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# Models for Changes Management in Infrastructure Projects

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**Abstract.** In paper is carried out the studies of the process of changes management in infrastructure projects. On the basis of systematic analysis, the terminological base of management the projects, programs and portfolios of projects has been expanded by formalizing the concepts of “infrastructure project” and “changes management in infrastructure project”. Has been developed a modified multi-criteria classification of infrastructure projects that allows to make a classification of infrastructure projects by identifying 5 criteria. The conceptual model-scheme of formation the parameters of changes management in infrastructure projects is presented. It allows to use standard mono-templates in the development of infrastructure projects taking into account the influence of multiparametric environment of project management (management functions) and the environment of each unique project. Has been developed a model-scheme of infrastructure projects development under the influence of project changes at different stages of the project lifecycle. It takes into account the possible impact of project changes at the points of trifurcation and allows to make a forecast of all possible variants of infrastructure projects development.

**Keywords:** infrastructure project, IT, technical systems, changes management, information system, project-oriented approach.

## 1 Introduction

Today in Ukraine and in the world, there is a rapid, but uneven development of science and techniques, information technologies and advanced management methodologies. This state of affairs poses a threat and challenges the impossibility of providing a comprehensive and high-quality management response to economic, social, safe, information challenges and crises, constant changes in the turbulent environment, and calls into question the stable and safe development of countries and territories, the functioning of infrastructure systems, in particular critical. Therefore, the main causes of such problems can be attributed to:

- differences in approaches to the implementation of different types and levels of projects, programs and portfolios of projects;
- integration processes;
- the use of different, non-standardized methodologies and standards, which creates the problem of their adaptation in the planning and implementation of national and global infrastructure projects.

## 2 Analysis of Recent Research and Publications

Issues of forming scientific and practical approaches to management of projects, programs and portfolios of project, processes of change management in complex IT projects were investigated by leading domestic and foreign scientists, in particular H. Tanaka, S. Bushuyev, M. Besedin, T. Hrynko, D. Kotter, I. Babayev, S. Chernov, S. Tsiutsiura, N. Bushuyeva, A. Shakhov, Yu. Rak, O. Medvedieva, V. Rach, E. Druzhynin, I. Chumachenko, I. Kononenko, V. Gogunsky, V. Vaisman, V. Yaroshenko., E. Cameron and others. In their research, scientists pay close attention to the essence of organizational changes, the construction of strategies, methods, models and mechanisms for management of projects, programs and portfolios of projects.

So, in particular, Professor S. Bushuyev in his scientific works investigates: information technologies for project management competences development on the basis of global trends [3]; the organizational maturity of projects, programs and portfolio of projects and their success [4]; development of breakthrough competence of project managers based on entrepreneurship energy [5]; a knowledge-based approach in project management in framework of project success analysis [18].

Scientists M. Besedin and V. Nagaev devoted their research to the fundamentals of situational approach and assessment in project management [2].

Researchers T. Grynko, E. Cameron are investigating about making sense of change management (models, tools& techniques of organizational change at the enterprise within the context of its innovative development) [7; 12].

Professor I. Babaev's scientific research highlights the issues of priorities management in the portfolio of projects in complex and dynamically variable environments [1].

Professor S. Chernov and scientists Chernova, L. S., Titov, S. D. devoted their scientific works to the study of algorithms for the simplification of solution to discrete optimization problems and its reduction [8; 9].

Professor S. Tsiutsciura with colleagues O. Terentyev, T. Honcharenko & T. Lyashchenko dedicated their research to highlight the problem of multidimensional space structures for an adaptive model of project data [17].

Professor N. Bushuyeva with scientists D. Bushuiev, V. Bushuieva & I. Achkasov are working on the research of IT Projects management driving by competence and their management development [3; 6].

Professors V. Rach, O. Medvedieva, O. Rossoshanska and A. Yevdokymova have devoted their scientific research to systematic modeling of development the innovative project-oriented enterprises [16].

Professor Yu. Rak Scientific School has been researching safety-oriented principles of management projects, programs and portfolios of projects; safety management in development projects and discrete-event modeling of the critical parameters of functioning the products of infrastructure projects at the planning stage [19, 20].

Professor E. Druzhynin and scientists O. Grigorov, G. Anishchenko, M. Strizhak, V. Strizhak dedicated their scientific research to the problems of analysis the approaches to dynamic systems modeling in project management [11].

