Modelling of project planning processes in high-tech technologies in the development of intelligent transport systems

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Abstract. The article describes the task of modeling a project for the development of a research and development management system (R & D) in transport sectors. The economic essence of the tasks is determined, the necessity of using information technologies is justified, the cost price calculation is formalized, design decisions are justified, informational support of the task complex is developed in the development of intelligent transport systems. Informational support of a set of tasks was developed, its software implementation was considered: data flow diagrams and functional diagrams were presented, and a system operation scenario was described. The management system solves the problem of determining the composition of research workers, calculating the planned and actual cost, the formation of contracts for the execution of work and the control of their payment cost analysis. The proposed management system can be used for any organizational structure of the enterprise and activities. The importance of solving to driven by energy efficiency in the transport sector. After the implementation of the system, the number of executed contracts will increase, profit from this area of the enterprise’s activity will increase, and the cost of processing information will also decrease.

1. Introduction
The relevance of the study is due to the need to support innovative projects in the field of R&D in transport systems, as world experience shows that R&D is the key to the competitiveness of a high-tech enterprise. Dynamic monitoring of R&D costs is topical, which makes it possible to make operational management decisions and carry out the necessary adjustment of plans when changing external conditions. A management system is needed that will solve the following problems: calculation of the planned cost of both scientific work and scientific and technical products; drawing up a contract for the performance of these works and monitoring the timeliness of payment of the stages of contracts; calculation of actual cost; analysis of the data obtained and the formulation of recommendations to scientific and industrial units that develop intelligent transportation systems.

Purpose: to offer a system of operational management of R&D, reflecting the real cost of research and scientific and technical products, capable of more effectively managing costs at various stages of the scientific and production process. In this regard, there is a need to develop a methodology for modeling project planning processes to develop a R&D management system. The solution to this scientific problem is of great economic importance. It was this circumstance that determined the
choice of the topic and the main directions of the study. The lack of ready-made solutions in this matter makes this task relevant.

In article [1] is presented a new mathematical approach to project management based on mental models. The article [2] discusses the managerial consequences of increasing the absorption potential in the management of research projects and the company. Management of not one project, but a portfolio of projects is considered in article [3]. Dependency matrices and visual presentation methods are used. For modeling and project management with limited resources in [4] it was proposed to use colored Petri nets, and in [5] the use of flexibility. A flexible presentation of the chart and table format allows project managers to easily and objectively determine the types of activities, the duration of which can be increased or shortened. In article [6], it is proposed to apply the principle of sustainable development for sustainable project management. Article [7] is devoted to the study of the dynamic relationship between project management and organizational innovation, article [8] to research on project management in terms of its relationship with related disciplines, article [9] integrating flexible methods and principles for interdisciplinary cooperation, and article [10] forecasting potential research areas in project management that may appear in the foreseeable future.

The role of corporate governance in the commercialization of radical technological innovations is considered in article [11]. Specific technological innovations are presented in the following works: in article [12] - design of control of galvanic lines, in article [13] control of the machining process on lathes, in article [14] modeling of an electric steel furnace, in article [15] a control model for road and transport engineering, in article [16] the development of production lines, in article [17] models for project management of R&D, in article [18] the assessment of R&D management systems.

As a result of the analysis of the described works, we conclude that the existing management approaches in high-tech technologies emphasize the development of control theory and the management of specific technological processes, without taking into account the influence of high technology.

Analysis of modern publications on the projects planning, the management and modeling of production processes in high technology shows that they are mainly devoted to conceptual questions or individual production processes.

High-tech production, as a rule, implements the full product life cycle. Such an enterprise requires integrated management of all life cycle processes. A knowledge-based production management system should provide the ability to return the product to the development stage. After conducting research, having received experimental products, checking its competitiveness in the market, the products are put into serial production.

One of the main areas of activity of a high-tech enterprise is to conduct research and development (R & D). By now, it has become obvious that the level of development of the scientific and technical sphere - science, education, high-tech industries, world technology markets - defines the boundaries between rich and poor countries, creates the basis for sustainable economic growth, and is the most important factor in solving various problems. Thus, the sphere of innovation is the basis for the qualitative growth of the economy.

