

Creation of a System for Managing and Coordinating Research and Development Activities at High-Tech Enterprises



Dobrova Katrina Benikovna, Dobrova Ekaterina Dmitrievna

Abstract: *The article considers the role of research and development in the activities of high-tech enterprises. The problems that arise during the implementation of innovation and investment activities of enterprises are analyzed, which are associated with the complexity of the commercial evaluation of developments and new products, the incompleteness of research, the lack of infrastructure for the design of new technologies, as well as the fragmentation of financial opportunities with development potential. It is concluded that most of the problems that arise at the design stage of research and development work cannot be effectively resolved by a set of separate measures. In this regard, the article proposes the construction of a management and coordination system for research and development. This system is integrated into a functional management system, focused on the successful implementation of innovative strategies and the growth of market value of high-tech enterprises. The main tasks of constructing such a system are given, its components are described in detail. The use of the "stage-gate" method to provide an objective selection of research and development work within the framework of the direction for the development of the project management subsystem is justified. The article presents the author's method of comprehensive assessment of the effectiveness of R&D projects, based on the use of an integral indicator. To reduce the subjectivity of the method of expert analysis, the need for the correct selection of experts is noted. Experts must have managerial experience in enterprises engaged in or financing research, development and commercialization of R&D results. The article presents a practical example of assessing the effectiveness of a R&D project for a specific high-tech enterprise.*

Keywords: *research and development activities, management and coordination system, high-tech enterprises, "stage-gate" method, comprehensive assessment.*

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I. INTRODUCTION

In accordance with the main provisions of the "Strategy of innovative development of the Russian Federation for the period till 2020", approved by the Decree of the RF Government dated 08.12.2011 №2227-R, the main purpose of the country development is to transfer the Russian economy to an innovative path of development and to increase importance of high-tech enterprises and industries.

Success in innovation activities of high-tech enterprises can be achieved in the implementation of fundamental and applied research, but also in the implementation of innovations, by expanding the links between science and production, implementing projects related to the transformation of ideas, research and development into technologically new or improved products [9]. The solution of these tasks is directly related to the performance of research and development activities (hereinafter referred to as R & D).

The processes of systemic disintegration that took place in the country's economy after the collapse of the Soviet Union had a significant impact on scientific and industrial organizations. Besides, many Russian high-tech enterprises were not ready to function in the market economy that requires restructuring activities for innovative changes. Despite the fact that the country has significant scientific and technical potential, scientific and industrial base is aging, the demand for the results of scientific activities is falling, there is a weak orientation of innovative potential to exploit scientific advances, there are challenges of technology commercialization, research and development, etc [3, 16].

II. THEORY

The problems of the high-tech enterprises development are reflected in the works by Avdonina B. N., Batkovskij M. A., Belokon S. P., Belyakov G. P., Gribova V. D., Eremeeva, S. V., Eremenko, M. V., Kokhno P. A., Fomina A.V., Chebotarev S. S.

The main problems of management and coordination of research and development include:

1. Conflict of interests of managers at different levels and misunderstandings between departments. Often when

designing new products, designers and engineers create a complex product that does not always meet the needs of certain market segments and end users (customers) [10].

2. Ineffective material and technical base of the innovation environment (excessive preponderance in the direction of the procurement of imported finished equipment to the detriment of the implementation of our own developments) [15, 16].

3. High R&D costs (costs of technological innovation often exceed the profit from an innovative product in absolute terms) [13, 14].

4. Low return on the implementation of new technologies.

5. Uncertainty and high risks when creating new products and technologies [3].

6. Lack of a comprehensive analytical system on a single base of a single IT platform, including the R&D information module in the processing, evaluation and analysis of information.

7. Lack of comprehensive monitoring (a change in the structure and volume of R&D leads to an increase in information about external and internal economic factors that complicate R&D management and require constant monitoring, comparison with advanced analogues in order to develop high-quality managerial decisions) [7].

8. The lack of a unified methodological support for the analysis of the effectiveness of R&D results (in the framework of traditional financial accounting and analysis, there is no unified methodological support for the effectiveness of long-term and medium-term scientific research) [10].