Professor I. Chumachenko with scientists N. Dotsenko, D. Chumachenko conducts their research in the field of project-oriented resource management of forming adaptive teams in the environment of multi-project projects [10]; and modeling of the processes of stakeholder involvement in command management in a multi-project environment. [15]

Professor I. Kononenko and researchers Aghaee A. & Lutsenko S. are working on investigation of project management methodology and guide formation's method [13]; and application of the project management methodology synthesis method with fuzzy input data [14].

However, after detailed analysis of the scientific achievements of domestic and foreign scientists in the field of management the projects, programs and portfolios of projects, we can say that there are still unresolved issues: isolation of infrastructure projects as a separate link in the classification of projects in accordance with international standards and requirements; and studies of the changes impact on the development of infrastructure projects at different stages of the project life cycle. Therefore, finding and identifying solutions to this scientific and applied problem is an urgent task.

**Object of study.** Processes of formation the parameters of infrastructure projects management and forecasting their development at different stages of the project life cycle under the influence of project changes.

**Subject of study.** Models for changes management in infrastructure projects at different stages of the project lifecycle.

**The task of work.** Modeling and researching the process of changes management in infrastructure projects at different stages of the project lifecycle. To solve this problem, we have formed the following tasks:

1) to carry out multi-criteria classification of infrastructure projects based on the use of fundamental principles and provisions of methodology of management the projects, programs and portfolios of projects, in particular system analysis, modeling tools, proactive and reactive management mechanisms in accordance with the requirements of current standards;

2) formalize the conceptual model-scheme of formation the parameters of changes management in infrastructure projects on the basis of project-oriented approach;

3) to develop the forecasting model of infrastructure projects development at different stages of project life cycle under the influence of project changes;

4) to expand the terminological base of management the projects, programs and portfolios of projects by formalizing the concepts of "infrastructure project" and "changes management in infrastructure project".

### 3 The Bulk of Research

Addressing the issues of forming the parameters of changes management in projects, programs and project portfolios and forecasting their development at different stages of the life cycle is a complex task, which in turn requires the use of a project-oriented approach in addition to the common project management tools. Since complex tasks are multicriteria, they need to be solved at a basic level and individually.

The first step is to analyze and formalize the concept of "infrastructure project" and to make their classification. Based on the elaboration of existing definitions of the concepts of "project" and "infrastructure", we have generated a unified concept. An "infrastructure project" is a process of executing a set of management, engineering actions and technical solutions that are limited in time and resources and implemented to create a unique product of the project, ensuring the coordinated activity of the IT sector, energy, education, transport, social sphere and safety.

The second step is to research the classification of infrastructure projects. Today, there are different approaches to classifying projects by classification, which have a number of identical features and a number of unique ones. However, since the subject of the research is infrastructure projects, we have carried out a systematic analysis of existing international classifications of projects, programs and project portfolios and modified the multi-criteria classification of infrastructure projects (see Fig. 1).

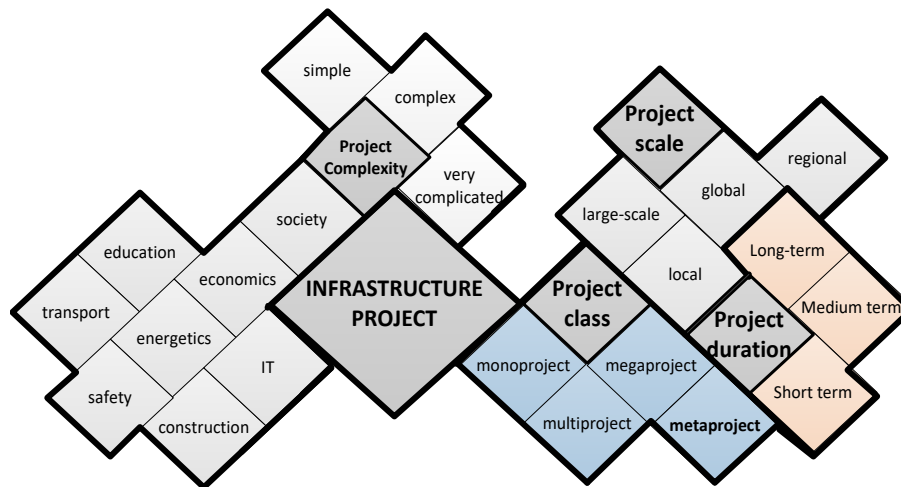


Fig. 1. Modified multi-criteria classification of infrastructure projects

Thus, according to the presented multi-criteria classification, infrastructure projects are divided into 5 criteria, which can be formally described by the dependence:

