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Improving the Mechanism of Innovation Planning with the System-Transdisciplinary Approach

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Abstract--- *The article considers the potential of using system-transdisciplinary tools in innovation management. The relevance of this research is determined by the fact that innovation management has no methods or techniques for estimating the temporal characteristics of innovation as a process. In addition, the scientific community has come to understand that the complex and multi-factorial systems used in research, which definitely include organizational systems, as well as disciplinary, inter- and multidisciplinary methods, have exploited almost all their potential. Consequently, further scientific advances objectively require new methods of exploring the mechanism of a company's development. Application of a multiplex transdisciplinary tool in planning enabled to develop an approach that can be used to determine the duration of different stages of the innovation process. This means not only efficient distribution of the company's resources over time, but also creating a justified roadmap for innovation. The retrospective analysis of implementing innovations in several enterprises, conducted by the authors, proved the validity of the proposed approach to planning the development of the company within the system-transdisciplinary methodology.*

Keywords--- *Innovation Process, Planning, Transdisciplinary Methodology, Transdisciplinary Methodological Approaches, Multiplex, Temporality, Resource Optimization.*

I. INTRODUCTION

Nowadays, a specific feature of the development of socio-economic systems is globalization processes which manifest themselves in the created and functioning political and economic interstate formations, as well as the accelerated development of transnational corporations. The latter realize their potential using the opportunities of global financial markets and the free movement of labor. Socio-economic systems are becoming more complex: innovative processes facilitate "quantitative consolidation of structural units, along with their significant qualitative changes" [1]. At the same time, the Russian government has set ambitious tasks within the industrial policy of the country that imply the advanced development of the Russian economy [2]. Modern Russia obviously needs to reorient its economy with the focus on innovation and technological development. This necessitated the development of a new approach to innovation which would ensure more efficient use of the innovative potential of enterprises and create incentives for its growth. In the 1950s, one of the authors of the concept of post-industrial

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society, Alvin Toffler, pointed out this trend [3]. This view remains true even today, whereas this process has become much faster, now resembling a rapid kaleidoscopic flicker [4].

It is widely agreed that innovation processes imply the transformation of scientific ideas, discoveries and inventions (scientific knowledge) into tangible results. This is connected with innovation planning, which should include both developing a system of innovative measures and determining the time period of the development and implementation of innovations in the organizational systems of various levels. Within the organizational system of the state level, innovation planning is carried out in the form of state regulation which coordinates innovation activities [5]. The expected result of the innovation is achieving the set goal, namely, "increasing the number of benefits for the party which introduces (implements) innovations; for businesses, this result means an increase in sales or cost reduction and, ultimately, an increase in profits" [6]. In short, the efficiency of innovation planning depends on objective answers to such as questions: What to do? How to do it? When to do it?

The relevance of innovation planning is quite obvious, since the incessant and ever-increasing flow of innovations underlies the development of a modern economy. The latter, due to innovations, shifted from an extensive to an intensive method of developing scientific and technical areas. This evolutionary process brought about smarter businesses and the need for a special type of management capable of planning, regulating and controlling this process.

At the same time, it is clear that the planning of innovative development is a sophisticated and, moreover, increasingly more complex process, which can be effectively managed only if new approaches are applied to study organizational systems. One of the main reasons for this is "the growing vacuum in the existing methodological approaches, both general scientific and specific to a particular area of economic science" [7]. Besides, it is quite evident that "the enormous complication of various processes, phenomena and their interrelations ... influences the goals and objectives of present and future research and necessitates the search for new methods and approaches, as well as the development of "methodological approaches of a higher level" [7].

These objective factors have stimulated innovative activities of economic entities and made the issues of effective innovation management of strategic importance, that is, "advanced management has moved once and for all into the field of strategic management and its scope is constantly expanding" [4]. Thus, at present the specifics of the economic development have changed the philosophy of management, the main task of which is now the strategic management of innovations through planning. The tasks and approaches of strategic and innovative management of the company are becoming closer (and even intertwined).

The modern methods of innovation planning are mainly based on a disciplinary scientific approach, which greatly limits the ability to understand their essence. As a result, the existing system of innovation management is not effective enough, which lowers the efficiency of many innovations for the economy and does not use all their potential. In her work "Technological Revolutions and Financial Capital. Dynamics of Bubbles and Golden Ages", Professor of the London School of Economics and Senior Researcher at Cambridge University, Carlota Perez points out that "the basis for future growth is found with a trial-and-error method" [8]. There was even a kind of an "alternative" idea, according to which the price of efficiency is too high, and companies need to focus not on

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efficiency, but on ensuring their sustainability [9]. In an interview to HBR, Jim Hackett, Ford CEO, talks about the redundancy of efficiency and companies' adaptability [10]. In fact, all these arguments express the same idea: economic actors cannot ensure the expected development if they apply traditional approaches, but do not have proper methodology for innovation planning (that is, ensuring sustainability and adaptability).

The economic reality develops in accordance with complex and multifactor patterns. This determines the relevance of multidisciplinary and transdisciplinary methods in the study of the innovation dynamics of developing socio-economic systems. These methods allow considering these specifics right at the planning stage. The need for a transdisciplinary approach to solving social development problems is indicated in the World Declaration on Higher Education for the 21st Century, which was adopted in 1998 at a conference at the UNESCO Headquarters [11].

II. MATERIALS AND METHODS

Despite the fact that the effective planning of people's purposeful activities has always been one of the crucial economic tasks, a crisis in the organizational systems management first manifested itself in the beginning of the 21st century. "Definitely, there is a loss of controllability... In almost all fields management entities are focused on their individual interests... The best cure for this disease ... is improving the mechanisms for promoting scientific knowledge in management" [12].

The modern economics has developed several approaches to understanding the essence of innovation planning. At the same time, each scientific approach is characterized by "special scientific ideas, specific only to this approach, which allow identifying and exploring the appropriate types of system objects (simple, complex, self-developing systems)" [13].

Classical scientific approach to management emphasized the object. Its theoretical description of the innovation process eliminated everything that related to the subject of management, that is, "was limited by the "subject-object" paradigm" [14]. At the same time, "such elimination is considered as a necessary condition for obtaining objective and true knowledge" [13]. The limitations of the classical approach "have been clearly demonstrated when trying to model social systems, conflict interactions, communication processes, social and psychological phenomena" [14].

