Assessment of the efficiency of quality management systems of agricultural planning and economic elements

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Abstract. The experience of assessing the efficiency of quality management systems for the organizational structures, agricultural planning, and common approaches to solving this issue are currently insufficient. As a result, there was a contradiction between practice that recognizes the objective need for a periodic assessment of the efficiency of the quality management system in the organizational structures of agricultural companies and the state of the scientific and methodological base for resolving these issues. The need has arisen for creating an automated system for choosing rational organizational and technological solutions based on modern design technologies, planning and forming a new element base for economic development of a system-targeted approach to assessing the level of stability of net assets based on IPSAS. On the basis of the well-known BIM technology for information modeling of objects, a bank (information base) of standard implementation plans (IP) is created, from which the most rational IP for this type of work is selected using the criteria research method based on modified genetic algorithms (GA). Issues of choosing a method of managing agricultural planning by the totality of implementation plans are considered. An analysis of the selection of the main methods of production of works that are increasingly used in the practice of constructing agricultural facilities will ensure the formation of new approaches to the logistics of transport support in agriculture.

1 Introduction

The problems of accounting and reporting net assets and the procedure for their formation, taking into account the specifics of the economic and legal status of property, are some of the most controversial when accounting for agricultural sector enterprises. The following methods were used: comparison, synthesis, analysis, logical approach, systematic approach. The most important factor in modeling the key performance indicators of a system-targeted approach to assessing the level of stability of net assets based on IPSAS is the multi-criterion of assessing the fundamentals of the management strategy for the elements of quality systems for operational and strategic planning of agricultural logistics and transport

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projects. Nowadays, to ensure competitive advantage within the country and in the global market, it is necessary to rapidly introduce modern technologies and ensure their availability. One of the advanced technologies today, which allows creating prototypes of models based on the digital version of the object, is 3D printing technology. This technology allows erecting buildings of small and medium height. The basic principle of a 3D printer is to use additive technology, i.e. the layered construction of a building structure based on a digital model using robotic mechanisms. 3D printing is of great interest in the construction industry due to the insufficient automation of the production of building structures and materials [15-17,18,19], as well as technological processes associated directly with the construction site. The relevance of this technology increases annually, as it allows solving a number of traditional problems in the construction industry: minimizing the risks of industrial injuries, low qualifications of workers and low labor productivity, high material and energy consumption, construction time, environmental problems and a large amount of construction waste and debris. The efficiency of construction production, its final results are largely determined by the degree of organization of the construction processes, which in turn depends on the quality of solving the design problems of the organization of construction and work and, first of all, the formation of models for the construction of objects and choice based on the most rational organizational and technological solutions (OTS). Organizational and technological design is the most important element in the preparation of construction and includes the tasks of modeling building processes in the construction of facilities. Solving the problems of organizational and technological design of construction (both with or without using a computer) is fraught with a number of difficulties that are caused by insufficient consideration of the existing methods of organization and technology of construction production, real conditions of work, and the capabilities of modern computer technology. In this regard, there is a need to improve methods for solving the problems of designing the organization of construction and work, taking into account the requirements of construction practice, in particular, modeling the construction of facilities and choosing the most rational organizational and technological solutions.

As part of the automation of the choice of a method for performing construction work on the basis of totality of implementation plans (IP), a multi-criteria optimization model based on genetic algorithms was developed to select the most suitable analogue of a standard IP.

Implementation plans (IP), which are part of the Method Statement, are usually developed for complex types of work and work performed by new methods. They are the basis of the scientific organization of construction processes and are developed in accordance with existing Russian standards (SNiP, GOST, ENiR, instructions).

An implementation plan is a set of rules, norms, instructions and schemes for the implementation of a given project or part of it. Using IP allows excluding different variations and interpretations of a particular mode of action in this situation. This is an instruction that allows you to most effectively and quickly do a given type of work.

The structure of an implementation plan: scope; organization and technology of work; requirements for quality and acceptance of work; calculation of labor costs, machine time and wages; work schedule; material and technical resources; safety precautions; technical and economic indicators. The main purpose of the IP is to assist builders and designers in the development of technological documentation. According to the Labor Code, the technological sequence of construction processes is established, weekly-daily schedules and work orders are compiled. They are used to justify the duration of the construction of facilities in calendar plans and network schedules. IPs are developed by leading design and construction companies to carry out general construction and specialized work. In some cases, IPs are developed for integrated construction and installation

processes [11-15]. It is possible to facilitate the development of IPs, improve their quality and reduce development time only through the use of the most modern information technologies [14]. By linking the automated selection algorithm for a typical IP with an information modeling program, it becomes possible to use the methodology not only for design, but also for the actual production of work. For example, in the production of stone work with the help of masonry robots, the work of which is carried out on the basis of the information model of the building by selecting the necessary IP.

2 Efficiency criteria and restrictions

The analysis showed that in the last decade, Russian scientists conducted research and proposed effective developments in the field of modeling building processes and choosing organizational and technological solutions based on them, optimizing the parameters of flow and parallel-flow organization of construction, the variant design of technological and organizational solutions; methods for improving the regulatory framework of organizational and technological design are proposed; possibilities of a comprehensive assessment of options have been expanded. This is confirmed by the development presented in the works of Afanasyev V.A., Antanavichyus K.A., Beletsky B.F., Budnikov M.S., Buslenko N.P., Velichkin V.Z., Voropaev V.I., Golub D.G., Isakov A.A., Mikhailov V.S., Nebritov B.N., Sadovsky V.I., Rybalsky V.I. Fokov R.I., Oleinik P.P., as well as in the works of research, design and educational institutions in the field of construction [1,4,5.6,7,8,9,10,11,12,13,14-17].