$$I_p = \langle P_e, P_k, P_c, P_s, P_t \rangle, \quad (1)$$

where,  $Ip$  – infrastructure project;  $Pe$  – is the criterion responsible for the project implementation area (IT, safety, construction, energy, society, economy);  $Pk$  – is the project class criterion (megaproject, multiproject, monoproject and metaproject, most likely sphere of application are safety-oriented systems, in particular civil protection system);  $Pc$  – project complexity criterion (simple, complex, very complicated);  $Ps$  – project scale criterion (local, regional, global, large-scale);  $Pt$  – is the project duration criterion (short-term  $t_{lim} \in [0;3]$ , medium-term  $t_{lim} \in [3;5]$ , long-term  $t_{lim} \in [5;\infty]$ ).

In the process of planning and implementing infrastructure projects, the set of described criteria is basic, and the choice of formation criteria may have different criteria structuration and combination, which in turn will allow to make qualitative approach to planning and management of different types of infrastructure projects.

The third step of the research is to conceptualize the formation of parameters of changes management in infrastructure projects based on a project-oriented approach. The solution to this problem lies in the plane of identification of the process of infrastructure projects changes management. Having made a semantic analysis of the terminology and methodology of changes management in projects, we can confirm that changes management in projects is a complex of organizational and technical project management process that involves implementing a set of measures to investigate changes in a project, their development, influencing to the project lifecycle, and applying project-oriented management to respond to changes in the project at the stages of initiation, planning, practical implementation and commissioning of the project in order to obtain the project product.

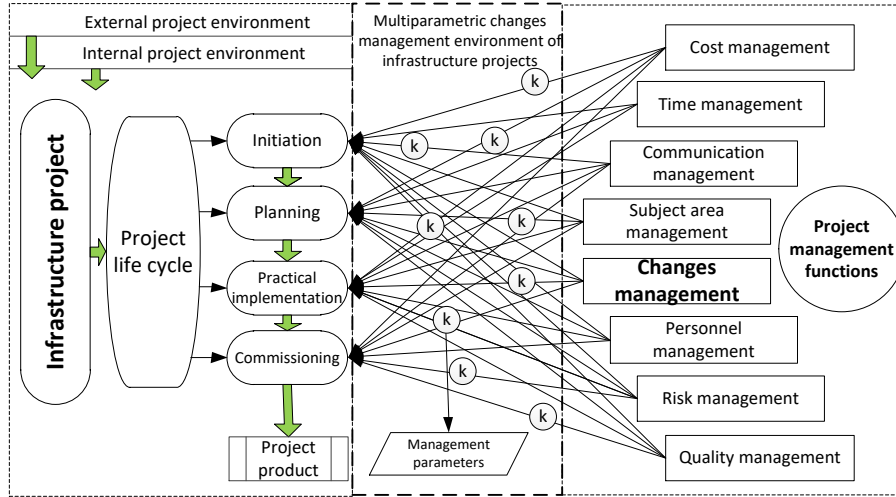
The life cycle of this type of project in structure is not different from other projects, but its content is unique for each new project. The conceptual feature is the ability to use standard mono-templates for infrastructure projects, however, taking into account the influence of multiparameter environment of project changes management. Thus, taking into account the above and based on a project-oriented approach, we have formed a conceptual model-scheme of parameters formation for changes management in infrastructure projects (see Figure 2).

A model-scheme is formed as complex interconnected structure which consists of three blocks of management process. It can be formalized as a dependence of all elements of project environment that works under the influence of project changes and turbulent factors:

$$\begin{array}{c}
 Ei; Ee \\
 \Downarrow \\
 Ip \\
 \Downarrow \\
 Pp
 \end{array}
 \Leftrightarrow
 \begin{array}{c}
 Pl/Pm \\
 Fs \\
 Fp \\
 Fr \\
 Fi
 \end{array}
 \left| \begin{array}{ccccccccc}
 Mv & Mt & Mk & Ms & Mc & Mp & Mr & Mq \\
 k & k & k & k & k & k & k & k \\
 k & k & k & k & kn & k & k & k \\
 k & k & k & k & kn+1 & k & k & k \\
 k & k & k & k & (kn+1) \rightarrow \infty & k & k & k
 \end{array} \right.
 \Leftarrow Mf, \quad (2)$$