"In the context of neoclassical science, the development of ideas about management basically means overcoming some limitations of the subject-object paradigm" [14]. The neoclassical scientific approach highlighted the relationships between the management object and its management activities. Within this approach, the clarification of these relationships was regarded as a prerequisite for the objectively true knowledge of the management process. At the same time, it does not link management activities with the social values of the considered objects [15].

The post-neoclassical scientific approach assumes that the knowledge about the object of management is associated not only with its activities, but also with the value and attitudes of the subject of management. This is accompanied by "the increasing emphasis on the communication of the subjects that create the reality, on how these processes restrict their freedom" [16]. This scientific approach to the management of complex self-developing systems results in the symbiosis between the causal understanding of the future development of the system and the target orientation of this development. To apply this symbiosis in management, one should use highly complex

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methodological tools, which is practically impossible in the framework of an interdisciplinary (neoclassical) approach. "To solve the problems which become relevant nowadays one should go beyond particular disciplines and attract external assistants possessing fundamentally different types of knowledge and special socio-humanitarian technologies... In the context of classical and neoclassical scientific rationality, classical cybernetics and cybernetics of the second order were the main areas of knowledge raising management problems, whereas in post-neoclassical science, the focus of management development is shifted to philosophy, synergetics, political and economic sciences, socio-humanitarian ergonomics and social cybernetics" [13]. This statement is confirmed by the fact that "these trends can be easily traced in most Nobel Prizes in the economy over the 21st century" [17].

The arguments given above make it possible to conclude that the system-transdisciplinary approach should become the basic scientific method at the present stage of innovation management. Consequently, the development of innovation management as a science should include not only solving theoretical and methodological problems, but also practical problems of managing the development of complex organizational systems, as well as problems of innovation planning.

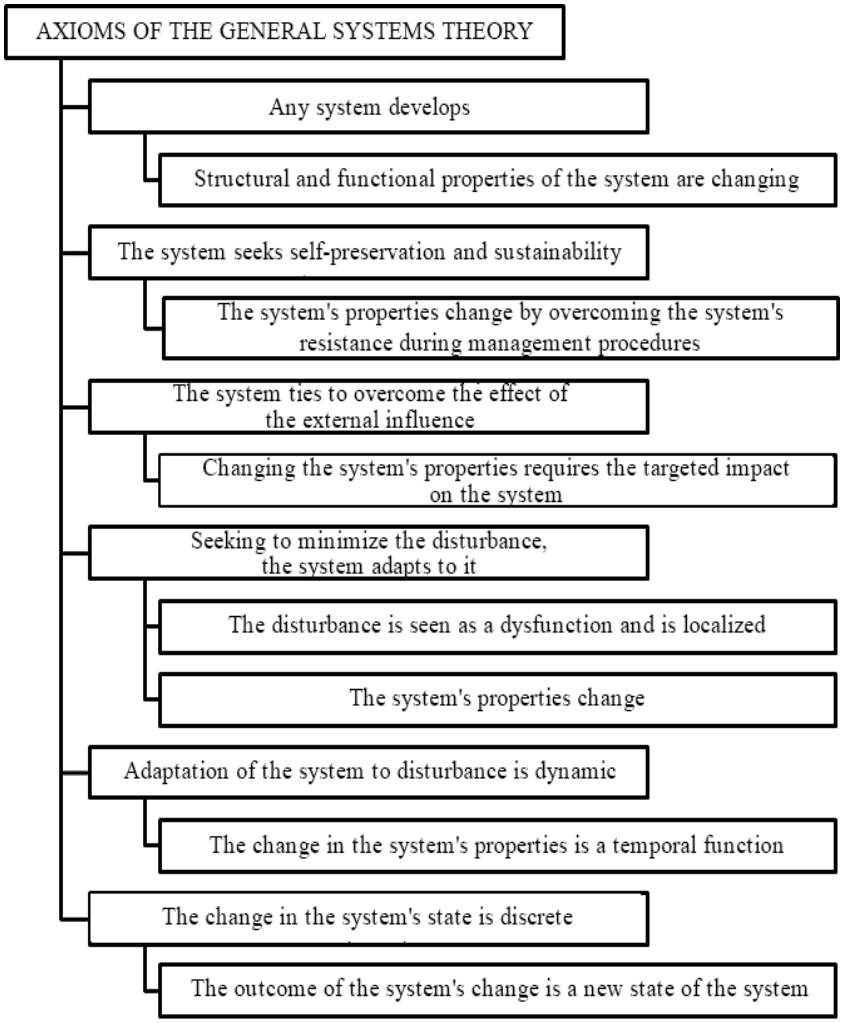

Figure 1: The Provisions of the General Theory of Systems Acting as Axioms

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The general theory of systems is based on the provisions that act as axioms (see Fig. 1) and are directly connected with planning the development of organizational systems. The innovation in the organizational system facilitates changes in the structural and (or) functional content, leading to innovation. The effectiveness and predictability of this process depends on their proper preparation (planning) and implementation. "The preparation and gradual implementation of innovative changes are called the process of innovation... The result of this process is innovation as an implemented and utilized change..." [18].

Many innovations do not produce the expected effect since they are not introduced timely and management decisions about the innovation of an enterprise are taken, as a rule, according to the "intuition" of the highest management body of the enterprise or by an order of the government agency. Consequently, the main problem of innovation management is the lack of a comprehensive methodology for temporal innovation and strategic planning.

The theory of innovation has been developed both by Russian (L.I. Abalkin, A.I. Anchishkin, L.S. Blyakhman, S.V. Valdaytsev, L.M. Gokhberg, P.N. Zavlin, O.V. Inshakov, N.D. Kondratyev, S.V. Kortov, B.N. Kuzyk, D.S. Lvov, V.I. Mayevsky, Yu.V. Yakovts, and others) and international researchers (P. Doyle, J. Keynes, P. Drucker, Ph. Kopler, R. Metcalfe, R. Nelson, D. North, P. Samuelson, B. Santo, R. Solow, B. Twiss, C. Freeman, J. Schumpeter, and others). However, there has been hardly any research on the methodology of innovation planning as one of the factors determining the timeliness and temporal possibility of implementing innovations. This necessitates further study of the innovation management methods at industrial enterprises which would consider all possible factors affecting innovation, that is, the methodology based on a transdisciplinary systems approach.