Analysis of the research suggests that a number of problems related to the complexity of commercial evaluation of developments and new products, incomplete research, insufficient infrastructure for the new technologies design, as well as the disparity of financial opportunities with development potential, cannot be effectively solved by a set of separate measures.

The purpose of this article is the theoretical justification and development of practical recommendations for improving innovation and investment activities by building an R & D management and coordination system.

III. METHODOLOGY

At most Russian enterprises, R & D is implemented without reference to strategic goals. The current approach to managing the R & D system does not cover all the target areas. R & D is carried out mainly within the framework of a state order and does not form a reserve for future demand. The R & D system itself is a complex subsystem for managing the activities of high-tech enterprises. Its complexity is due to the heterogeneity of tasks, the uncertainty of results and a high degree of risk at all stages, the heterogeneity of its elements and the relationships that arise between these elements. The study of the specifics of the domestic high-tech enterprises functioning confirms that certain measures aimed at improving the efficiency of innovation and investment activities do not fully solve the problems and difficulties existing at the R & D stage [3, 11, 12].

In this regard, it is proposed to build an R & D management and coordination system (hereinafter – R & D MCS), which affects all aspects of the company's activities. The main tasks of building such a system are:

- 1) improving the R & D selection process efficiency;
- 2) achieving planned R & D results;
- 3) supporting sustainable development of the enterprise;
- 4) improving the efficiency of allocation and use of all types of resources.

To solve these tasks, it is necessary to integrate the R & D MCS into the process of managing innovation and investment activities. The structure of the R & D MCS at a high-tech enterprise is shown in figure 1.

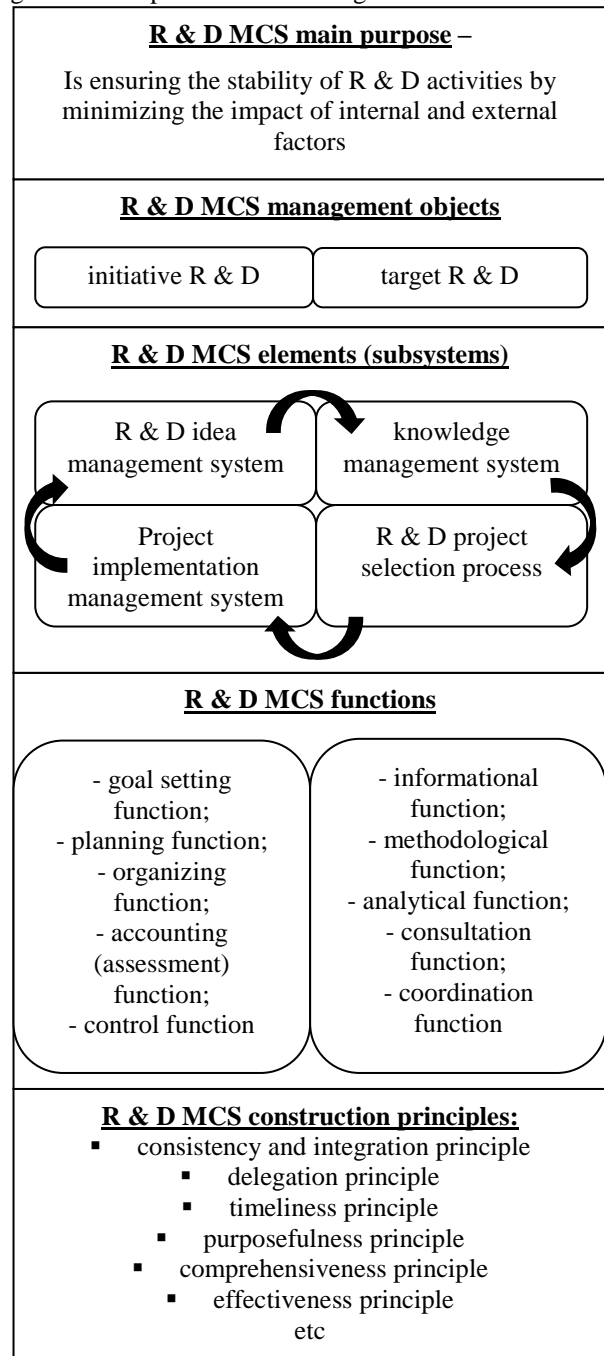


Fig. 1. R & D management and coordination system in the functional management system of a high-tech enterprise

According to the data in figure 1, the main components of the R & D MCS are the following:

- 1) setting a goal that determines the feasibility of applying the R & D MCS at the enterprise;
- 2) identifying the objects that will be covered by the R & D MCS;
- 3) R & D MCS elements system (subsystems) with its own tools; the elements system creation will allow developing competencies in the development of competitive technologies and products;
- 4) set of common principles for the formation of the R & D MCS that ensure the effectiveness of its application in the process of R & D management;
- 5) R & D MCS main functions, the implementation of which ensures the achievement of the goal.