Modern methods and techniques of organization of construction production involve the use of information modeling (BIM), which involves the creation of a single information model of a building object, the necessary base for its creation, and their use and development at various stages of design, as well as at the stages of construction and operation. Building Information Modeling (BIM) is a process of collective creation and use of building information that forms a reliable basis for all decisions throughout the life cycle of an object (from the earliest concepts to detailed design, construction, operation and demolition). The BIM toolkit is designed to eliminate redundancy, re-entry and loss of data, errors in their transmission and conversion.

Real-time visualization and localization require context and sensitive information (for example, space, place, time) for the normal functioning of the system. Thus, the BIM model can provide spatial relationships, while sensor technology can provide location and time information. Modern methods of localization (indoors) use probabilistic algorithms to assess orientation, which often require a lot of computing power. Since the model contains the exact location of the components, the following advantage is provided when using the BIM model: there is no need to assess the true position of the landmarks, and at the same time, the complexity of the process and the machine operating time of the algorithm are sharply reduced.

BIM technology of information modeling of objects is the development of the generally accepted computer aided design system (CAD). The main difference from the latter, in addition to three-dimensional drawing, is that the model has a database containing detailed information about the technological, technical, architectural, engineering and construction, estimated, economic characteristics of the object. Depending on the specific requirements, the base can be supplemented with legal, operational, environmental and other information, the most important for our case is the base of implementation plans for the performed work [1,7,8.9,10,11,13,15-18]. As indicated above, in order to optimally choose the IP from the information base according to the studied criteria, a technique based on modified genetic algorithms (GA) has been developed. The GA technique offers the use of three optimization options:

- compliance with the required project duration,
- minimization of project cost indicators,
- minimization of indicators of mechanical equipment,
- minimization of indicators of the complexity of processes.

The objective function is as follows:

$$\sum_{i=1}^{n} \sum_{j=1}^{m_i} C_{ij} * K_{ij} + I * D + P * \sum_{i=1}^{n} \sum_{j=1}^{m_i} C_{ij} * K_{ij} \qquad (1)$$

Under the constraint $D \leq T$, where n is the number of works in the project; m_i - the number of IP alternatives of the process i; C_{ij} - direct costs of the i-th process, when alternative j is selected; K_{ij} - the binary variable of process i, when alternative j is selected, then K_{ij} is 1, otherwise K_{ij} is 0; I - indirect project costs per unit of time; D - process execution time; T - the required process execution time; P - indirect percentage of costs.

One of the possible typical implementation plans, the most optimal one, should be selected for the process. In this case, it is necessary to observe time and resource restrictions, which can be represented as follows:

- relationship of the type (end-start)

$$S_B \geq S_A + D_{Aj} + L_{AB}, \qquad (2)$$

- relationship of the type (start-start)

$$S_B \geq S_A + L_{AB}, \qquad (3)$$

- relationship of the type (end-end)

$$S_B + D_{Bj} \geq S_A + D_{Aj} + L_{AB}, \qquad (4)$$

- relationship of the type (start-end)

$$S_B + D_{Bj} \geq S_A + L_{AB}, \qquad (5)$$

where S_B – start time of the process B; S_A - start time of the process A; D_{Aj} - duration of the process A when alternative j is selected; D_{Bj} - duration of process B when alternative j is selected; L_{AB} - routine break.

An automation model based on modified genetic algorithms was developed taking into account the acceleration of obtaining the optimal choice of IP due to the assessment of ineffective solutions during the operation of the algorithm and their exclusion. At the stage of forming the information base of the IP (population) for each technological process, its repeatability is checked. If the same individuals exist in the population, then the final choice of the best option will be carried out taking into account the studied criteria and the weights of their influence established by experts. In addition, each IP is tested for applicability and adaptability to specified conditions [1,3-11]. The population is assessed, selected, propagated and updated until the conditions for stopping the algorithm are met. Thanks to this, the individual with the best indicators for this project will be selected. In other words, the principle of the algorithm is as follows: after selecting the most suitable implementation plans by the name and design features, if there is a problem of further selection of the IP, the algorithm prefers the following IP:

- *first of all, with a lower cost,*
- *secondarily, with the shortest duration,*
- *on a third-priority basis, with the lowest value of mechanical equipment,*
- *on a fourth-priority basis, with the lowest value of labor costs*.

3 Results and Discussions

Each implementation plan is identified by a unique identification number (id) by which the request is executed. In turn, the type of work that contains the plan is also determined by its identification number. So, the electronic directory is focused on personal and mobile computers. It is designed for WEB resources. Therefore, its compatibility is free to any platforms, and further development and updating of the system will not create any problems for users, since the system is located in the cloud. Let's consider the rules for the formation of criteria from previously accepted indicators for comparing options. Criteria can be built according to three principal options.

1. As a criterion, one of the indicators that has a clear dominance over other indicators (for example, task completion time or project cost) is taken. Such a criterion is called simple.

