
Organizational mechanism of the research infrastructure development in framework of european integration

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Abstract: based on an analysis of the development of the European Research Area (ERA), European Research Infrastructures, models and organizational approaches to the sharing of scientific equipment (core facility) and research infrastructure, an organizational mechanism for the development of research infrastructure within the framework of European integration is proposed.

This organizational mechanism is aimed at creating conditions for the transition from the application of the organizational approach of sharing scientific equipment (core facility), which uses centralized organizational management models and hierarchical organizational management structures, to the organizational approach of research infrastructure used by research communities and based on scientific data, computing systems, communication networks and tools, which uses different organizational management models, with the subsequent transition to the application of the "Quadruple Helix" organizational approach of the research infrastructure ecosystem within the framework of a network organizational management structure.

Five levels of organizational development are identified: sharing of scientific equipment (core facility) by national scientists (collective use center), sharing of scientific equipment (core facility) by national and international scientists (collective use center), sharing of scientific equipment (core facility) by national and international scientists (fund, platform, alliance), research infrastructure and «Quadruple Helix» ecosystem of international research infrastructure.

The organizational development mechanism includes: set of organizational structural components that ensure orderly interaction towards achieving levels of organizational development and organizational changes in strategic orientation, organizational structure, institutional and legal form, organizational procedures while supporting: planning systems, research/innovation, data computing, information and data exchange, integration into the European Open Science Cloud (EOSC), electronic infrastructure platforms (e-IRG) and European Research Area (ERA) tools.

The proposed organizational mechanism for the development of research infrastructure within the framework of European integration provides new opportunities for cross-border cooperation for scientific communities within the framework of the "Quadruple Helix" ecosystem of research infrastructure, which increases public participation and strengthens the responsibility of scientific research for society as a whole and develops global partnerships of research infrastructures in the European Research Area (ERA).

Keywords: European Research Area; organizational mechanism; organizational structural components; organizational approaches; sharing of scientific equipment; research and technological infrastructure; research infrastructure ecosystem.

1. Introduction

Over the past decades, the European Union (EU) has made comprehensive policy efforts to strengthen global competitiveness by supporting European science, technology and innovation policies for growth, sustainability and prosperity [1].

The European Research Area (ERA) was launched with the aim of creating a single market for research and innovation for the free movement of researchers, scientific knowledge, innovation and the development of a competitive European industry. The European research landscape is focused on strengthening cross-border cooperation, competition, and improving national research and innovation policies [2, 3]. The European Research Area (ERA) is based on the implementation of: a governance system, including the ERA Forum, the ERAC (European Research Area and Innovation Committee), the Council, the Pact for Research and Innovation in Europe; and an ERA policy agenda with concrete actions [4].

The European Research Area (ERA), as a theoretical concept of a political project to address the fragmentation of the EU research and innovation system (1973), is recognized by Article 179 of the Lisbon Treaty, which defines the free movement of researchers, scientific knowledge and technology (2007), Article 182 of the Lisbon Treaty is used to establish the legislative measures necessary to implement: the European Research Area (2009), the ERA Roadmap (2015), the ERA National Action Plans (2015-2020), the ERA objectives responding to new challenges such as the green and digital transitions (2019), the adoption of the Pact for Research and Innovation in Europe and the ERA Policy Agenda for 2022-24 (2021) [5].

The ERA policy agenda for 2022-2024 identified four priority areas: deepening the existing knowledge market; jointly addressing the challenges of the transition to green, digital technologies with increased societal participation; expanding access to research and innovation across the EU; and developing joint investments and reforms in research and innovation [6]. The ERA Policy Agenda 2025-2027 outlines voluntary actions aimed at translating research and innovation (R&I) policy priorities in Europe into concrete actions, bringing together EU Member States, countries associated with Horizon Europe, research and innovation stakeholders and the European Commission to make ERA a reality [7].

