INFORMATION SYSTEMS FOR METROLOGY

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***Abstract**: An important application of the information technology (IT), which is the creation and improvement of Information Systems for Metrology (ISM) is discussed. These systems initially had a form of Metrological Database (MD) and Metrological Knowledge Bases (MKB). At present, the advanced versions of these systems have a form of the Metrological Expert Systems (MES) using artificial intelligence methods. Two selected examples of Information Systems for Metrology and their practical use are described. An actual state of the ISM ("CAMPV System") designed and developed in the Department of Metrology and Diagnostic Systems, Faculty of Electrical and Computer Engineering at Rzeszow University of Technology, is presented. The system consist of the portal for communication with the system via the Internet and the Metrological Database (MD) collecting the data on the specification of measurement equipment as well as the data obtained in the process of equipment calibration. It has been planned that the system will be expanded by adding the Analytical Metrological Database (AMD) and Metrological Knowledge Base (MKB). A full version of "CAMPV-Expert System" will be dedicated to the computer-aided design of electrical and electronic measurement channels as well as the computer-aided validation of measurement processes, which include such channels.*

***Keywords**: information systems for metrology, metrological databases, metrological knowledge bases, metrological expert systems.*

***ACM Classification Keywords**: A.0 General Literature - Conference proceedings*

***Conference topic**: Industrial Control and Monitoring*

Introduction

The development of microelectronics and related development of information technology (IT) has enabled the creation of measurement information systems (MIS), which allow for measuring and collecting large amounts of measurement data. A vital part of the measurement equipment is the software, which carries out important functions related to the performance of measurement activities and therefore determines the accuracy of final results obtained in the measurement process. Such kind of software is called measurement systems software (MSS). The measurement results are now the primary source of our knowledge about the objects and the phenomena of the real world. The metrology therefore has become the basis for the development of many different fields of science, industry and trade. Measurement results are also the foundation on which the scientific claims are created. In the industrial applications, the measurement results are used for the assessment of products' conformity with their technical specification, the evaluation of the quality of manufacturing processes as well as the control and monitoring of their condition. In the trade, the mutual financial settlements are often based on the measurement results. In each of these areas the highest possible quality of measurement results is desired. The basic condition of reaching this goal is the proper design and appropriate execution of the measurement process. Moreover, the quality of measurement results largely depends on the quality of the hardware and software as well as the level of competence of the operators supervising the measurements processes. The management of the measurement equipment and the effective control of the measurement processes require some additional metrological actions such as calibration, repeatability and reproducibility analysis (R&R) as well as inter-laboratory comparison (IC). This increases the need to collect the data concerning the properties of the measurement equipment and the data obtained in the calibration processes. For this reason, the Metrological Databases (MDB) are created with the use of appropriate IT.

The general model of the measurement process, which incorporates the main factors determining the numerical values of the final measurement results is presented on the Fig.1., on which the measuring equipment is specified by a rectangle. The measurement equipment includes both hardware and software. The circle inscribed in the rectangle marks software as an integral part of the measurement equipment. The software is now incorporated in almost all kinds of measuring equipment as it outscored other technologies when it comes to the implementation of important measurement functions such as: measurements process control, correction of the numerical values of the measured quantity, saving the measurement results as well as reading, decoding and displaying them.

