Adaptive management of investment and construction projects

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Abstract. The modern conditions of investment and construction projects' realization, particularly incompleteness, inaccuracy and lack of characteristics' clarity of the project and environment of activity are highlighted in the article. The relevance of introduction of adaptive management methods and complex characterization are presented. Methods of the target function formation of investment and construction projects management are considered in the article. Moreover, the parametric approach based on the best result of managerial impacts is defined. The informational basis of input into the model is determined: actual project indicators, quantitative and qualitative description of the project status and situational problems. The adaptive essence of the management model has been identified as situational management. The conclusion of precedents and the description of construction production situations in the form of indistinct states model with the usage of linguistic variables were substantiated on this basis. The fragmentary example of the precedents base based on the studied experience of investment and construction projects implementation is presented in the article. The author developed a basic algorithm of decision-making in the system of adaptive management of investment and construction projects. Prospects and predicted effects of introduction of adaptive management of investment and construction projects at micro-level and macro-level are determined.

Keywords: adaptive management, investment and construction project, situational management, production model

1 Introduction

The analysis of modern management of investment and construction projects allows us to conclude that the models used at the stage of construction production preparation and scheduling do not allow to effectively predict the development of the project, because they are static. Furthermore, they reflect organizational and technological solutions only at the time of signing of the construction contract [1, 2]. It causes a complex of problems, particularly an increase of the project coast and resource losses. At any moment, the

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parameters of the investment and construction project implementation may change due to random factors of a highly turbulent environment. It is also difficult to formalize.

Obviously, the investment and construction project management as a socio-economic system takes place in conditions of partial, inaccurate and indistinct knowledge of the project characteristics and the investment and construction sector characteristics. It is due to several reasons:

- a sophisticated complex of a large number of heterogeneous influence factors,
- the specifics of the economic interests and relationships of the investment and construction project participants,
- a steady practical trend of exceeding budgets and deadlines for the projects' implementation, etc.

It is not possible to obtain an accurate management object model in such a situation, therefore engineering forms of investment and construction projects management occur.

2 Research methodology

This article has been prepared based on a complex of various research methods. Both classical management theory and engineering methods of project management are accepted as the initial methodological basis. The provisions of the systematic approach and systems management, which were being implemented with the help of using the methods of the decision-making theory and results-based management, were used. The actualization of the proposed method of the investment and construction projects' management is based on the usage of the intelligent automatic control principles, optimization methods and the basic provisions of precedent modeling.

3 Results and discussion

Recently, a "non-classical" approach to the theory and practice of management has been actively developing, particularly to the management of complex microsystems of investment and construction projects with the help of the using algorithms and intelligent management methods [3-11]. An adaptive management model can be defined with the help of the essence of this approach: it is management with partial priori information about the managed process, which changes as more information is acquired [12]. The content of project functions is corrected and optimized in adaptive management until the desired result of project activity and the corresponding production and economic goals of the management subject (participant in the investment and construction project) are achieved in the current period [13].

It should be emphasized that adaptive management of investment and construction projects should be comprehensive:

- control adaptability in identifying deviations of actual indicators from the planned indicators of the project,
- adaptive goal-setting and regulation of project execution and project parameters,
- adaptive identification of the situation based on comparison with the existing database,
- adaptive search for a solution to a situational problem based on comparison with the solutions existing in the database.

The development of the adaptive management method begins with the formation of a management model according to the previously created information model of an investment and construction project. A certain scientific interest may be caused by the parametric management model of construction, which traditionally includes the following iterations. The controlled parameters of the investment and construction project create an information base. Furthermore, the projects' characteristics of the controlled parameters and the boundary indicators of their change, which provide the preset mode of operation of the investment and construction project, are set. The overall management impact is determined and particular management impacts on parametric changes in investment and construction projects are distinguished in this model.

It is believed that:

- firstly, the parametric approach based on the impact on already changed project indicators in this management task differs between multi-temporal changes and impacts by the time lag. Secondly, it does not provide a return to the planned development trajectory;
- a management model based on the trajectory of the current project development will more accurately allow us to observe heterogeneous quantitative and qualitative changes, predict further development with the help of the taking into account these changes, regulate the project development;
- it is proposed to perform a model assessment of the development trajectory of an investment and construction project not on the basis of project indicators, but on the basis of the characteristics of the situation, which shows the current result and the degree of approximation to the planned result of the project. Moreover, the assessment should be generalized.
- over time, management impact is possible in a number of aspects: firstly, in approaching the desired result with a minimally acceptable deviation, and secondly, in correction of the desired result. Management impact is performed with respect to the current intermediate subjective result, characterized multiparametrically both quantitatively and qualitatively,

It is worth discussing the formulation and possible solution of the problem of optimizing the project state in the goal-setting processes of investment and construction projects management. In the case of a parametric approach , the target function can be defined in the following way:

- the complex of project parameters serves as a goal function. In this case the optimization problem is solved by multi-criteria,
- the cost, as a complex of cost indicators, serves as a goal function. Other project parameters are constraints.