III. RESULTS

Changes in public life have led to changes in the methodology of science, namely, the emergence of a new model of generating knowledge (Mode 2 Knowledge Production), presented in 1994 in the work "The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies" [19] by M. Gibbons, C. Limoges, H. Nowotny, S. Schwartzman, P. Scott, and M. Trow. "Mode 2" became an integral part of innovative systems and determined new bases of knowledge production – interdisciplinarity and social heterogeneity. Disciplinary sciences began their transformation into transdisciplinary research.

Existing scientific approaches can be classified according to the understanding of how complete our knowledge of the surrounding world is. In accordance with this criterion, we can distinguish the following main types of scientific approaches:

- In line with the disciplinary approach, the world around us is considered as a set of separate subject areas;
- The interdisciplinary approach implies that if the studied subject areas are similar we can use methods of one discipline to study another one;
- The polydisciplinary (multidisciplinary) approach uses a generalized research subject with certain disciplinary areas as its elements. In this case, as a rule, all disciplinary areas are regulated by their own

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disciplinary methodological principles. This approach allows spotting similarities of the studied objects that have not been previously detected, which enables new interdisciplinary research. An example of such interdisciplinary economic research can be found in the works of V.A. Melnikov on quantum economics. It considers the economy "from the perspective of the quantum economic structures constituting it and forming an integral invariant economic system" [19];

- The transdisciplinary approach implies a higher level methodology in which the studied object (phenomenon) is considered "beyond the framework of any particular scientific discipline, while this "outward movement" is directed towards the macro-world. Every fragment of a given world, environment, any area of them that has natural physical and (or) logical boundaries is initially considered as a "structured environment" which can be studied using the same principles, approaches and models" [7]. "The transdisciplinary (hyperdisciplinary) system approach focuses on solving the tasks of scientific knowledge (methodology of knowledge), which includes its forms and construction principles. This approach implies creating a holistic natural science picture of the world and its development, which is of great importance for the scientific and humanistic worldview" [11].

Researchers in many countries are developing the transdisciplinary methodology of scientific knowledge. For instance, these scientific schools can be found in England, Spain, Portugal, Italy and France (International Center for Transdisciplinary Research), the USA and Canada (Institute of Complex Problems Santa Fe), China (State Program for the Development of Important Basic Research No. 973), Switzerland (Network transdisciplinary studies in the natural and human sciences at the Academy of Sciences of Switzerland), Russia (Institute of Philosophy, Russian Academy of Sciences, Institute of Transdisciplinary Technologies). In the University of Hamburg (Germany) transdisciplinary research is a separate scientific specialty. Graduates receive a diploma stating that they are experts in the field of transdisciplinarity.

Although there are certain differences in understanding its main categories and research methods, these are united by the "common paradigm – the emergence of new scientific dimensions and abandoning the attmepts to build one-dimensional models of the multidimensional world" [20]. Also, it is understood that transdisciplinarity "can be described as a new stage of scientific research with an open system of interactions, not limited by the disciplinary framework and which combines such elements of the social system as science, education and innovation" [1].

It should be noted that "transdisciplinary approaches... are extremely rarely used in modern research, and they are not actually applied by theoretical economics" [21].

The structure of the Russian school of transdisciplinarity is shown in Fig. 2. At present, there are several industries widely implementing the transdisciplinary approach in practice. These are architecture and construction, education, economics, ecology, health care, as well as prevention of antisocial activities and terrorism.

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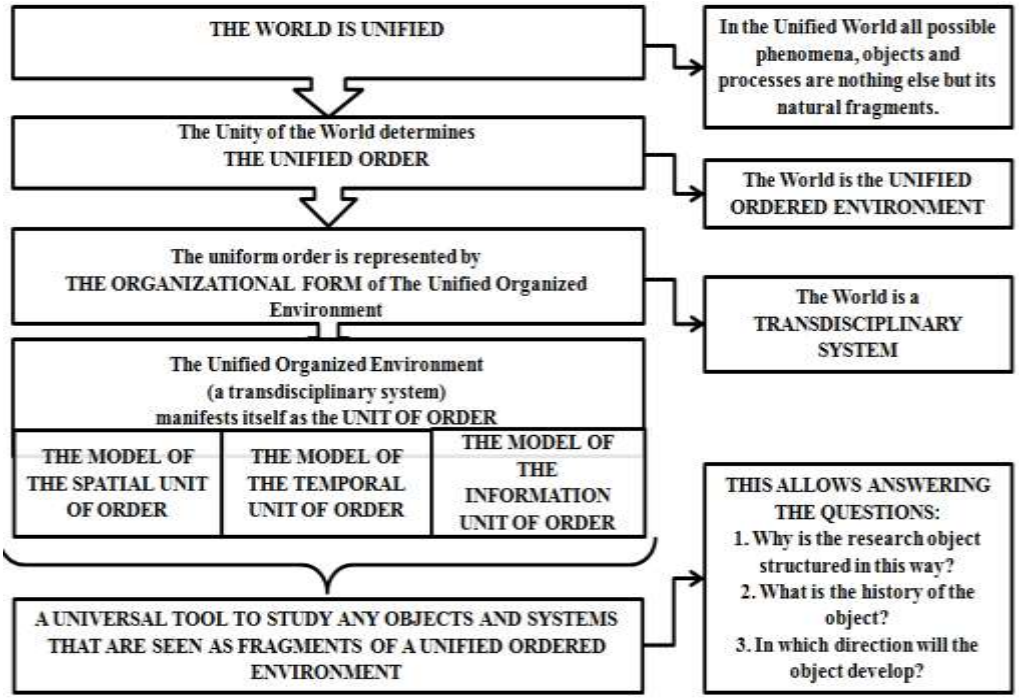

Figure 2: The Structure of the Russian School of Transdisciplinarity

The following transdisciplinary methodological approaches have become popular in economic research:

1. The theory of autopoiesis that was founded by Chilean scientists working at the intersection of biology and epistemology. In the mid-1970s Humberto Maturana and Francisco Varela put forward a hypothesis according to which "the mechanism that turns systems into autonomous unities manifests itself through autopoiesis, which is the process of reproduction (self-generation) of its components by the system for preserving its identity" [7]. As German sociologist Niklas Luhmann noted, autopoietic systems are the systems that generate not only their structures in the network of their elements, but also the elements of which they consist (according to Humberto Maturana). These elements are produced by the system only, actually, due to the fact that they (regardless of their energy and resource base) are recognized as differences. Elements represent information that alternates the system. Therefore, they are the application units for the creation of more application units for which there is no correlation in the surrounding world.