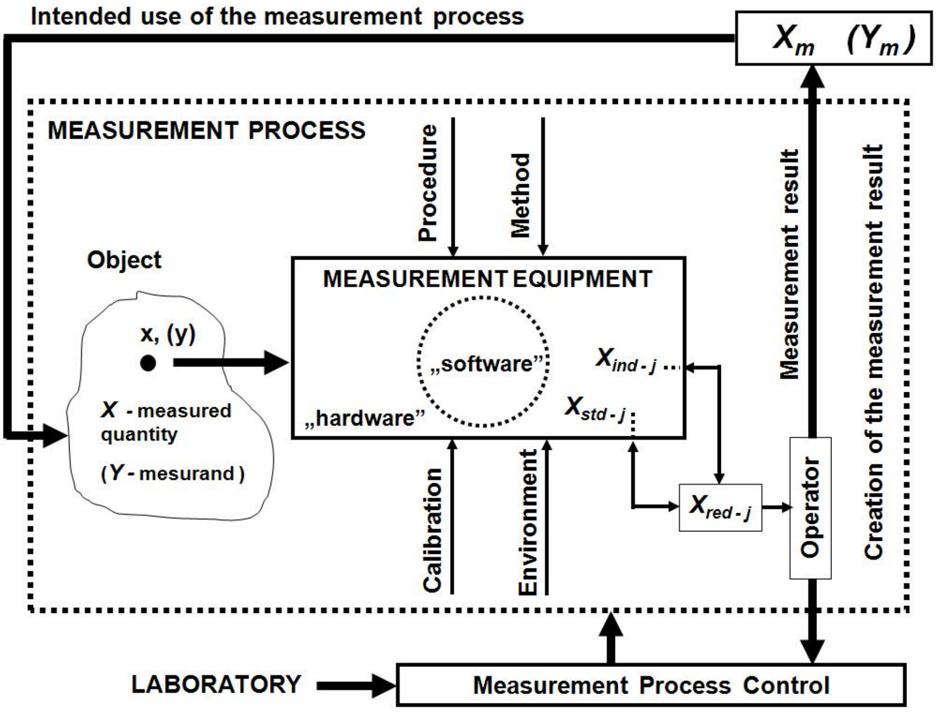


Fig.1. The general model of the measurement process.

x *- numerical value of the measured quantity*

y *- numerical value of the measurand*

$X_{ind\text{-}j}$ *- numerical value indicated on the display of measurement equipment*

$X_{std\text{-}j}$ *- numerical value stored in the memory of the measurement equipment*

$X_{red\text{-}j}$ *- read the value, on which measurement result (* X_m *), is created*

Y_m *- measurand, calculated based on several measured quantities (* X_i *)*

The general model of the measurement process, as shown in Fig.1., has been developed taking into account the original definition of the measure proposed in [1], and models of Information Measurement Systems (IMS) proposed in [2]. These models take into account the types of measurement scales. With such approach, this model is universal and can be applied to all situations in which measurements are carried out. It is independent from the measurement scale adopted to implement the measurement procedure as well as from the composition of the hardware and the software.

The types of the measurement scales have been defined in [3]. In every area of possible application - scientific research, industry or trade - the measurement processes are performed in the specific order. The ultimate goal is always to describe the properties of the real object according to its true state. It allows for making right decisions when it comes to the objects' management and helps the scientists in formulating the accurate and consistent descriptions of the reality of the phenomena. Relevance assessment of the actual state of measured properties of an object, event or phenomenon, depends largely on the accuracy and proper interpretation of obtained results, which, in turn, is strictly associated with the type of the measurement scale. If above is not taken into account, not only the measurements become ruseless but their false results may lead to wrong decisions.

A definition of the measurement proposed in [1] is as follows:

„The measurement is a process of empirical, objective assignment of symbols to attributes of objects and events in the real world, in order to describe them". [1]

However, the proposal formulated in [2] differentiates the MIS due to the measurement scales used and has been developed in the following order:

"The models proposed in this paper can be used for the development of concepts, principles, and guidelines, which can support decision making in the arrangement of design and application of the Measurement Information Systems (MIS)". [2]

„In order to apply these scientific and technical achievements, the designer or the user of a MIS has a possibility to choose between different measurement procedures and also between different constructive modules of the MIS". [2]

Such approach - taking into account the definition proposed in [1] and the proposal of different types of MISs presented in [2] – allows for the correct interpretation of the measurement results and collected information about the measured object, event or phenomenon. Consequently, it makes possible to gain credible knowledge about the real world, manufactured products and also about the measurement science. In order to ensure the desired quality of the measurement results, one should design, manufacture and exploit the MIS using the appropriate hardware and software composition as well as taking into account the type of measurement scale applied in the measurement process. Only properly designed, implemented and applied MIS can be used to effectively collect large amounts of credible data. Credible measurement data can and should be collected in the Operational Metrological Databases (OMD). These databases currently represent the most basic form of Information Systems for Metrology (ISM). The more complex form of the ISM are systems in which the Analytical Metrological Database (AMD), also called data warehouse, is added to the OMD. The extraction of data from OMD to the AMD made through suitably designed ETL operation (Extraction Transaction Loading) provides a grouping of the data according to a well-thought-out strategies and allows for their storage in a useful and inviolable form. This is necessary to carry out various kinds of analysis, which require extracting desired information and knowledge. The concept of extracting information from the measurements and acquiring knowledge from obtained information is described in [4]. It justifies the usefulness of the definition of measurement proposed in [1].

The most complex form of the ISM are Metrological Expert Systems (MES), in which the properly prepared Metrological Knowledge Bases (MKB) are supplemented by automatic inference systems using artificial intelligence methods. Information Systems for Metrology (ISM), including OMD, AMD, MKB and Inference Systems (IS) can be used in metrology for the computer-aided design of measurement processes and measurement equipment (hardware and software). They can also be used to improve the competence of the operators, who supervise the measurement processes and improve the metrological characteristics of MISs, by adjusting the measured numerical values in order to ensure the accuracy of the final results.