The ERA Law (2026) defined: national obligations to increase investment in research and development to achieve 3% of GDP, the need for better coordination of research and innovation policies between the EU and the Member States, the need to improve conditions for researchers, the protection of scientific freedom, ethics and integrity of research, gender equality [8]. The initiative of a new set of measures (2026) strengthens Europe's international engagement through research and innovation. The initiative aims to strengthen Europe's global partnerships while protecting its strategic interests, keeping international cooperation open and secure, and increasing Europe's attractiveness for talent and innovation worldwide [9].

The European Research Area (ERA) platform aims to create a borderless single market for research, innovation and technology across the EU, facilitating the free movement of researchers, knowledge and innovation. It seeks to align national policies, increase competitiveness, strengthen cooperation and accelerate the digital and green transitions through structured, shared priorities [10].

Openness is a key concept of open scientific communities, which provides these communities with open science practices within the European Research Area (ERA) [11]. Open scientific communities, relying on scientific instruments and electronic infrastructures, contribute to the creation of knowledge and expertise across Europe and the world [12]. Open science is at the heart of European research policy. Open science is an approach to the scientific process that focuses on the creation and dissemination of knowledge through digital technologies. The aim is to ensure that Europe is best placed to reap the benefits of open science by opening up the research system between scientists and across disciplines to society at large. Open science fosters collaboration and improves the quality of research, making science more impactful for society [13].

The launch of the European Research Area (ERA) was a crucial step towards the emergence of a distinct European policy on research infrastructures and a coordinated European approach to the provision of research services on a European scale. Since the early 2000s, European policy on research infrastructures has developed in line with three policy initiatives: first, the creation of the European Strategy Forum on Research Infrastructures (ESFRI) in 2002 and the ESFRI Roadmap since 2006; second, the partial rethinking of the Research Framework Programme (FP), which

provided for the allocation of a budget starting from the Seventh FP (2007–2013) for the establishment and development of research infrastructures; and third, the creation of the European Research Infrastructure Consortium (ERIC) in 2009, a specific legal form governed by EU law [14].

The European Strategy Forum on Research Infrastructures (ESFRI) has a mandate from the Council of the EU to develop policy on research infrastructures in Europe, as well as to promote multilateral initiatives leading to better use and development of research infrastructures at EU and international level [15]. ESFRI supports the ERA law (2026) as a key opportunity to strengthen the European Research Area and ensure the formation of an ecosystem of European Research Infrastructures, emphasizing the central role of research, technology and digital infrastructures in promoting excellence, innovation, talent attraction and competitiveness [16]. ESFRI emphasizes the importance of supporting a holistic approach that integrates research, technology, scientific data, digital infrastructures and consolidates the governance of research and technology infrastructures to maximize their impact [17]. The European Research Infrastructure Consortium (ERIC) provides a legal framework that facilitates the joint creation and operation of major international research infrastructures, ensuring open access for European researchers [18]. ESFRI supports the further strengthening of the legal framework of the European Research Infrastructure Consortium (ERIC) to better support pan-European research infrastructures. Support focuses on three key areas: integration of ERIC elements, including staff mobility, integration of national nodes and harmonisation of legislation; stronger stakeholder relations, increased collaboration with industry, public authorities, academia and technology infrastructures; and long-term sustainability of the ERIC, with a focus on sustainable funding, strategic planning and infrastructure modernisation [19].

European research infrastructures specialized in specific subject areas of research are the basis for the implementation of ERA through Open Science, Open Science Commons and EOSC [20]. The European Open Science Cloud (EOSC) is a key initiative creating a federated pan-European ecosystem that integrates existing research infrastructures, data and services. EOSC serves as a foundation for digital research sovereignty, ensuring seamless access to data and computational tools across disciplines and countries [21].