The main goal of creating an R & d MCS is to ensure the stability of R & D activities by minimizing the degree of impact of internal and external factors. The management objects of the R & D MCS are initiative and targeted R & D projects. Initiative R & D is a work that is ordered by the company itself. Such R & D is carried out in order to create intellectual property that will be used within the enterprise for its own needs. Targeted R & D is carried out mainly within the framework of state orders, federal target programs, etc., and involves targeted funding from the state budget and the budgets of departmental bodies.

The formation of the R & D MCS is based on the following basic principles (this list is not exhaustive):

- 1) consistency and integration principle, involving interconnection of all components of the R & D MCS formation process, of all its elements and the relationship between subsystems, is the leading principle in developing R & D MCS and defining its content;
- 2) delegation principle, which means the distribution of functions, tasks and responsibilities among all participants in the R & D MCS;
- 3) timeliness principle, which indicates the need to develop the R & D MCS to solve existing problems in enterprises;
- 4) purposefulness principle – the R & D MCS should be verified for compliance with the strategic goals of the enterprise;
- 5) comprehensiveness principle - the R & D MCS formation should take place in a comprehensive manner, taking into account the influence of all factors;
- 6) effectiveness principle, characterized by the fact that the the R & D MCS should be focused on the successful implementation of the entire set of R & D projects and maximizing economic efficiency.

The R & D MCS formation process consists of 4 main stages, presented in the figure 2.

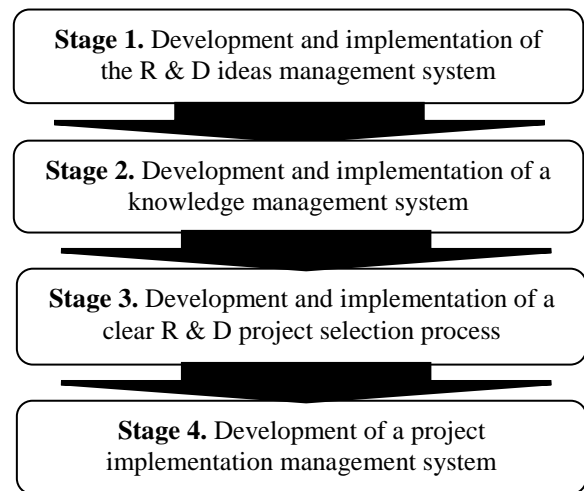


Fig. 2. Stages of the R & D MCS formation process at high-tech enterprises

Look at the main tasks of the organization of R & D MCS in each of the directions in more detail.

Stage 1. Development and implementation of the R & D ideas management system

Tasks of the "Development and implementation of the R & D ideas management system" direction:

- development and implementation of a system for collecting R & D ideas (internal and external);
- creation of information tools that ensure the operation of the system;
- development of a system for evaluating R & D ideas;
- creating an environment for attracting and developing researchers;
- implementation of a system of employee motivation (for example, the purchase of rights to an invention).

Stage 2. Development and implementation of a knowledge management system

Tasks of the "Development and implementation of a knowledge management system" direction:

- creation of a unified system with access rights differentiation, which includes a knowledge base, experts, thematic communities, etc.;
- creation of a corporate portal that includes the results of analysis of markets and consumer segments, the exchange of the enterprises` technological competencies, the exchange of competencies of research centers and laboratories.