The theory of autopoiesis made it possible to expand the methodology of scientific research and revealed that there are "self-creation zones" in the innovative environment. It also improved the mechanisms of strategic management.

2. The theory of chaos and complexity is a set of interdisciplinary and transdisciplinary approaches that are focused the processes of generation (development) of "self-organizing structures in systems that are dynamic, emergent, factual, and nonlinear" [21]. The theory of complexity is based on the fact that the individual elements (subsystems) are similar to each other at different levels of the system, and self-regulation, self-organization and attractors represent a combination of "endogenous and exogenous conditions, the ratio of which in space and time

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changes chaotically; it is the "face of chaos", the borderline state, a narrow zone between a system in the state of equilibrium, order, and chaos that destroys this system" [22]. The state of the system either generates processes of self-organization, or uncertainty and non-linearity of processes (unpredictability of the systems coexistence), or changes in the above processes.

This theory enables researchers to analyze economic processes occurring in a complex socio-economic system. However, one should bear in mind that these processes never repeat in exactly the same way as systems reach equilibrium at different points, demonstrate self-identity, or may self-organize. That is why it is impossible to predict in advance the outcome of the system's functioning.

3. The theory of fractals was proposed in the late 1960s by mathematician Benoit Mandelbrot (1924–2010), who "conceived and developed a new geometry of nature, and then used it in many different areas" [23]. This theory, formed at the intersection of computer science, biology, linguistics and mathematics, is based on self-repetition of patterns. This theory allows describing all the phenomena occurring in the world and also studies patterns revealed during the formation of such phenomena.

A fractal (from Latin 'fractus' – broken, fractured) is a set with such a characteristic as self-similarity: an object or a phenomenon is "exactly or approximately the same as its part, that is, the whole has the same shape as one or more parts" [24]; "usually this term is used for a geometric shape that satisfies one or more of the following criteria:

- Has a complex structure at any magnification;
- Is (approximately) self-similar;
- Has a fractional Hausdorff (fractal) dimension, which is more topological;
- Can be built by recursive procedures" [25].

Using the theory of fractals as the basis, American financier Ralph Elliott developed a theory for predicting the behavior of stock prices, reasonably suggesting that fractal geometry is applicable not only to natural phenomena, but also to social processes. He considered operations with shares on the stock market as one of these. Continuing to study the patterns of price behavior in financial markets, American businessman Charles Dow (1931-2015) used the theory of fractals to create a mechanism for predicting the behavior of prices for financial instruments. He claimed that "stock prices are subject to cyclical fluctuations: after prolonged growth, there is a long decline, then they rise and fall again" [26]. These works by Elliott and Dow are based on the wave diagram and the idea that "structures consisting of parts are in a certain way similar to the whole; these are self-similar structures, recursive models, and in its development each part repeats the development of the whole model" [21].

The theory of fractals makes it possible to formalize complex processes (objects) with high reliability, which is crucial for modeling innovation processes, as it helps to describe unstable systems and processes, and, most importantly, to formulate trends in organizational systems development.

4. The theory of turbulence describes turbulence as a phenomenon observed in a variety of processes, in which numerous vertices are formed. As a result, processes fluctuate and irregularly change from point to point and in time. "Currently, the concept of "turbulence" is widely used in economic research. However, it has no developed

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theoretical and methodological basis, but is applied intuitively. Turbulence is usually interpreted as a disordered movement characterized by a rapid change in market trends and strong fluctuations in economic indicators" [27]. Turbulence of economic processes leads the emergence of both regular and irregular changes in quantitative and qualitative properties during the development of organizational systems. That is why organizations of all levels and the world (national) economy have a particularly complex development trajectory. Constantly occurring changes make organizational systems "survive", while ensuring their development in the conditions of "extreme instability of the global economic system, when the probability of reaching its bifurcation point and/or breakdown is extremely high, and there are risks in various sectors of the economy" [21].

At present, the analysis of the causes of variability in the operating environment of economic entities is considered the most important task of strategic management. "But historically, economists focused on identifying patterns of static states of the economic system" [27]. Moreover, in 1993 Nobel Prize winner in economics Douglas North (1920-2015) argued that "there is no theory of economic dynamics" [27] and traditional approaches to analyzing the development cannot explain the nature of the volatility of economic processes. A common idea of the research papers of the 19th-20th centuries is the hypothesis that there is an abrupt change in the static states of the economic system. At present, researchers believe that "it is difficult or impossible to solve this problem using traditional economic methodology" [28].

The theory of turbulence allows one to identify multidirectional forces and actions leading to the emergence of the phenomenon of system dynamics. Besides, this theory helps to identify the susceptibility of specific economic subjects to certain external and internal influences and to determine the tactics of organizational and managerial behavior of the subject in uncertain conditions that are challenging for all economic entities.

5. The theory of economic genetics is based on an evolutionary approach to economic research and suggests that organizational systems have such properties as inheritance and variability, as well as certain relationships and connections evolving between economic entities.

The evolutionary approach to the study of organizational systems is based on the knowledge gained from other economic theories and "implies a transition from the concepts of static equilibrium in conditions of complete certainty and goal-rationality of interacting subjects to non-equilibrium dynamics in the situation of constantly changing conditions, resources, factors and subjects" [28]. The evolutionary approach "is based on the assumption that the composition of economic actors varies according to the laws of natural selection" [29]. This approach allows exploring:

- Stages of the life cycle of an organization;
- Variability of properties of organizational systems under the influence of the external environment;
- Adaptation of organizational systems to new operating conditions.

At the same time, it is clear that not enough attention is paid to such a basic property of an organizational system as economic inheritance, although it is the basis for the harmonious development of an economic entity.

The theory of economic genetics made it possible to put forward a hypothesis according to which the evolution of an economic entity has a genetic nature and is implemented by transferring "economic genes", which implies the mechanism of organizing and reproducing knowledge about:

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- Quantitative and qualitative characteristics of an economic entity;
- The functioning self-regulation mechanism of an economic entity;
- Business models and business strategies used by an economic entity;
- Composition and content of production factors and their interaction in the operation of an economic entity;
- Contradictions that influence an economic entity and how to resolve them;
- Failures in the operation of an economic entity and methods for their localization and elimination;
- Trends in the development of an economic entity;
- Stages of the life cycle of an economic entity.

