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ORIGINAL PAPER

DESIGN PRINCIPLES OF INNOVATION INFRASTRUCTURE AT THE MESO-LEVEL

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Abstract. The new stage of planetary development is characterized by a structural reset of the global economy, associated with increased tension between centres of power and imbalance accumulation in the global trade and financial system, on one hand, and given the great technological leap, by a significant increase in the role of modern technologies, high-tech industries, innovative solutions that can change the industry structure fundamentally, as well as business models, factors and conditions of national economies competitiveness, on the other hand. The effective innovation infrastructure formation, providing conditions for creating and implementing opportunities for integration and effective use of education, science, industry and business resources at all stages of the innovation process, should be considered one of the main incentives for innovation development. However, in Russia at present there is a problem of inconsistency between the actual activities of innovation infrastructure facilities and the declared objectives. In this regard, the design of innovation infrastructure based on basic principles should be recognized as the most important stage of its life cycle, which lays the foundation for its further balanced functioning and development. The purpose of the research presented in the article is to define and disclose the essence of the principles of designing meso-level innovation infrastructure – a set of regional, sectoral and branch innovation infrastructures. According to the purpose, sequentially: the analysis of the main scientific approaches to understanding the essence of innovation infrastructure has been conducted; the place of the design process in the life cycle of innovation infrastructure, as well as its role in providing its further effective and reasonable functioning and development has been defined; the technology (through the description of processes) of innovation infrastructure design has been revealed; the principles of meso-level innovation infrastructure design and their description of the essence and content nature has been described. Prospects for further research, in the authors' opinion, consist in detailed study of possibilities and mechanisms of the design process contribution to ensure the innovation infrastructure balance.
Keywords: project life cycle, innovations, innovation activity, innovation infrastructure, meso-level, design

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ОРИГИНАЛЬНАЯ СТАТЬЯ

ПРИНЦИПЫ ПРОЕКТИРОВАНИЯ ИННОВАЦИОННОЙ ИНФРАСТРУКТУРЫ МЕЗОУРОВНЯ

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Аннотация. Новый этап планетарного развития характеризуется, с одной стороны, структурной перезагрузкой мирового хозяйства, связанной с ростом напряженности между центрами силы и аккумуляцией дисбаланса в мировой торговой и финансовой системе, а с другой, – учитывая большой технологический скачок, – значимым повышением роли современных технологий, высокотехнологичных производств, инновационных решений, способных кардинально поменять отраслевое строение, а также бизнес-модели, факторы и условия конкурентоспособности национальных экономик. Одним из главных стимулов развития инноваций следует считать формирование эффективной инновационной инфраструктуры, обеспечивающей условия для создания и реализации возможностей интеграции и эффективного использования ресурсов образования, науки, промышленности, бизнеса на всех этапах инновационного процесса. Однако в настоящее время в России отмечается наличие проблемы несоответствия фактической деятельности объектов инновационной инфраструктуры заявленным целям. В связи с чем проектирование инновационной инфраструктуры, основанное на базовых принципах, следует признать важнейшим этапом ее жизненного цикла, на котором закладывается основа ее дальнейшего сбалансиро-

ванного функционирования и развития. Цель представленного в статье исследования состоит в определении и раскрытии сущности принципов проектирования инновационной инфраструктуры мезоуровня – совокупности региональной, секторальной и отраслевой инновационных инфраструктур. В соответствии с целью последовательно: проведен анализ основных научных подходов к пониманию сущности инновационной инфраструктуры; определено место процесса проектирования в жизненном цикле инновационной инфраструктуры, а также его роль в обеспечении ее дальнейшего эффективного и обоснованного функционирования и развития; раскрыта технология (через описание процессов) проектирования инновационной инфраструктуры; сформулированы принципы проектирования инновационной инфраструктуры мезоуровня и дано описание их сущностно-содержательной природы. Перспективы дальнейшего исследования, по мнению авторов, состоят в детальном изучении возможностей и механизмов вклада процесса проектирования в обеспечение сбалансированности инновационной инфраструктуры.
Ключевые слова: жизненный цикл проекта, инновации, инновационная деятельность, инновационная инфраструктура, мезоуровень, проектирование

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Introduction

The design, formation and development of the innovation infrastructure of the national economy largely determines its qualitative transformation into an economy of knowledge, high technology and high productivity, which is extremely important in modern realities, when Russian economy is forced to develop under unprecedented sanctions pressure, increasing opportunities on the conceptual policy implementation justified in terms of economic efficiency, import substitution of consumer and investment goods and technologies.