To solve the tasks within the directions under consideration, the authors propose the following activities:

- 1) holding regular contests for the best ideas and encouraging the winners for various qualities of the proposed
- 2) ideas;
- 3) introduction of a system for collecting proposals from employees with mandatory publication of the results of their consideration;
- 4) public or highly specialized discussion of problems on the corporate website;

- 5) organization of a system for publishing and discussing ideas on a corporate website – corporate crowdsourcing;
- 6) creating a system for assigning priorities to employees and teams within the enterprise as part of the development of new ideas;
- 7) assistance in legal registration of patents and other documents confirming the authors' priorities;
- 8) creating regulatory conditions for working on own ideas and projects within the company;
- 9) implementation of a system of employee motivation (one-time remuneration, purchase of rights to an invention, etc.).

To improve performance, the company's R & D service must interact with scientific and production departments, as well as with strategic marketing and sales departments, since these departments are the main generators of ideas.

Stage 3. Development and implementation of a clear R & D project selection process

The task of the "Development and implementation of a clear R & D project selection process" direction is to formalize the selection process for R & D projects in accordance with the strategic goals of enterprises: determining the stages of project selection for different R & D types (initiative / target), forming a pool of participants in the selection process for different types of projects (including the independent experts involvement), developing technical and financial selection criteria for different R & D types.

The selection of initiative R & D includes the following sequence of steps:

- 1) Creation of the R & D project passport. The R & D project passport contains all the necessary information for conducting a scientific and technical assessment.
- 2) Conducting a scientific and technical assessment of the project in order to select and filter existing ideas, analyze the project feasibility, evaluate the planned results, effectiveness and prospects for the project commercialization.
- 3) Meeting of the investment committee, which conducted a financial-investment assessment of the project, discusses the presence of the justification of the goals and action plan for the project implementation, checks the availability of funds for the project, the task of finding and attracting investors (in the absence of budget funds) is set.

- 4) Meeting of the scientific and technical council, where experts assess trends and scientific novelty, technological expertise, and assessment of technical and technological risks. Experts make a decision on the implementation of the project. If there is no possibility of making such a decision, the project is sent for revision.

The process of selecting targeted R & D includes, in addition to the above stages, a "Meeting of technical and technological committees". Within these sessions, experts of specially created working groups assess trends and scientific novelty, prospects for the project commercialization, technological expertise, assessment of technical and technological risks, financial and investment expertise, analyze the rationale for the goals and action plan for the project implementation [6].

The final stage of the selection process for both initiative and target R & D is the formation of a project team, the allocation of laboratory space and, accordingly, the start of the project work.

Stage 4. Development of a project implementation management system

Tasks of the "Development of a project implementation management system" direction:

- development of rules for making a decision on the continuation of the project based on the analysis of the results of work at each stage (using the "stage-gate" method»);
- development of a system of key performance indicators (hereinafter referred to as KPIs) for evaluating the effectiveness of R & D at the level of a project portfolio or individual project.

In this system, it is proposed to use the "stage-gate" tool, which is widely used in domestic and foreign practice [8].

The essence of the "stage-gate" method is as follows. The development cycle of any product should consist of several stages. The decision to move the project to the next stage is made only at meetings with the participation of all interested parties called gates. To ensure an objective selection, the decision is made based on an assessment by a number of pre-defined criteria. No project should "skip" such assessment procedures [1, 2]. An example of the formal "stage-gate" project selection process is shown below (figure 3).