In order to present the specific applications of ISM, two selected examples will be described as well as the current state of the third one, which currently has been in the process of design, implementation and development. The first example is the Metrological Knowledge Base - one of major components of the education system operators of Coordinate Measurement Machines (CMM) [5]. The second example is the metrological expert system using neural networks to predict corrections, calculate the Polish Universal Time Coordinate - UTC (PL) and propagate the Polish Official Time - OT (PL) [6]. The third example is a computer system supporting the validation of the measurement process, designed, implemented and developed in the Department of Metrology and Diagnostic Systems, Faculty of Electrical Engineering and Computer Science, Rzeszow University of Technology. Each of described examples implements the concept of knowledge acquisition from information extracted from the measurements data collected in the appropriate metrological databases and then stored in the metrological knowledge bases.

The process of extracting knowledge from data described in [4] goes in the order, which can be simply described as: *"measurement-information-knowledge".* This order has been used in all described examples, but in each one for different reason. In the first example, the objective is to improve the competence of the operators of CMM. The operator is the key person responsible for the creation of the final result in the model of measurement process shown in Fig.1. Therefore, the more complex is the measurement equipment, the more qualified the operator should be. In the second example, the metrological expert system analyzes the data published by the Time Laboratory of the International Bureau of Weights and Measures in Paris (BIMP) [7] and predicts the corrections, which allow for calculation of the exact value of the Polish Universal Time Coordinated - UTC (PL). The difference between these corrections and the corrections published by the BIMP should not exceed 10 ns. In the third example, the main goal is to use the *"CAMPV System" (Computer Aided Measurement Process Validation System)* for validation of the measurement process, conducted on the basis of historical calibration data of measurement equipment, stored in the metrological database. This system also allows testing and calibration laboratories for cooperating on-line.

The IT System for Metrology used in the European Education and Training Programme for operators of CMMs

The European education and training programme for operators of CMMs was developed in 2001-2005 within the European Research Project EUKOM [5]. This project was funded by "LEONARDO DA VINCI" programme of European Commission, DG Education and Training. The main objective of the project "European Training for Coordinate Metrology" was to create a common, Europe-wide approach to the training in the field of coordinate measuring technology, which would meet the requirements of continuing education. The results of the project were implemented by the association CMTrain e.V. [8], independent of CMM producers, which currently is being developed and tested of training by a mixed method. This method combines the capabilities of distance learning (e-learning) with verification of acquired knowledge during the practical handling of CMMs. In the original version the distance learning module was created with the ILIAS system [9], which is the open source software. The effectiveness of learning was achieved through a carefully prepared Metrology Knowledge Base developed by experts from the six centers from different countries. The project was coordinated by the Chair of Quality Management and Manufacturing Metrology at University of Erlangen-Nuremberg. [10]. The structure of Metrological Knowledge Base EUKOM system has been adapted into the learning material coherent and common for the whole of Europe.

The starting point for the study was to establish three levels of competence of the operators: level 1 - "CMM-User", level 2 - "CMM-Operator" and level 3 - "CMM-Expert." For each level of competence approx. 15 training modules was developed and made available online. Respective modules include the learning content appropriate for a given level of competence and concerning areas where knowledge is required and needed for the CMMs' operators. The areas include: metrology, geometry, statistics, computer science, quality management, standardization, measurement equipment, technology of production and technical drawing systems used in computer-aided design systems (CADs). Thanks to the cooperation of specialists in the field of construction and exploitation of Coordinate Measuring Machines, a three-levels metrological knowledge base structure was developed, which is shown in Table.1.

Table 1. Three-levels structure of the Metrological Knowledge Base of the EUKOM system for education of CMMs' operators

Types of qualification	Levels	Modules of the Metrological Knowledge Base of the EUKOM System.														
CMM- User	I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CMM- Operator	II	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CMM- Expert	III	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

The structure of the Metrological Knowledge Base of the EUKOM system, shown in Table.1., was developed by the eminent experts from seven European universities [10] engaged in the development of CMM metrology and its applications in the industry. The 3-levels structure of education, including about 15 basic training modules at every level of competence, was established after the adoption of the basic assumption that the industries using the CMMs need three categories of operators. Three categories of operators are needed so that the very expensive and complex measurement equipment, such as CMM, could be properly used and the desired accuracy of measurement results was ensured. It was found that the lowest level of competence (1-level) requires an employee (called "CMM-User") able to perform actions such as a simple measurement tasks involving: mounting the measured parts on a test bench and preparing the measurement procedure to start as well as operating the machine-controlled software. An employee called "CMM-Operator", whose qualifications were classified as “Level II” competence, should be able to define the measuring task on the basis of technical drawings, create software that controls the measurements, assess the accuracy of obtained measurements results and perform the correction of measurement results, taking into account deviations caused by various factors. The highest, “Level-3” of qualifications is intended for an employee who has been called "CMM-Expert." He should be able to plan, program and optimize the measurement for any established measurement tasks as well as estimate the uncertainty of the measurement results. Additionally, he should know and use quality management methods.