The focus on studying the innovation infrastructure in meso-level systems has a high level of significance, due to their role as a link between macro-level systems (national and global innovation infrastructure) and micro-level systems (local innovation enterprise infrastructures). The innovation infrastructure of the meso-level is a set of regional, sectoral and branch innovation infrastructures.

Conceptual and applied aspects of the evolution of the content and role of innovation infrastructures of various types have been actively discussed by Western scientists since the beginning of the 21st century, and every year the theoretical and applied interest in clarifying and developing this issue only increases (see [1-5], for example). The theory of innovation development is being actively studied and developed within the framework of traditional institutionalism: it is noted that in the current phase of innovation trajectories, the quality of the institutional system plays a crucial role, i.e. its ability to unite various participants in the process of innovation generation [6].

In the Russian scientific community, the issue of a generally recognized definition of the innovation infrastructure, which fully reveals its essence and nature, still remains open. So, from the standpoint of a systematic approach, the innovation infrastructure is a system of interrelated and complementary elements that ensure the implementation of all stages of the innovation process; it is built and operates on the principles of integrity, compatibility, structuredness, multiplicity, adaptability, etc. Representatives of the institutional approach characterize the innovation infrastructure as a complex of organizational and economic institutions that provide conditions for the effective innovation processes implementation; it is characterized by a certain proportionality between its constituent elements. Within the framework of the structural and functional approach, the innovation infrastructure is presented as a certain set of some static structure-subsystems that perform clearly defined functions (providing, stimulating, integrating), the purpose of which is to develop, implement and apply innovations. The process approach to understanding the innovation infrastructure defines it as a set of activities within a particular stage of the innovation process, which is provided by a set of interconnected systems (see [7-12], for example).

According to Art. 2 of the Federal Law "On Science and State Scientific and Technical Policy"[1], the innovation infrastructure is understood as "a set of organizations that contribute to the implementation of innovative projects, including the provision of managerial, logistical, financial, information, personnel, consulting and organizational services".

Despite the difference in terminological approaches, it is unequivocally understood that the presence of a developed innovation infrastructure contributes to the effective use of the scientific, technical and innovative potential of territories due to the rapid transfer of created fundamental knowledge to the main areas of society's activity [13]. When creating it, it is important to pay special attention to the design process based on a system of basic principles, being guided by which will

[1] Federal Law "On Science and State Scientific and Technical Policy" No. 127-FZ dated August 23, 1996 (as amended on July 2, 2021).

allow us to build the innovation process infrastructure as complete and balanced.

The purpose of the study presented in the article is to determine and reveal the essence of the principles of designing an innovative meso-level infrastructure – a set of regional, sectoral and branch innovation infrastructures – as a basis for ensuring the effectiveness of its functioning.

The information base of the study consists of official statistics on the innovation structure of Russia for 2022 and the scientific works of domestic and foreign scientists on this issue, presented in electronic libraries and scientometric databases: search requests have been introduced in the systems by the keywords «innovation», «innovation activity», «innovation infrastructure», «infrastructure of innovation», «systems design» , as well as by well-known researchers who studied the innovation infrastructure formation. The methodological and logical basis of the study is represented by the methods of systematization and content analysis.

Results and Discussions

A scientific review of terminological approaches has made it possible to formulate the author's content of the innovation infrastructure concept as an integration of complementary and interrelated structures that allow us to implement information, organize, consul, market, education and other services for the practical implementation of innovations, including activities aimed at the qualitative personnel transformation.

