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RESEARCH INFRASTRUCTURES IN CONTEMPORARY EUROPEAN SCIENCE

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This article is short review and summary, sometimes compilation, of the works explaining the contemporary conception Research Infrastructures (RI). The short information about Academic and Research Networks URAN and GEANT is given. The impacts of RIs on economics, on innovation, on scientific activity, and on society are described.

Keywords: research infrastructure, science, knowledge, education, cooperation, scientific community, Academic and Research Networks.

1. Introduction

There is known Programme of European Research Council (ERC) HORIZON2020. This Programme proposes and funds many different Topics and Projects at different domains of science. There are some big sections: Excellent Science, Industrial Leadership, and Societal Challenges. There are Topics about information and communication technologies; space; nanotechnologies; advanced materials; biotechnology; health; demographic change; food security; secure, clean and efficient energy; smart, green and integrated transport; climate action; environment; resource efficiency and raw materials; and so on at this Programme [1].

But there is no one concrete Topic in mathematics, mechanics or engineering. Although there are many scientific international journals, monographs, conferences, and symposiums on nonlinear dynamics, fracture mechanics, and other sections of Structure mechanics. For example, an International Journal of Nonlinear Dynamics and Chaos in Engineering Systems, Journal of Applied Nonlinear Dynamics, Journal Discontinuity, Nonlinearity, and Complexity; International Conference on Nonlinear Dynamics Complexity, XVIII International Symposium "Dynamics of Vibroimpact (strong nonlinear) Systems", the third International Conference on Structural Nonlinear Dynamics and Diagnosis, and so on [2]. The International Conference on Fracture, the 15th and 16th International Conference on Fracture and Damage Mechanics.

All Topics proposed by ERC concern International scientific cooperation and collaboration. Such cooperation and collaboration has to be oriented at building, filling, and development of Research Infrastructures. There is very typical Topic: "Policy and international cooperation measures for research infrastructures". This call focuses on reinforcing European research infrastructures policy and international cooperation. It is underlined that the investigations do not fund. Only creating and development of research infrastructures will be funded. The Europe 2020 strategy implemented by the European Commission gives a major role to infrastructures in the creation of the European research space.

The goal of this paper is to introduce the readers with conception Research Infrastructures and their role in contemporary European science. We used the materials of European Commission and some articles for this purpose achievement.

2. Research Infrastructures definition

ERC considers that "Research Infrastructures (RIs) play an increasingly important role in the advancement of knowledge and technology. They are a key instrument in bringing together a wide diversity of stakeholders to look for solutions to many of the problems society is facing today. RIs offer unique research services to users from different countries, attract young people to science, and help to shape scientific communities. RIs help to create a new research environment in which all researchers - whether working in the context of their home institutions or in national or multinational scientific initiatives - have shared access to unique or distributed scientific facilities (including data, instruments, computing and communications), regardless of their type and location in the world. RIs are therefore at the centre of the knowledge triangle of research, education and innovation, producing knowledge through research, diffusing it through education, and applying it through innovation" [3].

The European Commission Expert Group on Research Infrastructures writes at its report:" Reasearch infrastructures (RIs) lie at the heart of the knowledge triangle – the beneficial combination of research activity, specialized education/training and innovation that advances our knowledge and understanding across all scientific domains. European infrastructures are the large-scale or singular facilities, scientific instruments, distributed facilities and interconnecred networks, funded by Member States and supported by Community budget of the European Union and shared widely within and between scientific research communities" [4].

Research Infrastructures are facilities which support the work of researchers, serving scientists by gathering the observation data they need, treating this data and preserving it for future use (of a multidisciplinary nature whenever possible) [5].

Research Infrastructures have to ability to create rich research environments and attract and retain researchers and experienced engineers/technologists from different countries, regions and disciplines.

What are Research Infrastructures? European Commission gives such definition: "Research infrastructures (RI) refer to facilities, resources (including human) and related services needed by the research community to conduct research in any scientific or technological field. Research infrastructures include:

- Major equipment or group(s) of instruments used for research purposes;
- Permanently attached instruments, managed by the facility operator for the benefit of researchers, industrial partners and society in general;
- Knowledge-based resources such as collections, archives, structured information or systems related to data management, used in scientific research;
- Enabling information and communication technology-based (ICT) or "einfrastructures" such as grid, computing, and software communications;
- Any other entity of a unique nature that is used for scientific research" [6].

There are different types of research infrastructures with specific characteristics.

RIs may be "single-sited" (a single resource at a single location), "distributed" (a network of distributed resources), or "virtual" (the service is provided electronically).

These key infrastructures have not only been responsible for some of the greatest scientific discoveries and technological developments, but are also influential in attracting the best researchers from around the world and in building bridges between national and research communities and scientific disciplines.

Naturally the construction, development, and operation of RIs require the investments. In [6] there is very nice Figure showing the operation of RIs.