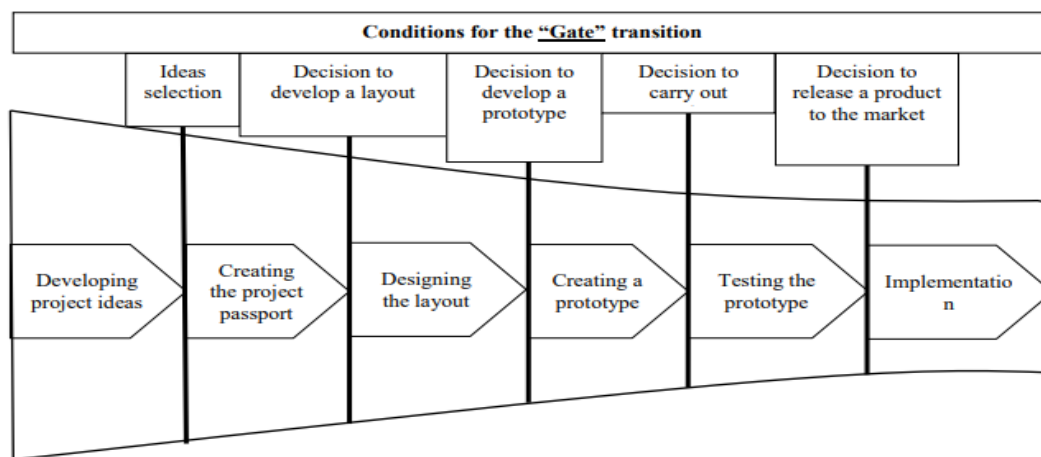


Fig. 3 Example of a product development cycle

According to figure 3, the "funnel" of the project is divided into 6 stages: developing project ideas, creating the project passport, developing a solution (layout), creating a prototype, its testing and implementation (release of the product to the market). The transition conditions are the decision to develop a layout, the decision to develop a

prototype, the decision to test the product, and the decision to release the product to the market.

Depending on the type of project (R – research activities or D – development activities), the development cycle, the list of stages, participants, and transition conditions will differ (Table-I).

Table-I: R & D development cycle using the "stage-gate" method

Project type	List of "stages" [5]	Project participants	Transition conditions («gates»)
Research activities	1) developing technical specifications (TS) for research activities; 2) choosing research directions; 3) theoretical and experimental research; 4) generalizing and assessing research results.	1. Engineering and technical employee (ETE) 2. Patent specialist 3. Designer 4. it professional 5. Economist	1. Positive conclusion about the feasibility of completing the task for research. 2. There is a need for this development. 3. Obtaining a patent.
Development activities	1) developing TS for development; 2) technical proposal; 3) preliminary design; 4) technical design; 5) developing the working documentation for manufacturing and testing of the prototype; 6) preliminary tests of the prototype; 7) state (departmental) tests of the prototype; 8) testing documentation and certification	1. Engineering and technical employee (ETE) 2. Designer 3. IT professional 4. Economist 5. Commissioning worker 6. Tester 7. Certification specialist	1. Positive conclusion about the feasibility of completing the task for development. 2. There is a need for this development. 3. Decision to create a sketch 4. Decision to develop the layout. 5. Decision to develop documentation 6. Decision on the pre-test 7. Decision on the state test 8. Positive result of certification

The KPI system for evaluating R & D performance at the project portfolio or individual project level will allow for timely monitoring of R & D results. At the individual project level, the project team's KPIs are set individually by the project manager.

Examples of KPIs include "deviation of key indicators for the project from the planned values (NPV, IRR, DPP, etc.)", "shortening the time of product launch". Examples of KPIs at the project portfolio level include: "changes in actual R & D expenditures compared to budgeted expenditures", "proximity of technology to practical use", etc.

IV. METHOD FOR A COMPREHENSIVE ASSESSMENT OF THE EFFECTIVENESS OF R&D PROJECT

The goal of a comprehensive assessment is assigning points and obtaining a comprehensive assessment for each R & D project by experts. A score is given by each member of the committee based on a number of pre-approved criteria, and the project proceeds to the next stage of review or revision based on the results of the assessment. From the point of view of business and market relations, a set of qualitative criteria is proposed for scoring R&D projects, grouped into the following integral indicators of project evaluation: innovative attractiveness, strategic importance and competitiveness [10]. Table-II shows an example of group of the main components for the R & D project assessment at high-tech enterprises.

Table-II: The system of indicators for assessing the effectiveness of R&D projects [10]

Integral indicators	Components
Strategic importance	- compliance with strategic goals; - the level of competitive advantages of the project results and the possibility of their long-term preservation; - compliance of the project with the priority areas of the strategy of the Russian Federation.
Innovative attractiveness	- patentability, availability of intellectual property; - the scientific novelty of the solutions proposed in the draft; - the relevance of the study and the uniqueness of the product.
Competitiveness	- the presence of the market and the possibility of commercializing the proposed project results; - customer availability and consistency with existing distribution channels; - the presence of competitors in the domestic and foreign markets.

The considered indicators and components allow for a comprehensive assessment of R&D projects of high-tech enterprises, but their combination is not universal. Experts can form a system of indicators that meets strategic goals and objectives of high-tech enterprises, which indicates the diversity and variability of the list of components.

