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INITIAL E-INFRASTRUCTURE FOR METROLOGY

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Annotation: The digital transformation of the economy is the result of profound changes in science, technology and society. The response to these changes should be the latest version of the SI and the corresponding development of the new measurement standards. In this regard, an important issue for metrology is to eliminate barriers towards digital transformation. Digitization of metrological data is becoming especially relevant. In solving this problem, the development of the metrological e-infrastructure plays an important role. The paper is dedicated to the presentation and generalization of the results and the problem of creating an e-infrastructure. Based on the analysis performed a preliminary scheme for the e-infrastructure implementation in NMI has been presented. In particular, one of the most important issues of digital transformation – the implementation of DCC – is also associated with the development of e-infrastructure.

Keywords: Digital calibration certificate (DCC), Digital metrology, Metrological e-infrastructure, Digital signature

Аннотация: Цифровая трансформация экономики является результатом глубоких изменений в науке, технике и обществе. Ответом на эти изменения должна стать новейшая версия СИ и соответствующая разработка новых эталонов. В связи с этим важным вопросом для метрологии является устранение барьеров на пути цифровой трансформации. Оцифровка метрологических данных становится особенно актуальной. В решении этой проблемы важную роль играет развитие метрологической электронной инфраструктуры. Статья посвящена представлению и обобщению полученных результатов и проблеме создания электронной инфраструктуры. На основе проведенного анализа представлена предварительная схема внедрения электронной инфраструктуры в НМИ. В частности, один из важнейших вопросов цифровой трансформации – внедрение ЦКК – также связан с развитием электронной инфраструктуры.

Ключевые слова: Цифровой сертификат калибровки (DCC), Цифровая метрология, Метрологическая электронная инфраструктура, Цифровая подпись

Annotatsiya: Iqtisodiyotning raqamli o'zgarishlari bu fan, texnologiyalar va jamiyatning chuqur o'zgarishlarning natijasidir. Ushbu o'zgarishlarga javobi SI ning so'nggi versiyasi va yangi o'lchash standartlarining tegishli rivojlanishiga to'g'ri keladi. Shu munosabat bilan metrologiya uchun muhim masala raqamli o'zgarishlar uchun to'siqlarni bartaraf etishdir. Metrologik ma'lumotlarni raqamlashtirish ayniqsa dolzarb bo'lib kelmoqda. Ushbu muammoni hal qilishda metrologik elektron infratuzilmani rivojlantirish muhim rol o'ynaydi. Qo'lyozma natijalarni taqdim etish va umumlashtirish hamda elektron infratuzilmani yaratish muammosiga bag'ishlangan. Tahlillar asosida NMI-da elektron infratuzilmani amalga oshirish uchun dastlabki sxema taqdim etilganini ko'rishingiz mumkin. Xususan, raqamli o'zgarishlarning eng muhim masalalaridan biri bu - RKTG ning amalga oshirilishidir hamda elektron infratuzilmani rivojlantirishdir.

Kalit so'zlar: Raqamli kalibrlash to'g'risidagi guvohnoma (RKTG), raqamli metrologiya, metrologik elektron infratuzilma, raqamli imzo

European initiatives in the field of scientific and metrological e-infrastructure. European Open Science Cloud (EOSC) is a European initiative that brings together the efforts on creating the concept of an open science cloud, aimed at developing an e-infrastructure that provides users with resources and services. The envisaged e-infrastructure is built by aggregating services rendered by different providers. According to the EOSC report this should be a "federated, globally accessible environment where researchers, innovators, companies and citizens can publish, find and re-use each other's data and tools for research, innovation and educational purposes". To promote digital transformation in legal metrology the development of a European Metrology Cloud (EMC) - coordinated European digital quality infrastructure for innovative products and services has initiated. According to the EMC approach, the exchange of information on legally regulated measuring instruments requires confidentiality to guarantee accuracy, traceability of measurement results and customer protection. It should be noted that, despite the commonality of the concepts of EOSC and EMC, there are fundamental differences between them in the approach to data confidentiality. One of the main service providers for EOSC is European Grid Infrastructure (EGI) – a federation of grid computing and storage resource providers to support research and development. EGI federation works closely with EOSC to provide storage facilities, technical services, analytics tools and support.

