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# RISK-ORIENTED APPROACH TO OPTIMISING MANAGEMENT IN THE CONTEXT OF USING BIM TECHNOLOGY

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*The article considers new approaches to the management of construction projects over the life cycle: design, construction, and operation of a building in the context of the introduction of information technology in Ukraine. In these circumstances, the scientific problems of assessing the impact of organisational and economic risks in a crisis situation and possible innovations in the future on the quality, timing and cost of construction for the survival of construction organisations have become particularly relevant. Based on the results of the SWOT analysis, the priority problems of managing organisational and economic risks in the construction industry have been identified. A methodology for assessing the risks of an investment project based on a risk-based approach is proposed. This will provide methodological support for obtaining real indicators for the leading project participants based on the current regulatory and reference framework using methods and models.*

## Introduction

The structural transformation process that has engulfed the modern global economy is characterised by new qualitative features and has become an organic component of global civilisational progress. The experience of developed countries shows that high levels of consumption come at a prohibitively high price: waste of land resources; irrational use of human potential; and disruption of the balance between human activity and the natural environment. Under these conditions, structural adjustment should contribute to the creation of the main (fourth) post-industrial civilisation, whose essential features should be:

1) transition to a new technological means of production and a new type of economic growth;

2) humanisation and socialisation of the economy;

3) the presence of different forms of ownership and economic systems, the evolution of economic relations and institutions;

4) strengthening of integration processes.

In Ukraine, the search for its own model of structuring the national economy is at an early stage and aims to implement a model of an open competitive economy of the European model. The structural imperfection of the national economy, the main features of which are the costly nature of production, raw material exports, monopoly energy imports, high external debt, territorial economic imbalances, irrational use of resource, production, scientific and technical potential, have had a negative impact on the dynamics of Ukraine's socio-economic development.

The objective basis for structural changes in the construction industry of Ukraine and optimisation of the industry structure is the mismatch of its capabilities with the general needs, violation of important proportions at all levels, the elimination of which is a prerequisite for its efficiency in the context of the industry's transition to the introduction of new BIM technologies. The use of BIM technologies is one of the key steps in the digital transformation of construction [9].

"BIM technologies are a tool for further reform, modernisation and digital transformation of the construction industry in Ukraine. Their systematic implementation at the state level will optimise the costs of construction and operation of facilities, increase the reliability and safety of buildings and structures, and make domestic construction products competitive", said Oleksiy Chernyshov, Minister of Communities and Territories Development.

*Building information modelling* (BIM) is a technology for optimising the design, construction and operation of a building, based on the use of a single model and the exchange of information on any object between all participants throughout the entire life cycle – from the owner's idea and the architect's first drafts to the maintenance of the finished building.

BIM technologies are a new approach to digital information management used in construction and urban planning that involves the collection and comprehensive processing of all architectural, design, technological, economic and other information about an object [11, 14]. Thanks to their use, it is possible to virtually recreate an object even before its construction begins, to track the processes of the life cycle of a construction project – from design to its construction, operation and dismantling. This approach makes it possible to increase the safety and reliability of buildings and structures, promptly manage construction and control the quality of construction work, significantly reduce the likelihood of errors in projects, reduce construction costs and optimise costs during the operation phase [2–4].

The use of BIM technology significantly increases the objectivity and reliability of design solutions, the likelihood of achieving the designed efficiency, and the ability to obtain real design indicators during the construction and operation of the facility. At the same time, a construction company within the framework of a contractor agreement gets a real opportunity to reduce the duration and cost of construction, increase profits and profitability, which is especially important for increasing the residual life of buildings and structures through innovative solutions [5, 6, 8].

**Risk-based approach to construction project management**

In the general methodology for assessing the statics and dynamics of the strategic innovative development of a building or structure for the future life cycle using BIM technology, in addition to digital software, it is necessary to take into account three main characteristics inherent in the economic system [1]:

– system capabilities – determination of real production capacities and provision of resources;

– accounting for and establishing the peculiarities of the relationship between the elements of the system – substantiation of real cause and effect relationships, search for implicit relationships in factor analysis;

– identification of explicit threats – risks of strategy implementation and its objective limitations.

An investment project risk is a set of possible circumstances that may lead to a decrease in the efficiency (profitability) of the project or the impossibility of its implementation. Risk is a certain probabilistic event that may occur and is associated with uncertainty. Risk management is a sequence of actions that allows for a reasonable balance of project risks and benefits. The purpose of risk management is to reduce project risks [1].

A risk-based approach to project management involves the gradual consideration of risks in the implementation of BIM technology for the development, implementation, and operation of a project according to a known algorithm:

- risk identification;
- identification and documentation of risks and their impact on the project;
- risk assessment – the probability of occurrence and quantification of the impact on project performance;
- response – justification of the necessary measures and resources to prevent and respond to threats;
- planning and organisation of actions in space and time to limit the impact of risks on the efficiency of design, construction and operation of the facility;
- implementation of measures to eliminate risks and assess their impact on technical and economic indicators that determine the economic efficiency of the project at all stages of its life cycle.