The training concept described above is presented in detail in [11]. This concept has been used to develop the Metrological Knowledge Base, intended for training of CMMs' operators near their workplace, but through the “e-learning” form. Rich experience and valuable results obtained during the execution and implementation of the EUKOM project are good case study showing how the Information System for Metrology should be designed for distance learning of the operators who supervise measurement processes. The first action should be to define the target group (or groups) of operators, supervising a particular type of measurement process. As in each “e-learning” system an essential part is the knowledge base, the structure of such a base should follow the basic assumption concerning the competence of the operator obtained after completion of training. The levels of these competencies should be determined by the professional research and educational centers, which work closely with the industry that uses a particular type of measurement equipment. The structure of a knowledge base, designed in such a particular way, and integrated into appropriately selected training materials, is the primary factor determining the quality of education systems of operators, who supervise measurement processes.

The information technology used in e-learning system for preparing and making available the knowledge base is a secondary matter. Currently, there are many platforms (open source software) for creating “e-learning” systems, for example: [9], [12], [13]. The choice between one of these or one of commercially offered platforms depends on such factors as an expected number of people simultaneously using the “e-learning” system, a kind of supplementary teaching materials that are to be made available to learners. Among other factors taken into consideration are: the ability of teachers to prepare individual learning modules, the possibility of easy modification of the content of the various education modules and the ability to verify the acquired knowledge. In any case, the decisive factor in the quality of Information System for Metrology (ISM) designed for distance learning of operators will be the structure of the metrological knowledge base. It should be developed by the experts in the field of measurements on the basis of agreed level of competence, which the person benefiting from the training and intended to play certain role in the measurement process should reach.

The IT System for Metrology designed to predict the corrections needed to calculate of the Polish Universal Time Coordinated UTC(PL)

Another type of Information System for Metrology (ISM) is an expert system designed for predicting corrections necessary to calculate the Polish Universal Time Coordinated - UTC (PL). This predictive information system for metrology has been continuously improved. Prediction of corrections values is implemented in this system by using various types of neural networks. [14]. This system allows for determining the Polish Official Time OT(PL) introduced in [15], [16] and valid in the Republic of Poland since 2004. This time is calculated as increased by one or two hours referring to the UTC (PL) [17], [18], [19]. It should be determined and maintained with an accuracy not exceeding 10 ns in relation to the universal time coordinated UTC determined by the Time Laboratory of the International Bureau of Weights and Measures in Paris (BIMP). BIMP creates UTC by calculating a weighted average based on systematic comparisons of 300 most accurate frequency and time atomic standards appearing in many countries around the world. BIMP also calculates corrections (PNMI) for each of National Metrology Institutes (NMI) including the corrections to the UTC (PL). In Poland, the Central Office of Measures (GUM) in Warsaw responsible for creation of the values of UTC (PL). The role of GUM in Poland is relevant to NMIs in other countries. The corrections for Poland (PPL) are determined by the BIMP and are published in a special bulletin "Circular T" [7]. These corrections are calculated for the day as:

$$P_{PL(BIMP)} = UTC - UTC\ (PL) \tag{1}$$

The problem is that the values of these corrections are announced only a month after their calculation in Paris. Therefore NMIs around world are forced to use the appropriate method to determine the predicted value of the corrections (PPRED) for the day. Predicting of the values of corrections is based on the historical collection of the corrections for each country published in the “Circular T" bulletin [7]. In different countries various methods of prediction are used. The most common is the analytic prediction method based on the linear regression method extended for stochastic differential equations [20]. Regardless of what prediction method will be applied, it is assumed that the error of such prediction for the day, for the NMI of the each country, should not exceed 10 ns, referring to the value of the corrections that will be published for this country in the bulletin "Circular T" [7]. Hence for Poland this condition can be formulated as follows:

$$\Delta = P_{PRED(PL)} - P_{PL(BIMP)} \ll 10\ ns \tag{2}$$

Although the analytic prediction method described in [20] is widely applied by NMIs and brings good results, it is certainly time consuming and quite difficult. For this reason, the studies [6], [14], [21] have been undertaken to develop and implement an IT system for metrology, enabling the automatic prediction of the corrections for Poland PPRED (PL). This system has been implemented and tested in the Time and Frequency Laboratory of GUM, responsible for designating and propagation of Polish Official Time OT (PL). This time is established for winter and summer and is calculated as:

$$OT(PL) = UCT(PL) + 1\ hour. \quad or \quad OT(PL) = UCT(PL) + 2\ hours. \tag{3}$$

