “composite approach” which was recommended in the “background paper” [3]. Metrology, standardization and conformity assessment systems are used in practice by business and government institutions to optimize manufacturing processes, health care systems, environmental care systems and safety systems. Effective implementation of these three fields at the same time of development, provides support for sustainable development, social welfare and facilitates regional, national and international trade. The key role of metrology in the efforts for sustainable development, was the central idea of the XVIII IMEKO World Congress, which took place in Rio de Janeiro in September of 2006. This idea was elaborated in detail and explained in the paper presented in the plenary session of this congress [4].

In metrology there are three fundamental fields of activity, 1) creating , improving and propagation of the standards and reference materials, 2) error and uncertainty analysis and their expression in calibration and measurement processes, and, 3) creating new measurement methods, systems and procedures. All fields of metrological activity are intensively developed and harmonized within an international scale. Very good results from the efforts of the international metrological organizations and international companies which manufacture the measurement equipment and software have been achieved. For example: **1** - more and more levels of standard credibility have been created and held by national and international metrological institutes [5], **2** - preparation of the final draft of the new international metrological vocabulary [6] and of the Supplement -1 to the GUM guide [8]. This guide made a singular international “revolution” in the way of its preparation and expression of measurement results. **3** - design and manufacturing of the intelligent sensors and “micro converters”, and the software for preparation of the virtual measurement instruments and the very complex information measurement systems.

The possibility of a rapid implementation of these metrological achievements in practice on a regional level, is a primary problem at present. The National Quality Systems for products, health care and safety improvement, apply in practice in regions, in specific production and service enterprises and in regional offices and institutions.

So, on a national level, the fundamental mechanism is the creation of legitimate regulations. These influence places where actual production or service enterprises are located. If government regulations are both strong and in harmony, they will be applied in given regions and products and services in these given regions can, without technical barriers, be offered on national or international markets. However, for the development and creation of new enterprises and service institutions, an appropriately educated labour force is needed. This labour pool should be well versed in the problems of contemporary metrology, standardization and conformity assessment systems. Also essential is an perpetual

improvement programme of education at secondary and higher school level, particularly those that educate engineers and managers. In the opinion of the author, at present there is an urgent need for the creation of regional metrological centres. These centres should be able to support the performance of the different testing and calibration laboratories, and educate their staff.

A. Measurement decision risk in conformity assessment systems.

The basic aim of creating the conformity assessment system is the assurance of the possibility of making credible evaluations of materials, products or services. These assessments should explicitly determine whether objects are in compliance with the requirements of the technical specifications or regulations. These systems are being formed by different organizations; they have a diversified reach and application aims.

The system which has a global reach is the system formed by nine international organizations connected to one committee *JCDMAS*, working under the patronage of the International Organization for Standardization *ISO* [3]. The aim of this system is to support the sustainable development and trade in the developing countries and those in their transformation phase. Having been created and approved by the International Electrotechnical Commission (*IEC*) the conformity assessment system can be a divergent model. This system consists of three subsystems: conformity assessment system for electrical equipment *IECEE*, conformity assessment system for electrical equipment for use in an explosive atmosphere *IECEX* and conformity assessment system for electronic components *IECQ*.

The individual conformity assessment system can be active in each of these subsystems. The systems of the "*first party*" are created by manufacturers. In this kind of system, the manufacturer does its own testing, on its own products, in its own in-house test laboratory, and provides a supplier's declaration of conformity. The systems of the "*second party*" are created by buyers. In this kind of system the company buying the product does its own testing. The System of the "*third party*" are an accumulation of networks of the accredited testing and calibration laboratories. This kind of system is created independently of the manufacturers and buyers, by independent testing services which carry out the tests. These laboratories can get certificates of competence from national or international institutions, which are often mutually co-operating in the system of mutual conformity assessment recognition. In Poland, for example, this kind of institution is the Polish Center for Accreditation, subordinated to the government. In the European Union, a uniform and modular conformity assessment system is already functioning. This system requires products to carry the *CE* sign. This sign confirms that the specified requirements in the *EU* regulations, relating to a product, are fulfilled [9]. There is no uniform conformity assessment system in the USA and there is no government institution for accreditation. Accreditation of laboratories and the certification of products are, in the USA, voluntary - but very often taken.