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These resources planned to be integrate into EOSC under the EGI Advanced Computing for EOSC (EGI-ACE) project. The objectives of the project are:

- Deliver the EOSC Compute Platform and expand the supply-side;
- Contribute to the implementation of the EU Data Strategy and the EOSC Data Commons to support the green deal, health, fundamental research and social sciences and humanities;
- Contribute to the realization of a global open science cloud.

Taking into account declared in EMC approach to data protection and requirements to the scientific data, one can make a preliminary conclusion that grid services have the necessary functionality to solve of above mentioned problems.

Grid for metrology. The grid was created to address high-energy physics problems within the Enabling Grids for E-sciencE (EGEE) project with financial support from the European Union. As a result of multiple transformations, it has become a universal platform for creating distributed computing networks. Now the grid – EGI federation – is becoming widely used not only for high-energy physics problems, but also for solving time-consuming problems in biology, medicine and other fields of science. Grid infrastructures are aimed at the distribution of computing and memory resources. It should be emphasized that remote control and data collection have been part of the existing grid concept from the very beginning, as well as a coherent and efficient data protection system. Thanks to the grid, a geographically distributed set of resources is presented to users as a single resource, where the grid plays the role of the operating system of a distributed computer. One of the important problems of metrological activities is the coordination and management of measurement processes in geographically dispersed regions through global networks in order to ensure measurement traceability and a high degree of confidence in measurement data. Grid services can solve the problems of interaction between remote instruments, as well as the protection of measurement data in global networks. The creation of grid was a response to the challenges associated with a qualitative leap in the increase of complexity of experimental physical installations and information systems, which requires new approaches to monitoring, control and maintenance. As already mentioned, the grid was originally created to solve problems in high-energy physics, namely to maintain the Large Hadron Collider (LHC), which is not only the most complex physical measuring installation created by mankind, but also a unique computing system. There, for the first time, they faced the problem of a lack of computing resources for processing a vast amount of information generated in experiments at the LHC. It has been designed and tested by a unique team of the most highly trained programmers and physicists for use in extremely demanding environments. It will hardly be possible to assemble such a strong team for such a grand challenge in the near future. At first sight, it may seem that this example solved all the problems of interaction between measuring instruments and the grid. But it is not exactly this way. The grid was created in parallel with the LHC, and the processing of data from the LHC detectors was not only a software solution, but rather a hardware and software solution available only to the LHC developers. Over time, grid users increasingly needed to integrate their measuring instruments into the grid to build information and measuring systems with increased data protection transmitted over long distances, as well as for remote access to instruments. To solve these problems, the following projects were created: Deployment of the Remote Instrumentation Infrastructure (DORII) and then Grid Enabled Remote Instrumentation with Distributed Control and Computation (GridCC). These projects were the result of multi-year funding of the 7th EU Framework Program. The goal of GridCC was to apply the grid capabilities for safe, remote, joint work of the team towards monitoring and management of the instruments and data generated and stored on distributed scientific equipment using traditional grid resources. Within the GridCC project, the Instrument Element (IE) [3,4] was developed, which was successfully used in various scientific collaborations for remote interaction with instruments in the grid environment. IE provides reliable work with data, their integrity and confidentiality (Fig. 1).