The task of the proposed algorithm in the market conditions of Ukraine can be solved by firms based on the modern regulatory and reference base with the use of methods of dynamic statistical modelling of the life cycle scenario with access to COSTS and SYNERGY EFFECT – joint evaluation of research results.

In this case, the risks for the investor-customer are as follows:

- delay in entering the market with products (goods, services) if the contractual terms of the project are delayed;
- Increase in construction costs due to changes in quality, timing, prices and tariffs, as well as "freezing" of invested funds;
- increase in operating costs of future production or housing by cost elements: depreciation, material costs, labour and social contributions.

For a construction company, project implementation risks are associated with the following factors:

- disruption of construction financing by the customer;
- changes in the contractual price of works;
- losses due to underutilisation of production capacity and material and technical facilities;
- poor quality of work and delays in its completion;
- increase in inventories and freezing of working capital;
- additional general production and administrative losses in case of failure to meet contractual construction deadlines.

A risk-oriented approach remains common to all participants in a construction project, but there are different requirements for project reliability, feasibility, and sustainability [1] (see Table 1).

Table 1

**A risk-oriented approach to evaluating a construction project**

| Project participants | Reliability | Realisability | Sustainability |
|---|---|---|---|
| investor-operator | technical | financial | market |
| designer | technical | resource | market |
| general contractor | economic | production | resource |

The risk-oriented approach adopted in the scientific study in the process of implementing BIM technology requires a modern regulatory and reference framework, as well as the use of methods and models that will create methodological support and real indicators at levels 4D-8D in accordance with the scheme (Fig. 1), which shows the leading project participants [1, 7].

The analysis of short- and long-term dynamics indicates that the recovery in construction will be long and unstable, and it creates new requirements for scientific research into the economic problems of the industry. In overcoming the crisis, the leading role is assigned to state regulation, and at the level of a construction organisation – to crisis management, in order to diagnose in time and find innovations for survival and development in the phases of recovery and growth.


**Fig. 1.** Leading participants in the implementation of the project using BIM technology

In these conditions, the scientific problems of assessing the impact of organisational and economic risks in a crisis situation and possible future innovations on the quality, timing and cost of construction, for the survival of construction organisations, have become particularly relevant [10].

These problems are studied by SWOT analysis methods.

SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) is a method of strategic analysis and forecasting that provides a structured scenario of a situation for which a management decision needs to be made. SWOT analysis allows you to identify and structure the strengths and weaknesses of a situation, as well as threats and potential opportunities for improvement in a matrix form. The components of the SWOT analysis can be ranked, and to reduce subjectivity, factor analysis is used with the selection of factors-causes, indicators, criteria [7, 12, 13].

In our case, based on the results of the SWOT analysis, the following issues have been identified as the top priorities for managing organisational and economic risks in the construction sector of Ukraine:

- optimisation of the construction schedule, taking into account the interest of the investor-developer and the production capabilities of contractors;

- improvement of the pricing system in construction based on a risk-based approach to resource management and assessment of the economic efficiency of construction projects;
- resource saving and labour productivity growth as a basis for assessing the economic efficiency of the formation and implementation of the strategic potential of the construction complex of Ukraine.

## Assessment of the impact of organisational and economic risks on the quality, timing and cost of construction in the context of bim-technologies implementation

Two groups of methods are used to assess the risks of an investment project.

1. Qualitative assessment methods:
   - expert – general assessment of individual risks by experts (high, medium, low) and integral assessment;
   - cost-benefit analysis – identifying potential risk areas and expected cost changes;
   - analogies – for projects that are repeated by analogy with already completed projects.
2. Quantitative assessment methods based on the mathematical apparatus of probability theory, mathematical statistics, simulation modelling, and processing of expert opinions:
   - adjustment of the discount rate – changes in the interest rate on the securities market;
   - reliable cash equivalents – expected changes in cash flows due to project profitability;
   - sensitivity of performance indicators – changes in project performance indicators in the event of a change in the complex of factors that determine it within certain limits with the allocation of risk zones in the case of a multivariate calculation (for example: long-term interest rate $I = 0.05 - 0.3$; investment return rate $E = 0.05 - 0.4$);
   - the level of project sustainability – determining the level of assimilation of the projected volume of production when the profit is equal to 0 – the break-even point, which is determined by the formula with the construction of a graph.

Evaluation of the project's effectiveness is completed by analysing its sustainability by determining the break-even point (*BEP*) and building a schedule:

$$BEP = (Cn - an)/(P - an), \qquad (1)$$

where $P$ is the price without VAT, UAH/unit;

$Cn$ is the operating cost;

$an$ is the variable cost.