In all described conformity assessment systems, independently of their reach, the kind and application of the purpose, the testing of conformity is carried out by such methods that enable the minimizing of measurement decision risk. This risk is evaluated as to the probability of the manifestation of two kinds of events. The first event is the false acceptance of an object though, in fact, the object does not conform to specification and the second event which is the false reject of an object, when, in fact, the object conforms to specification. To clarify this problem we can use a simple example. In this example the assessed characteristic X of the object is being measured on a continuous measurement scale. In this example, the evaluation of the object is measured by the interval of value defined within the limits of the specification - low *LSL* and upper *USL*, with a nominal target value X_{NOM} . This formed the basis of the criteria for the conformity assessment. Moreover, an additional assumption was adopted: the measurement results obtained in the measurement processes used for the conformity assessment, do not include the systematic errors and their variability may be characterized by expanded uncertainty U . The conformity assessment diagram is presented in fig.1. This diagram shows the taking of the adopted assumptions into consideration and enabling the graphical illustration of the intervals in which the measurement decision risk can appear.

On the basis of the diagram shown in fig.1, it is possible to take out the essential conclusion important for the credibility of obtaining results from the conformity assessment.

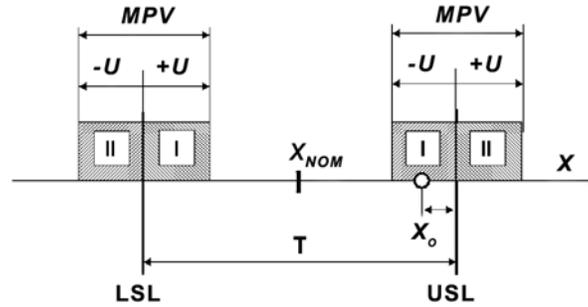


Figure 1. The conformity assessment diagram

U - expanded uncertainty of the measurement process
 MPV - Measurement Process Variability ($MPV=2U$)

If the real value X_o , of the tested characteristic X of the evaluated object will belong to the range of values $[(LSL+U), (USL-U)]$ it is an assessment of the conformity of the object to the requirements of the specification and will be fully credible. In this situation the evaluated objects will conform to specification without any doubt. If the probability will arise that the real value X_o , of the tested characteristic $-X$ of the evaluated object will belong to the ranges which are marked **I**, a probability of the events existing in the false rejection of the object, will also arise. The result will be a measurement process variability $MPV=2U$. The probability of the appearance of such events is called "**false reject risk**". This kind of case is marked in fig.1. The real value X_o of the tested characteristic X of the evaluated object will belong to the range **I**, as seen on the right side of the diagram at the $r = [USL - X_o]$ point. If we assume, for simplification, that it is possible to describe the distribution of measurement results from the imperfection of the measurement process with normal probability density function $N(\mu, \sigma)$, it is possible from this simple case to calculate the false reject risk. The value of this risk will be equal to the value $P = [1 - P(z)]/2$. Where $P(z)$ is of the value probability read out from the appropriate statistical table of $N(0,1)$ distribution for $z = (USL - X_o)/\sigma_{pp}$. Where σ_{pp} is the standard deviation i.e. the standard uncertainty of measurement results, which are obtained by use of the measurement process. If a probability will arise that the real value X_o , of the tested characteristic X of the evaluated object will belong to the ranges which are marked **II**, a probability of the events consisting in false acceptance of the object will also arise. The result will be a measurement process variability $MPV=2U$, too. The probability of the appearance of such events is called "**false accept risk**". So, the value of the probability of events appearing in both kinds of false assessments of the agreement called the "**measurement decision risk**" should be estimated with the help of the rules taken for conditional probability. The calculated value of the numerical measure of this probability will depend on the variability of the examined characteristic X of the evaluated objects and from the measurement process variability (MPV)

B. Measurement process validation.

On the basis of the diagram shown in fig.1, it is possible to make the following conclusions: **A-** the level of the measurement decision risk can be held lower than the permissible value, if the possibility of controlling the variability of the assessed object, exists and the parameters of this variability are known. **B-** the level of the expanded uncertainty U of the measurement results obtained from the measurement process can be held lower than the permissible value if a possibility of controlling the variability of each crucial factor influencing the measuring process, exists too.