The federated environment of European e-Infrastructures, implemented in the European Grid Infrastructure (EGI) through the Core Infrastructure platform, is a key enabler for distributed management and processing of big data and a fundamental basis for implementing the EOSC service integration and management system, which facilitates collaboration between research communities. The approach to implementing EOSC through the Open Science Commons relies on a federation of cloud hubs, where the cloud hub provides data, services and capabilities in a standard and interoperable way. The hubs apply the cloud services paradigm to facilitate sharing, data reuse and tools through virtualization [22]. The European Data Infrastructure (EDI) is a core component providing high-performance computing (HPC), high-speed connectivity and massive data storage to support the European Open Science Cloud (EOSC). It allows researchers, industry and public services to process, move and share big data across borders [23].

European research infrastructures, as part of the system of long-term development of research and innovation in Europe, are able to integrate scientific fields and create centers of knowledge and innovation around research infrastructures, attracting highly qualified experts and providing a space for the exchange of knowledge, ideas, and cooperation between industry and academia [24].

Research infrastructures are of fundamental strategic importance for Europe's global competitiveness and remain at the heart of the knowledge triangle: research, education and innovation.

The European ecosystem of research infrastructures encompasses numerous institutions and stakeholders working at the forefront of scientific discovery [25]. Research infrastructures and technology infrastructures are the backbone of the European research and innovation system. They range from cutting-edge laboratories, large scientific instruments and data centres to pilot lines and testbeds. Together, they support the full innovation cycle – from basic research to the deployment of new technologies. This makes them essential for scientific excellence, competitiveness and

technological sovereignty of Europe. The key priorities of the European Strategy for Research and Technology Infrastructures include: strengthening the ecosystems of all infrastructures, promoting improved access for scientists, researchers and innovative companies to cutting-edge equipment and services across Europe, attracting and developing talented people, improving governance and alignment of national and European priorities, and strengthening international cooperation and resilience [26].

Thus, over the past decades, the European Union (EU) has made comprehensive efforts to create political, legal and organizational mechanisms for the formation and development of the European Research Area (ERA). The launch of the European Research Area (ERA) was a decisive step towards the emergence of a separate European policy and legal mechanisms that promote the creation and development of European Research Infrastructures specializing in certain subject areas of activity and are the basis for the further development of the European Research Area (ERA) through the application of an open approach, open scientific communities (Open Science Commons), open science (Open Science), the European Open Science Cloud (EOSC) and electronic infrastructure (e-IRG).

2. Research of existing solutions of the problem

European research institutions and universities use different organizational approaches to use complex, expensive scientific equipment to conduct advanced scientific research. The main organizational approaches are: shared use of scientific equipment (core facility), research infrastructure (RI), research infrastructure ecosystem.

The organizational approach of sharing scientific equipment (core facility) applies centralized management models and provides access to shared resources, allowing for collaboration, knowledge exchange, and the development of new research methodologies and approaches. It provides access to scientific equipment and services on a non-competitive fee basis [27]. Core facilities can be located in shared facilities, such as units of academic or educational institutions [28], in a pool of scientific equipment shared by several universities [29], in a research operations office that provides access to shared scientific equipment by several scientific and educational institutions [30], platforms for sharing equipment [31], strategies for sharing research resources [32], etc. Subjects of scientific and scientific and technical activity who may be provided with the services of a collective use center and other organizational forms of shared use of scientific equipment include scientific and scientific and pedagogical workers, students, masters, postgraduate students, associate and doctoral students, other scientists, as well as scientific institutions, higher education institutions [33].

The organizational approach of research infrastructure is used by research communities to conduct research, promote innovation and includes: scientific equipment (or toolkits), knowledge-based resources (collections and archives of scientific data), computing systems, communication networks and tools. Research infrastructures (RIs) are implemented according to different organizational models: central sources and laboratories for experiments and measurements, coordination and management of distributed observatories or laboratories, remote access to resources for computing, data, sample storage, etc. [34].

The European Strategy Forum on Research Infrastructures (ESFRI) identifies six stages of organizational development of research infrastructure [35].

The research infrastructure development model defines research infrastructure as a platform that integrates facilities, resources, and services (scientific equipment, scientific data, sample repositories, archives, electronic infrastructures with software, computing systems, and communication networks) to conduct research and facilitate innovation [36].