The Ministry of Science and Higher Education of the Russian Federation provides basic information on innovation infrastructure on the electronic portal of the National Information and Analytical Center for Monitoring the Innovation Infrastructure of Scientific and Technical Activities and Regional Innovation Systems, according to which in 2022 in Russia there are 3968 elements of the innovation infrastructure: 603 objects, 3333 subjects, 32 world-class scientific and educational centers [14] (*Table 1*).

However, there is a problem of discrepancy between the actual activities of the innovation infrastructure elements and the stated goals of creating an environment promoting the innovation activity development. In this connection, the design of innovation infrastructure, based on basic principles, should be recognized as the most important stage in its life cycle, which lays the foundation for its further balanced functioning and development [15].

The process of designing[1] an innovation infrastructure can be illustrated and characterized by a variety of options for action algorithms; within the framework of this study, in order to reveal its content, processes similar in meaning and significance are considered as modeling, designing, foresight, forecasting, anticipation and planning.

[1] Process of designing, projecting (from Latin – projectus, "thrown forward"), the process of creating a project – a prototype of an intended or possible object, state.

Table 1 / Таблица 1

Elements of Russia's Innovation Infrastructure, 2022 / Элементы инновационной инфраструктуры России, 2022 г.

Elements / Элементы	Quantity, units / Количество, ед.
Innovation Infrastructure Facilities	603
Business Incubator	65
Industrial Park	61
Innovative Centre	3
Cluster	169
Consortium	3
Nanocentre	9
Science City	13
Special Economic Zone	49
Territories of Priority Social and Economic Development (TPSED)	115
Technological Platform	5
Technology Park	111
Subjects of Innovation Activity	3333
Leading Universities	72
Scientific Centres	137
Other Organizations	3124
World-Class Scientific and Educational Centres	32

Source: [14] / *Источник:* [14]

Therefore, modeling is the construction and detailed study of models of real-life objects, processes or phenomena in order to obtain reliable explanations of these phenomena, including the prediction of their further development. The use of the “innovation funnel” by Wheelwright-Clark [16] can be considered a successful example of modeling in relation to the design of innovation infrastructure, which clearly displays the process of selecting (screening) ideas as they move according to the life cycle stages of this project: the stage of origin (setting the problem of designing an innovation meso-level infrastructure) is characterized by the maximum number of immature ideas, but being affected by a number of internal and external factors, they are significantly dropped out up to a limited number of promising options for the project product (*Fig. 1*).

Designing is the process of creating a material image of the object being developed (innovation infrastructure); it tends to work with full-scale models and their graphic representation (for example, diagrams illustrating the composition of infrastructure entities, their functions, complementarity and relationships, as well as innovative processes inside and outside the system).

Foresight is based on a consistent chain of logical cause-and-effect relationships, revealing the patterns of the innovation infrastructure development, when the reasons for its inception, the forms of functioning and the course of development are known, which makes it possible to qualitatively substantiate the forecast for the near future. Back in 1927, N.D. Kondratyev highlighted three types of socio-economic phenomena foresight: 1) foresight of irregular events; 2) foresight of more or less regular events; 3) foresight of the general develop-

ment of certain socio-economic trends [17]. In the context of the modern VUCA-world (Volatility; Uncertainty; Complexity; Ambiguity), the foresight of the meso-level innovation infrastructure functioning is of particular importance in achieving its balance, however, given the situation, the expediency of such foresight has value only in the short term (up to 1 year).

