The System of Uniformity of Measurement Assurance Facing Digital Transformation of the Economy

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Abstract. The article presents the guiding directions for the development of the system of the uniformity of measurement assurance in the Russian Federation. It addresses the challenges that can arise in connection with the implementation of the Digital Economy concept. The directions considered in the article are provided with the examples, the realization of which can be seen already today or will be seen in the nearest future.

1. Introduction

The term “digital economy” is generally understood as economic activities supported by digital information technology. The digital format of data, a key factor of production in all areas of socio-economic activities, makes the country more competitive, improves the quality of people’s life, offers better conditions for doing business and, ultimately, ensures the economic growth and national sovereignty.

The challenging digital issues in Russia are presented in the documents of strategic planning, issued by the Russian leadership, the government’s Program “Digital Economy of Russia” is among them. It must become one of the drivers accelerating scientific and technological development in the country. Many experts consider that in the implementation of this Program the active role should be played by enterprises of the aviation industry. This will benefit their competitiveness not only on the domestic market, but on the world market as well. The plan for overall digitalization is part of the state program “Development of the Aviation Industry Until 2025”.

The digital economy will cause digital transformation of the system of uniformity of measurement assurance (SUMA), metrological support being its one of the most important elements. It is connected with the implementation of new technological capabilities in the industry – machine learning and artificial intelligence; processing of very large amounts of data, processing of unstructured data, real-time data processing; predictive management; a great number of cheap sensors and measuring devices; real-time control systems; augmented and virtual reality, etc. as well as new requirements for the system of uniformity of measurement assurance [1–3].

According to Russian metrologists, one of the results of the digital transformation will be a significant increase in the amount of sensors, measuring instruments (MIs) and measuring systems. This is one of the main challenges of today’s metrology. In addition, these sensors, in most cases very tiny, will be used far and wide, even in difficult-to-reach places, and may be in possession of different owners. So, all this requires completely new approaches to be developed and applied towards metrological support, including remote automatic verification and calibration, the widespread use of the cloud technologies, and formation of large datasets (Big Data).
To adapt to new conditions new rules are needed and it will be necessary to develop and use normative documents regulating entirely new metrological procedures.

What steps are supposed to be taken today at the beginning of this not so easy path towards digital transformation of the UMA system?

To answer this question we will consider three main interrelated aspects of the digital transformation of the UMA system: legal framework, methodological, and technical.

2. Description of the research

2.1. The legal aspect

The legal aspect envisages a revision of the legal and regulation framework in the country, related to the uniformity of measurement assurance.

The digital economy management is based on forecasting the development of the digital economy and digital technology, on reviewing the monitoring results and controlling the fulfilment of the program for the development of the digital economy. Regarding the system of uniformity of measurement assurance, it means that its development should be based on forecasting the demand in measurements, monitoring the current state and coordination of development and production of measuring equipment in all sectors of the economy. Thus, the long-term tasks for the system of uniformity of measurement assurance in the Russian Federation are as follows:

- monitoring the system of uniformity of measurement assurance, forecasting the needs of the economy and society in measurements. The results of fulfilment of this task are important for the development of the economy as a whole, and are to be available to a vast majority of legal entities and physical persons, and individual entrepreneurs;

- coordination of the activities of the authorities in the development and production of measuring equipment in the country. This important activity focuses on satisfying the requirements of all sectors of the economy in measuring instruments (for example, intelligent sensors), and is the key condition for the digitalization of production through introduction of internet of things in the industry.

These important for the digital economy tasks are to be fixed in the national law regulating the uniformity of measurement assurance.

An important element of the digital transformation of the system of uniformity of measurement assurance is the application of electronic document management system, a tool which allows to radically improve the interaction between various entities in the digital environment. The electronic document management is especially important for the procedures, directly connected with production, trade, health services, etc., such as type approval of measuring instruments (reference materials), and verification of measuring instruments. These procedures are used to determine the legal use of measuring instruments (reference materials) in the area of state regulation.

Today’s practice of document management, used for metrological procedures for the purpose of type approval of reference materials (RMs) or measuring instruments (MIs), as well as verification of MIs, the results of which determine the applicability of MIs and RMs in the state-regulated sphere, is based upon paperwork. At the same time there is a procedure for downloading the results of these metrological procedures into the State Information System. However, this information is not legally bound. Therefore, such information cannot be used by the federal state metrological supervision bodies as references for their evidential basis, or it cannot be used by legal entities and individual entrepreneurs as evidence that the MI they want to use is of an approved type and complies with metrological requirements. The country has at its disposal huge amounts of information related to the uniformity of measurement assurance, however their practical value is limited. This provides a good reason to develop proposals for the transition from paperwork to electronic registration of the results of work (services) concerning type approval of the MI (RM) or verification of the MI and thus giving this information legal relevancy.
Digital transformation in the uniformity of measurement assurance, as other countries’ experience has shown, inevitably results in building spatially distributed measuring systems with numerous intelligent sensors in them and cloud structures for storing and processing data, “digital twins” of measuring instruments to be integrated in the automated technological process control systems, “digital twins” of measurement standards to perform remote verification (calibration), etc. All these call for developing new requirements for measurements, RMs and MIs. In particular, the simulation of measurement process of real parameters of objects during virtual testing will be legally regulated, and also the methods for virtual measurement of parameters of objects will be prescribed, which will require appropriate revision of the national legislation related to the uniformity of measurement assurance.

2.2. The scientific and methodological direction
The scientific and methodological direction is primarily connected with the solution of the above mentioned task of monitoring the UMA system, forecasting the demand of the economy and society in measurements.