The model of research infrastructure development within the framework of European integration applies the Quadruple Helix approach and defines the structural levels at which the phased development of research infrastructure is determined in the context of the transition from organizing research using a collective use center to applying the organization of research using research

infrastructure within the framework of integration into the European landscape of research infrastructures [37].

European research infrastructures are divided into types that demonstrate and those that are landmarks, local and distributed location, location by domains and fields [38].

However, individual research infrastructures do not have all the equipment and resources needed to address complex scientific/societal problems and challenges, especially when they are multidisciplinary or interdisciplinary in nature. The development of a research infrastructure ecosystem offers new opportunities to expand the scope, impact and efficiency of individual research infrastructures, but requires significant incentives that will help policymakers and managers to support research infrastructure ecosystems across research disciplines and increase the added value of research infrastructures for society [39].

The organizational approach to creating and developing a research infrastructure ecosystem is aimed at supporting cutting-edge science that can be the basis for making political and managerial decisions to solve scientific/societal problems and challenges [37,40]. Research infrastructure ecosystems encourage the consolidation, integration and further development of integrated research infrastructures at regional, national, and European levels [41].

In a dynamic and globally connected economy, traditional organizational structures are rapidly reaching their limits and network organizational structures represent a modern evolution of classic traditional organizational structures. A network organizational structure brings together, as internal teams, departments or external organizations, functioning as a single entity, together to achieve common results. It offers flexibility and agility to respond to current challenges or changes in the market, while promoting collaboration and innovation, allowing network participants to pool their expertise and generate creative solutions. In contrast to traditional organizational structures, a network organizational structure focuses on connections and collaboration [42]. The organizational approach of the network organizational structure involves a transition from a rigid organizational hierarchy to a flexible structure of interconnected units, teams or external partners. Key mechanisms include: decentralized decision-making, cross-functional team collaboration, digital communication and technology, and a culture of trust. This allows network organizations to combine the advantages of small specialized units with the resources of a larger organization, increasing innovation and efficiency [43].

Network organizations represent an evolution of organizational models that stimulate the development of cooperation, knowledge exchange, and the reduction of structural and cultural barriers to the development of more productive organizational work [44]. The organizational approach of the network organizational structure is an adequate response to the dynamic and innovative external environment. Five stages of development are identified: exchange, development, expansion, action, and inter-organizational learning, as one of the goals of the network, which enhances its achievements [45]. The transition from traditional hierarchical organizational structures to network organizational structures represents a modern fundamental transformation in modern organizational design, and organizations that implement network structures are the most successful and receive significant advantages: flexibility and speed of response to market changes, promotion of innovation due to diverse views and experiences [46].

Thus, the transition from the application of the organizational approach of sharing scientific equipment (core facility) to the application of the organizational approach of research infrastructure and organizational approach of the research infrastructure ecosystem is inevitable. The key drivers of this transition are: the cost and complexity of modern scientific equipment, expensive maintenance and operation of scientific equipment; the need for highly qualified expertise, technical personnel; the need to solve complex problems through interdisciplinary science; the transition to large-scale data, the digitalization of scientific research, the need to use open science practices that require computing power, high-quality data storage; the integration of research infrastructures and international cooperation.

International cooperation within the framework of organizational approaches of research infrastructure and research infrastructure ecosystem covers the sharing of unique facilities (laboratories, instruments) of European Research Infrastructure Consortiums (ERIC), access to data through the European Open Science Cloud (EOSC) and the European Data Infrastructure (EDI), participation in projects and roadmaps of the European Strategy Forum on Research Infrastructures (ESFRI), joint research and public-private partnerships within the framework of European programs.

The application of organizational approaches to research infrastructure and research infrastructure ecosystems reinforces the contemporary evolution of organizational development in a dynamic and globally connected economy, which is associated with the transition from the traditional hierarchical organizational structure of organizational management to a network organizational structure.

However, there are few scientific publications on organizational mechanisms for the development of research infrastructures, including organizational mechanisms for the development of research infrastructure within the framework of European integration.