Obvious difficulties are observed in the presented description of the goal function of the parametric approach. These difficulties are the presence of partiality, the problem of priority relations and the possibility of significance loss, the solution problem. It is proposed the definition of a such management decision that will help to achieve the planned or adjusted subjective result, that is, the momentary effectiveness of participation in an investment and construction project. This proposal is an alternative to parametric optimization of individual indicators (cost, time, quality, etc.) or their deviations from the norm. The project indicators, that have already been changed at the time of optimization, are not being optimized, but the management processes of investment and construction projects are being optimized.

The implementation of the considered approach puts forward the best current result as a target function. This result which will be received as result of managerial influences. In the case of result management, parametric indicators of the desired result such as the name of the result, the time and place of obtaining the result, a system of indicators for evaluating the result, the resource involved in obtaining this result are developed [14]. The management functionality has the form of a relationship between the generalized result indicator and the project characteristics in this case.

$$R_{ICP} \rightarrow maxF(k_t x_t, u_t x_t, Res_f) \quad (1)$$

$$\text{with restrictions } Res_f \leq Res_p \quad (2)$$

where x_t – characteristic of project activity;

k_t – coefficients characterizing the influence degree of the management factor on the project indicators;

u_t – coefficients characterizing the influence degree of factors that cannot be influenced by the control system;

Res_f, Res_p – actual and planned resource support of the investment and construction project.

The presented concept of the management model has an information basis resieved during the control of the project implementation: actual current project indicators, a quantitative and qualitative description of the project state and situational problems. The intermediate or final result, measured quantitatively and qualitatively is as a global management parameter in the considered direction of result-oriented project management. The difficulties of quantitative and qualitative assessment of the project result lead to the necessity for situational assessment and situational management.

A problematic situation, which actually determines the state of the project work at the current moment, is formed as a result of the analysis on the basis of the facts of project activity that have hold and becomes a short-term management object. For example, the problem of reducing the effectiveness of participation in the project is a consequence of the fait accompli of the cost increase of building materials. A such result can be considered as a source of the problem. And, of course, it is being talked about regulating not the deviation of the materials' cost, but about minimizing the negative deviation of the result or the effectiveness of participation in the project.

The task of an investment and construction project management (adaptive situational management or result management, when the result is described by the situation) is come down to optimizing the future project result, specified with respect to the participant of the investment and construction project, in this formulation. The participant is also the management subject. In other words, the achievement of a result based on decision-making and the implementation of management measures is expressed with the help of a situational model showing which one situation should be chosen so that the new result corresponds to the required conditions. If it is possible, conditions should be previously planned or corrected due to the impossibility of corresponding the planned ones.

When the task of identifying the state of the control object and forming generalized images (classes of object states) occurs, the difficulty of the formalization of the project result leads to the need for situational management. It is for carrying out the selection of management measures at the next iteration. The selection is being done by analogy of the new current situation with previously encountered situations, which are stored as experience of investment and construction projects implementation.

The required model of situational decision-making characterizes a combinatorial problem of considerable dimension in project management. It is necessary to use a conclusion based on precedents for the solution of this problem. There are the following iterations: a description of the situation and the solution of the problem, the foundation of the solution application, and the result of the solution usage as feedback. In addition to the main purpose of management, this model can provide solutions to other specific tasks. It contributes to the development of an adaptive management system for investment and construction projects:

- formation of generalized images of project states based on a priori information,
- identification of the project state based on its intermediate results,
- study of the influence of input parameters on the translation of the project into various states,
- forecasting the activity of the project in the complete absence of control impacts conditions,
- forecasting the activity of the project under different variants of control impacts.

The adaptive management of the investment and construction projects implementation can be based more effectively : on the description of construction production situations in the form of an indistinct model of acceptable states with the usage of linguistic variables to represent state assessment. The difficulty of mathematical models of real project processes, connected with the desire to increase their appropriateness and take into account all factors influencing on investment and construction project implementation, requires the usage of indistinct models.