2. A criterion is formed by two or more indicators by their convolution into a composite criterion. The latter, as a rule, has the form of a function where the relative importance of indicators is not taken into account (they are accepted as equally valuable). An example of such a criterion is the rate of work V, which is the ratio of the volume of work Q to the time of their completion T:

$$V = \frac{Q}{T}.$$
(6)

3. The criterion is formed from n particular criteria K_i, the relative importance of which can vary. For this, a generalized criterion K_o is used:

$$K_o = \sum_{i=1}^{n} \alpha_i K_i \rightarrow \min(\max),$$
(7)

where α_i — weight of each i-th criterion K_i.

When forming a generalized criterion, two problems must be solved:
- determine the significance (weight) of each particular criterion, i.e. set the value of α_i;
- overcome the "dimension problem" of particular criteria, i.e. fulfill the first criterion requirement.

The significance of particular criteria can be established in two ways:

An expert method (or an expert survey method), the essence of which is described in the mathematical literature. Briefly, it can be described as follows: a group of experts is interviewed, each of which gives its own assessment of the significance of each particular criterion. Then, the obtained data are processed by the methods of mathematical statistics, and a certain average (or compromise) value of α_i is found;

The method of *"relative preferences",* which is a special case of the expert method (this is the method of one expert - the decision maker). Its essence is in the following actions.

The decision maker, individually or with the help of colleagues, arranges each of the particular criteria in a row in descending order of their importance.

For example, if four particular criteria are used and they are arranged in the order: $K_1 > K_2 = K_3 > K_4$, this means that K_1 is more important than K_2, K_2 is equivalent to K_3, and K_3 is more important than K_4. Such a record is called an *"order relation"*.

If K_1 is more important than K_2 ($K_1 > K_2$), then criterion K_1 is assigned an importance factor $\beta_{12} = 3$.

If K_1 is equal to K_2 ($K_1 = K_2$), then $\beta_{12} = 2$.

If K_1 is less important than K_2 ($K_1 \leq K_2$), then $\beta_{12} = 1$.

To calculate α_i, a scoring square matrix is constructed in which the partial criteria K_i are arranged in rows and columns (Table 1).

Table 1. Scoring matrix for calculating the coefficients α_i.

Criteria	K_1	K_2	...	K_n	$\sum\limits_{i=1}^{n}\beta_{ij}$	α_i
K_1		β_{12}		β_{1n}	$\sum\limits_{i=1}^{n}\beta_{1j}$	α_1
K_2	β_{21}		...	β_{2n}	$\sum\limits_{i=1}^{n}\beta_{2j}$	α_2
...	...	...	...	...	...	...
K_n	β_{n1}	β_{n2}	...		$\sum\limits_{i=1}^{n}\beta_{ij}$	α_n
					$\sum\sum\beta_{ij}$	$\sum\limits_{i=1}^{n}\alpha_i = 1.0$

In each row, at the intersection of a row and a column, values of β_{ij} are assigned that correspond to the order of preference of the row criterion over the column criterion. As a result, for each i-th row, one can get the sum of the significance coefficients for the criterion K_i ($\sum\limits_{i=1}^{n}\beta_{ij}$). Summing up these results by columns, we get

$$A = \sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}. \tag{8}$$

The coefficient of significance of the criterion K_i will be equal to:

$$\alpha_i = \sum_{i=1}^{n}\beta_{ij} \ /A. \tag{9}$$

Example: Calculate the coefficients of significance of the criteria, if the ratio of their order is established: $K_1 > K_2 > K_3 = K_4$. **Solution**

Let's build a scoring matrix (table 2). In cell $K_1 – K_2$, we will write the number 3, because $K_1 > K_2$. Since K_1 will be more important than all other criteria in the row (transitivity property, if $K_1 > K_2$ and $K_2 > K_3$, then $K_1 > K_3$, i.e. set of ordered pairs of elements of this set), then the number 3 should be written in the two remaining cells of the first row. Thus, the sum of the numbers of the first row will be 9. Similarly, fill in all the other cells of the scoring matrix (in cell $K_4 – K_1$, there will be the number 1, because $K_4 < K_1$; in a cell $K_4 – K_3$ there will be the number 2, since $K_4 = K_1$)

Table 2. Scoring matrix.

Criteria	K_1	K_2	K_3	K_4	$\sum_{i=1}^{n} \beta_{ij}$	α_i
K_1		3	3	3	9	0.375
K_2	1		3	3	7	0.292
K_3	1	1		2	4	0.167
K_4	1	1	2		4	0.167

$A = 24$ $\sum \alpha_i = 1.00$

Summing up the numbers in the column $\sum_{i=1}^{n} \beta_{ij}$, we get $A = 24$. Hence

$$\alpha_1 = 9/24 = 0.375; \ \alpha_2 = 7/24 = 0.292; \ \alpha_3 = \alpha_4 = 0.167.$$

The condition $\sum \alpha_i = 1.00$ is satisfied.

To solve the problem of "dimension" in equation (7), not the absolute values of K_i are used, but their normalized values calculated by the formula:

$$K_i^{\text{n}} = \frac{K_{i\text{a}}}{K_i^{\text{lim}}}, \tag{10}$$

where $K_{i\text{a}}$ and K_i^{lim} - the actual and limit (or normative) values of the criterion, respectively. Using formula (10), different-dimensional criteria are reduced to one-dimensional (in fractions of a unit).