In this context, research on changing the organizational approach to the sharing of scientific equipment (core facility) to the application of organizational approaches to research infrastructure and research infrastructure ecosystems using the organization of a network organizational structure is important and relevant.

3. Research results

Based on the analysis of European political, legal and organizational mechanisms for the formation and development of the European Research Area (ERA), organizational approaches to the sharing of scientific equipment and European research infrastructures, an organizational mechanism for the development of research infrastructure within the framework of European integration is proposed. This organizational mechanism is aimed at creating conditions for the transition from the sharing of scientific equipment (core facility) within the framework of a traditional hierarchical organizational management structure to the application of the “Quadruple Helix” ecosystem of international research infrastructure within the framework of a network organizational management structure, Fig. 1.

The organizational mechanism includes a set of structural components that ensure order and interaction: organizational level of development, strategic orientation, organizational structure, institutional legal form, organizational procedures, and support systems for structural components.

The proposed mechanism defines five levels of organizational development: sharing of scientific equipment (core facility) by national scientists (collective use center), sharing of scientific equipment (core facility) by national and international scientists (collective use center), sharing of scientific equipment (core facility) by national and international scientists (fund, platform, alliance), research infrastructure and «Quadruple Helix» ecosystem of international research infrastructure.

The strategic orientation depends on the stage of development and varies from orientation on national priorities/challenges to orientation on European priorities/challenges, smart specialization (RIS3), national and European roadmaps for the development of research infrastructures, integration into the European landscape of research infrastructures.

The organizational structure depends on the stage of organizational development and changes from the application of a linear/matrix management model to the initial network structure, when there is no single rigid management center and there are possibilities for changes by adding or removing participants, which remain independent to the application of a network organizational structure and network organization of IT infrastructure within the «Quadruple Helix» ecosystem of the research infrastructure of the European Research Infrastructure Landscape.