The project tasks are beyond the traditional formal description because some parameters are inaccurately or qualitatively set quantities for which the transition between the states "belongs to the class" and "does not belong to the class" is uninterrupted. In other words, an investment and construction project should be considered as an indistinct system, for the description of which the apparatus of the theory of indistinct varieties and indistinct logic is used. The development of a indistinct management model for investment and construction projects should contain indistinct production rules, which with a fixed management goal (for example, preservation of the values of a controlled parameter in a certain range of acceptable values), describe decision-making and an action plan at a qualitative level, in the expected result [15].

Situational management methods involve the collection of experience, which is formalized in the form of production rules. It is known that the production model of knowledge is a model based on rules, which allows us to present knowledge in the form of sentences like "If (condition), then (action)". It is believed that the left part determines the result of the project activity in the form of deviation vectors. The right one reflects different types of logical consequences: both possible reasons of deviations, and possible solutions that determine a set of measures, the implementation of which allows us to stabilize the execution of project work as to the chosen norm of the result.

The content of the precedent database can occur both before the start of management based on a priori information with the help of real or simulated precedents, and in the process of management, after processing the result of the control action. A fragmentary example of a such database is presented in Table 1.

Tab.1 The base of adaptive management precedents of investment and construction projects

Set of precedents for a set of parameters	**Possible solutions**

Low-quality planning at the stage of development of working documentation, late issuance of working documentation, changes in working documentation during the work execution	Documentational examination, correction of project solution mistakes, development of an alternative project solution, elaboration of current project solution considering some necessary changes
Mistakes in the calculation of work volumes	Agreement of a new estimate with a new work volume with the customer, elaboration of current project solution taking into account some necessary changes, reduction of production costs to compensate the additional work costs, reduction of the contractor's expenses
Deficiency of some necessary works in the contract agreement. The necessity of additional work, which is not included in the contract	Correction of the project cost, singing the additional agreements with the customer for additional work, elaboration of the current project solution taking into account some necessary changes, reduction of production expenses to compensate for the additional work costs, reduction of the contractor's expenses
Suddenly resulting necessity of drainage of building territory, organization of additional utilities, the carrying out forced irrigation, etc.	Cost correction, signing the additional agreements with the customer, taking into account all additional work, reduction of production expenses to compensate for the expenses of additional work
The lack of financing	Involvement of loans, the project reworking, changing the project concept
The changing the cost of materials provided by the project	Harmonization of other materials, finding of new suppliers, correction of the project cost, reduction of the contractor's expenses
Material imbalance, inconsistent schedules for procurement, delivery and usage of materials and constructions	Improvement of procurement planning and inventory management, reduction of contractor expenses, change of suppliers, harmonization of other materials
Change in the cost of third-party services used during the construction process	Finding of the other service providers, the consideration of changes in terms of cooperation, correction of the project cost, reduction of the contractor’s expenses
Lack of the staff qualification. Dysfunctional organization of work	Staff training, the finding of more qualified staff, improvement of work organization
Work safety violation entailing work disruption	Compliance with safety regulations, compensation for damage
Noncompliance with construction technology, the work performance violation, and consequences of their correction	Strengthening of supervision of work production, author’s supervision, staff training
Various current violations by the contractor against project equipment	Reduction of the contractor’s expenses
Frequent change of contractors	More rigorous selection of contractors, the strengthening of the work supervision
Long-term bureaucratic processes (examination, authorizations, etc.)	Development of work schedules taking into account additional time, the finding of alternative ways to accelerate bureaucratic processes

Change of customer requirements. Various current customer violations (previous contractor's work is taken with violations or area is not prepared after previous contractor	Development of the current project solution taking into account some necessary changes, measures allowing to continue the construction in the current conditions, cost correction
Unpredictable changes of climatic conditions	Stop the construction process during the period of natural anomalies, measures allowing to continue the construction in the current conditions

It is noted separately that the study of uncertainty, the usage of methods of indistinct varieties and linguistic variables are beneficial in the economy and, particularly, in our task. There are several reasons for this:

- indistinct varieties perfectly describe subjective activity and contribution to project results,
- the complex of methods of the indistinct varieties' theory allows us to use a value approach, to transform the cost of an investment and construction project into value;
- it is possible to formalize both the particularities of the investment and construction project and the cognitive particularities of subjects connected with this object within one model,
- using this management method, an increase of the possibilities of qualitative and quantitative assessment of the project status appears,
- in this model it is possible to use probability descriptions as probability distributions with indistinct parameters, etc.