2. The project planning process modeling methodologies

The basis of the planning methodology of the project to build a R&D management system is the formation of a functional information model of the management system.

Given the features of high-tech production, the following methodology for constructing a functional model of a high-tech enterprise is proposed:

1. Description of the scientific and production system as a whole and its interaction with the external environment:
   - selection of the purpose of modeling, the direction of development of the model and its boundaries;
   - justification of the necessary level of detail;
   - selection of objects, functions, input and output quantities, controls, mechanism;
2. Breakdown into production, research and development subsystems;
3. Description of the subsystems;
4. Justification of the next decomposition.

Modeling is carried out in three main stages:
- model building,
- check of adequacy,
- analysis of the model in terms of the effectiveness of business processes.

The profit from orders under R & D contracts may be about 20% of the total profit of the enterprise. Thus, it is important for an enterprise to ensure the correct and high-quality execution of such contracts, while at the same time producing a quick calculation of the cost estimate for conducting scientific work, analyzing costing cost items and possible ways to reduce them.

For the customer of R & D, it is important not only to quickly and efficiently carry out scientific work directly, but also to quickly draw up contracts, as well as to determine the contract price of such works.

The R & D management system should address the following tasks: determining the composition of the research team for R & D; calculation of the planned cost; drawing up a contract for the performance of work and monitoring the timeliness of payment for the stages of the contract; calculation of the actual cost; analysis of the data and formulation of recommendations.

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The model of the R & D management system is shown in the form of the IDEF0 functional diagram. The processes occurring in the system are shown in Figure 1-4. Within each process, we single out processes of deeper levels - subprocesses, which are also objects of control.

Forward planning focuses on the feasibility of investment decisions. To achieve this goal a business plan is drawn up. Business planning is carried out for each specific investment project.

The following documents are included in the reports of the R & D management system:
- the plan of the fund of free working time used to determine the scientific group for the implementation of the research and development contract;
- order on the composition of the research team for the implementation of each contract, containing data on employees who will perform scientific work;
- the calendar plan for the R & D contract, containing data on the number and name of the work (stages), the time and cost of their implementation, as well as the final result and procedure for accepting each work (stage) of the contract;
- cost estimate for each R & D contract;
- protocol agreement on the contract price for R & D, representing the agreement between the customer and the contractor on the value of the contract price for the implementation of R & D at each stage of the contract;
- the act of acceptance of scientific and technical products, signed by the transfer of work performed from the customer to the performer;
- costing for each stage and contract to reflect the actual costs of performing R & D;
- wages, taking into account the basic and additional wages for each employee involved in the execution of works under research and development agreements;
- a statement containing data on direct and indirect costs, written-off costs and total costs from the beginning of the year or the beginning of work;
- cost analysis for costing items, which is an analysis of the implementation of the plan item by item and comparing the actual costs with the planned ones;
- analysis of the cost of materials;
- analysis of the impact on the cost of labor costs;
- analysis of overhead costs.
Figure 1. Functional diagram "Project Planning".

Figure 2. Detailing the "Project Planning" chart.
Figure 3. The analyze life-cycle of high technology products.

Figure 4. The process of forming a business plan.

When collecting and registering primary documents, the R & D management information system records information on the media, here the necessary actions of a person and technical means. In determining the scientific group and the timing of the implementation of the system, the most optimal schedule is formed and the composition of researchers who will be involved in the implementation of this research and development agreement is determined.

At the stage of the formation of the contract, an estimate of costs is determined, a contract is concluded for the performance of scientific works and control is introduced for the payment of these
contracts. Here the manager is provided with information about the payment, on the basis of which a decision on early termination of the contract may be made. The calculation of the actual cost is made by the system automatically without direct human participation, in addition to costing, a grouping sheet, a material report and a table of salary are compiled.