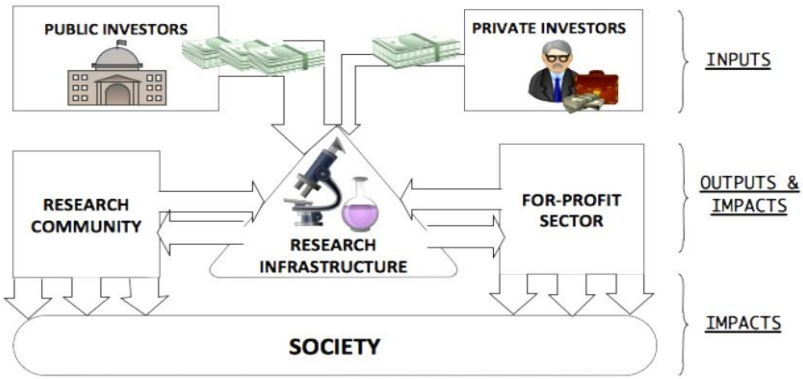

Fig. 1. Stakeholders and beneficiaries of investment in research infrastructure

3. Short information about Research and Academic Networks URAN and GEANT

The development of scientific exchange programs, leads to the need to recognize amongst the research infrastructures based on very high-level human networks, for ensuring hosting and managing events of international impact.

Except well known social networks there are Research and Academic Networks [7].

Kyiv National University of Construction and Architecture (KNUCA) is URAN Association Member. URAN – Ukrainian Research and Academic Network – was created under decision of Ministry of Education of Ukraine and National Academy of Science of Ukraine with support of universities, institutes of Ministry of Education of Ukraine and National Academy of Science of Ukraine in accordance with Joint resolution of Presidium of NAS of Ukraine and Board of Ministry of Education of Ukraine of June 20, 1997.

The purpose of establishing of URAN Association and the principal goal of activity of the Association is coordination and integration of efforts of the Association Members to ensure creation, development and usage of sole Ukrainian National Research and Education Network, increasing of education and science level in Ukraine, implementation of principles of information-oriented society, competitive joining of Ukraine to the Global information-oriented area and representing of interests of the Association members in institutions of government authority as well as in Ukrainian and International organizations.

URAN is Internet Provider for KNUCA, it provides the set of services for own users. For example, Video conferencing service, free WiFi Internet service in university campuses, Project "Scientific Periodicals of Ukraine", Ukrainian Scientific Citation Index (UInCit), Project "Scientific Conferences of Ukraine", Science of Ukraine in the mirror of SciVerse Scopus scientometric database, Services to Scientific Research and Educational Institutions [8,9].

URAN provides the exit into GEANT – pan-European Network for Research and Education. The GÉANT high-speed network is just one of many examples of e-Infrastructure initiatives launched to facilitate cooperation among researchers. E-infrastructures enable scientists to share knowledge and resources and bring real benefits for ordinary people.

On March 2009, GEANT have certified Ukrainian scientific-educational network URAN in the presence of Ukrainian users. These processes are at the stage of concluding URAN connection to GEANT. Certification of company executives held Dante (the managing company of GEANT) John Sievers and representative of the Trans-European Association of Research and Education Network Valentina Cavali.

GÉANT means community collaboration and is built on networks, services, people and innovation.

It brings together more than 30 million researchers from 34 European countries and has channels in different regions of the world. GEANT is co-financed by the European Commission and European networks of national science and education, and non-profit organization managed by DANTE, which is tasked with planning, construction and operation of network infrastructure in Europe for the needs of science and education. Currently, a second stage of the project GEANT is realizing – GÉANT2 [10-12].

4. Research Infrastructures impacts evaluation

How are the RIs impacts evaluated?

The impacts of research infrastructures relate to the impacts of the research and innovation that they facilitate. These can be classified as direct scientific impacts, the new knowledge created and the theoretical advancement of science achieved via the research they facilitate, and indirect or technological impacts, the innovations in the production of goods and services that arise as spin-offs from the development of research infrastructures or the benefits accruing from the advances in scientific knowledge that stem from their operation [6].

a) ***Economic*** impact is evaluated:

- by number of commercial suppliers and scale of their support at design and construction phase;
- by number of scientists, students, state-owned or private enterprises that benefitted from RI services at operational phase.

b) Impacts ***on innovation*** are evaluated:

- by number of joint development activities with suppliers and number of contracts concluded for high-tech or specialist services at design and construction phase;
- by number of collaborative research projects and volume of funding at operational phase.

c) Impacts ***on human resource capacity*** are evaluated at operational phase:

- by number of new jobs for research and technical staff;
- by number of Master thesis defended, where knowledge and skills gained on RI were exploited;
- by number of graduates trained on RI;
- by number of foreign students as % of all students trained on RI;
- by data on the post-diploma employment path of those graduates trained on RI.

d) The impact of RI ***on scientific activities*** can result in accumulation of new knowledge and methodologies to push the boundaries of fundamental science. There is an inherent tension between the development of non-proprietary research, which is published in relevant scientific journals and can be accessed by other

interested parties, and propriety research where knowledge and technical data, which can be basis for specific inventions, are not disclosed openly.