The experts determined a single grading scale and its range: each component is assigned a score that lies in the range from 0 to 3.

The comprehensive assessment of each R&D project is determined as follows:

$$CA = \sum_{j=1}^n P_i \times W_j \quad (1)$$

where: CA - comprehensive assessment of R&D project;

P_i – point assigned by experts for each component of each integral indicator;

W_j – weight of each integral indicator.

The Point is defined as the arithmetic average of all the points that the experts assigned for each component.

Experts should have managerial experience in companies that carry out or finance research, development and

commercialization of their results. Experts provide a reasoned conclusion about the project feasibility.

In order to present a reasoned conclusion by the experts on the feasibility of the project, it is necessary to use the data presented in the Table-III.

Table-III: Scale of appropriateness of the implementation of the R&D project

Range of comprehensive assessment values	Feasibility of the project
[0;3)	It is impractical to implement a R&D project
[3;6)	R&D project implementation entails certain risks
[6;9]	It is advisable to implement the R & D project

V. RESULT AND DISCUSSION

Based on the calculation results, a comprehensive assessment of the research and development project of a high-tech enterprise was received in the amount of 6 (Table-IV).

Table-IV: Illustration of the calculation of a comprehensive assessment of a R&D project

Integral indicators	Components	Point (P _i)	Weight (W _j)	Assessment
Strategic importance	- compliance with strategic goals;	3	0,2	1,2
	- the level of competitive advantages of the project results and the possibility of their long-term preservation;	2		
	- compliance of the project with the priority areas of the strategy of the Russian Federation.	1		
Innovative attractiveness	- patentability, availability of intellectual property;	1	0,5	3
	- the scientific novelty of the solutions proposed in the draft;	2		
	- the relevance of the study and the uniqueness of the product.	3		
Competitiveness	- the presence of the market and the possibility of commercializing the proposed project results;	3	0,3	1,8
	- customer availability and consistency with existing distribution channels;	1		
	- the presence of competitors in the domestic and foreign markets.	2		
Comprehensive assessment				6

According to the scale of appropriateness of the implementation of the R&D project, experts were prepared a motivated conclusion on the feasibility and necessity of implementing this R&D project.

The use of the management and coordination system for research and development at high-tech enterprises allows to:

- 1) improve the efficiency and effectiveness of the R & D selection process;
- 2) achieve the planned R & D results;
- 3) implement sustainable development of innovative and investment activities of the enterprise;
- 4) improve the efficiency of allocation and use of all types of resources;

- 5) build successful communications between departments that are directly involved in the process of creating and implementing R & D;
- 6) conduct a comprehensive assessment of R & D projects by both the company's specialists and external experts.
- 7) get a reasoned opinion on the feasibility of R & D projects implementing.

VI. CONCLUSION

The development of high-tech enterprises through successful implementation of innovative and investment activities is a key factor for growth and development.



Continuous improvement of products and technologies, effective use of existing potential and resources, as well as constant adaptation of the internal development strategy to changing environmental conditions are necessary conditions for the high-tech enterprises' activities. This conclusion justifies the need to create a R & D management and coordination system at high-tech enterprises, which will allow taking into account the specific features of their investment activities. It is impossible to solve the problems associated with the successful implementation of R & D projects and the proper return on their implementation without creating favorable conditions for generating ideas, increasing the number of initiative R & D projects and improving the scientific background. It is proved that the R & D management and coordination system at high-tech enterprises is aimed at increasing the stability of innovation and investment activities, financial stability and growth of the scientific potential of the enterprise. Moreover, this system is focused on the successful implementation of the innovation strategy and is integrated into the functional management system of the enterprise. Errors arising in the management and coordination of R&D in high-tech enterprises should be eliminated by establishing communications between departments in order to exchange information about promising segments and products, analyzing markets and consumer segments, both at the request of R&D employees, and the strategic marketing functions initiated. In addition, interaction is necessary to understand the world's best practices and the formation of unique (advanced) tactical and technical characteristics, as well as to initiate R&D ideas and projects.

The development of such a system in modern operating conditions requires systematic planning, analysis and control of all stages of innovation and investment activities and improvement of project management methodology, including R & D.

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