In practice, there are often situations where not all criteria have the same way of optimization (i.e. all tend to either minimum or maximum). For example, expenses, losses, deadlines for putting objects into operation tend to a minimum, and profit, pace of work, profitability and others – to a maximum). In this case, equation (7) is divided into two parts: minimized criteria are collected in one part, and maximized criteria in the other. If we denote the first group by K_i ($i = 1,2,\dots,m$), and the second through K_j ($j = 1,2,..,l$), then formula (10) takes the form:

$$K_{\text{o}} = \sum_{i=1}^{m} \alpha_i K_i^{\text{n}} + \sum_{j=1}^{l} \alpha_j \frac{1}{K_j^{\text{n}}} \to \min, \tag{11}$$

and $m + l = n$.

Thus, the essence of the concepts of "criteria" and "restrictions", as well as the rules for the formation of particular and generalized criteria, were examined. In the theory of decision making, there is the concept of "*decision efficiency*", which in essence is a concept of its quality. The encyclopedic definition of "efficiency" of any system comes down to its effectiveness, the degree of achieving the goals. In this context, the efficiency of the decision should be considered as an indicator characterizing the quality of the decision, the degree of use of financial, material and labor resources. The measure of efficiency is the criterion of efficiency. By definition, efficiency does not exist regardless of the goals for which, in fact, a decision is made, as well as the conditions for the implementation of these goals. If we change the goals and (or) construction conditions, then a previously effective solution may be ineffective. For example, the transition to a market economy from the

planned economy of the USSR led to the fact that the old standard construction decisions were ineffective, since they did not adequately reflect new goals (the main of which is making a profit).

Similarly, efficiency does not exist separately from the efficiency criterion. If, by definition, efficiency is an indicator of the degree of achievement of goals, then the criterion is a measure of the assessment of this degree. For example, a solution that is optimal according to the criterion of cost of production may be unacceptable by the criterion of its demand in the market (nobody needs cheap, but unclaimed products).

The efficiency of the decision is divided into *expected* (predicted) and *actually achieved*. The first is assessed at the stage of development of projects (investment projects) of the construction organization, the second - after it is finished upon completion of tasks. Goals have a different nature. When making decisions on the construction of transport facilities, economic, industrial (technological), social, environmental and other goals are pursued. Therefore, the efficiency of decisions can be divided into economic, operational, industrial, social, and environmental.

The *operational* (or general) efficiency E_o is generally understood as the ratio of the scope of actually performed (or predicted) work Q_a to the planned (directive) indicators Q_{dir}:

$$E_o = Q_a/Q_{dir} \qquad (12)$$

The *economic* efficiency of the decision E_E is assessed by the ratio of the economic effect (profit, profitability of production) P to the costs Z, due to which this effect was achieved:

$$E = P/Z. \qquad (13)$$

All other types of efficiency are calculated similarly using dependencies of the type (10) or (11). At the same time, the appropriate indicator of the effect in monetary or physical terms should be set in the numerator. To work with the database, a set of QtSql classes is connected for working with databases using the SQL structured query language and the QSqlDatabase class to represent the connection to the database. To demonstrate the operation of the algorithm for improving the adoption of OTS in the production of stone work, a matrix of parameters was built from the information base of implementation plans (IP), which presents the parameters from the IP: cost, duration, mechanical equipment, labor costs.

Typical implementation plans are compared according to the weight of the influence of the criteria on the project. As a result, priority is given to the choice, and the total weight of the influence of the criteria on the project is greater for the selected IP, which will be selected by the algorithm for use in the construction and installation works in the building project.

In addition, the characteristics of workspaces (type, size, and location) and the work that occurs in the areas of activity during the construction process change in time and move in three dimensions. Without the use of 4D modeling, conflicts of workspaces at the construction site are almost impossible to detect. The development of a visualization model of work with 3D workspaces based on the information model of the building and taking into account the time parameter from the construction schedule allows tracking the progress of work and determining any conflicts between their workspaces even at the design stage [8,9,10].

In some cases, it is important that the designer is promptly provided with an information base containing: requirements for the installation of scaffolding and examples of their location; regulations for production quality control of work, including input, operational

and acceptance control; methods for determining the need for materials, products and structures, machines and equipment, tools, and devices; requirements for transportation, warehousing and storage of products and materials; safety measures and labor protection, environmental and fire safety; information on other issues that are reflected in the IP. When solving specific targets contained in the IP, the latter should ensure full compliance with the input and output data of these tasks with the requirements of regulatory and methodological documentation. Software modules that automate the solution of specific problems must have calculation and graphic components. Variants are possible when graphical modules are implemented as a kind of customization of the latest AutoCad package, and the calculation modules of the program work, for example, in the FoxPRO and C ++ environment [14]. Programs should have an established regulatory and methodological base containing text, digital, tabular and graphic materials. The database must include regulatory and reference documents. Software modules are required to provide: selection of a crane according to cargo parameters and lifting height; drawing a crane with reference to the objects of the construction site; calculation of the need for inventory office buildings; formation of technological schemes; computer-aided design of pits; selection of an effective use of earthmoving and transport equipment; calculation of water reduction in pits and trenches; selection of lifting devices; calculation and selection of lighting equipment; calculation of loads and energy consumption for construction and installation works; calculation of the need for storage areas. It is necessary that the output of the work of the calculation modules of the programs be an organizational and technological documentation executed in accordance with the applicable standards in the form of calculated, graphic, formalized text materials. The documentation generated in this way without any modifications could be used by the contractor in the construction of the facility. Nowadays, on the automated development of the IP work is underway. A necessary condition for the automation of IP development is their unification, and the degree of unification is objectively low. At the moment, there is no automated solution to a number of problems: layout of formwork, installation of scaffolding, solutions for the production of geodetic works, etc. It is still impossible to automate the coordination of joint work of construction equipment in cramped conditions. For example, several cranes in a small area may collide with boom equipment. It is extremely difficult to determine the optimal schedule for their joint work and movement [11,12,13,17-21]. However, there are areas of IP, the automation of which is the prospect of the near future. This is the formation of realistic images of models for performing specified types of work; use of banks and databases. For example, for construction machines, tools, labor-intensive base [11,12,22-25]. Based on the entered design and calculation data, tabular reports are generated: a schedule of work, a statement of the volume of work, calendar schedules of the need for equipment and personnel. For the design of drawings, a database of construction equipment and graphic symbols is used. The selection of load-lifting mechanisms is carried out on the basis of the entered data: mass and size of cargo and load-lifting devices; radius of cargo; lifting heights. Such cranes are selected from the base, the lifting characteristics of which meet the specified conditions for lifting the goods, taking into account the regulatory reserves for the height of the lift and the mass of the cargo. The program allows you to automatically calculate the radii of the working and hazardous areas, as well as draw their designations on the drawing.

