ISSN 2409-9066. Sci. innov. 2017, 13(2): 5—23 doi: https://doi.org/10.15407/scine13.02.005

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INSTITUTIONAL SUPPORT OF INNOVATIVE R&D IN THE FORMATION OF SINGLE RESEARCH AREA IN THE EU AND UKRAINE

The necessity of developing innovation ecosystems as common tools of research and innovation management under rapid growth of interdisciplinary research in the most high-tech industries of the world leading countries has been established. Paradigm of the creation of the European research area based on the three priorities (open science, open innovation and regional smart specialization) has been analyzed. Proposals to the National Action Plan for actualizing the Ukrainian research space based on implementation of the Roadmap for the Creation of Single European Research Area for 2015–2020 and to the draft Strategy for the Development of High-Tech Industries of Ukraine until 2025 have been elaborated.

Keywords: innovation ecosystem, open science, open innovation, Ukrainian space research, and the ERA Roadmap.

Today, throughout the world, the institutional support of R&D development is realized through a variety of mechanisms, such as *areas of science, science parks, technology parks, industrial parks, research and innovation centers, transfer centers, technological and business incubators, startups, spin off companies, venture capital, and seed funds.* Particular attention is paid to studying the interaction of specific mechanisms to support research and innovation, especially clusters, research and innovation networks, and technology platforms that have been swiftly growing in advanced economies the first decade of the 21st century.

Currently, these structures in the economy of post-Soviet countries are analyzed by Russian (*S. Bodrunov, L. Voronina, O. Golichenko, N. Hustap, I. Dezhyna, M. Egorov, A. Zlyvko, R. Nyzhehorodtsev, M. Pluzhnyk, A. Ponarina, S. Ratner, M. Rogachev, N. Shelyubska, A. Schrier*) and Ukrainian (*A. Androsov, P. Bubenko, T. Bova, O. Volkova, V. Geyets A. Danilenko, M. Denisenko, M. Didkivskyi, I. Egorov, M. Yohna, M. Kizim, S. Korsunskyi, A. Mazur, A. Nikiforov, I. Odotyuk, O. Salikhova, V. Seminozhenko, O. Symson, V. Solovyev, V. Stadnyk, L. Fedulova, A. Cherep, A. Shevchenko* and others) scholars. However, the problem of introducing new mechanisms to support R&D development within the formation of single research area in EU member states and the prospects for Ukraine's involvement in the development of modern research and innovation infrastructure need to be scrutinized.

CREATION OF ERA AS KEY TO A NEW SYSTEM OF INSTITUTIONAL SUPPORT OF INNOVATIVE DEVELOPMENT

At the level of national legislative acts *innovation cluster* was defined in 2008 *The Concept of Clusters and Cluster Policies and Their Role for Competitiveness and Innovation as «groupings of independent undertakings — innovative startups, small, medium and large undertakings as well as re-*

search organizations — operating in a particular sector and region and designed to stimulate innovative activity by promoting intensive interactions, sharing of facilities and exchange of knowledge and expertise and by contributing effectively to technology transfer, networking and information dissemination among the undertakings in the cluster» [1]. Hence the innovation clusters underlie the European strategy for enhancing the role of regions in definition of national innovation policy based on regional intellectual specialization, which means *choice, at the regional level, of areas where they can maximally contribute to economic development by supporting R&D and innovation within the framework of identified fields of specialization* [1].

Another direction of studying interactions between institutions of generation and commercialization of knowledge is a paradigm of the network structure of R&D and innovation activities in the post-industrial economy, the implementation of which has been secured by a rapid development of information technology. Castells' research (1999) describe in details the formation of network management based on the benefits of spatial structures [2, 3]. Thus, M. Castells defines the network structure as set of interrelated IT units and the network undertaking as specific entity able to generate knowledge, to process information effectively, to adapt itself to changing market conditions, to be flexible for rapid change in organizational and economic instruments under influence of radical cultural, technological, and institutional reforms, and to implement innovation as major competitive advantage [3].

Although the cluster has been remained key mechanism of innovation development in advanced economies, in 2003, the EU started to form the concept of technology platforms (TP) and to combine them with established local clusters [4, 5, 6, 7]. In general, the technology platform is a mechanism for combining efforts to create a common development strategy for specific direction for the sake of all stakeholders as well as a tool to structure the interests of various stakeholders in specific fields of industry in the context of addressing global and specific national problems [8, p. 214]. The network platform is aimed at creating links to determine the purpose and support of research and development [9].

Hence, the present-day EU innovation policy foresees the following types of partnership: *European innovation partnership, European technology platform, contractual and institutionalized public and private partnership (PPP), cluster and grid structures of the European Institute of Innovation and Technology, European industrial initiatives, and public partnerships* [8]. The main policy measures to support the interaction of clusters and technology platforms in some OECD countries include the following:

- Creation and consolidation of clusters through government programs and promotion of network structures and services for business entities in order to coordinate the clusters;
- Creation of network platforms using links within science (promotion of joint research centers and centers of benefits), science-industry relationships (promotion of PPP), and connections within the industry (promotion of sectoral networks);
- Internationalization using a program for competitiveness clusters and clusters of benefits [8, p. 9; 216—218].

However, in 2013 the EU, the United States, Japan, and South Korea (as global technology leaders) started to build their science and innovation policy based on the model of four helices *«power — science — civil society — business»*, which has many players and prevents takeover of all by one structure, by powerful transnational corporations (TNCs) either. In this model, the main element is the innovation ecosystem instead of the cluster or the TP. In particular, Ukrainian scholars *Fedulova* and *Marchenko* define innovation ecosystem as *«...a set of organizational, structural and functional components (institutions) and their relations involved in the creation and application of scientific knowledge and technology, which determine legal, economic, and social conditions of the innovation process and ensure the development of innovation at both the corporate level and the*

level of region and country as a whole, based on the principles of self-organization» [10, p. 26].

Starting with 2012, the EU member states and associated countries have been partnering to build the European Research Area (European Research Area, ERA) within the framework of priority smart growth (economic growth based on knowledge and innovation) of the *Europe 2020* strategy and *Innovation Union* leading initiative that involves improving the conditions for access to funding for research and innovation in order to transform innovative ideas into products and services, which facilitate the creation and quality of jobs.