Investigating this issue, specialists have developed a concept of monitoring and predictive assessment of measurement needs, which is summarized here as the following sequence of steps:

1. Gathering initial information on measurement requirements by conducting surveys among federal executive authorities, industrial enterprises and companies, state regional metrology centers. Information is to be submitted in a standardized data format. It should be mentioned that the collecting of information is already underway.

2. Summarizing and processing the gathered information. Afterwards a multidimensional array of data is formed, giving an idea of the level of satisfaction of current needs and the projected demand in measurements for a certain time frame, the ratio of the amount of calibration to verification work, the characteristic of such work (services) as testing, verification, etc. This information can be compiled as follows:
   - federal executive bodies;
   - branches of industry;
   - areas of activities;
   - spheres of state regulation in assurance of measurement uniformity;
   - measurement domains.

The acquiring of data and reviewing the results of the monitoring and forecasting of the requirements in measurements allow to identify key factors in realizing the goals and solving the tasks of the development of the UMA system, and also in achieving the targeted values of development indicators within the managing time-frame.

3. Based on the monitoring results and forecasting, the development of proposals concerning the creation of measurement standards.

4. Based on the information acquired while implementing steps 2 and 3, taking efficient management decisions for the benefit of the UMA system.

It is evident that today the best effect of the realization of the proposed concept can be achieved through a software-distributed system, the stakeholders (subscribers) of which operate in a single information and communication space. However, the concept of monitoring and forecasting the requirements in measurements can be realized through software only elementwise. To this end, a prototype of a hardware-software system (HSS) has been developed, providing the automated solution of problems described at stages 3 and 4. This HSS implements modern mathematical methods for information processing and modeling of, for example, genetic algorithms used to solve problems of optimization. The use of an HSS prototype can help getting options for optimizing work plans for the development, modernization and maintenance of state primary standards within a given time-period of planning, with various scenarios of funding.
2.3. The technical direction

The technical direction is associated today with meeting such challenges as the development of an e-platform to be used for sharing information by manufacturers, suppliers, and consumers; the simulation (modeling) of measurement processes for real-world parameters of objects during virtual testing; the development and implementation of a digital calibration certificate; methods (procedures) for the virtual measurement of certain parameters of an object, etc.

Calibration of measuring instruments is one of metrological activities. The calibration results are certified by issuing a calibration certificate. Introduction of the digital calibration certificate is being widely discussed today in many countries. The document ISO/IEC 17025 “General requirements for the competence of testing and calibration laboratories” contains minimum requirements for the calibration certificate. It envisages a printed on paper version of the certificate and an electronic version, which is in fact an electronically made copy of the paper certificate. Meanwhile, we consider the concept of “a digital calibration certificate” needs to be expanded.

The digital calibration certificate helps solve the key task — the confirmation of metrological traceability of the measurement result, allowing the result to be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty. For the “reference” can be a definition of a measurement unit through its practical realization, or a measurement procedure, or a measurement standard.

Metrological traceability requires an established calibration hierarchy, i.e. a sequence of calibrations, starting from the basis for comparison and ending with a working measuring instrument. What is more, the result of each calibration depends on the result of the previous one in this sequence. The digital calibration certificate must allow to monitor each step of the calibration process with maximum credibility, taking into account all the necessary data that ensure the obtaining of the specified calibration result. Meanwhile no access is permitted to the chain of calibrations to make changes. Provided any calibration step is not available or replaced by some fictitious data the impossibility of obtaining a digital calibration certificate should be guaranteed. Thus, the consumer will be protected from sham or even fraudulent activities. A digital calibration certificate that meets the above-mentioned requirements can be obtained through block-chain technology.

Metrological traceability does not guarantee that the measurement uncertainty corresponds to the measurement task being solved. In this case, the consumer analyzing the calibration chain should be able to determine the stage of the hierarchical calibration chain that will satisfy him/her in terms of uncertainty or some other indicators. Our understanding of the digital calibration certificate is that it is a software product that provides the consumer with a number of services, enabling a successful solution of a measurement task with the help of a calibrated measuring instrument.

Another priority task that needs to be solved is the development of an e-platform to be used for sharing information among manufacturers, suppliers and consumers of measuring equipment. The need for such platform is caused by the absence of the information base today, that could accumulate the consumers’ needs in measuring instruments and the capabilities of the industry to meet them. Because of this manufacturers are not able to form a long-term package of orders that could justify the financial investments necessary for the production of measuring instruments, and consumers, in their turn, do not know who should they address for a prompt solution of their problems. The suggested e-platform, in our opinion, should exercise the following functions:

- information: providing access to view the list of customers (organizations) and consumers (organizations), working on the e-platform, obtaining information regarding any organization of interest;
- marketing: providing information concerning MIs which are in demand, and their potential customers; helping choose designers, manufacturers, suppliers of the required measuring instruments;
- advertising: making available in a single information space the data regarding an organization by placing by that organization their own information on the e-platform;
- trade: allowing to organize competitive bidding, and carry out a whole range of various trade and procurement measures for the acquisition and execution of work (services) associated with the development, manufacturing, and supply of measuring instruments;
- analytical: allowing to evaluate the activities of the organizations registered on the e-platform by various indicators, to compare the measuring instruments offered, to make a choice of partners;
- security of information: ensuring the security of electronic document management with the help of certified cryptographic information security tools.

Such e-platform will allow to respond with maximum flexibility to the market needs in domestically manufactured measuring equipment, will provide MI manufacturers involved in high-tech areas a gradual transition from making one-time orders to making long-term production programs, which will reduce the cost of domestically manufactured MIs.

3. Conclusion

In conclusion, we would like to note that the above described directions of digital transformation of the UMA system form the basis for realizing a set of measures to ensure the agreement of the UMA system with the tasks of development of the digital economy, focusing both on the development of the existing conditions and creating new ones for the emergence of promising digital technologies in the assurance of measurement uniformity.

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