Selection of pile drivers is carried out on the basis of the selected standard size of piles. Pile drivers are selected from the information database, the technical characteristics of which allow the loading of piles of a selected diameter and mass. In addition, the database contains the following types of equipment: concrete mixer trucks; concrete pumps; lifting platforms; bulldozers; drilling rigs; machinery for bored piles; pipe layers; excavators. New functionality and filling the program databases can be a breakthrough in the development of organizational and technical documentation. Therefore, the priority for developers is the

implementation of wishes received in feedback. As for the users, among the experts and constructive critics, the developers hope to see those who are directly connected with the development of implementation plans and the introduction of new construction technologies [12,13,25-28]. The level of product quality and the construction period correspond to the directive ones. There were no environmental violations during the construction process, which implies that these indicators will be limitations. The efficiency of the processes included in the system is given in (Table 3).

Table 3. Process efficiency of the quality management system.

Process No. (P)	Quality management system processes	Rating	Normalized indicator	Weight coefficient
1	2	3	4	5
Management processes:				**0.33**
1	Strategic planning. Development of quality policies and goals	6	0.6	0.29
2	regulatory support	6	0.6	0.21
3	analysis of a system by management	5	0.5	0.37
4	bringing the requirements of consumers, legal and regulatory requirements to the personnel (internal exchange of information)	7	0.7	0.13
Main processes:				**0.5**
	Provision of resources:			0.25
5	personnel management	7	0.7	0.5
6	infrastructure management	7	0.7	0.37
7	work environment management	6	0.6	0.13
	Processes of project life cycle, interactions with consumers and subcontractors:			0.75
8	project life cycle processes planning (preparation of production)	6	0.6	0.23
9	consumer processes	7	0.7	0.16
10	subcontracting processes	7	0.7	0.09
11	procurement management	6	0.6	0.13
12	organization and implementation of construction and installation work	7	0.7	0.23
13	commissioning	7	0.7	0.16
1	2	3	4	5
Auxiliary processes:				**0.17**
14	document management	6	0.6	0.056
15	record management	6	0.6	0.056
16	inappropriate product management	7	0.7	0.072
17	customer satisfaction measurement	6	0.6	0.105
18	product monitoring and measurement	7	0.7	0.139
19	internal audit	5	0.5	0.139
20	management of devices for monitoring and measurement	6	0.6	0.117
21	corrective actions	7	0.7	0.083
22	preventive actions	6	0.6	0.094
23	continuous improvement	6	0.6	0.139

The effectiveness of the processes is presented in the form of a diagram:
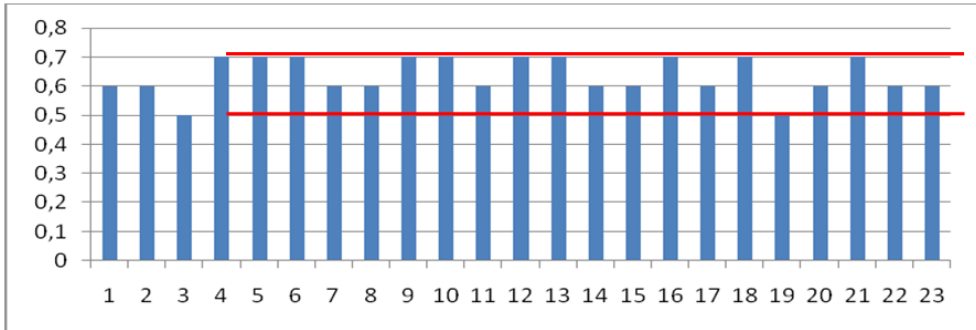
**Fig. 1.** The effectiveness of the system processes.

Calculation of weighting coefficients was carried out by the method of relative preferences. The significance of the processes, groups of processes was determined by an expert survey of officials of the construction management. After the calculations, the efficiency of the system was: $R_{Syst} = 0.62959$. From which it follows ($0.5 < R_{Syst} < 0.7$) that the level of functioning of the system is average and shows the need for corrective actions to improve the functioning of processes (improve the quality of processes). Figure 1 can help identifying the processes that need improvement. Due to the fact that no cost accounting for the quality management system is carried out in management, the calculation of economic efficiency was carried out as the ratio of actual indicators of economic efficiency to planned ones (revenue, profit), the significance of the criteria: $\alpha_1 < \alpha_2$

$$K_{OE}= 0.25 \quad K_{OE} = 0.25 \times \frac{157914}{178000} + 0.75 \times \frac{1478}{3000} = 0.59129 \rightarrow 1(\text{max})$$

1. Nowadays, quality management systems within a single technological cycle represent disparate quality systems of management and departments. There are no unified approaches to building systems. In order to increase the efficiency of quality management, it is recommended to create a unified quality management system, which should cover not only management bodies, but also subordinate units (Fig. 2)**.**

2. To ensure the coordinated work of the quality services of management bodies and subordinated units, it is recommended to establish ***uniform requirements*** for the documentation of the quality management system, criteria for the effectiveness of processes and methods for assessing them. This will improve interaction on the issues of quality of processes and products of subordinate units, both among themselves and with management bodies.