It should be noted that the planning of the development of any object (system) can be seen as planning of quantitative and (or) qualitative changes in the states of these objects (systems), but one should bear in mind the consistent complication of their internal and external relations.

The sequential change of the state of an object (system) in the course of its development is a strict interrelation of time (temporal) intervals. Each of them is determined by the predisposition of an object (system) only to certain changes. In addition, there are some objective regularities:

1. The system should develop, but in its development the system is oriented towards self-preservation and sustainability;

2. Seeking stability and self-preservation, the system tries to minimize the effect of external influence (disturbance);

3. Trying to minimize disturbances, the system:

- either perceives a disturbance as an enhancement of the main function of the system;
- or treats a disturbance as a dysfunction and seeks to neutralize it;

4. The adaptation of the system to the disturbance occurs by changing the structural and functional properties of the system.

In practice, when planning the duration of a particular stage of the innovation, managers rely mainly on experience (their own or someone else's) and on their own intuition. "Many businessmen are focused only on the laws of marketing, their own intuition, as well as the usual economic concepts illustrating the current state of their business – receipts and expenses, profit and loss. Therefore, in the unobvious competition between scientists with their complex economic concepts and the opinion of family and friends, businesspeople often listen to the latter [30].

However, it seems clear that innovation planning cannot be spontaneous and should be carried out on the basis of principles that establish general rules for planning, developing and implementing innovations.

By the early 1980s, science and society understood that di-disciplinary and multidisciplinary approaches could not solve complex multifactor problems of the economic development. This can be due to the fact that "within the framework of interdisciplinary and multidisciplinary approaches complex multifactor problems almost always "break " into disciplinary components, as a result of which it becomes easier to formulate problems, but almost impossible to solve them effectively" [31]. The emerging transdisciplinary systems approach makes it possible to

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develop new methods for managing complex organizational systems based on the theory of autopoiesis, the theory of chaos and complexity, the theory of fractals, the theory of turbulence, and the theory of economic genetics.

Modern economics distinguishes more than 1380 types of cyclicity, ranging from 7 minutes to 700 years [32]. There are 75 types of cycles of general business activity ranging from 16 to 60 years and 23 types of wave cycles from 35 to 108 years [33]. Each type of economic cycles affects the characteristics of other economic fluctuations, as well as cycles of different nature can resonate (synchronize) and, "with all the diversity of cyclical dynamics in different regions, countries, civilizations, there are common cycles that establish the common rhythm)" [32]. The life cycles of the product, goods, and technology are the most significant, basic for the micro-level of the organizational system [34]. The demand life cycles are important for the organizational systems of the meso-level. The development of macro-level systems is considered to be closely connected with the Kondratieff-Schumpeter cycles and the technological paradigms of Glazyev-Perez. Besides, S. Kuznets introduced the concept of an "epoch-making innovation", Yu.V. Yakovets considers waves of basic ecological innovations within the developing humanist-noospheric post-industrial society [35].

Understanding the development of an organizational system through the prism of transdisciplinary allowed presenting the innovation cycle as a transdisciplinary model [36], in which each development stage is seen as a corresponding wave. Also, this model of an organizational system development was transformed into a methodological tool – multiplex (the ordered set of development waves), which included:

- Building a model of the innovative development of an organizational system;
- Determining the dynamics and relative duration of the particular stages of the organizational system development;
- Estimating the temporal-wave characteristics of the organizational systems development, using the principle of universal proportionality.

Multiplex (from a Latin term denoting something complex and repeated) is a natural complex of interrelated waves that logically fragments the development process of an organizational system.

A multiplex wave is a natural sequence of developmental periods with certain calendar duration, depending on the temporal state of the organizational system.

Naturally, to apply such a model when planning the innovative development of an organizational system, one should determine both its stages and their duration. To this end, it is proposed to use methodological approaches and methodological tools created and used in mono-, inter- and multidisciplinary sciences. The analysis showed that Elliott Wave Theory can become one of the tools for studying the cyclical nature of the development of economic entities: it is "a mathematical theory of how the behavior of society or financial markets develops and changes, presented in the form of identifiable models" [37].

The conducted studies confirmed the hypothesis that in the development of any economic entity there are "sensitive periods, which are characterized by a certain combination of structural and functional properties determining the sensitivity level (susceptibility level) of the system to various disturbances. These periods of development, as certain intervals of the individual development, determine the intervals during which the enterprise

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has a predisposition to implement this or that type of innovation" [38]. The cyclical nature of the innovation in the organizational systems development:

- Causes a recurrent change of periods related to the system's predisposition to quantitative and qualitative innovations, periodically replacing each other in time;
- The change of trends in the development of the system over time causes periodic changes (fluctuations) in the structural and functional properties of the economic entity, that is, innovations.

These arguments made it possible to create a new mechanism for planning innovation, which takes into account the temporal factor of economic entities development and is based on the following provisions:

1. Existing economic entities are characterized by certain parameters that can be presented in the relevant transdisciplinary information unit of order, objectively reflecting the state of the studied subject;
2. The innovation process of the economic entity may have latent parameters;
3. Differential perception of the development of an economic entity is a natural phenomenon;
4. A full description of any developing system must be presented by describing its intrinsic attributes: space, lifespan, information, that is, according to the possibility to fulfill in time the innovative potential of an economic entity;
5. The space-time-information structure of an economic entity during "any, no matter how strong, cardinal differences obeys the law of the trinity of space, time and substance which is the same for all layers" [39].

IV. DISCUSSION

The working hypothesis of the study implied that the application of a system-transdisciplinary methodology in innovation management will provide a new understanding of the patterns of innovative development of socio-economic systems, which will allow improving the efficiency of time-based innovation planning in an industrial enterprise. This hypothesis is reflected in the following key ideas:

1. The use of a system-transdisciplinary approach in innovation management ensures effective forecasting and planning of the development of an industrial enterprise through effective innovation;
2. There is a direct temporal relationship between the degree of radicalization of innovation and the stage (period) of the development of an enterprise as an organizational system;
3. There is a strictly defined sequence of periods of the enterprise development, which largely determines the possibility of implementing innovations of different nature;
4. Using the system-transdisciplinary methodology allows one to develop a conceptual model of innovative development of the enterprise and to determine both the direction (quantitative or qualitative) of the enterprise development and the duration of its calendar periods;
5. Temporal models of the enterprise development make it possible to identify deviations in this process, which enables to give development forecasts at a new level of knowledge and more effectively plan and design various innovative activities [40].

