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Modern Approaches to Administration of Long-Term Science-Intensive and High Technology Projects

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ABSTRACT

The article introduces a novel and relevant research methods which were based on the most topical principles of project management, focused on effective time, price, and final results management. The aim of the following article is to highlight the peculiarities of the modern approaches to the administration of long-lasting science-intensive and hi-tech projects that distinguish these projects from the traditional methods. Special attention was given to the methodology of such managerial aspects as substantiation of the system-forming principles, placed in the root model of administration of long-term scientific-intensive and hi-tech projects and development of roadmaps by the creation stages of scientific-intensive processes, including the maintenance events and corresponding documents for each stage. As a result, the groups of hard and soft factors were revealed incoherence to project management influence factors. Also, the role functions and distribution of responsibility of members of scientifically-intensive projects/programs were defined. With the help of analysis of nature dependencies related to the strategic aspect of the project, an increase of initial costs of the long-term and high-risk projects had also been described.

Keywords:ISO 21500-2014, PRINCE, L.C. model, hard factors, life cycle, soft factors, technology roadmap, project management, team building

1. Introduction

In current time we observe the extra attention to the implementation of project management methods into the activity of economic subjects of different levels. This management type's peculiarity is focusing the attention of the project's interested persons at the term and price (profitability in case of commercialization) of its results' achievement [1-3].

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Other important aspects of project management are the increased technical complexity of performance and project participants' low emotional involvement. However, as it is shown in the works [2, 4], the last statement is not true for large and long-lasting projects (megaprojects), in which a big role is given to the human factor and, accordingly, emotional involvement that demands a special approach to project's stuff management.

2. Literature review

2.1. Features of mega projects

It is noted in [5] that megaprojects have a range of quantitative and qualitative features:

- the required amount of investments is more than $1 bln;
- change of life of more than one million people;
- realization takes five years and more;
- the attraction of increased public attention;
- an essential role of the government;
- special complexity and risks;
- vast infrastructure component;
- a big number of involved staff and contractors;
- long-term social and economic effect;
- multiplicative influence on involved economy sectors.

These features may be to any extent referred to long-lasting scientific-intensive and high technological projects, which leads to a range of problems in the process of their realization. According to the source [6], which refer to the USA body in research, audit, and statistics − Government Accountability Office (GAO), the delay with the realization terms of 38% of aerospace and defense programs of USA is up to 2 years, 26% of them – 4 years, 14% – more than four years and only 33% of programs do not run behind schedule. According to the same data, the increase of the price of goods unit in the present time is 31.2%, and it is expected that it will increase in 2018 up to 41.2%, if not to use any remedial measures.

Another problem is connected to the cross-border relationship of adjacent regions or countries in terms of innovation, which is becoming omnipresent in the age of globalization. The productivity of such relationships depends on the strategic cross-border coupling of innovative milieus and requires the close attention of public authorities. Being out of balance, the cross-border relationship may cause the shift of R&D subject area, change in specialization, intellectual resources outflow, etc., decreasing the input value of local, territorial capital in national accounts (the worst scenario being the alienation of the region's innovation system) and significantly lowering the chances of mega projects to be realized [7].

2.2. Reasons for the problems in the aerospace and defense sectors

The reasons for the mentioned problems in the aerospace and defense sectors of industry are as follows:

- increasing processing complexity of goods;
- lack of qualified staff;
- problems in the complicating supplies chain;
- strengthening of political factors in decision making;

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- problems in program management.

This work aims to study the modern approaches to managing long-lasting, scientifically intensive, and high technological projects.

3. Methodology

Choosing the up to date approaches and standards in the sphere of project management, we should note first of all the PMBOK® (Project Management Body of Knowledge)[8], which was tested during certification of managers of Airbus corporation and received the development in standard ISO 21500:2012 [9]. Taking into consideration the human factor role and emotional involvement in the realization process of the major and long-lasting projects as an additional approach oriented to well-balanced stuff management (creation of the project team, its administration, and motivation of team members), it is necessary to mention the PRINCE method (Projects IN Controlled Environments).

3.1. Main principles of PRINCE method [2]:

- business warranting;
- the clear organizational structure of the managing team of the project;
- a results-oriented approach to planning;
- division of the project into administered and controlled stages;
- flexibility applicable at the level suitable for the project.

3.2. Procedures of project management under the PRINCE methods:

- project start (S.U.);
- project launching (I.P.);
- project planning (P.L.);
- project administration (D.P.);
- stages control (CS);
- control of stages borders (S.B.);
- administration of product manufacturing (M.P.);
- project completion (C.P.).