UTC (PL) is determined with use of the Polish Atomic Time Scale - TA (PL) created on the basis of mutual comparisons of atomic time standards used by over 20 Polish laboratories under and two foreign (Lithuania and Latvia) [19] collaborating under the agreement [17], [18]. The leading laboratory is the laboratory of the Polish Academy of Sciences, Space Research Centre (AOS) in Borowiec [22], for which BIMP separately calculates corrections PAOS (BIMP) and publishes them in the "Circular T" bulletin. AOS also participates in the creation of the Galileo-European Satellite Navigation System [24]. Studies [21], [23] showed that thanks to TA (PL) it is possible to meet the requirements of a specific inequality (2). Using the TA (PL) and the ISM, which automatically predicts the corrections PPRED (PL), GUM creates UTC (PL), which is one of the most accurate national UTCs in the world. Fig.2. shows the block diagram of the ISM using artificial neural networks [21]. This system combined with GUM's selected atomic time standard ensures the creation of UTC (PL) with an accuracy not exceeding 10 ns with respect to UTC time set by the BIMP in Paris.

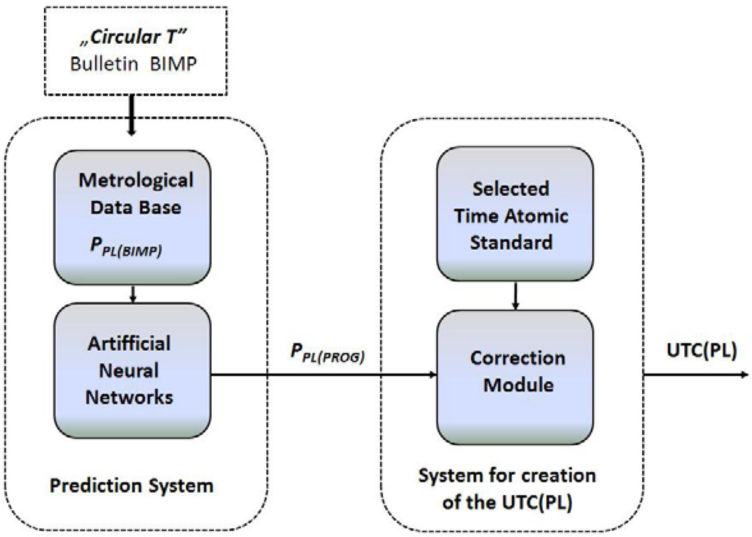


Fig.2. Block diagram of the ISM intended for automatic predicting of corrections PPRED(PL and for creation of the UTC(PL)

The IT System for Metrology intended for Computer-Aided Measurement Processes Validation - "CAMPV System"

Validation is an activity aimed at experimental verification of whether the properties of the method, object, process or software fulfill the requirements for their intended use. The summary of validation must provide the appropriate certificate definitely confirming that the outcome of the validation is positive. In case of the designing process, the goal of validation is to check and confirm that the prototype of the product meets the requirements of the application, for which the product is designed. In case of the measurement process, validation is an experimental verification and confirmation that the measurement characteristics of the measurement process meet the requirements of its intended use. The full validation cycle of the measurement process - developed and described in [25] - is a set of action, which should result in the issuing of a certificate confirming that the metrological characteristics of the measurement process meet the requirements of its intended use. The full validation cycle consists of 7 specific steps:

1. Identification and characterization of the intended use of the measurement process (IUMP)
2. Determination of metrological requirements for the intended use of measurements (MRIUMP)
3. Choosing the right measurement process (SMP)
4. Determination of metrological characteristics of the selected measurement process (MCMP)
5. Comparison of the metrological requirements of the intended use of measurement process (MRIUMP) with the metrological characteristics of the measurement process(MCMP)
6. Determining result of the comparison and say whether it is positive or negative
7. Execution of one of alternative actions:
7.1. If the result of the step 6 is positive: preparation and generation of validation certificate
7.2. If the result of the step 6 is negative: selection of a different measurement process followed by determination of the measurement characteristics of the new measurement process (step 4) leading steps 5 and step 6.

Fig. 3. shows the flow diagram of the full validation cycle of the measurement process [25].