To implement the *Innovation Union* initiative a package of measures at the EU level has been developed, including:

- Completion of ERA and elaboration of program for strategic studies focused on energy security, transport, climate change, efficient use of resources, health and aging of population, environmentally friendly production methods, etc.;
- Improvement of the framework conditions for innovative businesses;
- Implementation of European partnerships in the innovation field between EU and the Member States at the national level in order to accelerate the development and application of technology for addressing the identified problems and challenges;
- Enhancement and further elaboration of role of EU tools for innovation promotion (structural funds, framework programs for R&D development, including *Horizon—2020, Competitiveness and Innovation Framework Program (CIP), Strategic Energy Technology Plan, (SET-Plan)*, etc.).

A set of measures has been foreseen at the national level of EU member states, as well [11].

The ERA creation means:

- To identify the principal global challenges related to the ERA member states;
- To create joint R&D infrastructure to address them;
- To stimulate mobility of researchers in order to enable their involvement in certain local research infrastructure;
- To widely use electronic infrastructure (*e*-infrastructure), unification and development of local research infrastructures;
- To harmonize standards for management of national innovation systems based on joint examination of projects and general funding principles [11].

ERA is mainly based on the *open science* paradigm that has been developed since 2013 and is built upon common unified *e*-infrastructure with free access for researchers from everywhere. In particular, *European Open Science Cloud* (EOSC) foresees availability of technologies for combining and providing services to public and private users as well as a free access system for ultimate users [12]. In May 2015, the EU Council discussed new *Digital Single Market policy* (DSMP) within the framework of which the Open Science Cloud would be affordable, service-oriented, and inclusive for all stakeholders and would enhance R&D, namely:

- Facilitate not only the development of state-of-art science and multiuse of research data, but also increase in jobs and enhancement of competitive ability in Europe;
- Lead to raising efficiency of investments in science infrastructure throughout Europe via promoting their compatibility and interaction in unprecedented scale;
- Ensure open direct access to advanced digital facilities, resources, and expertise required for cooperation and science development involving intensive data processing and computations to researchers of all disciplines;
- Involve researchers into management, coordination, and preservation of resources respecting interests of all stakeholders;
- Enable the use of public and private investments into e-infrastructure made in the two recent decades in order to ensure advantages of R&D and innovation [13].

The EU Council has adopted some decisions on target influence aimed at digital transformation of European industry and encouragement of digital entrepreneurship [14, 15].

Within the framework of ERA, there is implemented the *open innovation* conception, in particular, as European technology platform (ETP) in priority fields of innovation, namely:

- Bioeconomics (7 platforms);
- Power engineering (8);
- Environment (1);
- IKT (9);
- Production and processes (8);
- Transport (5);
- Cross-cutting ETP Initiatives: NANOfutures initiative; ETPIS (the Cross-ETP Initiative on Industrial Safety); and ConXEPT (Consumer Goods Cross-ETP) [16].

Among key remarkable events [15] promoting ERA development in 2015—2016, there was EU Forum in May 2015 where ERA representatives discussed a wide range of problems concerning new start of Europe in the sphere of innovation, enhancements of networks, and cooperation with wide European innovation community and established the following priorities:

- Facilitate a progress in the first wave of creation of European Knowledge and Innovation Communities (KIC), namely: Climate-KIC, EIT Digital, and KIC InnoEnergy;
- Creation of five new KIC, namely: EIT Health and EIT Raw Materials (launched in 2014), EIT Food and EIT Manufacturing (in 2016), and EIT Urban Mobility to be held in 2018;
- Joint use and advancement of EIT best practice [16].

In May 2015, the EU Competitiveness Board at its meeting adopted the Road Map for ERA creation for 2015—2020 (hereinafter referred to as the ERA Road Map for 2015—2020) with an assignment to implement it at the national level of Member States and associated countries till the end of 2015 (later the term was extended till April 2016) [17]. EU assumes the national ERA road maps are principal elements for reforms of national research systems to influence general level of R&D in EU in the context of its competition with the United States and China. This document contains plan for reforming EU R&D and innovation sphere foreseeing 9 priorities of R&D system development and conditions for its use (see Table 1).

In June 2015, at the *New Start of Europe: Opening of ERA of Innovation* conference several important decisions were made:

- Creation of ERA, transition to implementation at the national level, and start of application to innovation have been declared;
- Priorities of ERA use via three «O» — open science [18]; open innovations; openness to the world have been finalized;
- The first conception of the European science cloud creation till March 2016 has been adopted;
- New activities have been proposed: *a*) creation of European fund for investments into new generation of large European innovation corporations, *b*) introduction of Quality Mark for applicants who have been assessed as excellent but cannot be funded from *Horizon—2020*, in order to assist them to get financing from structural funds; *c*) creation of European Innovation Board (to support best practice in innovation similar to the European Research Council for Research Support); *d*) introduction of European initiative on research integrity, which includes the following conceptions: «Science 2.0», «Open innovation 2.0», and «Education 2.0» [19, 20].

In December 2015, the revised Lund declaration (that underlay *Horizon—2020*) established the four priorities in terms of addressing global social problems, which allow the researchers from associated countries (including Ukraine) to join the European road maps without remotely, without necessity to leave the home country:

- Open science and open innovation for addressing social problems by cohesion;
- Cross border research and R&D infrastructure;
- Global cooperation and effect on addressing social problems for the ultimate user.

Based on these documents, in January 2016, ERAC Work Program 2016—2017 was adopted. It contains clearly stated priorities for R&I development at the super-national and national levels and the tasks to be done as follows:

1) To prepare strategic recommendations at early stage of policy development in the field of science and innovation;

2) To consider effect of other policies on R&I and to prepare recommendations on respective responses;

3) To consult on implementation of R&I policy and to propose measures to support this policy [21].

On May 27—28, 2016, the conference of EU ministers was held within the framework of regular meeting of EU Competitiveness Board. At the meeting, the parties finally agreed as follows [22]:

1. *Domestic Market — Industry — Space Policy:*

1) The single digital market, including:

a) basic principles of online provision of content services in the domestic market have been agreed;

b) conclusions on the development of single digital market technologies and upgrade of communal services have been adopted;

c) effect of digitalization on productivity of services related to competitiveness survey has been discussed;

d) ways to improve the use of space data from European space programs for creation and growth of jobs have been discussed;

2) Improvement of competitiveness regulation in order to ensure future benefits from innovation friendly environment.