It is necessary to develop a tool for the translation of linguistic variables into mathematical language - a belonging function that sets the degree of confidence, with which elements of some varieties belong to a given indistinct set. It is done in order to introduce the indistinct varieties' method into the adaptive management system. The experience of investment and construction projects' management is stored in the knowledge base of the management system in the form of a description of problematic situations and managerial impacts, which makes up a situational development model of a specific investment and construction project [16-18].

In fact, the interpretation or recognition of the text based on the digital formalization may be considered as the beginning of the process of the situational management. The received information is compared with the existing information database about various situations in the system layer of the production model. It allows us to make managerial decisions. The production model of the investment and construction project management involves the following input linguistic variables:

- quantitative actual indicators received as a consequence of supervision,
- qualitative actual indicators of the project status,
- events that can lead to changes, assessed quantitatively and qualitatively.

Deviations, which are input linguistic variables for managerial decision-making, are determined based on the product rules. In other words, the first task of the production model is to identify deviations in accordance with the basic principles of adaptive management. This production model in terms of database forming and precedents is based on expertise of modelled systems that are transformed into an indistinct model. It is very important to minimize the mistakes of model outputs due to optimization of ownership functions'

parameters of linguistic variables. Output linguistic variables describe the response methods to actual and predictable cost deviations.

The level of factors is interpreted, and possible solutions are worked out at the output stage of adaptive management of investment and construction projects. These factors may be presented, for example, as the compliance of this level with the permissible borders of variability. The following decision-making technology, which is presented in the form of the algorithm in Figure 1, can be used to select optimal adaptive management measures.

4 Conclusions

The developed approach to project management in construction, including an adaptive model, should be considered as methodical support and, at the same time, as a requirement to the information model of a specific investment and construction project. The adaptive control is one of the first iterations under conditions of perspective usage of artificial intelligence. Comprehensiveness and systemization of adaptive management of investment and construction projects allows us to achieve the efficiency of project management in modern conditions of turbulent environment and multitasking of management systems: identifying deviations and managing project indicators, situational identification and finding effective management solutions. The suggested parametric model maximally fulfills the conditions of adaptive situational management and can be implemented on the description of construction production situations in the form of indistinct model of acceptable states with the usage of linguistic variables for representing assessments states. Implementation of the suggested model of investment and construction projects management will lead to multi-level effect. It leads to the raising of the management efficiency of specific investment and construction projects and the increase of the positive subjective result of participation in the project at the micro level. It leads to the achievement of the strategic development goals of construction, which were declared in a number of policy documents, at the macro level [19-20].

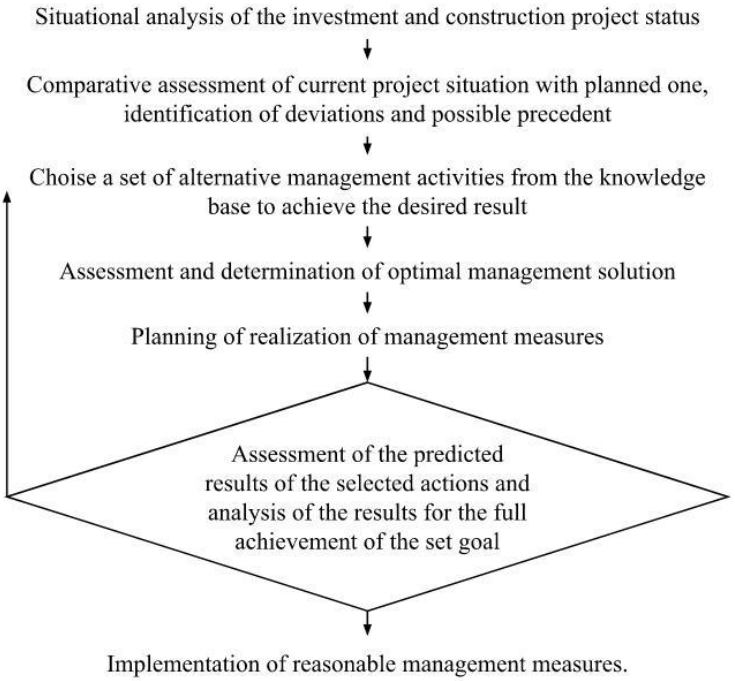

Fig.1. Decision algorithm in the system of investment and construction projects adaptive management

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