Effective supervising of the measurement processes is possible in the situation when their periodic and versatile validation is being carried out. The validation is a process in which evidence is provided to the fact that the metrological characteristics of the measurement process **MCMP** meet the metrological requirements of the intended use of measurements **MRIUM**. The process of comparing characteristics **MCMP** with requirements **MRIUM** is called the "**metrological confirmation process**" and its realization is described in the international standard [10].

The measurement process validation flow chart is presented in fig.2. The final result of the validation is the certificate of metrological confirmation. This certificate should explicitly state that the metrological requirements of the intended use of measurements are fulfilled. Leading the validation of

measurement processes according to the flow chart introduced in fig.2, is a complex metrological task requiring suitable competence and appropriate equipment.

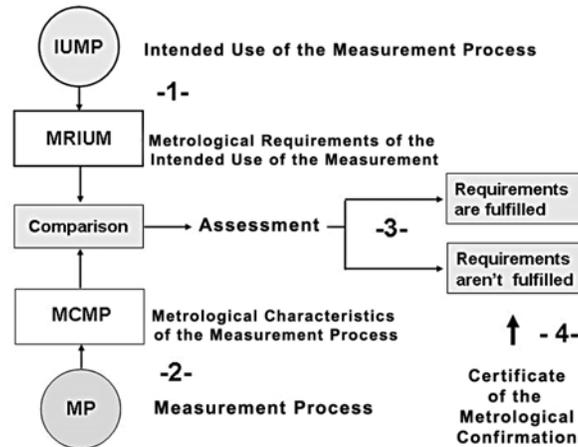


Figure 2. The measurement process validation flow chart.

This task covers 4 stages of action:

1. Determination of Metrological Requirements of the Intended Use of Measurements (*MRIUM*).
2. Determination of Metrological Characteristics of the Measurements Process (*MCMP*).
3. The *MCMP* comparison with *MRIUM* and making an evaluation.
4. Processing data and generating the validation certificates.

In making the 4 stages, noted above, a computer system consisting of appropriate computer equipment, the software and the metrological database, is of great help. The metrological database should be designed in a way that allows for the collection of general technical data and historical data from the calibration of elementary channels and measurement modules of which the measurement systems consist for the realization of the intended use of the measurements. Each intended use of measurements is achieved with the use of determined measurement processes, and simple or complex measuring equipment. Thanks to the data collected in the metrological database, appropriate validation designs can be accomplished for different measuring processes. Such processes can take into consideration simple and complex measurement systems. The prototype version of an information system aided measurement processes confirmation stayed in the publication [11]. At present an updated version of the named system - CAMPV (Computer Aided Measurement Process Validation) is being realized. This system is intended for the regional metrological centre.

C. Computer Aided Measurement Process Validation - *CAMPV*

Every computer system aiding measurement process validation is realized within the determined information infrastructure contained in the local area network - LAN the most popular connection with the Internet network; the right programming environment which allows for the creation of data acquisition software for measurement systems, and calibration software which allows for the creation of a metrological database in which it is possible to collect historical calibration data.