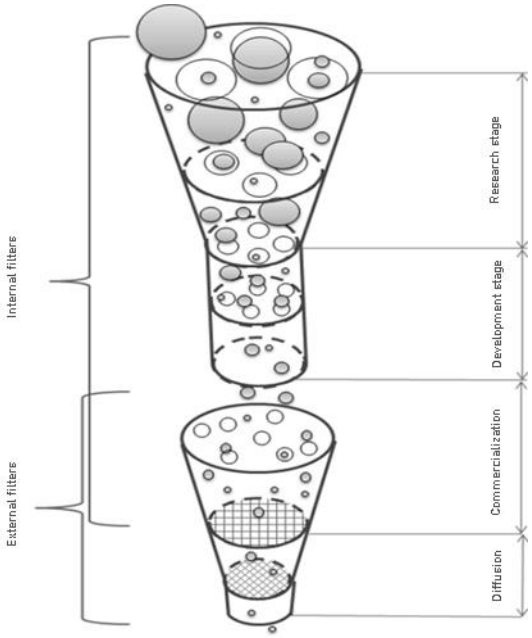

Fig. 1. **The Wheelwright-Clark Innovation Funnel Model /** *Рис. 1.* **Модель «инновационной воронки» Уилрайта-Кларка**

Source: images from the Internet / *Источник:* картинки сети Интернет

Forecasting is a process of building prospects (forecasts) for the innovation infrastructure development based on past and present data, most often by analyzing trends. The most effective modern forecasting tool is the Foresight method – a technology through which the proposed changes in the future are discussed by combining the efforts of all subjects (innovation infrastructure), anticipating changes, highlighting phenomena and processes that become dominant in the future. Foresight is different from other future research technologies – it allows a deeper understanding of the nature of changes, problems and opportunities, and therefore it is expedient in terms of the qualitative selection of the best (innovation infrastructure) development scenario and the development of an algorithm of actions for its implementation [18].

Anticipation reveals the dynamics of the innovation infrastructure through processes by the means of which different actors, having different expectations, coordinate their actions depending on them and form the agenda of the future [19]. The success of the design in this case will depend on: the volume and quality of information about the process of organizing the functioning and development of the innovation infrastructure; clarity in the formulation of the design task and the validity of choosing a method for solving it; the availability of the necessary computing facilities and computing equipment in accordance with the chosen method.

Planning is a justification of the ways of making decisions by using a qualitative organization of the innovation process and ensuring the future achievement of the expected results. This process is especially important for the innovation infrastructure design, since in this case it is necessary to highlight the main scientific and technical areas and problems that are prerequisites for the formation of its next level.

Understanding these processes and concepts, the stages of their achievement and implementation methods is the essence of design.

Therefore, the innovation infrastructure design should be understood as a strategically directed scientifically based activity in terms of its practical implementation, aimed at constructing a highly efficient innovation infrastructure in the near future, the main task of which is to identify possible options for the predicted and planned development of its subjects and processes they generate to support, service and stimulate innovations [20, 21].

The process of innovation design keeps to a certain technology, in rare cases, any stage does not go sequentially, but in parallel with the next one, thereby speeding up this process (*Fig. 2*) [22].

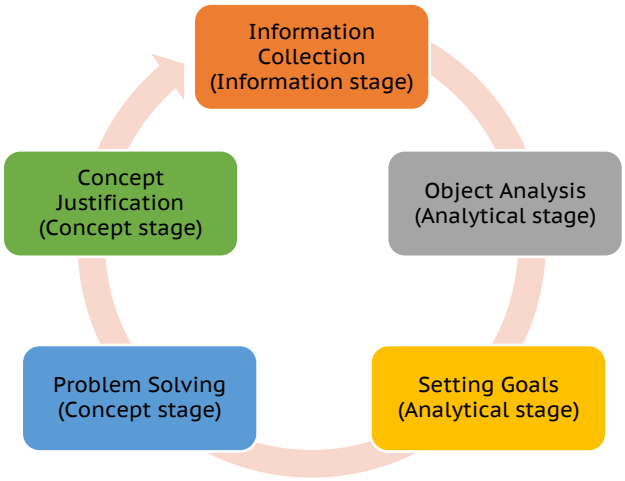

Fig. 2. **Innovative Design Technology /** *Рис. 2.* **Технология инновационного проектирования**

Source: [22] / *Источник:* [22]

The process of designing a meso-level innovation infrastructure should be based on a number of principles of a systematic approach (*Table 2*), being guided by which in the future will allow for the qualitative innovation infrastructure formation and development, taking the specifics of designing innovation systems of different territories, industries and sectors into account.