3.3. Logic of formation of the approach to the management of the major long-lasting scientifically intensive project

The typical division of the modern process of management of scientifically intensive and high technology projects and programs into the stages of the life cycle (L.C.) and their content is shown in Fig. 1.

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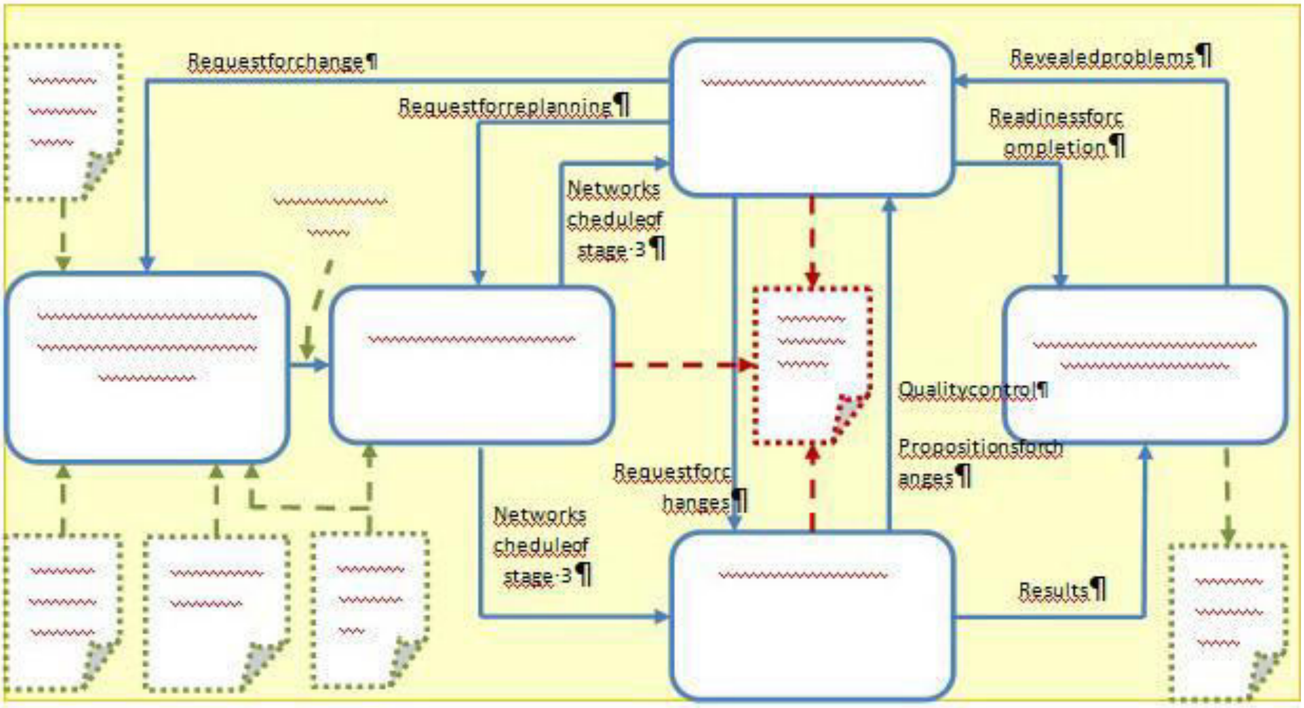

Fig. 1. Stages and content of the scientifically intensive projects management process

Using the ISO 21500 standard [9] may be accepted as the system-forming approach at developing the model of management of long-lasting scientifically intensive and high technology projects. This standard considers the interaction of project management process groups with their main input and output. Herewith, as mentioned above, the usage of other elements of project management standards that approve themselves in other spheres is not excluded.

4. Results

4.1. Process of roadmaps creation

Based on ISO 21500, there was developed the model of structured management under the principle of road mapping as a basis of planning methods for a wide range of events aimed to create technological roadmaps. Herewith, as the basis, we assume the division of the process of projects and programs management into the stages and content shown above in Fig. 1. The stage by stage presenting the process of roadmaps creation by the example of one of the key stages of the life cycle (project development) of the high technological goods is shown in Fig. 2.