Table 1

Priorities of Development of Research System and Conditions of Its Use for Innovation in EU as Defined by ERA Road Map for 2015–2020

Priority	Content
Smart R&D management	R&D management based on communication and partnership between science, government, business, and society
Implementation of EU standards for international assessment of R&D quality and effectiveness	Assessment for project and institutional financing. Optimization of ratio between project and institutional financing of R&D for the national system
Setting of objectives for R&D development	Objectives shall consolidate efforts at the national level to reach the goal and to avoid fragmentation of efforts (for example, to address key social problems and global challenges)
Creation of modern R&D infrastructure	R&D infrastructure shall ensure achieving of goals and integration of Member States and associated countries to European and world ones. Development and implementation of joint road maps for creation of R&D infrastructures
Common vision of addressing priority issues	Introduction of joint project financing, standards for assessment of R&D quality and procedures for R&D application (for instance, Joint Programming Initiatives, Framework Program Horizon 2020)
Mobility and career growth of researchers	Implementation of meritocratic principle of researcher recruitment and competition to attract the best gifted ones in the global market. Implementation of innovative (PhD) training principles
Implementation of open science principles	Open science based on open e-infrastructure: open access to publications, data and their repeated use; tools for intensive exchange of professional knowledge and expertise
Implementation of open innovations	Open innovation based on the model of four helices (science — government — business — society) — Open Innovation 2.0 and harmonization with protection of intellectual property rights
Implementation of intelligent specialization strategy	Intelligent specialization strategy foresees the application and delivery of global science to local clusters of innovation business

Note: Table is based on [17].

2. *Research and Innovation (R&I):*

1) Having discussed the open science capacity, the following conclusions on transition to open science system have been made;

2) Conclusions on the results of implementation of 7th framework program for research (FP7) and on future prospects for the creation of friendly R&I regulative framework have been adopted.

In addition, the conference participants stressed importance of research infrastructures for ERA operation and development of innovative and competitive Europe and approved ERA Road Map 2015—2020 (Strategy Report and Roadmap Update 2016) prepared by European Strategy Forum on Research Infrastructures (ESFRI). The road map is aimed at simplifying procedures, reinforcing efforts of Member States and at ensuring the following: *1)* common understanding of strategic goals for the next years; *2)* a toolkit for supporting innovation development in the Member States; *3)* implementation of national policies in a way that maximally corresponds to their peculiarities and priorities [17].

Hence, the advanced economies — leaders in technology — have acknowledged that the open science ruins barriers around universities and ensures the society to be able to derive maximum benefits from scientific knowledge, as well as stimulates a maximal growth in the contribution of researchers, universities, and research institutions.

PROSPECTS FOR THE CREATION OF NEW R&D AND INNOVATION INFRASTRUCTURE IN UKRAINE WITHIN THE NATIONAL R&D AREA

The creation of national innovation system, the formation of innovation clusters, the technology transfer and operation of science and industrial parks, as well as options for creation of technologic parks, special (free) economic areas, and special investment regimes aimed at developing the national R&I support system have been discussed in Ukraine for many years.

At the same time, the Ukraine-EU Association Agreement signed in 2014 (partial implementation of Deep and Comprehensive Free Trade Area (DCFTA) that came in to effect since 01.01.2016) has allowed Ukraine to maximally utilize the extended FTA for economic and R&D growth [23, 24, 25]. Pursuant to this Agreement:

- Cl. 374 The Parties shall develop and strengthen their scientific and technological cooperation in order to contribute both to scientific development itself, and to reinforce their scientific potential for contributing to the resolution of national and global challenges;
- Cl. 375, para.1: Such cooperation shall take into account the Ukrainian objective of gradual approximation to EU policy and legislation on science and technology;
- Cl. 375 paragraphs 2 and 3: Cooperation between the Parties shall be aimed at facilitating the involvement of Ukraine in the European Research Area. Such cooperation shall assist Ukraine in reforming and reorganizing its science management system and research institutions, in order to support the development of a competitive economy and knowledge society.

In addition, Cl. 376 Cooperation shall take place particularly through:

- exchange of information on each other's science and technology policies;
- participation in the next EU Framework Program for Research and Innovation Horizon 2020;
- joint implementation of scientific programs and research activities;
- joint research and development activities aimed at encouraging scientific progress and the transfer of technology and know-how;
- training through mobility programs for researchers and specialists;
- the organization of joint scientific and technological development events/measures;
- implementation measures aimed at the development of an environment conducive to research and the application of new technologies and adequate protection of the intellectual property results of research;
- enhancement of cooperation at regional and international level, notably in the Black Sea context, and within multilateral organizations such

as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organization for Economic Cooperation and Development (OECD) and the Group of 8 (G8), as well as in the context of multilateral agreements such as the UN Framework Convention on Climate Change (UNFCCC) of 1992;

- exchange of expertise on management of research and science institutions in order to develop and improve their capacities of conducting and participating in scientific researches [24].

To implement the Agreement, the CMU by virtue of its Resolution of September 17, 2014, no. 847-p approved the Action Plan for Implementation of Association Agreement between Ukraine, on the one hand, and EU, European Atomic Energy Community and their Member States, on the other hand, for 2014—2017 [25]. Pursuant to the Action Plan, the Ministry of Education and Science is charged with the following responsibilities:

1) To ensure integration of the national technology transfer network into the European one (Cl. 374 — 376 of the Agreement);

2) To proceed with cooperation within the framework of Joint Committee on Cooperation in the sphere of science and technology in order to ensure involvement of Ukrainian R&D institutes in EU R&D programs and Ukraine's approach to ERA (pursuant to Cl. 375).

In addition, pursuant to paragraph 7.14 Science, Technology, and Innovations of EU-Ukraine Association Agenda to (annexed to Association Agreement) the MES is responsible for the following «*... The Parties shall cooperate in: ensuring exchange of best practices regarding the organization and implementation of research and innovation policies as well as the management and review of related programs and flagship initiatives; support the reinforcement of Ukrainian capacities in the research and innovation domain, notably in improving the framework conditions for facilitating research industry partnerships and the market exploitation of research results; intensifying implementation of the provisions of the Agreement for scientific and technological cooperation between Ukraine and the EU*» [24, 25].

