Information technology application in the construction project life cycle

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Abstract. Development management models of object information base are necessary for definition the volume of resources and construction object cost at each stage of building life cycle taking into account the existing requirements to definition each type of cost at stages from PRE-BIM to RE-BIM. To develop and implement the cost management system of the object in the construction industry, it is necessary not only to determine the main levels and parameters of choice when taking into account decisions from the organizational and technological documentation, but also to build an architecture of application software based on artificial intelligence for the operation of the management system at all subsequent stages of the life cycle of the construction object. It is important to determine the main factors influencing on the process of decision-making, and the parameters of the formation of input and output data for modelling each stage of the life cycle of the object, as well as technical and economic indicators of the information model by stages. The diversity of digital technologies opens new possibilities for every project and the cost model help to connect the processes throughout project lifecycle.

1. Introduction

According to the strategy of scientific and technological development in Russian Federation in the next 10 - 15 years, the Russian Federation priorities of scientific and technological development should be considered those areas that will allow to obtain scientific and scientific-technical results and create technologies that are the basis of innovative development in products and services at the domestic market, Russia's stable position in the foreign market, and will provide the transition to advanced digital, intelligent manufacturing technologies, robotic systems, new materials and methods of construction, the creation of systems for processing large amounts of data, machine learning and artificial intelligence.

In order to modernize the construction industry and improve the quality of construction, it's must be provided:
- transition to the life cycle management system of construction projects (the management system) through the introduction of information modeling technologies;
- adoption of information modeling standards, as well as harmonization of previously adopted regulatory and technical documents with international and Russian legislation;
- formation of standard project documentation libraries for information modeling;
- training of specialists in the field of information modeling in construction;
- stimulation of development and use of domestic software for information modeling of buildings and structures [12].
The end-to-end technologies of the digital economy are:

- big data (1),
- neurotechnology (neural network) (2),
- artificial intelligence (3),
- distributed registry systems (blockchain) (4),
- quantum technology (5),
- new production technologies (6),
- industrial Internet (7),
- robotics (8),
- sensorics (9),
- wireless connection (10),
- virtual and augmented reality (11).

The following technologies are applicable in the construction industry:

- Big data (1) - in terms of urban development and investment decisions;
- Neurotechnology (neural network) (2) - when creating an enterprise risk management model, production cycle planning, the detection of faults and prevention of emergency situations, forecasting;
- Artificial intelligence (3) - in the development of urban planning and investment solutions;
- Distributed registry systems (blockchain) (4) - in terms of financing and logistics of construction projects;
- New production technologies (6) - in terms of production of building materials and products, additive and hybrid technologies;
- Industrial Internet (7) - the concept of building info communication infrastructures, implying the connection to the Internet of equipment, sensors, automated process control system (ACS);
- Robotic technology (8) - in terms of mechanization of construction production and operation;
- Sensorics (9) - in terms of the use of equipment that provides the technological purpose of buildings and structures;
- Wireless communication (10) - in the engineering support part of buildings;
- Virtual and augmented reality (11) - in terms of information modeling of construction [13].

2. Methods

Building information model (BIM) is a well-coordinated, coherent and interconnected model of the object, having the ability for calculation and analysis, geometric reference, working with computer, using specific software, allowing necessary updates of numerical information about already existing object or still under design [1].

The model at the stage of pre-project is called Pre-BIM, at the stage of designing – D-BIM, at the stage of execution or construction – C-BIM, at the stage of facility management or exploitation – E-BIM, at the stage of reorganization or waste recycling – Re-BIM (Table 1) [2].

Application of monitoring and control systems in BIM models during the construction stage of lifecycle will improve the management efficiency of the construction processes and will help to detect deviations from established parameters, thereby allowing to take timely corrective action.

At each stage of project life cycle, digital technologies are applied to different degrees. Table 1 shows the distribution of digital technologies by stages of project life cycle upon Russian experience.

### Table 1. Distribution of digital technologies by stages of project life cycle

| Num | D-BIM model | C-BIM model | E-BIM model | RE-BIM model |
|-----|-------------|-------------|-------------|--------------|

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In this table, the value "100%" reflects the absolute direct dependence of decisions on the specified technology, 90% and below - decision-making is focused on these technologies or can apply them, but also compares additional factors that have a higher rank when making a decision.

