

The importance for Ukrainian R&D system RI's mapping and the Slovak case study

The necessity of RI's mapping in Ukraine remain one of the key and important issue of the national R&D policy during almost 10 years. The attention shifting to the security from the 24 February 2022 on the contrary confirms the importance of increasing the role of science.

The relevance of this research is extremely high in the context of the need for recovery after the war with Russia. During the aggression, Ukraine is facing serious challenges and the necessity to rebuild various sectors, including science and research. Military actions have resulted in significant damage to research infrastructure, including universities and research institutions. The mapping of Ukrainian research infrastructure can serve as a key tool for the identification, planning, and restoration of these facilities.

Furthermore, for the effective restoration of the research and development (R&D) sector, it is crucial to have access to up-to-date information. As a tem years ago, Ukraine needs the instrument to efficiently visualize and disseminate data on research centers, laboratories, and academic institutions. It will become a vital instrument in the recovery and strengthening of Ukraine's scientific potential after the war.

The state of research on the issue and direction

In 2000, the EU initiated the European Research Area at the Lisbon Summit. The European policy on research infrastructure, defined by the European Strategy Forum on Research Infrastructures (ESFRI), established in 2002 and regularly publishing a roadmap since 2006, plays a crucial role. The European Research Area initiative is a key component of the strategy for all EU research and innovation framework programs, including "Horizon Europe," the largest European program for research and innovation funding. This initiative aims to make the European scientific landscape more competitive and contribute to the development of scientific potential.

Regarding the European experience in this matter, the European policy on research infrastructures defined by ESFRI serves as the primary starting point. Since 2006, ESFRI regularly publishes an Action Plan - the ESFRI Roadmap [Strategy Report on Research Infrastructures. Roadmap 2021. [Online]. [cit. nn.nn.2023] Available from: https://www.esfri.eu/sites/default/files/ESFRI_Roadmap2021_Public_Guide.pdf], identifying research infrastructures of European significance and meeting the long-term needs of the European scientific community.

The issues of research infrastructures, their registration, and mapping are well-explored in professional literature. Several authors worldwide have worked on their definition and categorization (Anderson, Sh. (2013). "What are Research Infrastructures?" *International Journal of Humanities and Arts Computing*, October 2013, 7, (1-2): 4-23 <https://doi.org/10.3366/ijhac.2013.0078>), as well as assessing their impact and usage (Mayernik, M.S., Hart, D.L., Maull, K.E. and Weber, N.M. (2017), "Assessing and tracing the outcomes and impact of research infrastructures." *Journal of the Association for Information Science and Technology* (68): 1341-1359. <https://doi.org/10.1002/asi.23721>).

European projects (MERIL [MERIL-2. [Online]. [cit. nn.nn.2023] Available from: <https://cordis.europa.eu/project/id/654296>], CATRIS[Catalogue of Research Infrastructure Services. [Online]. [cit. nn.nn.2023] Available from: <https://cordis.europa.eu/project/id/824173>], and ONLINE S3 [ONLINE Platform for Smart Specialisation Policy Advice. [Online]. [cit. nn.nn.2023] Available from: <https://cordis.europa.eu/project/id/710659>] or VRE4EIC [A Europe-wide Interoperable Virtual Research Environment to Empower Multidisciplinary Research

Communities and Accelerate Innovation and Collaboration. [Online]. [cit. nn.nn.2023] Available from: <https://cordis.europa.eu/project/id/676247>]) have been involved in the inventory of research infrastructures. Within these projects, a methodology for registering research infrastructures [Martin, P. et al. (2019) "Mapping heterogeneous research infrastructure metadata into a unified catalogue for use in a generic virtual research environment." *Future Generation Computer Systems*. (101) : 1-13, 0167-739X, <https://doi.org/10.1016/j.future.2019.05.076>.], and creating European registers of research infrastructures has been developed [MERIL. [Online]. [cit. nn.nn.2023] Available from: <https://portal.meril.eu/meril/>]. Separate research has also been conducted on the use of CRIS in the registration and assessment of research infrastructures (Fabre, R. et al. (2021) "Evaluating the scientific impact of research infrastructures: The role of current research information systems." *Quantitative Science Studies* 2021; 2 (1): 42–64. https://doi.org/10.1162/qss_a_00111).

In Ukraine, the mentioned theme is underdeveloped, increasing the relevance of implementing the project. In this regards we can mentioned only studies related to the national CRIS system or those indirectly mentioning the need for mapping (Auhunas, S., Zharinov, S. (2021). Development of Patterns in research information management using the of persistent identifiers: findings from a National survey in Ukraine. PIDapalooza 2021 (27-28 January 2021), Portugal, Lisbon).