Open access to RI also induces more regular inward flow of researchers promoting closer involvement of local teams in international research networks (brain exchange). Such interaction can generate important learning effects for experienced and early stage researchers alike. Increase in international recognition of leading scientists and the capacity of research teams can attract further international competitive funding to the research system. In addition, researcher experience gained during the set-up and operational phase of RI can have further policy impact through contributions to RI roadmaps.

Impacts ***on scientific activity*** are evaluated at operational phase:

- by number of articles published in the ISI[1] level international scientific journals as a direct result of research using RI;
- by number of methodologies/designs developed;
- by international patents granted and published patent applications;
- by number of PhD dissertations completed;
- by number of scientific events organised on research topics directly relating to RI services.

e) Broader impacts ***on society***.

Regarding wider social impacts, it is important to outline that research infrastructures can play an important role in scientific communication and scientific education. RI can be used to inspire school students to learn STEM[2] subjects. For example, large scale RI may organise open days for the general public or for schools. The policy decision on investment in RI can also be widely reflected in the press leading to increased public awareness of science.

Broader impacts ***on society*** are evaluated at operational phase:

- by number of organised RI open days for wider public and any available data on participant satisfaction with the events;

[1] ISI level – is International Scientific Indexing. The ISI server provides indexing of major international journals and proceedings. Author can get information about international journal impact factor, proceedings (research papers) and information on upcoming events. All the journal pages have pointers to Web pages of the publishers which are integrated into the ISI stream pages. The purpose is to increase the visibility and ease of use of open access scientific and scholarly journals. If your journal is indexed & got validated stamp from ISI, you can request for the calculation of impact factor for your journal.

[2] STEM (**S**CIENCE,**T**ECHNOLOGY, **E**NGINEERING, **M**ATH) is complex multidisciplinary approach to the education. It combines natural sciences with technologies, engineering and mathematics. As in life all subjects are integrated and correlated into the one whole model. Now the conception STEM-education is inculcated more active into different educational programmes in many countries. International conferences are holding, STEM-centers are organized. It is very important to learn the science, engineering and mathematics in integrality because these domains are correlated closely in practice [13].

• by number of press articles on the investment in research infrastructure; by number of new or improved products, services, solutions as a result of research using RI that are diffused in society;

• by account of improved local infrastructure, community services, increase in local cultural/recreational activities due to RI.

5. Conclusions

European Commission Expert Group on Research Infrastructures gave such recommendations [4]:

1. New approaches to European wide collaboration in constructing and using research infrastructures with active inclusion of the smaller EC countries and new Member States should be established.
2. Fostering human resources is key to the efficient operation and the long term vitality of RIs.
3. The close relationship between universities and RIs contributes to an effective educational and scientific ecosystem, which can be attractive and supportive for industry.

The strengthening the concept of the European Research Area will create a unified all across Europe which will:

• enable researches to move and interact seamlessly, benefit from world-class infrastructures and work with excellent networks of research institutions;

• share, teach, value and use knowledge effectively for social, business and policy purposes;

• develop strong links with partners around the world so that Europe benefits from worldwide progress of knowledge, contributes to global development and takes a leading role in international initiatives to solve global issues.

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ДОСЛІДНИЦЬКІ ІНФРАСТРУКТУРИ В СУЧАСНІЙ ЕВРОПЕЙСЬКІЙ НАУЦІ

Стаття є коротким оглядом та коротким викладом, інколи компіляцією, робіт, в яких роз'яснюється сучасне поняття Дослідницькі Інфраструктури. Дана також коротка інформація про Академічні та Дослідницькі мережі URAN та GEANT. Описується ефект та вплив Дослідницьких Інфраструктур на економіку, інновації, наукову діяльність та суспільство.

Ключові слова: дослідницька інфраструктура, наука, знання, освіта, кооперація, наукове товариство, Академічні та Дослідницькі мережі.

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ИССЛЕДОВАТЕЛЬСКИЕ ИНФРАСТРУКТУРЫ В СОВРЕМЕННОЙ ЕВРОПЕЙСКОЙ НАУКЕ

Эта статья представляет собой краткий обзор и краткое изложение, иногда компиляцию, работ, объясняющих современное понятие Исследовательские Инфраструктуры. Дана краткая информация об Академических и Исследовательских сетях URAN и GEANT. Описывается эффект и влияние Исследовательских Инфраструктур на экономику, инновации, научную деятельность и общество.

Ключевые слова: исследовательская инфраструктура, наука, знания, образование, кооперация, научное сообщество, Академические и Исследовательские сети.

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Table 0. Fig. 1. Ref. 13

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