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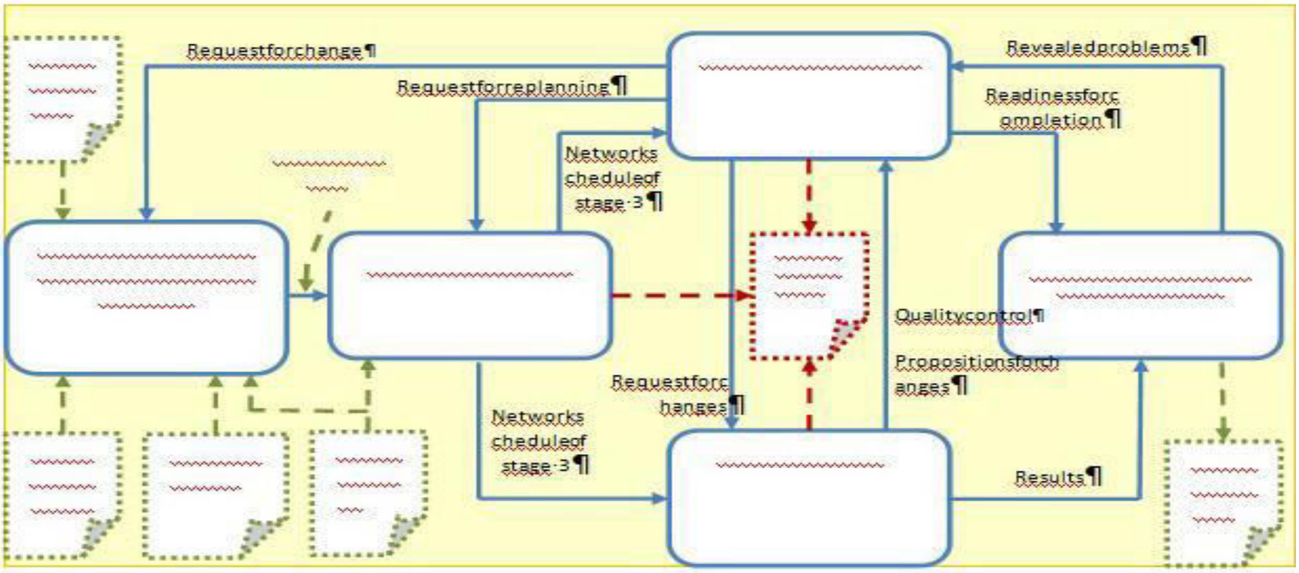

Fig. 2. Roadmap of project development for the creation of hi-tech goods

4.2. Maintaining documentation

The listed stages are logically interrelated according to the standard [9]. They are accompanied by the maintaining documentation, which, as it is seen in the scheme, includes for each of them the following:

- reports on the previous stage;
- performance specification (P.S.) for the beginning stage;
- the contract for the current stage;
- feasibility study (F.S.) of the stage;
- network schedule of the stage;
- map of risks characteristic for this stage.

In the same manner, there are formed the technological roadmaps for other stages. In such a way, for technological roadmaps creation process management, we may define the range of corresponding structural blocks, which with more detailed consideration may be linked to levels of technological readiness (LTR, see [10-12] of the projected object. Groups of the management processes for separate stages should be regulated by the inner regulatory and organizational-administrative documentation developed at the corporative level and by the harmonized with the progressive world standards in the sphere of projects management (PMBOK®) and [9].

4.3. Structural blocks

Such structuring increases the controllability of stage by stage management process, which reflects on the achievement of efficiency and effectiveness (terms-price) of the project within the system approach described, for example, in the reference book [13] and illustrated in the material [14].

4.3.1. The detailed distribution of time expenditure

The detailed distribution of time expenditure is defined as the result of integrating network planning and feasibility study of the project.

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4.3.2. The stage of preliminary formation of the appearance of scientifically intensive goods

At this stage, when there is a deficit of initial data, there are used statistical and expert data on labor intensity and needed resources depending on the project's main parameters and requirements. In this case, it gets interesting to use a close to theoretically founded [15]*relative distribution of cumulative expenditures of the type*:

$$C\left(\frac{t}{T}\right)=\frac{c(t)}{C}=\left(\frac{t}{T}\right)^{\alpha\left(1-\frac{t}{T}\right)},(1)$$

where C is the cumulative cost of project realization, defined based on general work effort (labor intensity of project); t/T- the non-dimensional ratio between the number of the current year of project realization t and its general duration in years T; α = Tβ, ( ) − correcting exponents, which are defined based on projecting experience.