where,  $Ip$  – infrastructure project;  $Fs$  – initiation phase;  $Fp$  – planning phase;  $Fr$  – implementation phase;  $Fi$  – phase of commissioning;  $Pl$  – project life cycle;  $Pm$  – is a multiparametric environment;  $Mv$  – cost management;  $Mt$  – time management;  $Mk$  – communication management;  $Ms$  – subject area management;  $Mc$  – changes management;  $Mp$  – personnel management;  $Mr$  – risk management;  $Mq$  – quality

management;  $k$  – management parameters;  $Mf$  – management functions,  $Pp$  – project product;  $Ee$  – external project environment;  $Ei$  – is an internal project environment.



**Fig. 2.** Conceptual model-scheme of parameters formation for changes management in infrastructure projects on the basis of project-oriented approach.

The first block reflects the life cycle of the infrastructure project and its impact on the internal and external project environment

The second block is the block of project management functions, where in addition to the basic ones, the changes management function of the infrastructure project will be key. Research of the process of changes impact into infrastructure projects management has allowed us to formalize the following definition:

Infrastructure project changes management - is a complex process of making and implementing management decisions to ensure prompt response to any changes in the amplitude of project deviations in order to minimize the negative manifestations of crisis phenomena and the balanced functioning of its organizational and functional subsystems.

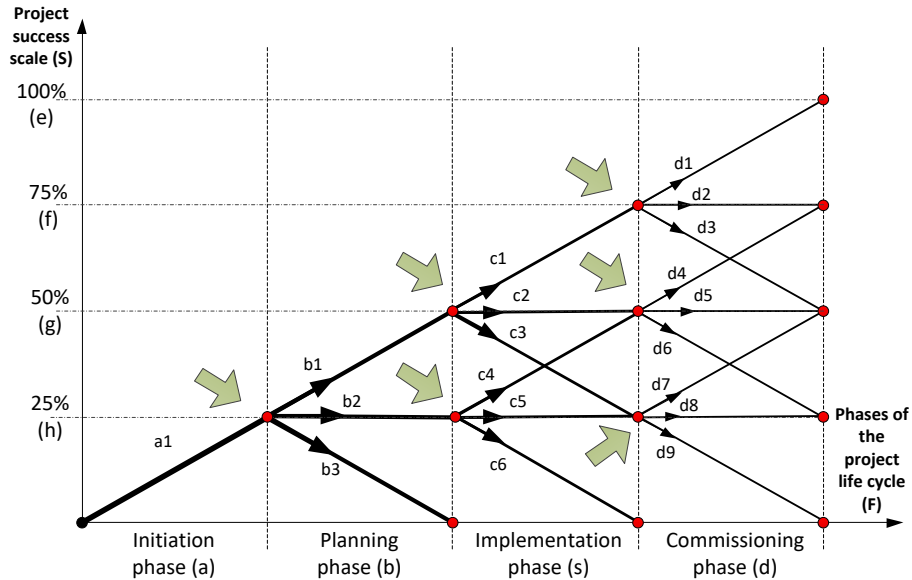
The third block describes the interaction of project management functions with its life cycle in a multiparametric environment of project changes management, and is described by dependencies:

$$k = \langle t; e; Mp; Mm; I; r \rangle, \quad (3)$$

where  $k$  – management parameters;  $t$  – time parameters;  $e$  – economic parameters;  $Mp$  – planning and evaluation parameters;  $Mm$  – parameters of the chosen methodology, organizational structure;  $I$  – parameters of change (technological, organizational, environmental impact);  $r$  – parameters of risk exposure.

The fourth stage of the research is the process of determining the impact of changes on the development of an infrastructure project. This process should be

considered in the context of the whole project life cycle, taking into account the possible development of the project under the influence of changes (see Figure 3).



**Fig. 3.** Model - scheme of the development of infrastructure projects under the influence of project changes at different stages of the project life cycle

This model-scheme is formed in a two-dimensional plane, built on the axes of the abscissa (F - phase of the project lifecycle) and ordinates (S - scale of project success) and includes all possible options for the development of infrastructure projects.

The peculiarity of the process of forecasting the development of infrastructure projects is to take into account in the model six points of trifurcation that are located at the intersection of the abscissa and ordinates (ah; bh; bg; cf; ch; cg), where is the greatest impact of changes on the project.

The trifurcation points in a project – are places in the project that are affected by project changes, and when they are responded to by applying a proactive management methodology, they form 3 possible options for further development of the project: positive, neutral and negative.