Application software is being developed for the development of information infrastructure consisting of digital platforms for working with data to meet the needs of consumers at all levels. In particular, for the construction industry, the architecture of such software is formed taking into account the target function, which consists in the transition to the life cycle management of objects through the development and implementation of information modelling technologies [14].

One of the main advantages of using such systems is the ability to predict changes in value from stage to stage of the life cycle of the object. To determine the value of the object the participants of investment-construction process it is necessary to analyse the possible solutions for the organizational-technical, organizational, resource, organizational, economic, organisational and regulatory level, as well as any risks of attack of adverse circumstances or security of the facility and its infrastructure [3].

Artificial intelligence systems (or algorithms with the possibility of self-learning) in real time dynamically give the opportunity to set the necessary parameters for solving problems to achieve the goal. Systems of multi-level parametric choice of design solutions based on information modelling should be built according to the following principles.

In such systems the sequence according to stages of creation of object, on the principle from the General to the particular has to be kept. At the beginning, the economic feasibility of the construction of the object is determined, after which the volume-planning, structural, architectural and organizational-technological solutions are consistently determined. The next principle laid down in the decision-making algorithm is the possibility of variant selection of each decision on technical and economic indicators, including the calculation of operating costs already at the stage of pre-design studies. Of course, to increase the speed of the system to generate the most optimal option in the current environment will allow the use of standard solutions (projects). Among other advantages and disadvantages of using a typical design for the described system, it is cost-effective for construction organizations to use standard (prefabricated) structures. The most important principle is to take into account the mutual influence of the selected options at each level, implementing the principle of complexity of solutions (space-planning, architectural, structural, organizational and technological) [11].

|   | 100% | 100% | 100% | 100% | 100% |
|---|------|------|------|------|------|
| 2 | 60%  | -    | 80%  | 60%  |      |
| 3 | 90%  | -    | 90%  | 100% |      |
| 4 | -    | 100% | 100% | 100% |      |
| 6 | 100% | 100% | 100% | 100% |      |
| 7 | -    | 50%  | 50%  | 50%  |      |
| 8 | 100% | 100% | 100% | 100% |      |
| 9 | 90%  | 100% | 100% | 100% |      |
| 10| 100% | 100% | 100% | 100% |      |
| 11| 100% | 100% | 100% | 100% |      |
It is important to follow the principles of system engineering with the use of information and communication technologies in order to create a system of object cost management using digital technologies in the construction industry.

To organize the process of information modelling of the object by applying digital technologies, it is necessary to create software, hardware, network resources, databases and libraries of components, standard projects [4].

The description of the applied technologies at the design stage (D-BIM) is laid down in the technical requirements at the pre-design stage (PRE-BIM). The description of the applied technologies at the construction stage (C-BIM) is determined by the project of construction organization and the project of works at the design stage (D-BIM). The description of the applied technologies at the stage of facility management or building exploitation (E-BIM) is determined by the composition of cyber-physical systems and standards of operation of buildings and structures at the design stage (D-BIM) [10].

To make a decision on the optimal construction technology, it is necessary to compare the options according to certain criteria with specified restrictions. Artificial intelligence technologies will make it possible to do this in a shorter time. Table 2 shows the selection criteria for comparing traditional building construction technologies and additive technologies.

**Table 2. Factors favoring additive and traditional production**

| Favour additive technologies | Favour traditional manufacturing |
|------------------------------|---------------------------------|
| Small production volumes     | Large production volumes        |
| High cost of materials       | Low cost of materials           |
| High cost of machining       | Ease of machining parts         |

Proper formation of the process chain, ensuring technical and organizational interoperability when using additive technologies will allow us to speak not only about the need, but also about the economic advantages and effectiveness. To ensure technical interoperability in additive technologies, it is necessary to build a clear interaction of BIM platforms and organize competent settings for the implementation of the set goals. This will allow you to automate the technical component for production using additive technologies [9].

The definition of value, its clarification, occurs from stage to stage of the project life cycle.

At the stage of pre-project (PRE-BIM), the cost of the object is determined by the consolidated indicators determined by the objects-analogues. At the design stage (D-BIM), the cost of the object is specified due to the fact that the calculation is made according to the estimated standards and types of specific works with specific volumes and resources calculated for this purpose, then the resulting cost can be specified in connection with the examination of design estimates, changes in design decisions.