The *European Living Standards and Ukraine's Rightful Place in the World* Strategy approved by the decree of the President of Ukraine of 12.01.2015 no. 5/2015 [26] in the best way takes into account both Association Agreement and Europe 2020 Strategy with smart, sustainable and inclusive growth of knowledge-based society as priority.

In 2015, within the framework of implementation of Ukraine-EU Association Agreement in the sphere of science and technology the following outcomes were reported:

1) Agreement between Ukraine and EU (as exchange of notes) on resumption of EU-Ukraine Agreement on R&D cooperation has been ratified;

2) EU-Ukraine agreement on Ukraine's involvement in EU *Horizon—2020* — Framework Program on R&I (2014—2020) has been ratified;

3) Revised Law of Ukraine on Science and R&D Activities has been adopted;

4) Consultations on prospects for Ukraine's involvement in EAEC R&D and training programs as associate member are carried on;

5) Mandatory sale of foreign currency for the projects based on agreements related to involvement in EU international programs has been cancelled [25].

Pursuant to recommendations of parliamentary hearings approved by Resolution of Verkhovna Rada of Ukraine on status and legislative framework in the sphere of science and R&D development of Ukraine of 11.02.2015, no. 182-VIII, to submit the legislative proposals on amendments to laws in the R&D sphere for consideration by Verkhovna Rada were recognized as a priority. These amendments shall foresee as follows:

- To improve the system for identification of priorities in R&D development, as well as mechanisms for their implementation and mobilization of financial and tangible assets required for achieving the goals;
- Based on the experience of advanced economies, to introduce long-term planning in R&D sphere through adopting an innovative development strategy harmonized with ERA environment by Verkhovna Rada of Ukraine and approving

medium-term plans for development of science, R&D, and innovation activities by CMU [27].

Finally, the Law of Ukraine on Science and R&D Activities of November 26, 2015, no. 848-VIII [28] foresees as follows:

1. Clause 45: the main objectives of policy in the field of science and R&D are, in particular:

- To ensure scientific justification for identification of strategic tasks of economic and social growth;
- To reach high level of science and engineering development;
- To integrate the national R&D sector into the world and European research areas.

2. Part 4 of Clause 66 related to government support of international scientific and R&D cooperation states that the government shall ensure integration of national research area to ERA by implementing the ERA priorities, namely:

- Raising effectiveness of the national research area;
- Optimizing international cooperation in order to address global challenges;
- Ensuring involvement in EU framework and joint international programs;
- Harmonizing the strategy for the creation of government research infrastructures with Road Map for European research infrastructures;
- Creating favorable conditions for mobility of researchers;
- Ensuring gender equality;
- Full-fledged exchange, transfer and access to scholarly research knowledge.

The mentioned Law defines main goals and function of such elements of Ukraine's R&I infrastructure as centers for research equipment sharing; the National Research Center; State Key Laboratory; State Register of scientific property constituting the national assets; the National Academy of Science of Ukraine; science and R&D activities in the higher education system; the National Council for Science and Technology Development, Science and Administrative Committees; Identification Committee on Science; scientific NGOs; Council of Young Scholarly Researchers; regional research centers.

In addition, involvement of school youth in science and R&D through the system of specialized secondary schools and non-formal education establishments, including lyceums and boarding schools, Small Academy of Sciences of Ukraine or other similar establishments of non-formal education has been studied.

At the same time, in 2015, within the framework of Action Plan for Implementation of Ukraine—EU Association Agreement MES *1)* analyzed activities of technology transfer networks in EU and defined main organizations for cooperation (EEN, EBN); *2)* formed legislative proposals on the development of technology platforms, innovation clusters, and technology transfer networks and their inclusion in draft law of Ukraine on Support and Development of Innovation Activities, which is aimed at harmonizing Ukraine's legislative framework of innovation activities to the European one. According to MES data, a conception of the national technology transfer network is being elaborated; negotiations with EBN (European BIC Network) on conditions for involvement of Ukrainian representatives in the European network are being carried on, consultations with EC on optimization of EEN—Ukraine Consortium member and improvement of its operations are ongoing [25]. Hence, the above mentioned has testified to a very slow pace of implementation of Clauses 374—376 of Ukraine—EU Association Agreement, which foresee much wider tasks to implement which the government did not plan for 2015—2016 either.

However, till April 22, 2016, Ukraine did not submit for consideration of ERAC Committee its proposals on the National Action Plan Implementation of ERA Road Map for 2015—2020, which breaches the new Law of Ukraine on Science and R&D Activities and respective provisions of Ukraine—EU Association Agreement [29].

The implementation of Ukrainian Research Area (URA) is impossible unless the National Action Plan for Implementation of ERA Road Map for 2015—2020 has been elaborated and implemented for innovation development via: *a)* open sci-

ence; *b)* open innovation; *c)* smart specialization strategy; and *d)* support from EU via technical assistance in implementation of national priorities harmonized with ERA. Table 2 shows the main expected outcomes of ERA Road Map for 2015—2020 implementation in Ukraine.

Thus, we can conclude that Ukraine has very little experience in creation of the national research infrastructures, including the Ukrainian National Grid, as well as Centers of Excellence — the State Key Laboratory of Molecular and Cellular Biology. However, the transformation of the Ukrainian science in accordance with the modern challenges and its full integration into the European Research Area needs a new organizing and consolidating role of government and scientific institutions based on the close cooperation with the EU in terms of common strategizing of the development of science and innovation sector in Ukraine.