The scale of project success presented in the model is a conditional scale of values of infrastructure project development in the range [0; 100%]:

- where [0] is the value of decline and closure of the project;
- [25%] - the project will be implemented, without many requirements, the quality of the project product is low;
- [50%] - the project will be implemented, and half of the project requirements and product quality of the project will be taken into account;
- [75%] - the project will be implemented, most of the project requirements and product quality of the project will be taken into account;



- [100%] - the project will be implemented, all requirements for the project and product quality of the project will be taken into account.

After analyzing this model-scheme, we have calculated all the probable variants of infrastructure projects development under the influence of project changes, the results are shown in Table 1.

**Table 1.** Results of distribution of probable variants of infrastructure project development under the influence of project changes

S project success scale	Variant for development of infrastructure projects	Points of trifurcation	Number of variants for development of infrastructure projects	The overall importance of development variants %
100%	a <sub>1</sub> b <sub>1</sub> c <sub>1</sub> d <sub>1</sub>	ah;bg;cf	1	6,25
75%	a <sub>1</sub> b <sub>1</sub> c <sub>1</sub> d <sub>2</sub> a <sub>1</sub> b <sub>1</sub> c <sub>2</sub> d <sub>4</sub> a <sub>1</sub> b <sub>2</sub> c <sub>4</sub> d <sub>4</sub>	ah; bg; cf; cg; bh	3	18,75
50%	a <sub>1</sub> b <sub>1</sub> c <sub>1</sub> d <sub>3</sub> a <sub>1</sub> b <sub>1</sub> c <sub>2</sub> d <sub>5</sub> a <sub>1</sub> b <sub>1</sub> c <sub>3</sub> d <sub>7</sub> a <sub>1</sub> b <sub>2</sub> c <sub>4</sub> d <sub>5</sub> a <sub>1</sub> b <sub>2</sub> c <sub>5</sub> d <sub>7</sub>	ah; bg; cf; cg; ch; bh	5	31,25
25%	a <sub>1</sub> b <sub>1</sub> c <sub>2</sub> d <sub>6</sub> a <sub>1</sub> b <sub>1</sub> c <sub>3</sub> d <sub>8</sub> a <sub>1</sub> b <sub>2</sub> c <sub>5</sub> d <sub>8</sub> a <sub>1</sub> b <sub>2</sub> c <sub>4</sub> d <sub>6</sub>	ah; bg; cg; ch; bh	4	25
0%	a <sub>1</sub> b <sub>3</sub> a <sub>1</sub> b <sub>2</sub> c <sub>6</sub> a <sub>1</sub> b <sub>2</sub> c <sub>5</sub> d <sub>9</sub>	ah; bh; ch	3	18,75

Based on this systematization, we have received 16 variants of development of infrastructure projects under the influence of project changes, which are reflected by 6 trifurcation points.

Thus, the share of possible variants for the development of infrastructure projects in the range [25; 50%],

- 56% of the total number of infrastructure projects which will not be fully realized and of poor quality;
- 18.75% of the variants for the development of infrastructure projects fail;
- 25% of the variants of infrastructure projects development in the range [75; 100%] will be successful and qualitatively implemented.

This confirms the direct dependence of each of the variants for the development of infrastructure projects on the timeliness of management decisions, as a reaction to the impact of project changes, and a quality project-oriented approach in the early stages of the project life cycle is increasing the likelihood of its successful implementation.

## 4 Conclusions

The process of changes management in infrastructure projects has been investigated. The scientific and methodological foundations and standards of management projects, programs and portfolios of projects, modeling tools, system analysis methods and proactive management mechanisms were used for the research. The result of the research are:

- 1) expanding the terminological base of management projects, programs and portfolios of projects by formalizing the concepts of "infrastructure project" and "change management of infrastructure project";
- 2) a modified multicriteria classification of infrastructure projects has been developed;
- 3) on the basis of project-oriented approach, a conceptual model-scheme model-scheme of formation the parameters of changes management in infrastructure projects has been formed, conceptual feature of which is the possibility of using standard mono-templates of infrastructure projects, but taking into account the multiparametric environment of project changes management and environment of each unique project;
- 4) a model-scheme of the development of infrastructure projects under the influence of project changes at different stages of the project lifecycle is presented, which takes into account the impact of project changes at the points of trifurcation, and allows forecasting of all possible variants for the development of infrastructure projects.

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