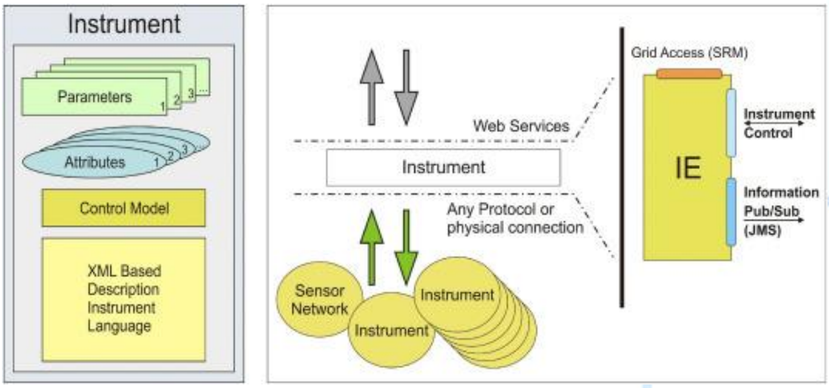

Fig. 1. Instrument Element [4].

Security in the grid. Security is at the core of the grid. Its components are both special protocols for secure data transfer and a multi-level authorization system that provides a deep differentiation of access rights to the resources of the grid [4]. Transfer protocol GSIFTP provides the functionality of the FTP protocol, however with support of the Grid Security Infrastructure (GSI). GSI assures the security in insecure public data networks providing such services as authentication, file transfer confidentiality and grid unified logon. GSI uses X.509 digital certificates as user and resource identifiers. This protocol is responsible for fast, safe and efficient file transfer. The Virtual Organisation Membership Service (VOMS) stores information on the affiliation of users to certain groups and virtual organisations and their role in them. User rights can be set depending on user affiliation to a particular virtual organisation, group or role (with VOMS). The grid security system has cryptography tools, a harmonious authorisation and right separation system based on electronic certificates.

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DCC concept. Proposals for DCC have been discussed for over a decade. During this time, many interesting ideas were expressed at conferences and in articles. The following works can be distinguished among the most significant. Participants of European projects on the DCC development (SmartCom, Gemimeg), the purpose of which is to develop an internationally recognized DCC format, carried out a brief analysis of the state of the art of this issue. There are proposals on methods of DCC distribution and substantiation for the need to create and modernize the DCC and it e-infrastructure in the articles. The form and rules for filling out calibration certificates from COOMET Recommendation were taken into account in the Electronic Calibration Certificate (ECC) implementation in the National Scientific Centre “Institute of Metrology”. The efforts, progress and prospects for the development of Measurement Information Infrastructure (MII), reported to the Committee of the National Conference of Standards Laboratories (NCSL) International. The results of developments in the field of DCC, taking into account the national features of China. New mechanisms for protecting measurement data based on Blockchain technology. Responding to the challenges of the digital economy, along with the formation of the D-SI Framework, the DCC concept is also being formed. The rapid growth in the number of calibrations requires the automation of both the calibration procedure itself and machine-readability for the automatic analysis of issued calibration certificates. The most commonly cited advantages for transition to DCC are:

1. The use of DCC allows the simultaneous access and use in multiple locations at the same time.

2. Machine-readability of DCC allows automating the verification of certificate availability, its validity period and obtaining information about its contents. Using a specific data storage format in DCC significantly reduces manual work, which, in its turn, reduces the time and cost required to manage calibration data while offering significant improvements in data integrity. In addition, machine-readability makes it possible to effectively assess the traceability of measurement results, since it contains data on the entire chain of calibrations up to the national measurement standards. By having all available information about the metrological traceability of sensors to SI with the associated measurement uncertainty given in the DCC.

3. Information from the DCC can be downloaded to the instrument directly without human intervention. This eliminates manual data entering errors.

4. Instruments are becoming more complex, which leads to an increase in the amount of information that must be contained in a calibration certificate. The availability of this information in digital form makes it easier to work with it both during human work and when automating the measurement process.

5. Saving transport costs when sending to the customer.

6. Saving paper and consumables.

7. The implementation of DCCs into practice will allow the use of calibration data for analysis by machine learning methods in artificial intelligence systems. Requirements for data format, storage, distribution and operation methods with DCC are given below:

1. The data format shall be specified.

2. When transferring, the data format shall maintain readability, integrity, and authenticity; the data shall not contain links or routes that may depend on the context of the system in which it was created, and the interpretation of the data shall be unambiguous.