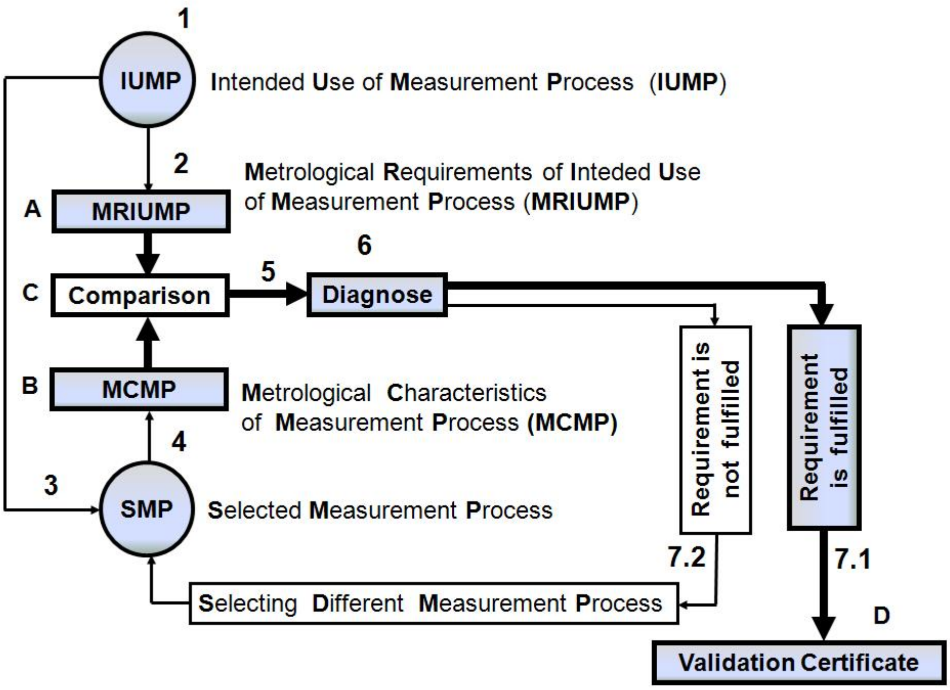


Fig.3. The flow diagram of full validation cycle of measurement processes consisting of 4 phases (A, B, C, D) and 7 specific actions

It should be emphasized, though, that the loop of steps: (7.2) - (4) - (5) - (6) can be repeated as many times as necessary to achieve the positive result of the step 6.

All seven steps are described in details in [25]. They can be grouped into 4 phases:

A – determination of the Metrological Requirements of the Intended Use of the Measurement Processes (MRIUMP),

B – determination of the Metrological Characteristics of the Measurement Process (MCMP),

C – comparison of MRIUMP with the MPMP according to assumed criterion of the validation,

D – generation of the Validation Certificate (VC) confirming that the selected measurement process (SMP) meets the requirements of its intended use.

The measurement process can be accepted and implemented for intended use only if the result of validation is positive. Such rule particularly refers to production quality control, conformity assessment of products or health and environmental protection. In order to execute all steps of the full validation cycle of the measurement process, relevant metrological data must be collected and stored, such as technical specifications of measurement equipment (hardware and software), results of its calibration and results of their statistical analysis, which are the metrological characteristics of evaluated measurement processes.

Having regard to above, the Department of Metrology and Diagnostic Systems, Faculty of Electrical Engineering and Computer Science in Rzeszow University of Technology has been undertaking systematic efforts [25], [26], [27] aiming in development of the most adequate methodology for validation of the measurement processes and creation of the information system, which would support the implementation of this methodology. The outcome of this work is the information system for metrology named "CAMPV-system" (the first part of the name is an abbreviation derived from the full name: Computer Aided Measurement Processes Validation).

Fig.4 shows the structure of the ISM of "CAMPV-system", including website portal providing the online access to the system and the metrological operations database (MOD) designed to collect technical data of the measurement equipment and the results of its calibration. Already designed and implemented modules of the "CAMPV system" are marked by dark background in Fig.4.