Taking into account these provisions and other conclusions drawn in this work, one can consider the development process of an organizational system as a wave obeying certain laws. Consequently, one can analyze

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these processes on a quantitative level using the apparatus of mathematics.

This mathematical apparatus would allow determining the time span of the various stages of the innovation process (an objectively necessary task when planning innovation). It may be based on the ideas of Russian scientists in the field of innovation management proposed in the late 1990s using the methods of morphological analysis [41], as well as the classification of innovations according to the degree of their radicalization, formulated by Slovak economist Frederick Valenta [42] (see. Fig. 3).

Having conducted the research, the authors built a multiplex model of the enterprise development, which accurately determines the duration of the innovation periods and synchronizes the subject-productive activities of an economic entity in the innovation process (see Fig. 4). Obviously, the total duration of the innovation process consists of the sum of the time intervals needed for working at each stage of the "innovation life cycle".

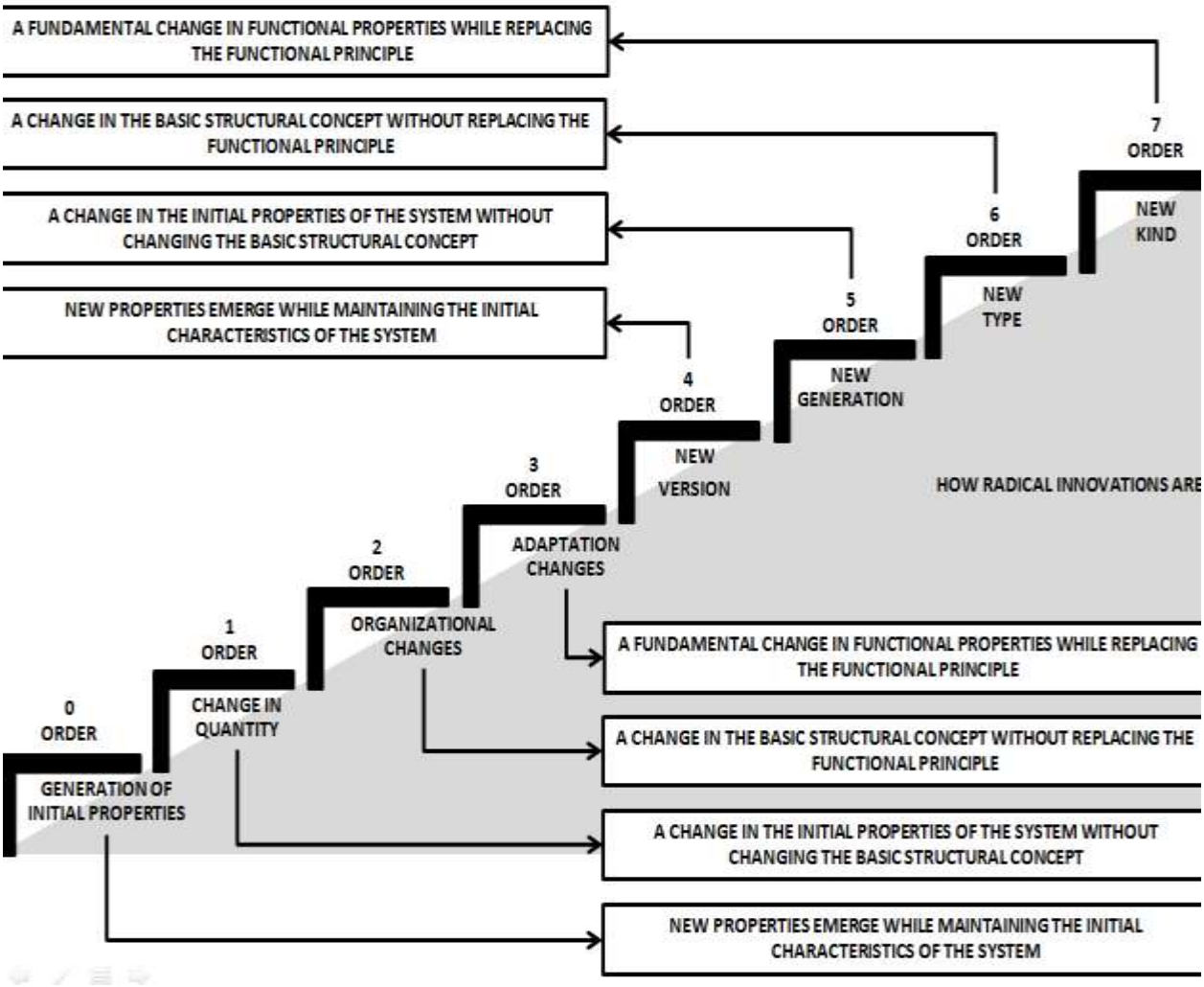

Figure 3: Classification of Innovations Depending on How Radical they are (according to F. Valenta)

This makes it possible to build a methodical tool for determining the temporal predisposition of an economic entity to specific events in the chain "science-technology-production" and to establish the optimal time intervals for:

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- Scientific development of an advanced technology and its implementation;
- Assessing the probability of the emergence of a similar product on the market;
- Rebuilding the production;
- Developing a technology for recycling products due to their wear and tear.

The existing innovation planning toolkit allows one to determine the overall complexity of the work on its implementation, but does not answer the questions about how many resources available to the economic entity should be attracted and at what moment. The proposed methodological approach helps to eliminate this drawback, which will certainly have a positive impact both on the effectiveness of the innovation planning and on the efficiency of the business entity. The latter will obtain a time-balanced chain of activities necessary for introducing innovations.