The first beginnings of organizing a new control system of science and innovations in Ukraine have already begun to appear in the form of innovative ecosystems, especially of virtual innovation eco-systems. Thus, an example of modern innovation ecosystem in Ukraine became *Sikorsky Challenge*, an innovative ecosystem established in 2014, the environment supported by *Kyiv Polytechnic Institute* National Technical University and *Kyiv Polytechnic* scientific park, in which a complete technological circle was realized beginning from searching the idea of new business to attracting the investments and creating the startup companies, which include *Sikorsky Challenge* startup school; *Sikorsky Challenge* festival of innovative projects; *Sikorsky Challenge* business incubator; *Sikorsky Lab* innovative technological environment; Center for Intellectual Property; *Sikorsky Challenge* venture fund [30]. The main objectives of this ecosystem are as follows:

- Attraction and selection of people, creative and willing to engage in the innovative business, from among inventors, scientists and students

Table 2

The Basic Expected Results of the Implementation of Roadmap SRF for 2015—2020

Basic measures on implementation	Expected results
In-depth integration of Ukraine to the SRF	This makes it possible to use Ukraine`s human resources for creating the Centers of Excellence with the use of resources of the European research infrastructures through the electronic means of digital technology. Ukraine has a required number of high-qualified staff of IT-industry of high level, and their inclusion in the European research infrastructure will allow Ukraine to solve a problem of insufficient scientific research financing.
Creating and coordination of the national roadmaps with the clear terms of implementation	It will stimulate the implementation of the European standards and procedures of expert evaluation of long-term projects, including the research infrastructure, Centers of Excellence, as well as the estimation procedure of scientific institutions. Coordination with the European Council and the European organizations which support SRF, as well as the international selection of members of Identification Committee and expert commissions for the scientific institutions evaluation, will make it possible to solve, in a civilized way, a potential conflict of interests between the Ukrainian scientists and the government bodies. Experts on the scientific institutions evaluation should answer for three groups of questions: What is happening today with the Ukrainian scientific system, as a whole? how effective are the current mechanisms that need to be improved? what should be done to improve the process of results evaluation and holding the contests?
Development and application of «Strategy of Reasonable Specialization» platform	This allows one to create the innovation development centers in all regions of Ukraine and disclose the potential of the Ukrainian scientists, including the depressed and old-industrial regions. Inclusion of the Ukrainian scientists in the SRF will promote to the creation of potential for realizing the converged advanced technologies in the science and production, as well as to the effective knowledge transfer between the state and private structures.

of Kyiv Polytechnic Institute, other universities, research institutes and businesses;
- Innovative entrepreneurship training of selected participants and creating the incentives to shape their technological ideas, such as growing business ideas, assistance to the participants in developing the projects and prototyping the business products;
- Search of investors — the business angels — to invest in the advanced projects (first and second round of investments);
- Selection of the best startup projects, involving trainers and experts of funds, investors, business- angels; organizing and conducting the contest of innovative business projects of Sikorsky Challenge Festival;
- Assistance to the participants — initiators of ideas in «sharpening» the selected startup projects for the stakeholders;
- Participation in the opening and launching the startup companies;
- Assistance and support in the protection of intellectual property rights (registration of copyrights, patents, licenses);
- Providing the legal, organizational and accounting support of the startup company to the second round of investments;
- Assistance in bringing the startup company to the international level.

The virtual ecosystem space implements the business-model B2C, and the implemented model of participant interrelations gives birth to a project. The virtual space ecosystem supports the implementation of projects with different objectives and provides the necessary staff of project team and interaction with the stakeholders.

In addition, yet since 2006, according to the existing European Technology Platforms (ETP) and on the initiative of a group of scientists and, as well as with support of the National Information Office (NIO) of framework programs of scientific and technical research of the EU in Ukraine, a start has been made on the development of proposals for the creation of the National Technology Platforms (NTP). The recent studies of the Ukrainian scientists associated both with the general issues of capability of NTP creation in Ukraine [8, 31, 32], and in the specific areas, including bioenergy [33], agro-food sector [34], advanced materials production technologies [35] and energy engineering [8, p. 232]. Meanwhile, now only one Ukrainian NTP assumed more or less organized form. In 2012, at the working meeting of the heads of clusters it was proposed and agreed upon the final structure of NTP «agro-food» [34], the prototype of which is *Food for Life* ETP. Other NTP are still under discussion and formation.

So, today it is the indisputable fact that the high-tech manufacturing is a key factor in raising the employment of population and wage level, which, in its turn, is the result of intensive growth of the world production and exports of high-tech products. However, the majority of traditional industrial sectors reached the «technology plateau» (slowdown in dynamics, fall in return on the investment, lack of radical innovations, etc.). It is evident that the intellectual, material resources and infrastructure space are not sufficient for the extensive growth at the expense of primary industrialization of emerging markets. As a result, the problem of increasing or even maintaining the production and export of high-tech products under the rapid deindustrialization conditions, landslide collapse of production turnout, both in the traditional and high-tech branches of industry, is sharpening for the developing countries (such as Ukraine).

Thus, according to the World Bank, which annually ranks countries based on the two indicators — (1) by R&D expenditure to GDP ratio, and (2) by the share of high-tech products in the structure of industrial exports to show the relationship between the R&D expenditure and revenues received from the results of R&D activities. Table 3 shows the costs figures of some countries on the research and development relative to GDP for the period of 2006—2013 [36].

In terms of the intensity of research and developments, according to the World Bank ranking,

the South Korea spends on science and research more than others (about 4% of GDP), followed by Japan (3.2%), the USA (2.8%) and the EU (2.2%). In Russia, this figure is about 1% of GDP. Close to the same level are Poland (0.9%), Ukraine (0.8%), India (0.8%) and Belarus (0.7%), i.e., at the level, when you cannot say that the science is not funded at all, but it is 3 times less than the advanced economies, which are currently the technological leaders.

According to the World Bank classification the high-tech products include: *1)* Aerospace, *2)* pharmaceuticals, *3)* computers, *4)* scientific instruments and *5)* electrical engineering, that is, the products with high research and development intensity.

Table 4 gives a comparison of high-tech exports in the structure of industrial exports for some countries in the period of 2006—2013 [37].

Note: The table is compiled upon the materials [37].

Table 4 shows that the highest percentage of high-tech exports belongs to the South Korea (about 27%); China (about 27%); Japan (about 18%); the USA (about 17%); Germany (about 16%); the EU (about 15%), which spend on the research and development from 4.5 to 2% of GDP. At the same time, the countries that buy a ready-made research and development, as well as the patents have a high enough percentage of high-tech exports, namely, Kazakhstan (about 36%), India (about 8%), Poland (about 7%), and which spend for their own research and development only 0.2%, 0.8% and 0.9%, respectively. Thus, Ukraine spending on the science 0.8% of GDP (that is 4 times less than the advanced economies), makes export supplies of high technology products about 5—6% of industrial exports (5 times smaller than Korea and China and 3 times less than the EU) [38, 39].