The information infrastructure, in which the project aimed at the design and development of the *CAMPV* system, is introduced in fig.3. A local area network of the Testing and Calibration Laboratory "LABBiKAL" at the Department of Metrology and Measurement Systems of the Rzeszow University of Technology is being used for the realization of this project. For creating and improving the required software a Microsoft.NET platform is used along with the specialist environment of the LabView graphical programming for measurement systems. The 8.2. LabView version permits an integration of programmes in conjunction with with programs created with the help of the Microsoft NET platform. The Metrological Database is put on a separate server. This Metrological Database is accessible through the interactive website for all testing and calibrating stands of the LABBiKAL laboratory. This database can also be used by interested external laboratories which gain access to it on the basis of

an agreement between the parties. The best solution is one place with equipment and performance that can focus on, and improve the metrological competence and information system. This place may play the role of the regional metrological centre. However, connection with the Internet network enables a wide access to the metrological database. This wide access to the metrological database can have a value for many small laboratories which are not able to create information systems that aid the validation of measurement processes, but which want to act according to the requirements of domestic and international conformity assessment systems.

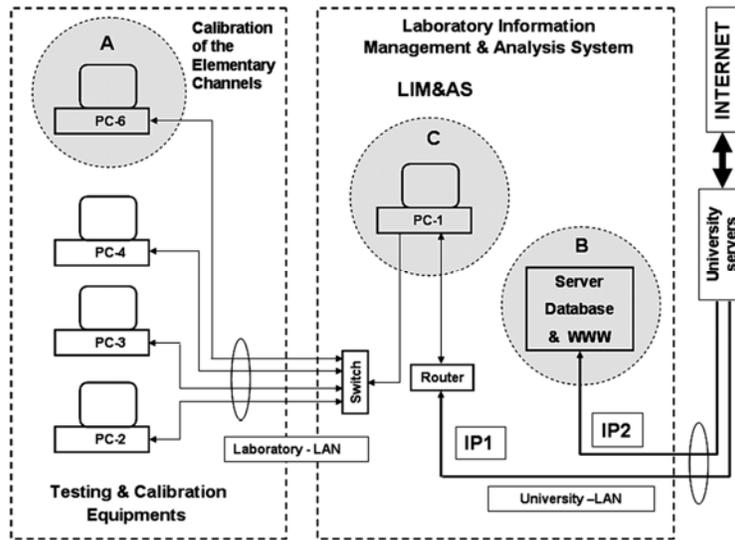


Figure 3. The information infrastructure in which the CAMPV system was created and developed.

The CAMPV system was created and is being developed in the information infrastructure introduced in figure.3. This system consists of three main parts, marked in figure.3. with letters: **A**, **B**, **C**. Part-**A** is a laboratory stand for calibration of elementary measurement channels and modules. Part-**B** is a laboratory information management system which can realize data analysis and the simulation of complex measurement system actions. Part-**C** is a metrological database located on a separate server. This database is accessible through the interactive website from the local LAN network or from any place in which the access to the Internet network is possible.

The structure of the interactive website assuring access to the metrological database is designed so that it is possible to correctly collect general technical data of elementary measurement channels and modules, together with data from the calibration of these channels and modules. Data gathered together in the metrological database can be used for defining the metrological characteristics of measurement processes (*MCMP*) and for the purpose for comparing these characteristics with the metrological requirements of the intended use of the measurements (*MRIUM*). In the metrological database, certificates of validation for individual measurement processes of which assessments were an object, are generated and collected.

II. Conclusions

At present, a need exists to create regional metrological centers, which represent the important pillars of the different kinds of conformity assessment systems. These centers are particularly needed in those regions in which laboratories do not meet the conditions of the domestic and international conformity assessment systems. The measurement decision risk appearing in conformity assessment systems should be evaluated and held below the permissible level, which was described for the given intended use of the measurement. Every measurement process used in a conformity assessment system should be evaluated on account of its usefulness and applied after the issue of the validation certificate. The validation of measurement processes is a complex metrological task, which covers four stages of action. Making these actions can at present be aided with the help of appropriately chosen and adapted information technologies. An example of an application of chosen and adopted information technologies for the validation of measurement processes, is the CAMPV system which was designed

and is being developed by the author. This system in the future can be used by laboratories working in enterprises manufacturing products for the aviation industry which form the association "Aviation Valley "[12]. Rzeszow University of Technology is a member of this association.

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