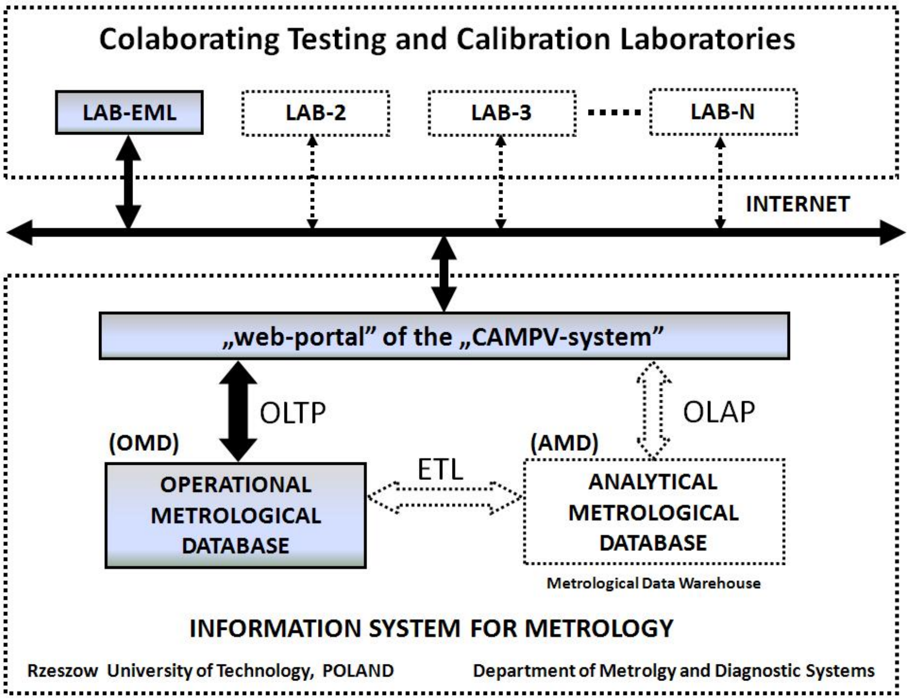


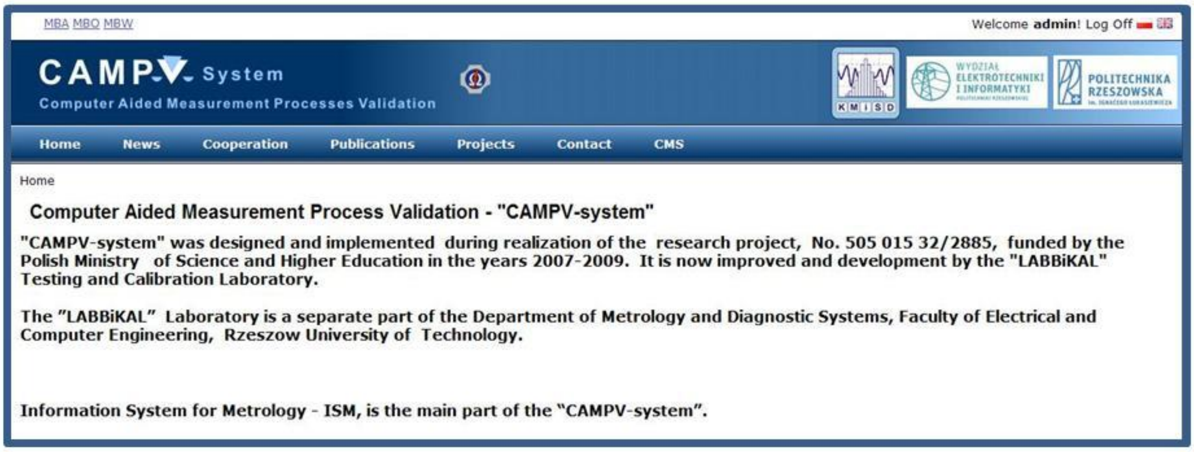
Fig.4. Structure of the CAMPV-system including already developed modules (dark background) and the planned module: Analytical Metrological Database (AMD).

The choice of information technology for respective modules depended on the progress of system's development and the experience gained during the process. Regardless chosen technology, the supreme and indisputable assumption has been as follows:

"ensuring authorized online access to the "CAMPV system" for collaborating laboratories and enabling the extension of system's functionality by adding new modules".

The first prototype of the website portal for the "CAMPV-system" was based on PHP technology, whilst the metrological database used mySQL [28]. The next version of the website portal was based on MS ASP.NET technology and metrological database used MS SQL 2005 technology. The choice of these technologies is explained in [29]. The most important reason for choosing the Microsoft's software environment was to ensure the continuation of the development of the "CAMPV-system". Moreover, the Microsoft Technologies can help in creating of more complex models of metrological databases in the future. The last but not least, Department of Metrology and Diagnostic Systems has had an access to Microsoft's MSDN license, including the license for use of the MS Windows Server. This software ensures compatibility between the created information system for metrology (ISM) and the operating system, which manages the work of the servers.