Thus, the crisis of the Ukrainian foreign trade of high-tech products after 2012 not only significantly accelerated, but also acquired new traits associated with both the hybrid war, which Russia has been waging against Ukraine, including the market foreclosure to the Ukrainian high-tech products, and change in the technological priorities in the global markets and increasingly intensive development of advanced production

Table 3

R&D Expenditure to GDP Ratio for 2006–2013 (%) (according to WB classification)

Country	Years							
	2006	2007	2008	2009	2010	2011	2012	2013
World	2.0	2.0	2.0	2.1	2.1	2.1	2.2	n/a
South Korea	2.8	3.0	3.1	3.3	3.5	3.7	4.0	4.1
Japan	3.4	3.5	3.5	3.4	3.3	3.4	3.3	3.5
USA	2.6	2.6	2.8	2.8	2.7	2.8	2.8	n/a
EU	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0
Germany	2.5	2.4	2.6	2.7	2.7	2.8	2.9	2.9
Poland	0.6	0.6	0.6	0.7	0.7	0.7	0.9	0.9
Chine	1.4	1.4	1.5	1.7	1.7	1.8	1.9	2.0
India	0.8	0.8	0.8	0.8	0.8	0.8	n/a	n/a
Russia	1.1	1.1	1.0	1.3	1.1	1.1	1.1	1.1
Ukraine	0.9	0.9	0.8	0.9	0.8	0.8	0.8	0.8
Belarus	0.7	1.0	0.7	0.6	0.7	0.7	0.7	0.7
Kazakhstan	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Note: n/a — data not available; Table is based on [36].

technology, as well as the appropriate restructuring of the world exports.

In 2015, KPMG in the annual publication on innovative technologies *Changing the Landscape of High Technologies* forecasted new global technology trends which, according to the international business, will be the most promising by 2020 [40].

Table 5 also summarizes the priorities in the sphere of industrial production technology in the EU, the USA, China and Ukraine [38, 39, and 40].

The MIT, ARTEMIS, NIST and UNIDO experts distinguish the following priority trends of industrial production technology [38, 39, 40].

- *control systems of production processes*, including the sensors of equipment condition, parameters of supply streams and condition (size, composition and others) of new facilities (to be processed or those that are grown);
- *multi-dimensional modeling of complex products* to optimize their various properties (strength, lifespan and, possibly, the production process) and customize the object, modifying it for the individual or small-scale production;
- *intelligent production management systems* (optimization of external and internal logistics, technological processes modes), including the field of robotics and Internet of Things;
- *system of creation and transformation (growing) of material objects*, including 3D-printing; infusion technology, which importance is growing; advanced methods of surface treatment and work with thermoplastics (the most important are the growth technologies);
- *materials, effective in creating the advanced actuators for the growth technologies*: composites and those that show their properties in the small-size structures.

In May 2016, realizing the need to reform the management system of high-tech sectors of the State and modernization of research and innovation infrastructure, the Department of Innovation and Intellectual Property of the Ministry of Economic Development and Trade of Ukraine has prepared and published for discussion a draft Stra-

Table 4

High-Tech Exports in the Structure of Industrial Exports in Selected Countries, 2006–2013 (%) (based on WB classification)

Country	Years							
	2006	2007	2008	2009	2010	2011	2012	2013
World	20.8	17.5	16.7	18.2	17.6	16.5	17.0	17.0
South Korea	32.1	30.5	27.6	28.7	29.5	25.7	26.2	27.1
Japan	30.1	27.2	25.9	21.5	19.9	18.1	17.8	17.8
USA	22.1	18.4	17.3	18.8	18.0	17.5	17.4	16.8
EU	18.5	14.0	13.6	15.2	15.4	15.0	15.4	14.3
Germany	17.1	14.0	13.3	15.3	15.3	15.0	15.8	16.1
Poland	3.7	3.0	4.3	6.1	6.7	5.9	7.0	7.7
Chine	30.5	26.7	25.6	27.5	27.5	25.7	26.2	27.0
India	6.1	6.4	6.8	9.1	7.2	6.9	6.6	8.1
Russia	7.8	6.9	6.5	9.2	9.1	8.0	8.4	10.0
Ukraine	3.4	3.7	3.3	5.6	4.3	4.4	6.3	5.9
Belarus	2.8	2.8	2.4	3.1	3.0	2.6	2.9	4.4
Kazakhstan	20.9	21.4	21.9	29.9	34.2	24.7	30.0	36.9

Note: Table is based on materials of [37].

tegy of Development of High-Tech Industries by 2025 [41], which partially contained the proposals on the implementation in Ukraine of the basic provisions of the Roadmap (SRF) for the period of 2015—2020. The above-mentioned draft Strategy is aimed at the formation of the necessary components of the innovation ecosystem, but has a lot of inconsistent regulations and needs a thorough revision.

The strategy includes five programs, which together make it possible to achieve the goals of the Strategy and create conditions for the innovation development of the economy:

1) Creation of high technology office (High Tech Office) as a tool to support the innovation projects;

2) Development of export-oriented innovation ecosystem;

3) Creation of digital agenda for Ukraine (Digital Agenda);

4) Attraction of innovative multinationals (Welcome MNC), a program to encourage and involve the international high-tech leaders in the development of production, the pursuance of research and in creation of jobs in Ukraine;

5) Approval of strategy for the development of *High Tech Nation* industries — the program of popularization of high technology, science and technology for the people of Ukraine, especially among the young people.

However, as shows the experience of leading countries, a base for the network structures dealing with the large-scale interdisciplinary research and subsequent commercialization of the results, according to the trends of science and technology, selected and agreed by community, is scientific and educational centers and research universities.

Thus, the example of creation of one of the elements of contemporary national research infrastructure in Ukraine, which is fully consistent with the Roadmap Foundation (SRF) for 2015— 2020, and their implementation in Ukraine is a pilot project to implement the concept of reference research university that provides «*...high quality alloy of the highest education and advanced research; it is also an individual approach to each student, his/her support by a scientific supervisor from the first years till the beginning of an independent scientific career; and finally, the maximum integration into the international research space, which is vital for the Ukrainian science*» [42].