In the more well-known project planning processes in high-tech technologies, for example, uses a hybrid management approach in article [19], structured goal-setting in article [20], and lean manufacturing methodology in article [21]. However, the concept of the life cycle of high technology products is not used anywhere.

In contrast to the considered processes, in the business processes presented in Fig. 1-4 we will use this concept. In the life cycle of high technology products, we distinguish two components: the life cycle of pilot products and products that have undergone pilot production and launched into serial production. A feature of high-tech products is the rapid updating of types of manufactured products. A large proportion of the costs in the life cycle of high-tech products goes to the formation of fixed capital, R&D, staff training, organization and support of production, marketing. R&D carries the main innovative burden and is characterized by a high degree of uncertainty and a high level of risk.

3. The formation of a database for a control system

Developed on the basis of the functional information model discussed in Section 2, a set of management tasks is presented in the form of a database. The organization of data in the database requires the preliminary systematization of various information and the display of its properties by content, structure, volume and relationships.

The database model is shown in Figure 5.

![Data model](Figure 5)

The usefulness and effectiveness of the logical model depends on the degree to which it displays the simulated domain. The subject area includes objects, their properties and characteristics, interaction and processes over them. When building a database, objects, processes or entities of the subject area are identified. For each object, a set of characteristics characterizing it (fields, details) is allocated.

The following is a description of tables (entities), fields contained in it, and data types.

Table 1 contains information about the customer under this R&D agreement.
Table 1. The essence of "customer".

| Attribute          | Description                      | Data type |
|--------------------|----------------------------------|-----------|
| Customer ID        | Customer identification code      | Counter   |
| Company name       | Company name                     | String    |
| Company address    | Legal Company address            | String    |

Table 2 contains data on the contractors involved to performer certain work.

Table 2. The essence of "performer".

| Attribute          | Description                                                   | Data type |
|--------------------|---------------------------------------------------------------|-----------|
| Executor ID        | Executor identification code                                 | Counter   |
| Full name          | Last name, first name and patronymic of the Executor          | String    |
| Department ID      | Executor identification code                                 | Number    |
| Position           | Position of the Executor                                     | String    |

Table 3 contains data on departments involved in the implementation of the R&D contract.

Table 3. The essence of "department".

| Attribute          | Description                           | Data type |
|--------------------|---------------------------------------|-----------|
| Department ID      | Department identification code         | Counter   |
| Name               | Department name                       | String    |

Table 4 contains information about the project when performing R&D at each stage of the contract.

Table 4. The essence of the "project".

| Attribute          | Description                           | Data type |
|--------------------|---------------------------------------|-----------|
| Project ID         | Project identification code           | Number    |
| Name               | Project name                          | String    |
| Customer ID        | Customer identification code           | Number    |
| Executor ID        | Executor identification code           | Number    |
| Date of creation   | Project creation date                  | Number    |
| Execution period   | Period of execution order             | Number    |
| Cost               | Cost of project                       | Number    |

Tables 1-4 reflect the main objects of the subject area and the relationship between them. The main components of tables are entities, attributes, and relationships. Each entity is a set of individual objects, which is different from all others. An attribute expresses a specific property of an object.

The model shown in Fig. 5 and tables 1-4, allow you to reduce all the information about existing projects into one database, forming an integrated information environment of a single information space.
4. Conclusion
1. The analysis of the state of development in the field of modeling and control of production processes, from which it follows that among the replicated control systems, there are very few focused on innovative high-tech industries.
2. A scientifically based methodology is proposed for modeling and constructing high-tech production management systems designed to intelligently support management in creating high-tech products, which differs from the well-known ones in that it uses a process approach based on the high-tech products life cycle.
3. Of practical value are:
   - An approach to the development of high-tech production control systems, which consists in a comprehensive review of the life cycle of high-tech products, allowing you to combine a planning strategy with operational management;
   - a functional-informational model of project planning in high-tech technologies, which are the basis for the development of the database of the R&D management system.
4. The provisions obtained in the work can be used in further theoretical and practical research and are aimed at specialists involved in the development and implementation of control systems in high-tech industries.

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