Nevertheless, the implementation of the RI's mapping instrument is critically important for the organization and visualization of information about research infrastructure across all universities and scientific institutions in the country. The map should enable users to filter displayed data and obtain detailed information about each scientific infrastructure object, including equipment, projects, and other key parameters.

In the context of wartime and post-war recovery, the development and implementation of the "Science Map of Ukraine" take on a new level of significance. It is not just a visualization tool but a key factor in supporting digital transformation in the field of science and research.

Tasks achievable in this context as a result of the project:

- The "Map" allows identifying research infrastructure objects crucial for addressing current challenges and needs in the field of science during crisis conditions. By visualizing key objects, the system facilitates quick identification and response to urgent challenges.
- Given that the "Map" will be interactive, scientific institutions and universities can efficiently collaborate, exchange resources, and information to collectively address issues.
- Considering changes in scientific activity due to war, the "Map" will help scientific groups and institutions quickly adapt and reallocate resources to support strategic research and initiatives.
- Through systematic data visualization, the "Map" becomes a tool for monitoring and evaluating the effectiveness of conducted scientific activities, identifying ways to optimize them.
- The "Map" can serve as a tool for digital coordination, assisting in managing scientific resources and logistics in challenging and constrained conditions.
- Digital infrastructure visualization expands the possibilities for the scientific field to impact socio-humanitarian processes, contributing to broader understanding and public participation.

Given the relevance of the topic in the context of post-war state recovery, the implementation of the mentioned project will ensure accurate and comprehensive representation of the locations of higher education and research infrastructure objects, allowing for a clear identification of resources available for recovery. Additionally, the data filtering capability will enable the systematic classification of infrastructure objects based on various criteria (field, region, research type, etc.). Detailed information on objects in the "Map" will facilitate efficient monitoring of resource utilization, including equipment, laboratories, and personnel, providing convenient access and utilization of information for recovery needs.

The analysis of the "Map" will clearly define priorities for restoring research and development activities after the crisis. For example, identifying objects that can be most effectively allocated for research in areas crucial for recovery. Moreover, the project will serve as a tool for transparency and the realization of open science principles, allowing the public and the international community to track and evaluate the development of research infrastructure in Ukraine.

The idea

In the development of the "Science Map of Ukraine" system, various issues will be addressed, including ensuring continuous updates and maintaining the relevance of information about research institutions and projects, accommodating the diversity of scientific fields and specializations for adequate representation of the entire scientific infrastructure, safeguarding the personal data of researchers and project information to avoid and prevent potential breaches of confidentiality, lack of data standardization, and coordinating data formats and standards with different research institutions.

The purpose of developing the "Science Map of Ukraine" system is to create a digital tool that facilitates the visualization and accessibility of information about Ukraine's scientific infrastructure. The primary objectives of this project are to enhance the transparency of the scientific infrastructure, specifically ensuring the availability and openness of information about research institutions, research projects, and other scientific entities. It aims to ease the search for partners and collaborators by facilitating the identification of potential partners for collaboration, supporting the development of the scientific community, engaging researchers and scholars in cooperation, developing an interactive user platform, disseminating information internationally, providing digital infrastructure for research, and creating a technical foundation for convenient interaction and data processing in the field of research. Achieving these goals will strengthen Ukraine's position in the global scientific community and contribute to the development of the country's scientific research infrastructure.

The need for developing the "Science Map of Ukraine" system, aimed at displaying and publishing data on the research infrastructure of higher education institutions (HEIs) and scientific institutions, with the capability of filtering displayed data and viewing detailed information about objects, arises from the absence of centralized and accessible information on the research infrastructure of HEIs and scientific institutions in Ukraine. The lack of a convenient mechanism for data publication and filtering restricts effective monitoring and collaboration in the field of scientific research.

The absence of a system that would facilitate easy categorization and visualization of information about research objects hinders the efficient utilization of available resources and contributes to ineffective interaction among researchers. The presence of objective criteria and filtering capabilities is critical for users to quickly and efficiently obtain information that aligns with their needs. Currently, the lack of this functionality complicates the effective use of research infrastructure.

The conditions of crisis, including armed conflicts and post-war recovery, require active support for the digitization of social and humanitarian processes, including the scientific sphere. The absence of an efficient tool for this purpose leads to unproductivity and resource loss. Therefore, it is crucial to create a system that ensures easy access to information not only for researchers but also for the public and higher education institutions, fostering mutual understanding, collaboration, and resource exchange.

In this regards, Ukraine needs the experience of EU country, already implemented the mapping of RI projects for case study.