On March 25, 2016, at the joint meeting the NAS of Ukraine and collegium of the Ministry of Education and Science of Ukraine made a decision

Table 5

Priorities in the Advanced Industrial Technologies of the EU, the USA, China, and Ukraine

The European Union	The USA	China	Ukraine
Advanced materials; Industrial biotechnologies; Micro- and nano-electronics; nanotechnologies and photonics; adaptive and reasonable production systems; digital, virtual and resource-efficient production; mobile and able to cooperate enterprises (network production and dynamic industrial chains); human centric production; consumer-oriented production	Sensors, measurement and control of processes; Contemporary design of materials, synthesis and processing technologies; visualization technologies, information and digital production; sustainable (rational) production; industrial nanotechnologies; production of flexible electronics; production biotechnologies and bioinformatics; 3D printing; Modern production and equipment for testing (quality control); industrial robotic engineering; Modern technologies of **shaping** and interconnection	ICT-industry of new generation; Bioengineering; Highly productive technologies and equipment; advanced materials; «reasonable technologies»	ICT-industry (first of all, in the sphere of software development; New composite materials with the prescribed properties; industrial nanobiotechnologies (first of all, biomedicine and pharmacy, new agrarian technologies); mathematic simulation for the creation of reasonable production systems; space research and developments (in particular, development of heavy rockets)

The table is compiled upon the materials [38—40].

to establish, on the basis of Physico-Technical Scientific and Training Center (FTSTC) of the NAS of Ukraine, *Kyiv Academic University* State Scientific Institution (KAU), which aims to modernize the network and increase the competitive ability of the Ukrainian higher educational institutions, provide the academic staff training for the research institutions and higher educational institutions, to develop a new generation of the national scientific elite in the natural science — mathematical and engineering spheres, create the opportunities for self-realization of personal potential of the talented youth in Ukraine, as well as to accelerate Ukraine's integration in the SRF [42, 43].

If successful, the regional academic universities will be created in Kharkiv, Dnipro, Lviv and Odesa. In 2016, it is planned to implement the first recruitment of masters in the amount of 100—150 people. In addition, the PhD training system can be radically improved in the NAS of Ukraine: the educational component of training for the postgraduate students will be held on the basis of the KAU and the research component on the basis of academic institutions. The world-renowned universities, such as California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT), are the examples of successful implementation of concept of the research university.

The governing body of KAU is the International Supervisory Board (ISB), which consists of the leading Western and Ukrainian scholars. The ISB functions are as follows:

- Regular evaluation of the quality of education and research training of students and post-graduate students with the assistance of independent international experts;
- Check of compliance of student and young researcher training programs with world trends in the development of scientific education and research fields;
- Organizing and conducting the open contests for the vacant posts of KAU professors-researchers, etc. [43].

On the recommendations of ISB, the research university KAU can create a number of centers listed in Table 6.

The creation and success of KAU may be the beginning of real reform of scientific and techni-

Table 6

Centers Attached to the KAU Research University

Name of Center	The basic functions
Center of scientific education (CSE)	Popularization of scientific research among the pupils, pre-university training and involving the talented youth in the KAU
Research centers (RC)	Pre-research training and research-innovation works of Bachelor of Arts, Master and PhD candidate on the basis of KAU, in cooperation with the academic institutions; Creating in Ukraine of Brain Circulation System instead of current Brain Drain; Discussion and identification of scientific directions of the research centers according to the present-day trends in the development of fundamental and applied sciences in cooperation with the International Supervision Council, the Scientific Council of KAU and the Scientific Council of the relevant academic Institute; Grant financing of scientific projects of RC by the NAS of Ukraine or the National Research Fund received on a competitive basis.
Innovation Center (IC)	Involvement of students, graduate students and junior researches of applied specialties in the innovative activities; Functioning according to the methods of innovation centers attached to the European universities.
Center of International Integration of KAU (CII)	Organizing the international scientific cooperation of KAU Departments, namely: Exchange of teachers and researchers; Internship for bachelors, masters and postgraduates in the leading European Centers and the European students and postgraduates at the departments and in the Research Centers of KAU; Conducting the joint schools and conferences; International innovative activities.

Note: Table is based on materials of [43].

cal sphere in Ukraine and may enable the NAS of Ukraine to become a true leader in the leading scientific research (including the creation of convergent technologies) which meet the pressing global challenges. KAU can also be a guide of innovative reforms in the country according to the rational specialization and integration into the European Research Area, taking into account the provisions of the Agreement on Ukraine and the EU, Strategy of Ukraine 2020 «The European Living Standards and Ukraine's Rightful Place in the World» and provisions of new Law of Ukraine on Science and R&D Activities of November, 26, 2015, no. 848-VIII, the Law of Ukraine on Education of July, 1, 2014, no.1556-VI, and new Law on Education.

The legislative provisions of such elements of research and innovation infrastructure as the technology parks, science parks, industrial parks, special (free) economic zones, as well as the provisions on the technology transfer, research university, identification of priorities of innovation activity and others require a substantial revision in view of the prospect for the implementation of key provisions of Agreement on Ukraine and the EU Association, as well as the preparation of the National Action Plan on the implementation of the Roadmap Foundation (SRF) for 2015—2020.

CONCLUSIONS

1. It was established that during the period of 2004—2015 the rapid growth of interdisciplinary research in the majority of core industries generated a need in using a more common management tool in the research and innovation activities than the technology platforms or clusters. The global technology leaders therewith began to build their research and innovation policy based on the model of four helices «*government — science — civil society — business*», which has many players to prevent the absorption by one structure (even powerful TNCs), in which the main element is not a cluster or technology platform, but the innovative ecosystem.

2. It is showed that beginning from 2012, the EU and associated countries have become the participants of the European research area development based on three priorities: *open science, open innovation, openness to the world*. The paradigm of open science therewith involves the creation of a unified *e*-infrastructure with the open access for the researchers from anywhere. The European cloud of open science is created within the paradigm that provides for technologies of joining and providing services to the public and private users, and the system of free access to end users of the system, as well as the strategy of a single digital market approved in 2015, in which the Cloud of open science will be available, service-oriented, embracing all stakeholders and will raise the research to the next level.