The process of designing innovation infrastructure at the meso-level is carried out in two stages: 1) a pre-project study of infrastructure maintenance of innovative processes; 2) innovation infrastructure design.

Table 2 / Таблица 2

Innovation Infrastructure Design Principles at the Meso-Level / Принципы проектирования инновационной инфраструктуры мезоуровня

Principle of / Принцип	Comments / Комментарии
Ultimate Goal	Combining the efforts of all the innovation infrastructure elements in order to create favourable conditions for the innovation activities implementation
Development	The ability of the innovation infrastructure elements to change, adapt to new conditions, improve
Balance	Equal importance of all the innovation infrastructure subsystems and their constituent elements
Efficiency	The practical plane of the activity of the innovation infrastructure elements, its feasibility and practicability
Transparency and Openness	The discontinuity of the innovation infrastructure elements, their readiness for cooperation
Coordination and Connectedness	Integration of the innovation infrastructure elements into a single system, achieving a synergy effect in the presence of their close interaction
Universality	The need to create an innovation infrastructure both in areas of high concentration of innovation potential and in innovation recipient regions
Feedback	The ability of the innovation infrastructure system to operate cyclically rather than linearly; applicable to emerging intra-system problems, as well as to all the innovation activity subjects, whose interests are expressed by the innovation infrastructure
Technology Commercialization	Supporting the innovation process from the early idea stage to market launch, critical to the commercial success of the new product
Evolutionary Development	Adjustment of the formed structure of its development under the influence of a number of new factors and progressive trends
Dividing the Process into Separate Stages of its Execution	The effectiveness of the design process with its detailed structuring
Differentiation	Implementation of the innovation infrastructure design process at the meso-level, since innovative development is carried out at the meso-level
Interrelations of Subjects and Objects	The emergence of new knowledge and innovations, their transformation into finished products – the role of the innovation infrastructure as an intermediary in the distribution and consumption under market conditions
Applications of Multivariate Solutions	Developing various options with the possibility of further selection of the most optimal of them, based on the goals and objectives of developing a particular innovation infrastructure project
Efficiency Ratings	Conducting a qualitative assessment of the innovation infrastructure for its compliance with previously established goals, objectives and needs

Source: compiled by the authors on the basis of a bibliographic review [1-6, 12-15, 23-26] / *Источник:* составлено авторами на основе библиографического обзора [1-6, 12-15, 23-26]

The final result of this process is the innovation infrastructure evaluation based on performance criteria: if its results show compliance, then the design process is completed; if the opposite result is obtained, it is necessary to return to the very first stage and repeat the process. Consequently, the fundamental basis for the innovation infrastructure effectiveness are laid for the most part in the design process.

Conclusion

The innovation economy development is impossible without its main element and mechanism – an innovation infrastructure that provides stimulation of innovation by creating conditions for the integration and efficient use of the resources of the innovation process subjects at all its stages. In fact, the outstripping growth of innovation activity and higher performance indicators are demonstrated by those meso-level innovation systems that "have a more developed innovation infrastructure, established and productive communications between the main innovation system elements: science and education, business and government" [27]. At the same time, the innovation infrastructure should not be an end in itself – it becomes a powerful lever for combining efforts, creating favorable conditions and providing comprehensive support to innovation processes.

It should be noted that the systems of innovation infrastructure always function in certain institutional, legal, economic and other conditions, and therefore, they differ in significant specificity in the functional direction and elements of the system, which cannot be ignored in the process of designing innovation infrastructure at the meso-level.

Authors' Contribution

The authors have made an equal contribution to the research: collection and analysis of the material; definition of goals and objectives, research methods; formulation and scientific substantiation of conclusions, registration of key research results in the form of an article.

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