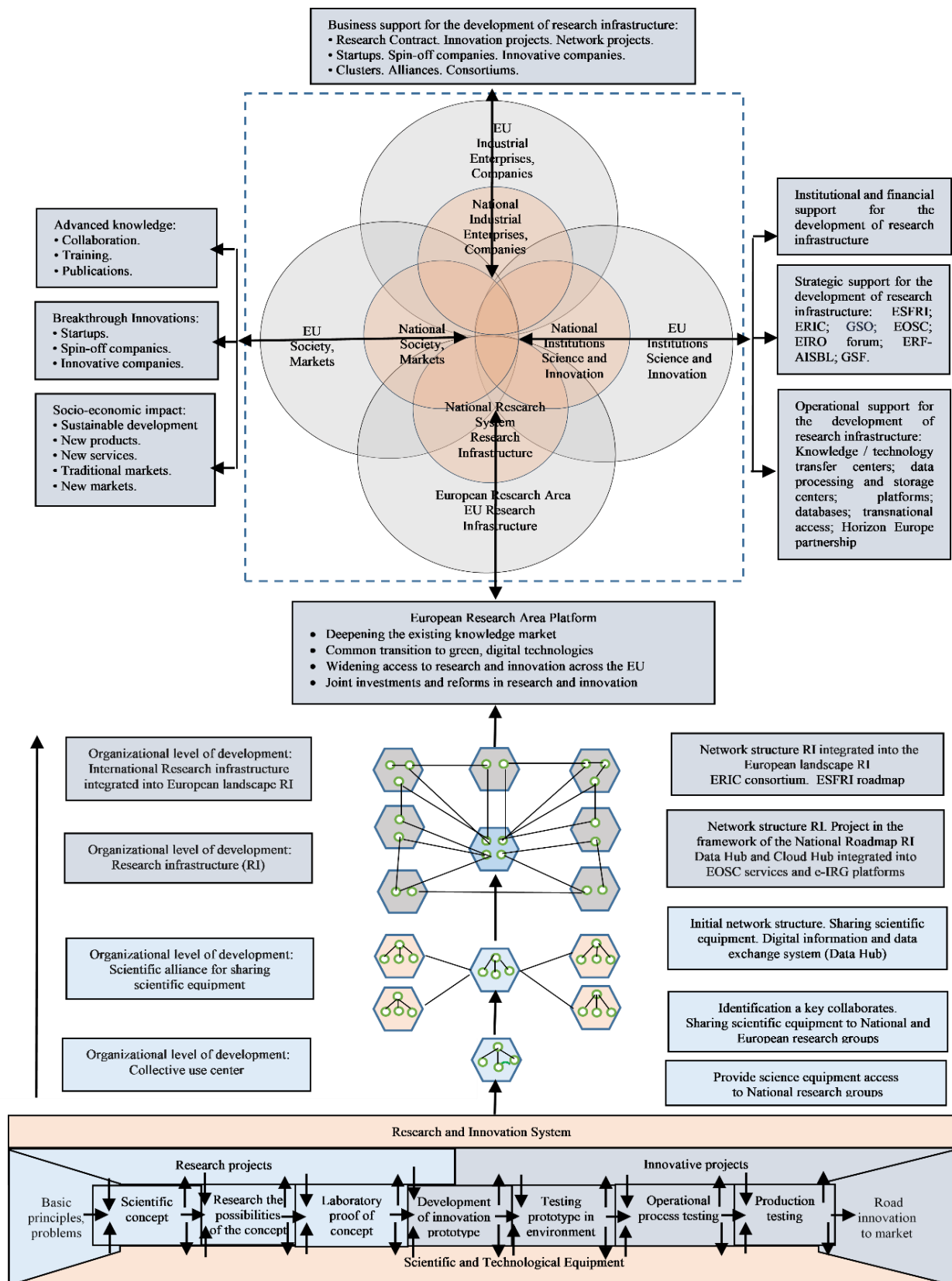


Fig. 1. Organizational mechanism for the development of research infrastructure within the framework of European integration

The institutional legal form changes in the process of changing the stage of organizational development from a unit within one institution, as a center for collective use, to the use of an

association (fund, platform, alliance) of scientific institutions, universities for the joint use of scientific equipment with the subsequent launch of a research infrastructure project consortium and the creation of a European consortium of international research infrastructure.

The main organizational development procedures include: acquisition of new scientific equipment, acquisition of software, digital and computing tools; use of open science practices and open innovation practices; creation of a knowledge/innovation center, support for startups/spin companies; support for technology transfer; support for joint national and European projects for the creation and development of research infrastructure; creation of a data center (Data Hub), creation of a cloud hub (Cloud Hub) and their integration into the European Open Science Cloud (EOSC) and electronic infrastructure platforms (e-IRG) and the European Research Area (ERA) platform.

Organizational procedures for establishing an ERIC (European Research Infrastructure Consortium): consultations with future ERIC members; preparation of application documents; completion of National procedures for coordination, consent and commitments of each future ERIC member; verification of the application for compliance with the requirements of the ERIC regulations; declaration of the host state on the recognition of the ERIC; recommendations for changes to the scientific and technical description and statutes; official request to the European Commission; request from the European Commission to the ERIC Committee; notification of the decision to the applicants and publication in the Official Journal of the European Union [47].

Organizational procedures for inclusion in the ESFRI roadmap: positive decision on country participation and recommendations of the National Committee for Research Infrastructures; documentation demonstrating the scientific quality and maturity of the consortium, governance structure and long-term financial sustainability; official letters of political and financial support; submission of the draft ESFRI application to the National Committee for Research Infrastructures; submission of the draft application to the ESFR Executive Board; assessment of the draft application by the strategic working groups and the implementation group; submission of recommendations by the Executive Board to the ESFRI Forum; inclusion in the ESFRI roadmap [48, 49].

The main components of the organizational mechanism for the development of research infrastructure within the framework of European integration are presented in Table 1.