Best practices from Slovakia

In Slovakia, a national policy document was prepared: Roadmap of research infrastructures - SK VI Roadmap 2020 -2030 [Cestovná mapa výskumných infraštruktúr - SK VI Roadmap 2020 – 2030. [Online]. [cit. 30.03.2022] Available from: <https://www.minedu.sk/cestovna-mapa-vyskumnych-infrastruktur-sk-vi-roadmap-2020-2030/>]. It is a key national document for research infrastructures also in relation to the update of ESFRI Roadmap 2021 within the EU. The material was prepared by the Ministry of Education, Science, Research, and Sports of the Slovak Republic in cooperation with World Bank experts and representatives of the Research Agency and was discussed by commissions for coordination of Slovak activities in ESFRI research infrastructures at the national level, acting as advisory bodies to the Ministry. The material was approved by the Government of the Slovak Republic by adopting the Resolution of the Government of the Slovak Republic no. 182 of April 7, 2021.

The main task of this document is to monitor the development and status of public and private research infrastructure on the territory of the Slovak Republic. It deals with the interconnection of research infrastructures with the economy, domains of smart specialization, international cooperation in the context of ESFRI and the forthcoming Framework Programme of the European Union in the field of research and innovation for the years 2021 - 2027 Horizon Europe.

The material briefly informs about the environment of research infrastructures at the national and at the international level, identifies established international research infrastructures, in of which the Slovak Republic is an observer or member and indicates the ones being prepared ESFRI projects in which the Slovak Republic is significantly involved. The document frameworks a system of assessment, monitoring, management and financing RI and establishes a vision and specific measures for the development of RI of the Slovak Republic in the next period.

[Zendulková, D.; Gavurníková, G.; Turňa, J. Map of Research Infrastructure as a tool of the Information System for Research, Development, and Innovation. *Procedia Computer Science*, Vol 211, 2022, Pp 47-56, ISSN 1877-0509, <https://doi.org/10.1016/j.procs.2022.10.175> .]

University science parks, research centres and centres of excellence rank among the most important research infrastructures in the Slovak Republic, whose detailed specification, focus, selected top infrastructure, as well as development tendencies, are specified in more detail in the material: "SK Roadmap".

The Slovak Republic is currently a promising member in three ESFRI projects and an observer in one project. In addition, he participates in the activities of one ESFRI project in the position of unofficial observer.

The Slovak Republic is currently a member of eight and a promising member of one ESFRI infrastructure. In addition, it participates in the activities of four ESFRI infrastructures in an informal position of the observer.

We collect the data to the SK CRIS system by the different ways. The first one is the Assessment of competence to perform research and development. The applicant for the assessment documents what infrastructures are available to him. This is primarily about laboratory equipment, or the laboratory as a whole.

National research infrastructures are usually inserted by the research organisations that operate them. Another source of information in this area is the grant agencies' data on the infrastructure built within the framework of EU SF projects.

The current version of the CERIF 1.6 data format contains data structures for the registration of laboratories (cf. Facility), laboratory equipment (cf. Equip) and services (cf. Serv) provided by the laboratory infrastructure [Dvořák, J., Brasse, V. (2019) "CERIF Tutorial: Autumn 2019" *Münster strategic membership meeting*, <http://hdl.handle.net/11366/1254>].

The evidence of research infrastructures is an integral part of the Slovak R&D information system SK CRIS. Its development at national level follows from EU activities in this area.

The software module for research infrastructure meets the requirements of CRIS system. It contains well-defined workflow and user interface. Created data model reached to achieve the maximal level of CERIF [EuroCRIS. Main features of CERIF. [Online]. [cit. 30.03.2022] Available from: <https://www.eurocris.org/services/main-features-cerif>] compatibility, including linking with main SK CRIS entities (Organisation, Project, Researcher). Classification schemes for research infrastructure respect the SK CRIS classification scheme system. This means that, in addition to internationally used classifications, the data model will also allow the implementation of other classifications, such as groups of science and technology areas [Číselník odborov vedy a techniky. [Online]. [cit. nn.nn.2023] Available from: <https://www.vedatechnika.sk/sk/veda-sr/odbory-vedy-techniky/>] as well as RIS3[Poznatkami k prosperite Stratégia výskumu a inovácií pre inteligentnú špecializáciu Slovenskej republiky. 2013. [Online]. [cit. nn.nn.2023] Available from: <https://www.opvai.sk/media/98825/poznatkami-k-prosperite-strategia-vyskumu-a-inovacií-pre-inteligentnú-špecializáciu-sr.pdf>].

The SK CRIS module Map of Research Infrastructure is in test operation now. It still waiting for routine use. Nevertheless, the database currently contains records of about 27 000 research infrastructures, laboratories and devices.