Methods for evaluating the effectiveness of the object management system

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Abstract. Evaluation of the effectiveness of systems lifecycle management the object of capital construction (further – Department) is a mechanism that allows objectively to determine the attainability of the goals and objectives of the project (hereinafter – project) as a whole and each of its stages, the efficiency of the organization and implementation of the project in the context of the rational use of resources. In accordance with the life cycle of a capital construction object is the period during which engineering surveys, design, construction (including conservation), operation (including current and major repairs), reconstruction, and demolition of a capital construction object are carried out. Performance assessment is an important element in the development of project and planning decisions that allows you to determine the level of development and progressiveness of the current management structure, projects being developed, and is carried out in order to select the most rational version of the management structure or how to improve it using the selected evaluation criteria. The set of performance evaluation parameters used for solving a specific task is determined based on the project specifics and the required technical and economic indicators. Methods of multivariate statistical analysis and multi-criteria evaluation were considered to assess the effectiveness of management systems. The essential point is the presence of a range of common parameters. This research can be used in the development of information systems in construction, as well as in investment and construction organizations to audit the quality of the management system and its segments.

1. Introduction

When evaluating the effectiveness of management systems, the following types of management systems should be distinguished:
- social;
- commercial;
- budgetary.

Social efficiency describes the social effects of the project (based on the aggregate of statistical indicators adopted for this region), commercial – its financial consequences for private participants in the implementation of the life cycle of the ACS, and budgetary – the financial results of the project for the Federal, regional or local budget.
Based on the definition of the ACS life cycle [1] and taking into account previous studies [2-7], we will highlight the stages of the ACS life cycle for evaluating the effectiveness of management systems:

- justification of investments;
- engineering survey;
- architectural and construction design;
- construction (including conservation);
- operation (including ongoing repairs), reconstruction, major repairs;
- demolition and disposal.

Improving the efficiency of life cycle management of capital construction projects using information modeling technologies is one of the main tasks of the Government of the Russian Federation. Currently, the Government has adopted a number of measures aimed at developing information modeling technologies in the construction industry. In the future, it is planned to develop this direction by introducing information modeling technologies in the field of urban planning, which allows managing the life cycle of a capital construction object starting with the preparation of an investment justification and ending with its demolition. In particular, it is assumed that the transition will be made to the assessment of the economic efficiency of capital investments at all stages of the life cycle of the capital construction object using information modeling technologies, taking into account the assessment of operating costs and the costs of demolition of capital construction objects [8]. Due to the lack of estimated standards for the performance of works (services) required to ensure the operation of capital construction facilities, and enlarged standards for the operation price, it is not possible to reflect the estimated (marginal) cost of operation in the investment justification, and subsequently in the project documentation – the cost of operation. Meanwhile, as practice has shown, often "cheap" construction, involving the use of the most accessible materials, products and structures, entails the need for significant investments in the maintenance and repair of capital construction in the future. Increasing the cost of construction through the use of high-quality materials, technological and engineering equipment can significantly reduce the cost of operating costs and increase the "life" of the capital construction object.

The formation of the information model is expected using information technologies and technical means, in this connection, the information model will be a database about the capital construction object, including information, documents, materials about the object formed during engineering surveys, preparation of investment justification, design, construction, operation, reconstruction, major repairs and decommissioning of the capital construction object.

The introduction of an information modeling mechanism will simplify and, consequently, reduce the cost of both construction (reconstruction, major repairs) and construction control and supervision, provide the ability to manage the life cycle of a capital construction object up to the demolition of such an object, and increase the transparency of capital investments [9-16].

Building information modeling technologies are being actively developed in many countries as a potential way to reduce economic costs while improving the quality of industrial and civil construction. The leading competence centers (States) focused on implementing BIM technologies are the United States, Great Britain, Singapore, China, France, Northern Europe, and South Korea.

The introduction of information modeling technologies in these countries takes place at a fairly deep level with the use of public administration (regulation) mechanisms. In the development of construction BIM technologies, States see an opportunity, in addition to reducing financial and time costs during the construction of capital construction objects, to increase the level of transparency of interaction between project participants throughout the life cycle of the capital construction object. At the same time, special attention is paid to the control of the object at the stage of operation, the costs of which can significantly (several times) exceed the costs of the initial stage of the object's life cycle (design) and the construction stage. The effectiveness of using information models to manage the life cycle of objects at this stage should be evaluated when planning the entire investment and construction project.
Object management is a complex type of service that includes not only the operation of real estate, but also providing all non-core activities of the organization. In addition to the obvious things, such as working with applications or servicing equipment, this includes, for example, providing food for staff, organizing jobs, energy management (energy saving management) [17].