At the stage of execution or construction (C-BIM) used working documentation, there is the probability of additional work, which could not be determined at the previous stage, the data are stored in the supervision of the designer, adjustments are made to the design documentation, but it is
important to note that if your changes affect the safety of the facility, the necessary re-examination of the project based on the changes.

At the facility management stage (E-BIM) our cost model is dynamic, as it receives data on all changes in engineering systems at regular intervals. However, the cost of operation can be predicted at the design stage, taking into account the requirements for the frequency of repairs and modernization of equipment using artificial intelligence. Although as at the construction stage, there are some circumstances that it is difficult to assume at the design stage, for example, crash or hardware breakthrough of utilities, so when you create a model cost object during its operation it is necessary to be guided not only regulatory requirements, but also to suggest possible unforeseen costs. In addition, at the operational stage it is important to reflect the projected increase in cost due to inflation, the cost of energy carriers, an increase in tariffs or conditions of energy supply to the object, taking into account the normative life of the object [5].

The cost of the object depends on the decisions made on the levels: organizational and technical, organizational and resource, organizational and regulatory, organizational and economic (fig.1).

The use of digital technologies in construction implies the use of integrated systems to implement a systematic approach to the design of the object and planning resources and costs. This information platform can only work under the following conditions: 1. It is necessary to determine the relationship of indicators to each other through a comprehensive analysis of possible boundaries of data aggregation intervals, on the basis of which it is necessary to implement a classifier of cost estimation levels at each stage of the life cycle. 2. It is necessary to divide the existing cost determination systems into two parts - for complex projects and separate processes.

3. Results
Scientific novelty is expressed in the proposal to introduce a system of multi-level parametric selection of design solutions based on information modelling to determine the amount of resources and cost of the construction object at each stage of the life cycle of the building, taking into account the current requirements for determining the estimated cost at the stages of pre-design studies, design, obtaining a positive expert opinion, construction, commissioning, operation, disposal of the object.

![Figure 1. Project cost function](image1)

![Figure 2. Software architecture on the base of artificial intelligence](image2)
Fig. 2 shows an integrated architecture of application software to determine the cost at each stage of the life cycle of the object. To implement software in construction and design organizations, it is necessary to prepare multi-format databases with certain rules for data entry and output of results for multi-level multi-criteria evaluation of solutions based on system analysis and the principles discussed above. The peculiarity of such an automated system implemented in the modelling process is the ability to set parameters and carry out automatic search, not only taking into account the input information, but also taking into account the decisions already made at the previous objects [5].

4. Discussion
Currently, there are many management systems that support the life cycle of the object (CALS, ERP). However, in the construction industry, such systems are rarely used to solve certain problems, that is, not comprehensively. The introduction of functional and complementary management models in construction will allow to better predict the subsequent possible changes in the system, calculate their consequences and mutual influence on other elements of the system, on the basis of modern management and information technologies that can keep records of the results and plan resources for the next stages of the life of the object [6,13].

Using information and communication technologies help to solve the following main problems of modern smart cities:
1. Ensuring efficient and optimal use of data, information and all types of resources.
2. Automation of production processes, decision-making processes in the event of deviations from the planned indicators.
3. Complex systems formation for interaction of production and social processes.
4. Ensuring information interaction between people as a mean of communication and information transfer.
5. Development of education system, system of knowledge accumulation and information culture of the society.
6. Predictive analysis of the industry development, forecasting of engineering systems, risk assessment and calculation of the probable consequences of adverse circumstances [7,8].

5. Conclusion
Modern information and communication environment in the construction industry requires the use of effective methods to improve production processes, ensuring timely exchange of information between the project participants, the production chain works, verification of their completion, resource usage accounting in time, the changes in the project, the formation of necessary and sufficient information base for the subsequent operation of the facility, monitoring of engineering systems and structures of the object.

Software tools based on artificial intelligence technology and methods should be developed in the construction industry. This will optimize the management system, the most qualitative decision-making, minimize the time spent on finding solutions, as well as control the implementation of government tasks, reduce the risks of the construction industry as a whole.

The creation of a system for the formation of an information model of the object taking into account various software for solving applied problems, implementing the principle of functional and complementary model of construction management, will avoid a large number of errors in decision-making, effectively use the time of the performers in the analysis of documents for decision-making, as well as real-time tracking of work, resource use and financial flows.

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