3. In order to improve management efficiency, it is recommended that the issues of regulatory support, development and implementation of new documentation be assigned to the quality service.
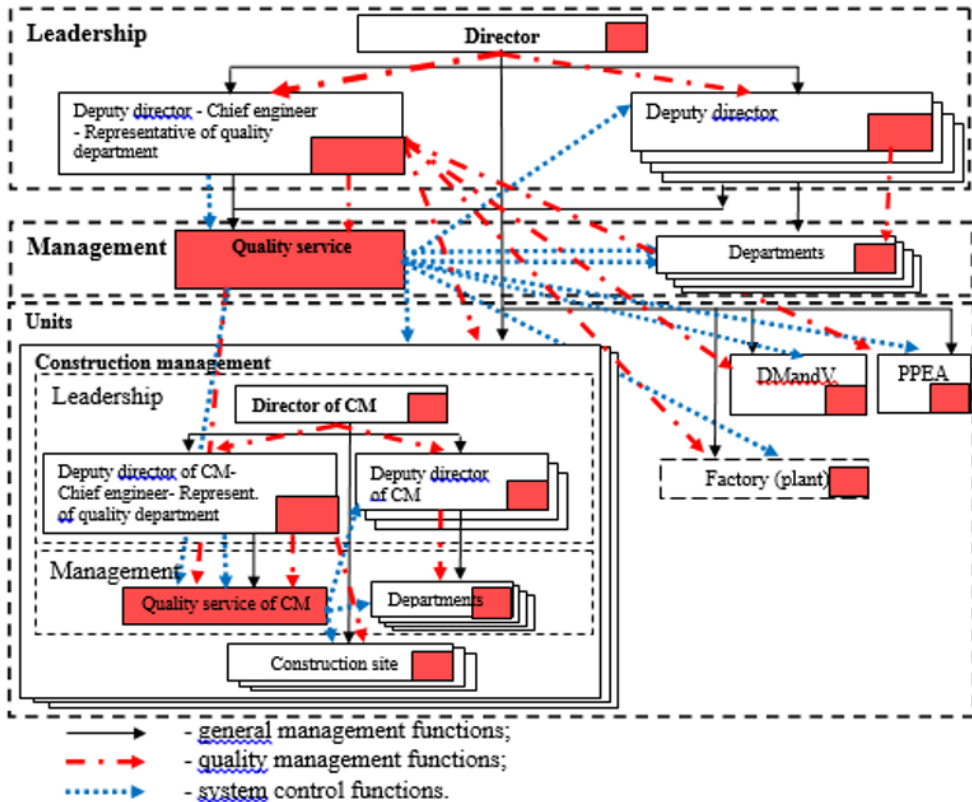
Fig. 2. A variant of the recommended organizational structure of the quality management system (quality services - separate units).

4. In order to maintain the quality management system at a high level, it is recommended to periodically assess the efficiency of the system, taking into account the changing production conditions and requirements for the quality of construction products. The frequency of such an assessment should be linked to a periodic analysis of production and economic activity. At the same time, it is recommended to consider the assessment of the efficiency of the quality management system as a separate analysis task.

5. The normal functioning of the quality management system requires certain costs for the maintenance of the management system, as well as costs for measures to manage product quality. To date, such costs are either not determined or determined in the general financial reporting system. Due to the high complexity of the process of calculating these costs, it is recommended that a system of accounting for the above costs be allocated from the general financial statements. Calculation and analysis of costs should be carried out in the process of assessing the efficiency of the management of quality system elements. Systematic accounting and analysis of quality costs will allow determining the causes of occurrence in a timely manner, managing them, and determining the best methods to reduce them.

6. The application of the system-target approach in the developed methodology makes it universal and applicable to any organizational and functional building systems, regardless of the function and the nature of the tasks performed. However, the objectivity of the information obtained as a result of an assessment of the efficiency of the system will largely depend on the correctness of setting goals and choosing indicators that determine their achievement. In the recommended system of goals, the goals of quality management should

be linked to the general goals of production management and issues of the appropriateness of economic activity.

The calculation of managerial effectiveness was carried out by assessing the degree of implementation of the management functions of the system using points (1÷5). A survey of construction company officials showed that all functions have equivalent meanings. Thus, managerial effectiveness was: $K_m = (0.8 + 0.8 + 0.8 + 0.6 + 0.6)/5 = 0.72$

Social efficiency in this study was considered as the degree of satisfaction of workers with social working conditions. The assessment was carried out through a survey of employees. According to the survey, the criterion of social efficiency was calculated: $K_{soc} = 0.7$.