2. Methods

This study considered the following methods for evaluating the effectiveness of management systems:
- multi-dimensional statistical analysis method;
- methods of multi-criteria evaluation.

The method of multivariate statistical analysis, as part of the quality control method, is a method that allows you to identify violations and problems in the organization of construction production and technological processes at each stage of the life cycle of the ACS to assess the effectiveness of management systems.

Quality is usually characterized by several indicators and these indicators can be correlated with each other. In the latter case, independent monitoring of individual indicators can lead to significant errors. The result of the control is often inadequate to the actual situation, since it is possible to skip the actual process breakdown, and unjustified stops when the used statistics go beyond the control limits [18-20].

The proposed method of multidimensional statistical control of quality indicators includes four stages:
- preliminary analysis of the training sample at the stage of the life cycle in order to determine statistics, select controls and determine their parameters;
- monitoring processes at each stage of the life cycle based on operational data (observation results) using selected statistical tools;
- determining the type of violation and quality indicators;
- unit decision support to stop the process or continue the work taking into account the reproducibility of the process and severity of non-random structures of different types.

Criteria for evaluating the effectiveness of the life cycle management system of a capital construction object are formed in two categories, based on the specifics of the functioning of management systems at each stage of its life cycle, according to the degree of compliance:
- criteria that characterize the degree of achievement of technical and economic indicators of the project;
- criteria that characterize the requirements for the organization and results of the process of functioning of management systems.

The choice of these categories of criteria is due to the fact that they inextricably affect the parameters of the investment and construction project, and, consequently, the effectiveness of the management system. Therefore, there is an additional problem of selecting and prioritizing the use of these criteria. The solution of this problem is possible within the framework of existing approaches to its solution, namely:
- in the methodological recommendations, preference is given to the criteria that characterize the achievement of technical and economic indicators of the project;
- in the current practice, the main criterion is selected, and the rest are used as restrictions. As the main criterion, as a rule, use all the same criteria that characterize achievement of technical and economic parameters of the project, but increasingly are also used and criteria requirements for the organization and results of operation of control systems;
- balanced use of all criteria in evaluating performance, with each of the criteria receiving a certain importance value.

However, another approach can be proposed that is based on the methodology of directed graph theory.

Let \( P = \{P_1, P_2, ..., P_n\} \) – a set of performance evaluation criteria that are considered in terms of the presence of certain parameters. Concretization of a specific goal for which it is supposed to
evaluate the effectiveness, fixes this nomenclature. Moreover, when changing the target, the set of
general properties may change. Let the nomenclature of parameters be described by a combination
\[ S = \{S_1, S_2, \ldots, S_m\} \].
The considered parameters for evaluating the effectiveness of varying degrees of importance, or
weight, that is, to varying degrees contribute to the achievement of the goal. In turn, each criterion
for evaluating effectiveness has a certain intensity of manifestation of a parameter in it.
In the process of evaluating the effectiveness, the following steps can be distinguished.
The first stage is the structuring of the problem, its interpretation in the form of a hierarchy, which
can be represented as a special class of partially ordered sets.
The second stage includes two components:
- determining the intensity of the manifestation of parameters for each of the considered criteria -
  weight from the point of view of a specific parameter;
- establishing the degree of importance of the weight of the parameters themselves relative to the
target in question.
To determine the weights, you must perform:
- paired comparisons of the proposals of applicants in terms of the intensity of manifestation of
each parameter in them;
- paired comparisons of parameters regarding their importance to the goal. This requires a certain
quantitative scale in which comparisons of pairs of criteria (parameters) can be expressed.

3. Results

Integrated indicators for evaluating the effectiveness of an end-to-end management system over the
entire lifecycle, calculated based on measurement values, provide a more accurate definition of the
results of changes in the dynamics of processes in management systems.
The calculation of any integral indicators consists of three stages:
- selection of particular criteria that will be used to build integral indicators;
- transformations of particular criteria for their comparability with each other;
- choice of the method of aggregating the transformed partial criteria.
Let's highlight the main criteria for evaluating the effectiveness of an end-to-end lifecycle
management system as a whole.
Integrated indicators for evaluating the effectiveness of an end-to-end management system reflect
the following indicators:
- saving the cost of creating a capital construction project;
- increasing the speed and quality of decision-making at all stages of the life cycle.
The efficiency of life cycle management of a capital construction project is reflected in the
following indicators:
- cost savings when creating a capital construction project;
- increasing the speed and quality of decisions made at all stages of the life cycle.
The most acceptable of all methods for determining the effectiveness of the life cycle management
system of a capital construction object is the method where it is recommended to take as a basis the
specific management costs calculated in relation to fixed assets and to the level of co-operative
supplies and production concentration associated with labor productivity for conditionally net
products (now we can already talk about standard-net products).