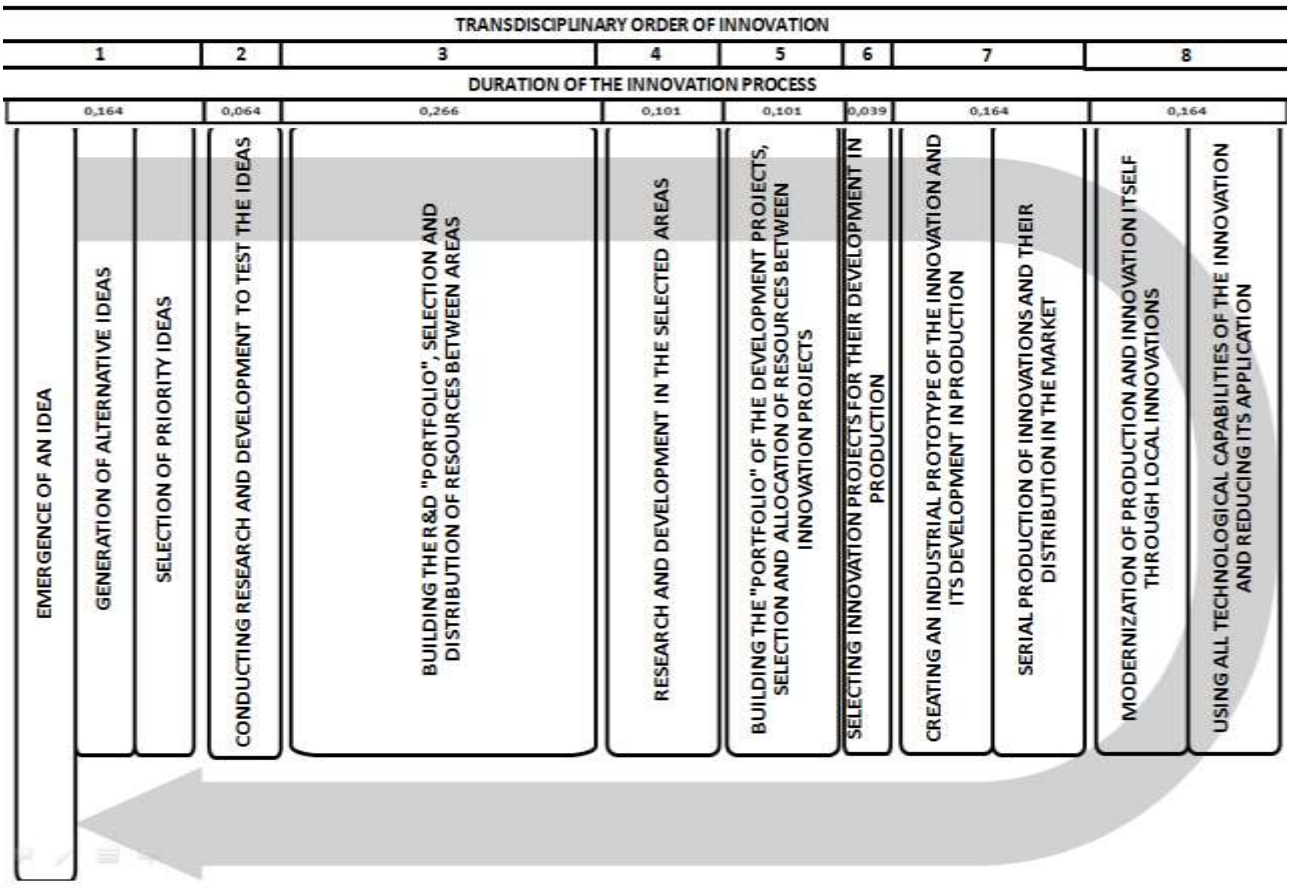

Figure 4: Time Synchronization of the Subject-productive Activities During Innovation

A system-transdisciplinary approach used to determine the temporal indicators of innovation increases the effectiveness of innovation planning as it takes into account the following:

1. Innovation is seen as a change in the structural and functional properties of an organizational system (business system) that occurs as a result of targeted (control) influences on it.

Innovative activities are aimed at improving the main function of the system.

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2. The transdisciplinary classification of innovations depending on how radical they are allows one to develop a multiplex of the organizational system development, and the identified patterns allow:

- To rank innovations in order of importance;
- To determine the calendar periods of management activities in such a way that their implementation does not conflict with the objective attributes of the development process.

These attributes are:

- Certain stages, periods and cycles of the development process are mandatory and have a strict sequence;
- Certain stages and periods of the process have a predisposition to strictly defined types of innovation.

3. The use of the development multiplex makes it possible to determine:

- Calendar dates and duration of stages, periods and cycles when developing a business;
- Objective dates of "control " and "critical " points within each calendar period during the overall transformation of the current business idea;
- The start date of working on the content of a new business idea and the time for completing the overall transformation of the current business idea;

4. The development multiplex ensures more comprehensive and objective implementation of all control functions. For instance, by calculating the calendar duration of the periods and determining the "normal" state of the process and deviations from it, one can see the nature of the required management actions and estimate the time periods during which:

- Taking these or other measures will give the greatest expected effect or it will be possible to assess the risk of the undertaken activities;
- Certain crisis phenomena may emerge;
- It is necessary to implement compensatory measures to reduce possible risks.

Adopting such an approach, one can successfully devise and implement plans for the innovative development of an enterprise with optimal (by the criterion of efficiency) use of resources.

To test the hypothesis put forward in the study, the authors analyzed the chronological sequence of changes in the model range of PAO AvtoVAZ and PAO KamAZ. It is obvious that these enterprises welcome innovation (due to great competition in the industry).

The analysis of the data on the released VAZ models shows that:

- 62% of VAZ models were produced in the periods demonstrating the features of the innovations of the 0th or 7th order;
- 32% of VAZ models were discontinued or transferred for production to other enterprises during the periods corresponding to the innovations of the 7th order.

At the same time, a number of models (Lada Kalina P Wagon, Lada Kalina P Hatchback, Lada Granta Sedan, Lada Largus, Nissan Almera) were not launched in time, which was one of the reasons for AvtoVAZ's "record " loss in 2015 (more than 75 billion rubles).

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A similar analysis of the chronological sequence of changes in KAMAZ model range in the period from 1976 to 2016 (see Fig. 6) showed that 61% of product innovations were made during the relevant periods of development, while a number of promising developments (for example, KAMAZ CMAX85, KAMAZ 6522, KAMAZ 4326-9, KAMAZ 54115) were not properly developed. It was also worth analyzing the correlation between the made investments in technical development and the temporal periods of KAMAZ development. According to the available data for the period from 2005 to 2015, a significant increase in the investments in technical development (from 2009 to 2014) did not lead to an increase in profits.