3. Implementation of *open innovation* concept involves the creation and support of the European technology platforms in the priority areas of innovation, namely the bio-economy (7 platforms); energy (8 platforms); the environment (1 platform); ICT (9 platforms); production and processes (8 platforms); transport (5 platforms); transverse (end-to-end) technologies (3 platforms).

4. In May, 2016, during the EC Ministerial Conference in the framework of the next meeting of the Council on the competitive ability of the EU, the Work Program was approved for the development of SRF for 2016—2017, which clearly formulated the priorities system at the supranational and national levels in the development of science and innovation and set the following objectives:

1) Providing the strategic recommendations at early stage in the development of policy in the sphere of science and innovation;

2) Consideration of the impact of other policies on the R&I agenda and making the recommendations as to the appropriate actions;

3) Consultations on the implementation of policies in the field of R&I and proposed measures for their support.

5. Clauses 374—376 of Ukraine—EU Association Agreement, which regulate the scientific and technical cooperation, have significantly broader tasks than those envisaged by the Action Plan for the Implementation of Ukraine—EU Association Agreement for 2014—2017.

The results of the plan implementation in 2015 are as follows:

1) Ratification of Agreement (by exchange of notes) between Ukraine and the European Union on the resumption of the Agreement between Ukraine and the EU on the scientific cooperation;

2) Ratification of Agreement between Ukraine and the European Union on the participation of Ukraine in the EU Program *Horizon—2020*, the Framework Program for Research and Innovation (2014—2020);

3) Adoption of a new version of the Law of Ukraine on Science and R&D Activities;

4) Consultations on the perspectives of Ukraine's associated participation in the research and training programs of the Euroatom;

5) Abolition of the mandatory sale of currency for the projects undertaken on the basis of agreements on the participation in the international programs of the EU.

At the same time, in 2015, the MES within the specified Action Plan confined itself to the following:

1) Carrying out of analysis of transfer technology networks activity in the European Union and the identification of main organizations for cooperation (EEN, EBN).

2) Formation of legislative proposals on the development of technology platforms, innovation clusters and networks of technology transfer and their inclusion in the draft Law of Ukraine on the Support and Development of Innovations.

The above measures indicate a very slow implementation of the tasks defined in Clauses 374—376 of Ukraine—EU Association Agreement, and the implementation of which was not even planned by the government in 2015—2016.

6. Since Ukraine did not submit to the ERF Committee its proposals for the National Action Plan for the implementation of the Roadmap ERF for 2015—2020, this is a direct violation of the new Law of Ukraine on Science and R&D Activities, as well as the relevant provisions of Ukraine—EU Association Agreement. To implement the Ukrainian Research Area, it is necessary to develop the National Action Plan for the implementation of the Roadmap ERF for 2015—2020, for the innovative development through: 1) open science; 2) open innovation; 3) strategy of reasonable specialization; 4) support of the EU through the technical assistance for the implementation of the national priorities agreed with ERF.

7. Draft Strategy of Ukraine on the development of high-tech industries by 2015 includes 5 programs and creates conditions for the development of innovation ecosystems in the country. The creation and success of the research universities in the regions of Ukraine, which have the largest concentration of research institutions (including the structures of the NAS of Ukraine) and the universities (KAU), may be the beginning of real reform of scientific and technical sphere in Ukraine and may provide the possibility for the NAS of Ukraine to become a true leader in the key scientific research that meet pressing global challenges, as well, as in the innovative transformation in the country, according to the reasonable specialization and integration into the European research area. All this can happen, taking into account the provisions of Agreement on the association of Ukraine and the EU, strategy of Ukraine, 2020 — «The European Living Standards and Ukraine's Rightful Place in the World», as well as the provisions of new Law of Ukraine on Science and R&D Activities, November 26, 2015, no. 848-VIII, the Law of Ukraine on Education, July, 1, 2014, no. 1556-VI, and new Law on Education.

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Recieved 05.10.16

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ІНСТИТУЦІЙНА ПІДТРИМКА НАУКОВО-ІННОВАЦІЙНОГО РОЗВИТКУ ПРИ ФОРМУВАННІ ЄДИНОГО ДОСЛІДНИЦЬКОГО ПРОСТОРУ В КРАЇНАХ ЄС І УКРАЇНІ

Обґрунтовано необхідність розвитку інноваційних екосистем як загальних інструментів управління дослідницькою та інноваційною діяльністю в умовах стрімкого зростання обсягів міждисциплінарних досліджень у більшості високотехнологічних галузей провідних країн світу. Наведено аналіз парадигм створення європейського дослідницького простору на основі трьох пріоритетів — відкритої науки, відкритих інновацій, розумної спеціалізації регіонів. Розроблено пропозиції до національного плану дій з реалізації українського дослідницького простору на основі імплементації Дорожньої карти зі створення єдиного європейського дослідницького простору країн ЄС 2015—2020 рр. та врахування їх у проекті Стратегії розвитку високотехнологічних галузей України до 2025 року.

Ключові слова: інноваційна екосистема, відкрита наука, відкриті інновації, український дослідницький простір, дорожня карта створення ЄДП.

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ИНСТИТУЦИОННАЯ ПОДДЕРЖКА НАУЧНО-ИННОВАЦИОННОГО РАЗВИТИЯ ПРИ ФОРМИРОВАНИИ ЕДИНОГО ИССЛЕДОВАТЕЛЬСКОГО ПРОСТРАНСТВА В СТРАНАХ ЕС И УКРАИНЕ

Обоснована необходимость развития инновационных экосистем как общих инструментов управления исследовательской и инновационной деятельностью в условиях стремительного роста объемов междисциплинарных исследований в большинстве высокотехнологических отраслей ведущих стран мира. Приведен анализ парадигм создания европейского исследовательского пространства на основе трех приоритетов — открытой науки, открытых инноваций, разумной специализации регионов. Разработаны предложения к национальному плану действий по реализации украинского исследовательского пространства на основе имплементации Дорожной карты по созданию единого Европейского исследовательского пространства стран ЕС 2015—2020 гг. и учета их в проекте Стратегии развития высокотехнологических отраслей Украины до 2025 года.

Ключевые слова: инновационная экосистема, открытая наука, открытые инновации, украинское исследовательское пространство, дорожная карта создания ЕДП.