4. Discussion

Performance measurement and evaluation are necessary to assess the current state and trends of
development, select areas of change, identify the most important growth factors, track and correct
unmanaged processes, make decisions about changes and predict their impact on key parameters,
and make plans for further improvement of the company and its divisions [21]. The literature
emphasizes the role of performance meters as indicators of the state of management systems. Measuring and evaluating performance is a prerequisite for the successful functioning and development of organizations and management systems.

Measuring and evaluating the effectiveness of management systems is based on the analysis and calculation of indicators that reflect the use of internal resources used or used in the implementation of an investment and construction project. The content of the concept of efficiency at the level of participants in the life cycle was limited to the framework in which they acted as components of the process. Efficiency is determined by the ability of management systems to choose priorities and solve tasks, subordinating them to the main direction.

When using the first basic model, the focus is on indicators that characterize the results of activities, the achievement of technical and economic indicators. Organizations are considered to be performing effectively if they have met their targets for producing products or providing services. The main focus is on internal efficiency, which characterizes output per unit of cost and is determined by dividing output by costs. This should ensure: high quality, satisfaction of demand, low costs and prices, as well as efficient distribution of products or services. Achieving these “output” parameters guarantees a sufficient return on capital, survival and growth of the organization, as well as satisfaction of consumer demand for the company's products and services.

Performance indicators are usually calculated in relation to profit and characterize the profitability of using the company's resources. The return on all capital (the rate of return or return on funds) is considered a generalizing indicator, since it reflects the structure and movement of all types of production and financial resources of the enterprise, the processes of converting resources into costs in the course of production and circulation, and compliance with market demand for products or services performed.

The matching method is carried out by pairwise comparison and sequential comparison. In a pairwise comparison, parameters for evaluating the effectiveness of their importance are compared in pairs, setting the most important in each pair. All possible pairs of objects are represented as a record of each of the combinations or in the form of a matrix. The total number of comparison pairs is:

\[ A = \frac{P(P-1)}{2}, \]  

\[ (1) \]

P - the number of parameters considered. As a result, the degree of importance of a particular parameter is determined from the data obtained during the comparison. Parameters may be equivalent. To streamline all the parameters considered, subsequent processing of the comparison results is necessary. It is most convenient to carry out pairwise comparisons and their processing using matrices as a tool. The weight of each comparison object is calculated by the formula:

\[ \overline{B_i} = \frac{\sum_{j=1}^{n} A_{ij}}{A+k}, \]  

\[ (2) \]

A_{ij} – the degree of importance of the parameter (A - total number of pairs).

The criterion of efficiency when comparing different variants of the organizational structure is the possibility of the most complete and sustainable achievement of the final goals of the management system at a relatively lower cost of its operation. The criterion for the effectiveness of measures to improve the organizational structure is the possibility of a more complete and stable achievement of the set goals or reduction of management costs, the effect of the implementation of which should exceed production costs within the regulatory period.

It is of fundamental importance for evaluating the effectiveness of a management system to choose a base for comparison or to determine the level of efficiency that is taken as normative. Here you can specify several approaches that can be used differentially for specific cases. One of them is reduced to comparison with indicators that characterize the effectiveness of the organizational structure of the
reference version of the management system. The reference version can be developed and designed using all available methods and tools for designing management systems, based on best practices and the use of advanced organizational solutions. The characteristics of such a variant are accepted as normative, while the comparative effectiveness of the analyzed or projected system is determined on the basis of comparison of normative and actual (design) parameters of the system using mainly quantitative comparison methods. You can also use a comparison with the performance indicators and characteristics of the management system selected as a benchmark that determines the acceptable or sufficient level of efficiency of the organizational structure.

5. Conclusions
The results of the study allow us to use the developed approaches to assessing the effectiveness of the life cycle management system of a capital construction project using information modeling technologies, as a factor contributing to an increase in the efficiency of the organization of construction of both individual projects and the construction industry as a whole.

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