Practically acceptable is an analytical defining of cumulative cost in each period by the formula (1), and then − calculation of current costs as a result of their difference in neighboring periods:

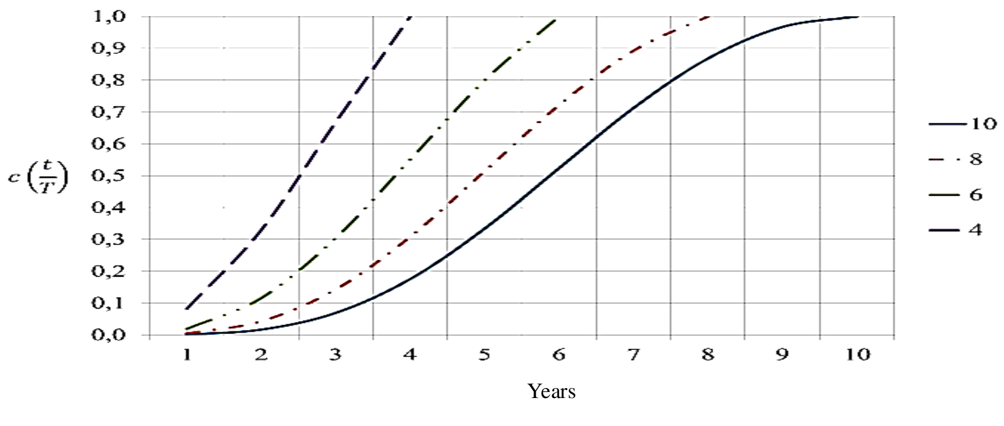
$$C_t\left(\frac{t}{T}\right)_i=C_t\left(\frac{t}{T}\right)_{i+1}-C_t\left(\frac{t}{T}\right)_i,(2)$$

where $C_t\left(\frac{t}{T}\right)_{i+1}$ and $C_t\left(\frac{t}{T}\right)_i$ — cumulative costs in (i+1)st and ist periods correspondingly.

4.3.3. The strategic aspect of the project

Against the background of increased attention to time and price management, we should not ignore the strategic aspect of the project, which includes the goal-setting, identification of priorities, monitoring of the current situation, and entering of timely necessary adjustments to the management process, as it is noted in the works [16, 17].

Fig. 3 presents the change of the cumulative and current costs for typical terms of long-term project realization (from four to ten years).



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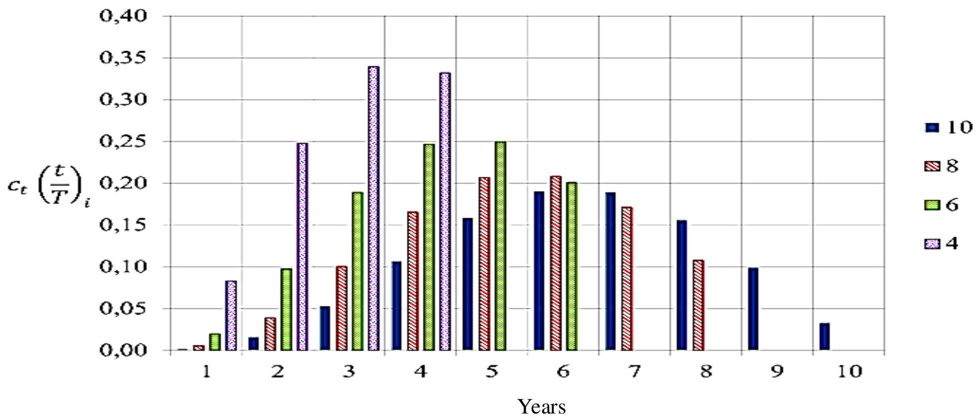

Fig.3. Change of cumulative and current costs by time periods

Analyzing the nature of dependencies shown in Fig. 3, it is possible to note the smoother increase of initial costs in the long-term (and riskier) projects, which is connected with project developers' effort to avoid big losses in case of conceptual change or cancellation of the project. Dependencies of this type are applicable for different stages of scientifically intensive product creation within the Functional-Cost Analysis [18].

4.4. Stuff management in conditions of long-term projects realization

Management of medium-term projects is usually connected with solving issues, which may be complicated intellectually or technically, though rather simple regarding the participants' interpersonal relations and emotional involvement. Nevertheless, in the large long-term projects, due to the duration and participation of many interested persons, there appears to be high emotional involvement [2]. Besides the "tough" factors' characteristic of projects, there also appears the influence of equally important "mild" specter (Table 1).