Table 1. Main components of the organizational mechanism for the development of research infrastructure within the framework of European integration

Organizational level of development	Основні складові організаційного механізму
Sharing of scientific equipment (core facility) by national scientists (collective use center)	• <i>strategic orientation</i> - national priorities and challenges; • <i>organizational structure</i> - linear/matrix management model, including the head of the center, scientific and technical council, equipment maintenance personnel; • <i>organizational legal form</i> - unit within a scientific or educational institution. • <i>organizational procedures</i>: - purchase of new scientific equipment and search for funding within the framework of national programs; - provision of access services to scientific equipment for conducting national research by scientific and scientific-pedagogical workers, students, masters, postgraduates, doctoral students; - contracts, regulations and instructions for access to equipment, schedules and rules for conducting research work; - cooperation with national industrial enterprises and SMEs, testing scientific results to determine ways to create innovations.

Continuation of the Table 1

Sharing of scientific equipment (core facility) by national and international scientists (collective use center)	• <i>strategic orientation</i> - national priorities; national roadmap for the development of research infrastructure. • <i>organizational structure</i> - linear/matrix management models, including the head of the center, scientific and technical council, equipment maintenance personnel; • <i>organizational legal form</i> - agreements on joint activities without the formation of a legal entity and the pooling of resources. • <i>organizational procedures</i>: - identification of key international partners and search for funding, including within the framework of European programs; - cooperation between national and European scientific institutions/universities, exchange of vision and establishment of trust; - regulations and instructions for access to scientific equipment for conducting research with the participation of international scientists. • cooperation with industrial enterprises and SMEs, testing scientific results to identify ways to co-create innovations.
Sharing of scientific equipment (core facility) by national and international scientists (fund, platform, alliance)	• <i>strategic orientation</i> - national and European priorities; national and European roadmap for the development of research infrastructure; • <i>organizational structure</i> - the initial network structure of relationships between research institutions, universities, interested participants; • <i>organizational legal form</i> - the charter and agreement of the association of scientific institutions, universities for the joint use of scientific equipment (Core Facilities) and includes a steering committee / coordination council, personnel for equipment maintenance. • <i>organizational procedures</i>: - agreement on goals, initial network structure, roles in the network; - establishing cooperation with international and European research institutions/universities, sharing vision and building trust; - purchasing software, digital data management tools; - synchronization of software and digital tools according to common access rules for research institutions and universities; - creation of a data center (Data Hub), providing access to the platform of data sets from different sources; - participation in projects of national and European programs; - cooperation with industrial enterprises and SMEs, testing scientific results and identifying ways to implement innovations.
Research infrastructure	• <i>strategic orientation</i> - national and European priorities; national and European roadmap for the development of research infrastructure, smart specialization (RIS3); • <i>organizational structure</i> – network organizational structure; • <i>organizational legal form</i> – consortium for the implementation of the research infrastructure project. • <i>organizational procedures</i>: - feasibility study of the research infrastructure project; - coordination of the research infrastructure project within the framework of the national and European roadmap;

Continuation of the Table 1

	- synchronization of the computing equipment of the data center (Data Hub) and the cloud hub (Cloud Hub) according to unified access rules; - integration of the Data Hub and Cloud Hub into the European Open Science Cloud (EOSC) and electronic infrastructure platforms (e-IRG); - access to grid networks, supercomputers, digital databases; - cooperation with European initiatives, including participation in competitions of European programs and ERIC. - use of open science practices at the stages of the scientific research process and open innovation practices at the stages of the innovation process; - use of current practices of technology and knowledge transfer, cooperation with incubators and accelerators; - support for startups/spin companies of research infrastructure.
International research infrastructure integrated into the European landscape («Quadruple Helix» ecosystem of international research infrastructure).	• <i>strategic orientation</i> - European priorities and international challenges; European Roadmap for Research Infrastructure Development, Smart Specialization (RIS3); European Structural and Investment Funds (ESIF) programs. • <i>organizational structure</i> - network organizational structure within the research infrastructure ecosystem. • <i>organizational legal form</i> - ERIC (European Research Infrastructure Consortium), the status is determined by all EU countries, the internal structure is determined by the statute of the founding country of the research infrastructure. • <i>organizational procedures</i>: - creation of a knowledge and innovation center, which provides a space for the exchange of knowledge and ideas, educational programs, support for start-ups and spin-off companies; - creation of ERIC (European Research Infrastructure Consortium); - inclusion in the ESFRI roadmap.