According to the results of the analysis, there is no doubt that the shortcomings in the innovation planning methodology led to significant economic damage for these leading enterprises of the Russia's automotive industry.

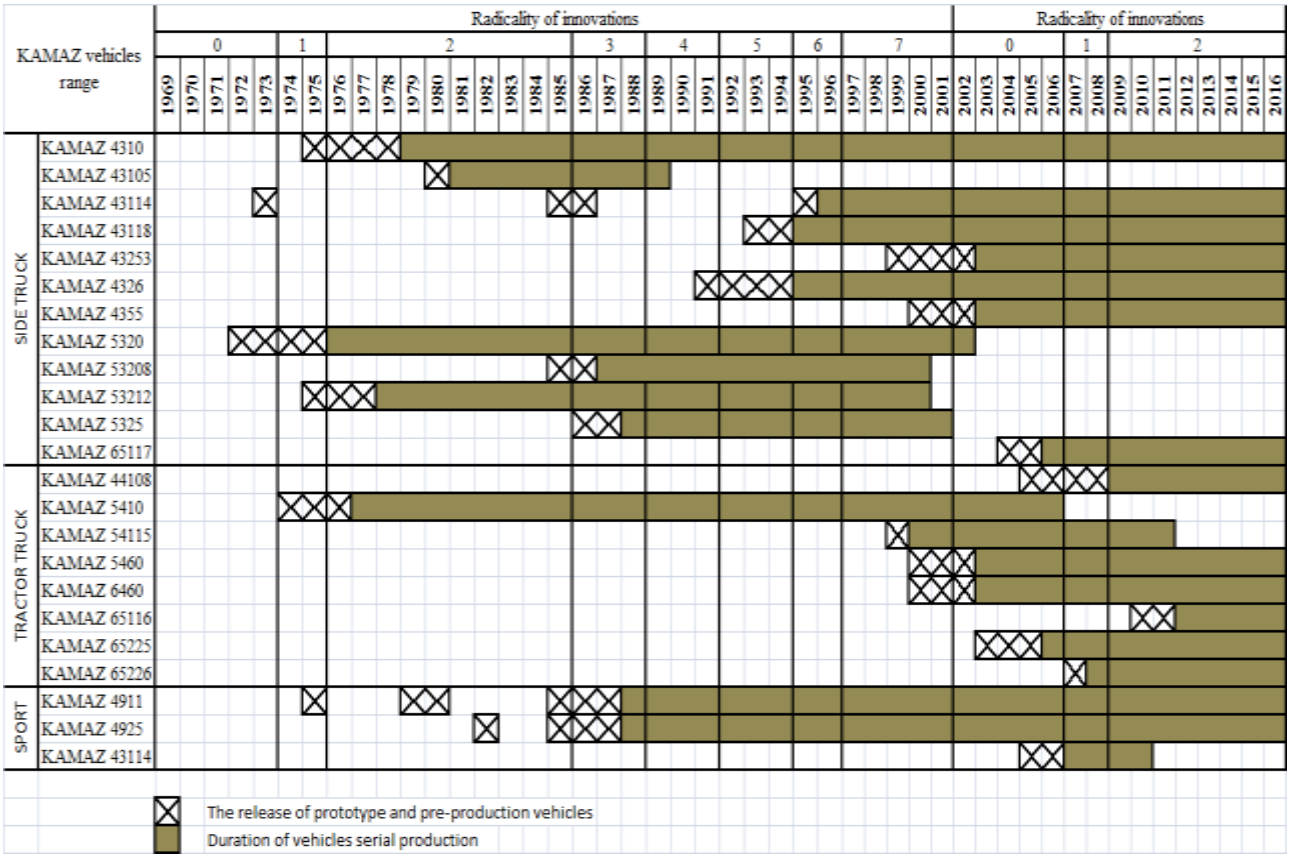

Figure 5: Production of KAZAZ vehicles for the period from 1976 to 2016 (a fragment, according to the site "Model range of KAMAZ vehicles ") [43]

The tools such as venture capital investments play an important role in the innovation planning process as they are necessary in the situation when the innovating organization does not possess the required financial resources. Venture financing emerged in the 1960s, and talking about it, one should mention the experience of the United States of America. Initially, this could be explained by the fact that during that period the USA experienced a significant decrease in the effectiveness of theoretical and applied research and development (R&D) of large research organizations, while small innovative businesses created 24 times more innovations per each dollar

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invested [44]. This led to a fabulous result: Apple, Intel, and Xerox are just a few examples of the successful projects implemented by attracting risky investments.

However, when one is to take a decision on attracting investors of this kind to a project when planning innovations, one should always remember that the efficiency of their participation will largely depend on what stage of the innovation process they will be attracted to. For instance, at the stage of fundamental theoretical research, developments are mainly funded from the state budget and other state support funds. At this stage, while the final result is not fully clear, one should not count on the help of a venture investor. At the same time, attracting such financial sources at the final stages of scientific and technical work is also debatable as at these stages the risks associated with the development of the industrial production of new products, services and technologies are significantly lower compared to R&D activities. The paper [45] provides a brief overview of unsuccessful innovation projects in the world, and also analyzes the main causes of failures, many of which turned out to be due to an unsuccessfully chosen period for attracting funding, that is, errors in innovation planning.

V. CONCLUSION

The practical significance of the conducted research on the potential of system-transdisciplinary methodology in innovation planning stems from the fact that the developed provisions and recommendations enable to more accurately set and solve both the theoretical problems of innovation management and the tasks of complex and multifactorial character. Using the developed tools, one can take better-informed decisions when planning the innovative development of enterprises or society, as well as analyzing, planning and forecasting the development of business systems.

The developed methods were verified using open access resources, which confirmed the validity of the proposed methodological approach and allowed the authors to conclude that it can be used to manage the innovative development of enterprises. In other words, applying transdisciplinary methodology in innovation management one can significantly increase the efficiency of both innovation management and innovation itself.

The results of the dissertation research can be used by enterprises of the rocket and space industry. They have been applied by the enterprises belonging to Non-Profit Partnership Self-Regulatory Organization "Energy-Efficient Technologies" and Autonomous Non-Commercial Organization "Institute of Transdisciplinary Technologies".

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