3. Distribution and operation methods shall satisfy the properties of long-term storage of information.

4. Certificate shall contain qualified/advanced electronic signature suitable for internal transactions (electronic IDentification, Authentication and trust Services Regulation), which uniquely identifies the signatory, including his organization and verification of the integrity of the document.

5. Storage, distribution and operation methods shall have possibilities for verifying: the validity of the user's digital certificate at the time of signing with an electronic signature, the identity of the signatory, his role and affiliation with a particular organisation.

6. The data format shall be recognized in the world.

7. The data format also shall have the ability to ensure the privacy policy of personal data when working with it and storing it.

8. Distribution and operation methods with certificate should have the ability to interoperate for the exchange of data between different applications.

9. The data format should provide the ability to automate conversions to other application formats.

10. Storage, distribution and operation methods shall allow replacement of both whole services or tools, and their individual components.

11. Data format, storage, distribution and operation methods shall provide possibilities for safe using without the need for special knowledge.

12. The controllability of data when working with them shall be protected.

13. Data format shall provide verification/validation of data.

14. Data format, storage, distribution and operation methods shall have the properties of scaling and modularity, i.e. provide the possibility of supplementing, changing and replacing with an unambiguous identification of all modifications, and in the case of a complete replacement, provide an unambiguous reference to the original document.

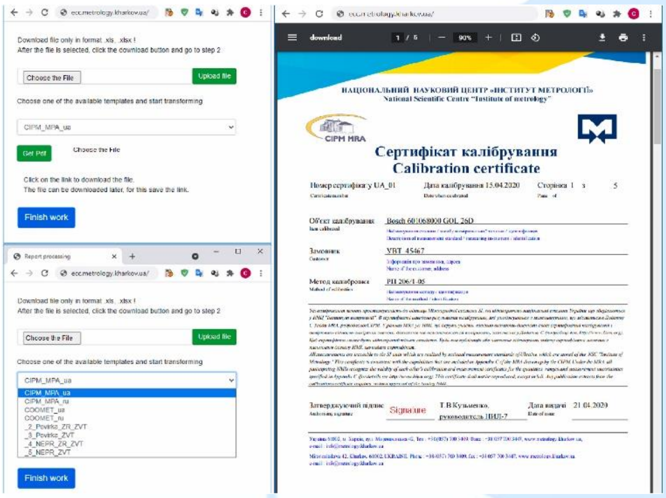
15. Data format, storage, distribution and operation methods shall be a withdrawal option from operation.

16. Distribution and operation methods shall provide end-to-end encryption capability.

E-infrastructure DCC based on grid middleware & cloud resources. The National Scientific Center "Institute of Metrology" (Ukraine) is developing and maintaining national measurement standards of Ukraine, disseminating the SI units by providing metrological traceability to the national references via the calibration services to customers. NSC IM has experience in the implementation of Electronic Document Management System (EDMS), one of the result of which should be a system of Digital Calibration Certificates (DCC). In NSC IM, the work on development of the electronic system for creation and storage of Electronic Calibration Certificates (ECC) was carried out, including the program that was developed as a java-servlet running in a browser (in Fig. 2). The purpose of electronic system is creation of the ECC with the future possibility of signing the obtained PDF-file with EDS. The created ECC fully complies with the requirements of COOMET Recommendation R/GM/15:2020 and it was the first step to realization of DCC architecture and e-infrastructure of NMI. The one who signs the certificate must have an EDS obtained from one of the Certification Centers. The ECC is signed twice: by the person who has carried out the calibration and by the person who approves this certificate, and after that it becomes valid. The recommended calibration interval and, correspondingly, the certificate retention period shall be established so that the definite or controlled metrological characteristics are maintained during this time period.