Systems supporting the organizational mechanism for the development of research infrastructure:

- research and innovation system that combines the use of research infrastructure and technological infrastructure, ensuring the implementation of research projects, obtaining scientific results and innovation projects, creating and implementing innovations;
- data center computing system (Data Hub);
- digital data exchange system of the cloud hub (Cloud Hub);
- system for integrating the data center (Data Hub) and the cloud hub (Cloud Hub) into the European Open Science Cloud (EOSC) and electronic infrastructure platforms (e-IRG) and the European Research Area (ERA) platform.

The Cloud Hub of a research infrastructure can be presented as a data hub collaboration platform that connects to the cloud hubs of other European research infrastructures, providing a virtual space for open scientific communities operating within the research infrastructure to conduct collaborative scientific research and facilitating the sharing and reuse of data on research results. The Data Hub platform within the Research Infrastructure Cloud Hub can provide simple and efficient access to large-scale datasets, allowing for the sharing, discovery, and processing of data from open scientific community sources within the Research Infrastructure. The Cloud Hub of the research infrastructure can be considered as a component of the European Open Science Cloud (EOSC) with standardization of interoperability and management of a set of components: user access portal (interface for researchers, including collaboration tools, documentation tools); resource management (data discovery, data management and processing service management); computing infrastructure (services

that provide integration of applications, algorithms and/or software); runtime environment (implements processing functions, receives data necessary to start processing, executes requests to manage resources necessary for data processing). Linking the resources of the Cloud Hub and Data Hub of the research infrastructure with the European Research Area (ERA) platform is achieved by combining them into the European Open Science Cloud (EOSC).

By adopting the international FAIR (Findable, Accessible, Interoperable, Re-usable) data principles, integration into the European Open Science Cloud (EOSC) and alignment with the ERA Policy Agenda can be achieved, ensuring that research infrastructure researchers have seamless access to data, tools and computing resources across Europe [50].

This will enable open scientific research infrastructure communities to deepen the knowledge base of research infrastructure, support the transition to green digital technologies, expand access to research and innovation in research infrastructure, and stimulate investment in research infrastructure.

4. Conclusions

The European Union (EU) has made comprehensive efforts to create political, legal and institutional mechanisms for the development of the European Research Area (ERA), strengthening global partnerships and international cooperation in Europe through research and innovation. European Research Infrastructures are the basis for the development of the ERA through the use of an open approach, Open Science Commons, Open Science, the European Open Science Cloud (EOSC), and e-Infrastructure (e-IRG).

However, research institutions and universities continue to apply the traditional organizational approach of sharing scientific equipment (core facility), which has significant drawbacks: expensive maintenance and operation of scientific equipment, the need to solve complex problems and challenges, the complexity of the transition to the digitalization of science and the use of open science practices using computing power, high-quality scientific data repositories, and network collaboration.

The proposed organizational mechanism for the development of research infrastructure within the framework of European integration ensures the transition from the application of the organizational approach of sharing scientific equipment (core facility) to the application of the organizational approach of research infrastructure and to the application of the «Quadruple Helix» ecosystem of international research infrastructure. The Quadruple Helix approach to research infrastructure ecosystems brings together government, academia, industry and civil society. Through the engagement of civil society (the fourth helix), research infrastructure activities should respond to societal needs, accelerating innovation.

The proposed organizational mechanism defines a phased organizational development that involves organizational changes in strategic orientation, organizational structure, institutional and legal form, and organizational procedures in a dynamic and globally connected economy, which is associated with the transition from a traditional hierarchical organizational management structure to a network organizational management structure of the research infrastructure ecosystem.

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