Given the above calculations, the efficiency of the quality management system of ICC "Zapad":

$K_o = 0.62959 \times 0.29 + 0.59129 \times 0.29 + 0.72 \times 0.29 + 0.7 \times 0.13 = 0.65385 \rightarrow 1(max)$

Analysis of the calculations of the results obtained within the *fourth stage* of the methodology showed that it is necessary to carry out corrective measures to increase the effectiveness of the processes (analysis by the management, internal audit, management of documents and records, measurement of customer satisfaction, etc.). For a more thorough analysis of the economic efficiency of the system, processes and measures to improve them, it is necessary to allocate costs in these areas from the general financial statements. Considering the fact that this performance assessment is the first for this construction company, it is possible to take this value as a base and use it for analysis in subsequent assessments - how much the system's performance indicators have improved or decreased.

As part of the study, verification of the proposed methodology and its implementation was carried out in ICC "Zapad" and IC "Garant". The results are shown in Table 4.

Table 4. Efficiency calculation results.

| No.	Company	R_{Syst}	K_{OE}	U_e	K_{soc}	K_o
	Significance of the criteria	0.29	0.29	0.29	0.13	
1	ICC "Zapad"	0.61758	1.28227	0.76	0.62	0.85196
2	IC "Garant"	0.62959	0.59129	0.72	0.7	0.65385

4 Conclusions

An analysis of the results shows that the efficiency of the system in IC "Garant" is higher than in ICC "Zapad". However, the generalized indicator says that the QMS functions more efficiently in ICC "Zapad", although each of the assessed companies needs to carry out activities aimed at improving the quality processes. In construction, perspectives in imitation of construction production and a visual project for the organization of construction, a project for implementation of construction operations; spatial and temporal coordination of construction participants; planning, management and control (plan/actual); site optimization and logistics; improvement of geodetic alignment works; deviation control; monitoring of labor protection and industrial safety: in the modular digital production of building structures and products with assembly at the construction site; rationalization of executive documentation and its full reflection in the information model of the object. Efficiency is a comprehensive concept that includes several private types of efficiency. From this it follows that assessing the efficiency of the quality management system is a multicriteria task in which production, economic and other criteria must be present. Taking into account the above terms, as well as the foregoing, we can formulate

methodological foundations for assessing the efficiency of the quality management system, which can come down to the following provisions [25,26,27,28,29,30]:

1. Since efficiency is the degree to which goals are achieved, it is necessary to formulate a goal for the achievement of which a management system has been created and make its decomposition. An example of target decomposition is shown in **figure 3.**

By definition of the concept of "efficiency", it is legitimate to talk about the efficiency of achieving each individual goal. In other words, it is possible to assess the efficiency of quality management of construction products as a whole, as well as the efficiency of tasks, for example: "Ensure compliance with product requirements", "Process quality management", etc.
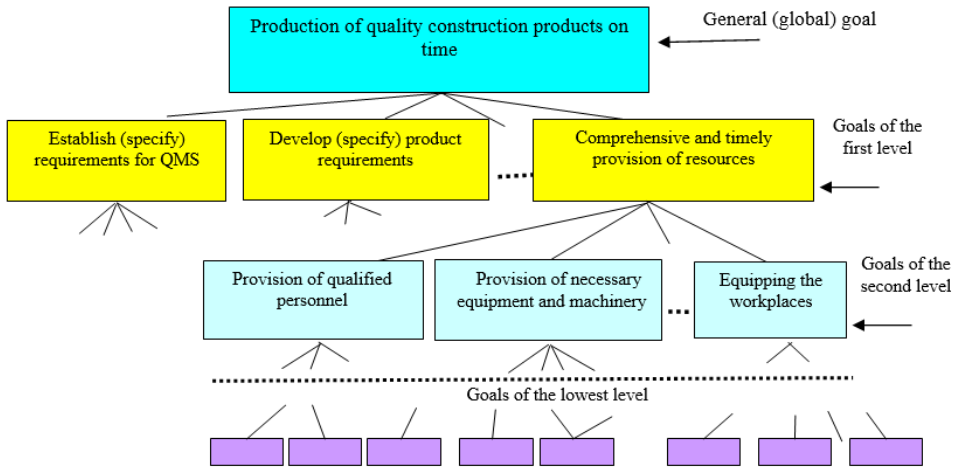

Fig. 3. An example of decomposition of quality management goals

2. Since the goals are of a different nature (production, economic, environmental, social, etc.), it's also wrong to reduce efficiency only to economic efficiency, because it (efficiency) can be industrial, economic, etc. The relationship between the categories of "goal" and "efficiency" is shown in figure 4.

3. Achievement of each goal is assessed by a system of indicators (cost, labor, time and others). In the theory of efficiency, these indicators are usually divided into two groups: *criteria and restrictions.*