In the near future the CAMPV-system is expected to be completed by adding the Analytical Metrological Database (AMD), indicated by dotted line on the diagram shown in Fig.4. Such component will ensure an appropriate grouping of the collected data and separating the AMD users from On-Line Transaction Process (OLTP) operations. The AMD also allow for using the Extraction Transaction Loading (ETL) operations to group data in the most suitable form for their future analysis. In order to find this form, the On-Line Analytical Processing (OLAP) has to be determined. Having above in mind, the future version of "CAMPV-system" will have an adequate structure, as presented in Fig. 4. CAMPV system has recently been improved by using newer versions of Microsoft technologies. The website portal has been rebuilt with use of Model View Controller technology (MVC v.3.), with the RAZOR engine and MS SQL 2008 environment for creating databases. This technology allows for dynamic changes in the structure of the menu names of the website portal as well as tabs and content published through Content Management System (CMS). It also allows for creating different language versions. Following this improvements, the website portal has become a module that not only can be quickly rebuilt but also easily expanded with use of the Microsoft Silverlight technology and WCF RIA Services. Fig.5. shows one of the portal screens appearing after selecting the "home" button.



Rys.5. The view of the website "home" of the website portal of the "CAMPV-system"

Operational Metrological Database (OMD) is currently being reconstructed with use of MS Silverlight technology. The advantage of this solution is that the User Interface (UI) of the webpage is loaded only once, and the data used to fill the forms are loaded later during work with the server. Other innovations are planned to be implemented in the future, including drag&drop technology applied for creating single measurement channels consisting of elementary modules or creating a complex measurement process with use of several single measurement channels.

Fig.6. shows the design of the future OMD website. It provides access to one of the modules of the OMD, which collects technical data of measurement equipment and loads files with calibration results of measurement equipment. This module - named Applied Measurement Processes (AMP) - will also be equipped with features such as creating measurement processes, collecting the results of the repeatability and reproducibility analysis as well as collecting the results of interlaboratory comparisons. The results of calibration loaded into the OMD are saved in the Excel 2007 files. In the future other formats are expected such as .csv and .xml.

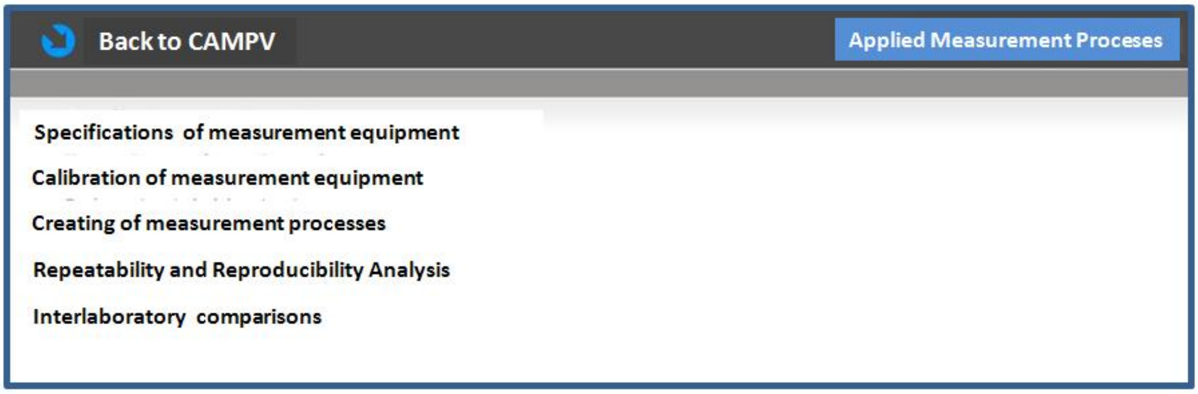


Fig.6. The design of the future Operational Metrological Database (OMD) website accessing Applied Measurement Processes (AMP) module of the "CAMPV-system"

Conclusion

Three examples of different Information Systems for Metrology (ISM) are described. The first one has been designed to train operators of coordinate measuring machines (CMM) with use of the "e-learning" system. A Metrological Knowledge Base (MKB) structure plays an important role in this type of ISM. Such MKB contains elementary teaching modules tailored to the level of competence of the operators, who improve their measurement skills. The second system has been designed to predict the corrections, which allow for creation of the Polish Universal Time Coordinated UTC (PL). The key module in this type of ISM is the structure of the artificial neural network predicting the corrections values. The third system has been designed for the computer-aided measurement processes validation. In this type of ISM the major role plays an open and modular structure, accessible through the website portal and ready for a continuous expansion. This ISM called "CAMPV-system" has been tested and developed in the Department of Metrology and Diagnostic Systems, Faculty of Electrical and Computer Engineering of the Rzeszow University of Technology. The target version of "CAMPV-system" will include two databases and a knowledge base. This form may become the basis for creation of the metrological expert system "CAMPV-EXPERT-system" supporting the validation of the measurement processes using artificial intelligence methods.

Based on above-described examples, one can conclude that the information technology contribute significantly to the development of the metrology and its applications. A key condition of successful creating of the high quality IT systems for the metrology is a close cooperation between scientists and practitioners in the field of computer science and metrology.

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