Table 1. Groups of factors influencing the project

"Tough" factors	**"Mild" factors**
Analysis of interested persons' positions	Team formation
Planning of the goals tree	Conflict management
The hierarchical structure of works	Training and development
Network planning	Communications
Feasibility study	Conduct of negotiations
Document flow	Corporateculture development
Resources management and budgeting	Cross-cultural interaction
Project changes management	Motivation
Contracts and supplies management	Creativity
Risks management	Leadership
Quality management	
Control and reports of project exponents	

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5. Discussion

Effective formation of teams (team building) has a special role when managing the projects because of the necessity to achieve the set results within time and budget limitations. To the traditionally increased attention factors, we may include the formation of the structure of personnel schedule and evaluation of direct and indirect costs for events on selection, training, and stimulation of stuff. At the present time, there's an increase of the role of team's development in general and their members individually, of motivation, conflict management competency, psychological compatibility, and underestimation leading to various expenses related to the human factor.

Efficient team building means consideration of the stage of team building, the creation of the atmosphere of cooperation, the opening of team potential, and the support of its members' cross-functional actions. Herewith, considering the full L.C. of the product, which may include several decades regarding exploitation, it should be taken into consideration the inevitability of change of part of the personnel and "blur" of stages of building the teams participating in the project, the complication of their functioning, changing of personnel motivation under the factors of changing external surrounding and inner project environment.

5.1. Responsibility zones of interesting subjects in L.C. model

The distinctive feature of the L.C. model from the conceptual model development to withdrawal of the model from service, as shown in Fig. 1, is that all essential stages are within the responsibility zones of interesting subjects which participate in scientifically intensive project/program:

- the leading organization which provide scientific guidance when creating the technological advance (T.A.) (stages 1−3);
- the main developer of the projected product (stages 3−6);
- operating officer (stages 5−6);
- the organization, dealing with storage and recovery (stage 7).

5.2. Role functions of the project's interested persons (personnel of all levels)

5.2.1. Stages 1−2

Stages 1−2 are the prerogative of scientific organization. At these stages, there occurs the formation of T.A. and partial removal of scientifically-technical risks, which define the practicability of passing to the next stages − engineering development of the future product.

5.2.2. Stage 3

At stage 3, the intensive interaction of scientific and project developing organizations occurs with the leading role of the leading developer.

5.2.3. Stages 4-5

Stages 4-5 are realized mainly by the development center. Still, depending on the extent of its interest at that interval of development, there may join a future operator who may influence the engineering decisions. As a minimum, the operator develops or participates in the writing of P.S. and operational requirements development.

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5.2.4. Stage 6

Stage 6 is the key one for the operator of the object. Still, its developer actively maintains the exploitation process (development of a technical description of the product, its technical maintenance regulations, operator's manual, documentation correction, technical maintenance and repairing, provision of component and replacement parts, etc.).

5.2.5. Stage 7

At stage 7, storage bases become the main subjects (may appear at stage 6 if it is necessary to temporarily preserve the products withdrawn from service), repair providers, and specialized organizations engaged with recovery.

Considering the logical sequence of the main stages and steps, there are defined the role functions of members of the aerospace project/program (Table 2) and the distribution of their responsibility (Table 3).

Table 2. Role functions of members of the scientifically intensive project/program

L.C. Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**
The leading organization-director of sciences	■	■	■				
Chief developer of the product			■	■	■	■	
Operator				■	■	■	
The organization, dealing with storage and recovery.						■	■

Table 3.Distribution of responsibility of members of scientifically intensive project/program

L.C. Stage	**1**	**2**	**3**	**4**	**5**	**6**	**7**
The leading organization-director of sciences	+	+					
Chief developer of the product			+	+	+		
Operator						+	
The organization, dealing with storage and recovery.							+

6. Conclusion

As a result of the conducted research, it had been found that the qualitative peculiarities of the large and long-term scientifically intensive projects lead to qualitative differences in management approach. It had also been described a relation of the dynamic influence of internal factors, connected risks, and specific execution price related to high emotional involvement of interested parties that presupposes usage of management methods at the formation stage of the inner environment of a project.

It has been assumed that an increase of the cumulative and current costs for typical terms of long-term project realization has to be smooth and avoid big losses in case of conceptual change or cancellation of the project. Also, in large long-term projects, there is an emergence of high emotional

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involvement of their main stakeholders, which adds the impact of "tough" and "mild" specters influencing the factor's management. This demands a clearer definition of the role functions and distribution of responsibility for the scientifically intensive project/program participants. It leads to the system approach based on the creation, monitoring, and constant updating of the standard documentation considering a logical sequence and distribution of responsibilities mentioned in Section 4.1.

1.
2.

The study's received results may become the basis of a methodology for the development of the strategic management of scientifically intensive projects.

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