A methodological approach to justifying the system of criteria and restrictions is presented in figure 5.
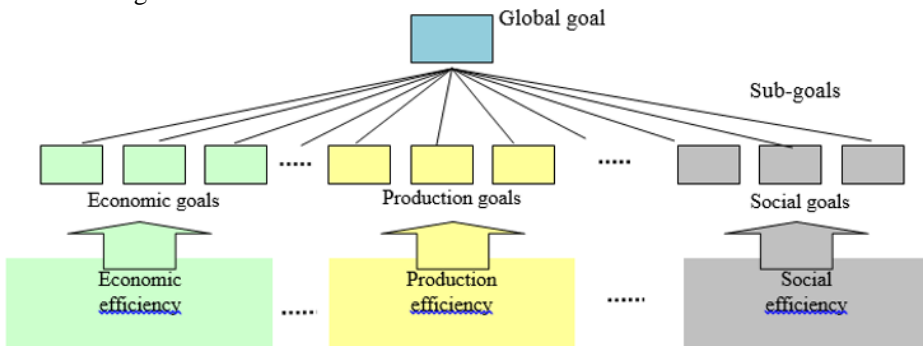
**Fig. 4**. The relationship between the categories of "goals" and "efficiency".
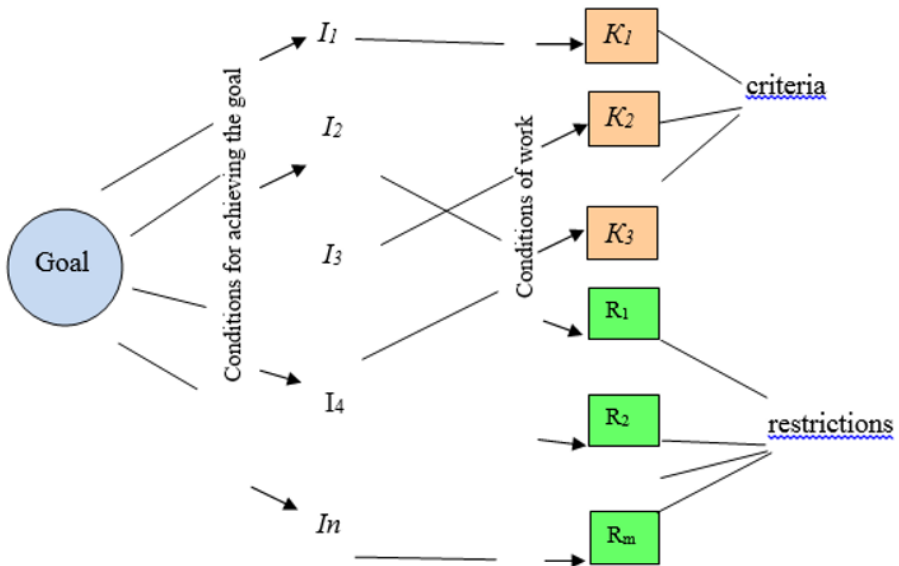
Fig. 5. The diagram of forming a system of criteria and restrictions.

The efficiency criteria themselves have different significance ("weight") in the system of accepted criteria.

The considered provisions can be regarded as the basis of the methodology for assessing the efficiency of the quality management system.

The proposed methodology is presented in four stages in figure 6**.**
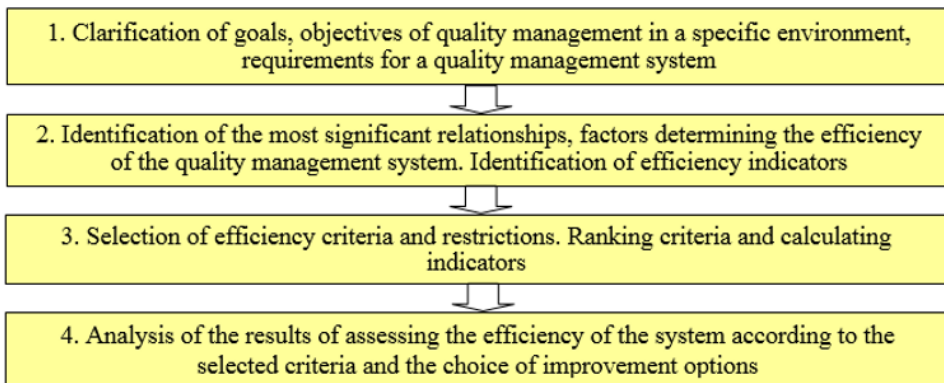
Fig. 6. Algorithm for assessing the efficiency of a quality management system.

At the first stage, the first and second provisions of the formulated methodological foundations are implemented - the goals are specified and their decomposition is carried out.

Goals in different conditions can be formulated in different ways. In this case, the quality parameters of the object are predefined. In practice, when setting goals, they will indicate both operational and economic (cost) indicators, i.e. goals of various nature.

The second stage will be devoted to identifying the most significant relationships between the elements of the system, the factors that determine its efficiency. These elements and factors will be developed and presented in subsequent studies.

This stage will be organically connected with the first stage, since the conditions and factors will determine the order of implementation of the goals, as well as the very system of assessing the efficiency of QMS. The calculation of the necessary parameters for the construction, installation and special works as part of the implementation plan, the automated selection of methods of construction and installation works on the basis of the selection of the necessary technical specifications by means of BIM technology is correct, which is confirmed by theoretical analysis and the practice of using the choice of the method of construction work by the totality of implementation plans. The issues of the integrated use of information resources, combining the functionality of different software tools, creating information models of various processes and objects, the development of methods and algorithms for processing and presenting information are widely discussed by the scientific community.

All this should ultimately lead to a reduction in the time of building construction; reducing the cost of creating an object; provide access to reliable information on the progress of construction; reduce waste; reduce injuries at the construction site, and increase the reliability and quality of the construction facility. In our opinion, when calculating net assets from gross receipts of economic benefits in fair value at the date of receipt, it is necessary to exclude the amount of liabilities calculated on the basis of the liquidation value of assets to be withdrawn at the date of liquidation. Thus, the excess of the value of gross receipts from the founder over the amount of these obligations will amount to the share of net assets that "belong" to the institution and are realized in the process of activity throughout its existence. It is also proposed to exclude the excess of liabilities over the initial book value of assets in terms of property assigned to the institution.

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