The $BEP$ level of 0.5–0.8 indicates high project sustainability and, together with other indicators, its economic efficiency:

- scenario method – development of several scenarios of project development with simultaneous changes in its parameters – from optimistic to pessimistic with the aim of reaching economic efficiency;
- simulation modelling – the Monte Carlo method simulates the laws of probability distribution of changes in project parameters with computer development and evaluation of many scenarios.

The leading role in risk forecasting belongs to economic and mathematical methods of extrapolation and modelling in combination with expert methods at a certain phase of the life cycle, especially in the context of the economic crisis, when we are now moving from the depression to the recovery phase.

The implementation of these transitions in the face of incomplete or inaccurate information about external and internal factors significantly increases the risk of creating and implementing a project in a market environment.

The level of risk is statistically determined by the following indicators:

- mathematical expectations $\left(\vec{X}\right)$ – the average value for *n* observations;
- fluctuations of the possible result:

a) absolutely, like

dispersion $(D)$: $$D = \frac{\sum\left(X_i - \vec{X}\right)^2}{n} \qquad (2)$$

standard – deviation $(SO)$: $$SO = \sqrt{D}, \qquad (3)$$

b) relative – coefficient of variation $(V,\ \%)$:

$$V = \frac{SO}{\vec{X}} \times 100. \qquad (4)$$

- the value of a particular indicator $(Xn)$ with a certain probability $(P)$ by the law of normal distribution:

$$Xn = \vec{X} + k \times SO, \qquad (5)$$

if $k = 1 - P = 0,683$; $k = 2 - P = 0,954$; $k = 3 - P = 0,997$.

We used this method to model the organisational and technological scheme of project implementation based on a network model with a 95.4% probability of duration risk.

We propose specific measures to reduce investment risk in the face of uncertainty of the economic result.

- Setting aside funds to cover expected costs. In Ukraine, in the process of determining capital investments, the risk by design stage can be as follows: concept $\pm 25\%$, feasibility study and preliminary design $\pm 15\%$, project $\pm 5-7\%$, tender – contract price. The consolidated estimate takes into account construction risks (up to 6%) and inflation risks, based on the inflation rate in the state budget.
- Redistribution of risk between project participants.
- Risk insurance - transfer to an insurance company.
- Collateral for invested funds.
- A system of guarantees from the state, banks, and investment funds.

Measures to reduce construction time are proposed for construction projects.

- Combining design and construction, starting with 10% of the project documentation.
- Reducing the period of project capacity utilisation to 1–2 months.
- Use of standard designs and unified structures.
- Commissioning of the final production process with the supply of raw materials from another enterprise - tail-end construction.
- Economic incentives from the customer: bonuses or sanctions, preferential lending, etc.

Particular attention should be paid to the risks that arise in project quality management. The quality of design decisions made in BIM at the 3D level is a leading factor in determining the effectiveness of architectural space-planning, structural, technological and other solutions that, taking into account market factors, will determine the organisational and economic conditions and risks during the design, construction and implementation of the facility.

BIM technology at the 3D level should help to eliminate the risks associated with quality management in a construction project, namely:

- errors in the design of architectural, planning and structural solutions that require redesign and additional work during construction;
- use of low-quality construction materials;
- violations of technology, hidden works and defects;
- low level of staff qualification;
- significant interruptions in the execution of works due to lack of funding, which leads to a decrease in quality and delay;
- imperfect or non-existent quality control system.

To eliminate the risks, we propose a quality control system for construction works using the International Organisation for Standardisation (ISO) standards, which should ensure quality in the development, implementation and operation of the project. The main provisions of ISO 9001-9004 provide for the coordination of the interests of the client, designer and contractor, a set of quality assurance measures, and quality control at all stages of the project life cycle.

The certification of design and construction organisations according to ISO 9001:9004 standards should ensure the level of risk of construction participants within the limits established by the National Standard of Ukraine DSTU B D1.1-1:2013, with additions and changes in subsequent years.

## Conclusions

The practical value of the models and methods lies in the adoption of modern computer models and methods by designers, managers of construction companies, and building operators to optimise innovative development and predict the use of production reserves. This will increase profits, save energy and resources, and increase the life cycle of the facility.

Forecasting the production potential of a construction company and justifying performance criteria at all stages, starting with the tender for the selection of a contractor, the conclusion of a contract and other supporting documents (a schedule of work, a plan for financing the construction of the facility in the current year, schedules for the transfer of project documentation and resources), is important.

Most developed countries are already actively using BIM technologies in the design of construction projects. In particular, their use is mandatory for public procurement projects. The Ukrainian construction industry currently has a very low level of digitalisation, and few organisations are using BIM technologies.

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