Fig. 2. Electronic calibration certificate developed in the NSC "Institute of Metrology".

It is necessary to improve the ECC developed by NSC IM in order the software to process calibration certificates automatically. For this purpose, a uniform template format of the certificate and a single storage format for these specifications data are required. The certificate template and additional calibration data storage format need not be uniform, but they should all be standardized. This requirement entails an increase in the amount of work required and the emergence of other difficulties, for example: maintenance of a non-standardized certificate would be difficult if the certificate was processed manually, and automatic processing using software would be impossible in principle. Fig. 3 shows a specialized EDMS for working with the DCC, the so-called e-infrastructure of NMI, where the main components are:



- Dataverse system for Datasets storage and operation.

- Certification Authority (CA) for working with Public Key Infrastructure (PKI) certificates.

- SignServer for signing documents and programs.

- Instrument Element (IE) for remote interaction devices with computation grid environment. The IE consists of the set of linked service for configuring, managing and monitoring of measuring instruments to allow their interaction with the rest of the computation grid.

-A digital twin (DT) is a mathematical model of a physical object or process that can reproduce the response of a real system, supplemented by measurement data. It is used to optimize the operation of physical systems without the risk of their failure.

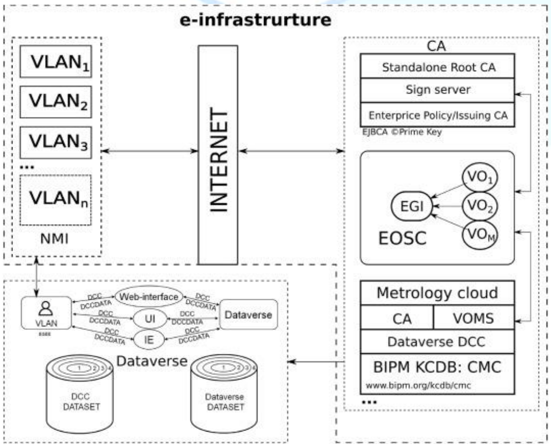


Fig. 3. Proposed e-infrastructure of NMI.

The Dataverse repository from the EOSC can be accessed in two ways through the traditional web interface and the grid infrastructure – European Grid Infrastructure (EGI Federated Cloud) by User Interface (UI) and IE the digital interface for measuring instruments.

Dataverse was designed for storing scientific data, their publishing, citing, downloading and analysing. This particular repository is used to store DCC Datasets.

References

1. BIPM, Worldwide metrology: What is metrology? https://www.bipm.org/en/worldwide-metrology/#metrology (assessed 07.20).
2. P. Howarth, F. Redgrave, Metrology in Short, 3rd Edn (Braunschweig, Germany: EURAMET), 2008.
3. Mohr P.J., Newell D.B., Taylor B.N. CODATA recommended values of the fundamental physical constants: 2014. J. Phys. Chem. Ref. Data. 2016;45(4):043102. doi: 10.1063/1.4954402. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
4. BIPM, Quality Infrastructure (QI): Definition, https://www.bipm.org/utils/common/pdf/QI-definition.pdf (assessed 07.20).
5. R.J.C. Brown, The importance of the measurement infrastructure in economic recovery (Teddington UK: NPL), 2020, https://www.npl.co.uk/getattachment/about-us/Who-we-work-with/Government/NPL-evidence-and-analysis/Importance-of-the-measurement-infrastructure-Final.pdf (assessed 07.20).
6. Grochau H., ten Caten C.S., de Camargo Forte M.M. Motivations, benefits and challenges on ISO/IEC 17025 accreditation of higher education institution laboratories. Accred. Qual. Assur. 2018;23:183–188. [Google Scholar]
7. Kunzmann H., Pfeifer T., Schmitt R., Schwenke H., Weckenmann A. Productive metrology – adding value to manufacture. CIRP Ann. 2005;54:155–168. [Google Scholar]