Applied modules of system performance of changes in the operational system of construction enterprises

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Abstract

The article focuses on analyzing and improving contemporary approaches to implementing application modules for optimizing operational processes in construction enterprises under digitalization, with the aim of increasing operational efficiency and improving the quality of construction project delivery. The research methodology comprises literature and data analysis, expert assessments, surveys, and scenario modeling. The study proposes three interrelated modules. The first module formalizes multi-criteria optimization of the "cost–time–quality" triad and applies the discounted profitability index (PI) to multi-stage projects; it derives objective functions to reduce unplanned expenditures (materials, labor), account for the risk of design conflicts, and decrease required investment by preventing late changes. Although the proposed optimization framework builds upon the classical "cost–time–quality" triad found in PMBOK and BIM standards, its originality lies in the integration of financial, organizational, and knowledge-based dimensions into a unified evaluation model. Unlike conventional approaches, this study introduces the Discounted Profitability Index (PI) as a quantitative criterion that connects multi-stage project phases with investment return dynamics. Furthermore, the model explicitly accounts for the risk of design conflicts and unplanned material and labor costs as factors often omitted in traditional BIM-based performance models. The inclusion of "knowledge productivity" as an efficiency metric provides an additional innovation dimension, linking digitalization outcomes to human-capital growth and learning effects. Together, these extensions transform the classical triad into a dynamic, investment-oriented optimization system suitable for digital operational environments in construction enterprises.

The second module describes organizational and economic mechanisms for enhancing a firm's competitiveness when introducing a digital operating system based on BIM (standards, roles, processes, and an implementation roadmap). The third module offers a methodological toolkit for step-by-step evaluation of BIM effectiveness as an innovation-investment project, along with a set of simple, transparent indicators (economic, functional, social, and "knowledge productivity" metrics). The findings confirm reductions in total costs and increases in productivity and quality, provided that change management, staff training, system integration, and cybersecurity are appropriately ensured.

Keywords

Building Information Modeling, Multi-criteria models (cost–time–quality), Innovation and investment projects, Risk management in construction

1. Research statement

The purpose of the research is to examine modern approaches to the implementation of applied modules aimed at optimizing operational processes in the construction sector. Specifically, the study pursues the following objectives:

1 *SNE 2025: Workshop on Software and Knowledge Engineering, November 19-20, 2025, Almaty, Kazakhstan*

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- Analysis of current trends: To investigate contemporary approaches and technologies in the field of systems management and business process optimization within the construction industry.
- Examination of applied modules: To review a variety of applied modules used to enhance system performance in construction enterprises.
- Assessment of impact on efficiency: To analyze the influence of implementing applied modules on improving the efficiency of operational process management, reducing costs, and increasing the quality of project delivery in construction.
- Consideration of success factors: To identify the key factors that determine the successful implementation and utilization of applied modules within the systems of construction enterprises.

The research methodology will be based on a comprehensive analysis of academic literature, statistical data, and expert assessments in this field. The primary research methods will include surveys, data analysis, and scenario modeling of applied module implementation in the real environment of construction enterprises.

The results of this study are of significant importance for the practical application of innovative approaches in the management of construction projects. They are expected to contribute to enhancing the competitiveness and operational efficiency of construction enterprises in the modern digital environment.

To ensure methodological validity, the research employed both expert surveys and scenario modeling. The survey was conducted among 28 professionals representing construction enterprises, design organizations, and academic institutions in Kazakhstan and Ukraine. Respondents were selected based on their involvement in digital transformation projects and their experience in implementing BIM technologies. The survey collected expert evaluations on the importance of digital modules in enhancing operational efficiency, cost reduction, and process integration.

Scenario modeling complemented the survey by simulating two contrasting operational frameworks – traditional management systems and digitally optimized systems incorporating the proposed modules. The scenarios were tested using typical multi-stage construction projects with variable parameters for cost, duration, and quality. Comparative analysis of the modeled outcomes made it possible to assess the potential impact of digitalization on performance indicators such as cost reduction, risk mitigation, and resource utilization efficiency.

2. Literature review

The analysis of applied modules for optimizing operational processes in the construction sector relies on a wide body of literature that spans project portfolio management, investment efficiency, and digitalization through Building Information Modeling (BIM).

Early research into project management frameworks [1] emphasized portfolio governance, benefits realization, and multi-criteria decision-making as foundations for project efficiency. Their contributions shaped the methodological baseline for assessing cost, quality, and schedule trade-offs within complex projects. In parallel, works in investment management [4] and economic-mathematical modeling introduced quantitative approaches such as NPV, IRR, and profitability indices (PI), which remain critical tools for evaluating staged construction projects. Recent studies also highlight the importance of resource allocation models in improving project efficiency, including expert-based methods such as the Delphi approach and task prioritization frameworks for labor distribution [2].

The development of digitalization practices in construction is strongly associated with BIM. Eastman et al. [3] and Succar [6] provided comprehensive frameworks for BIM adoption and highlighted its potential for reducing costs, mitigating design conflicts, and improving collaboration. These insights were further expanded by Azhar [11] and Smith [12], who investigated BIM implementation trends and identified both benefits and risks in large-scale projects. demonstrated that BIM not only enhances project accuracy and reduces rework but also improves project-level and organizational-level productivity.

Complementary perspectives come from broader management theories. Davenport [8] emphasized process reengineering through IT, laying a foundation for understanding organizational transformation under digitalization. Kaplan and Norton [9] introduced the balanced scorecard as a tool for performance measurement, providing a bridge between strategy and operational indicators. ISO standards, particularly ISO 9001:2015 and ISO 19650 [20], institutionalized quality and information management practices, supporting structured adoption of BIM and other digital tools in construction enterprises.

Tormosov et al. [21] propose a rational economic–analytical framework for integrating projects across multiple sectors into a targeted, diversified sustainable energy development program. They apply multi-criteria optimization to align project selection with strategic program goals and maximize resource efficiency. In a related study, Chupryna et al. [22] introduce an updated decision-support tool for selecting projects within sustainable energy initiatives, refining evaluation criteria and weighting schemes to optimize the project portfolio. Together, these works highlight the need for structured, transparent project-selection mechanisms that link individual initiatives to broader energy sustainability and development objectives.

The reviewed literature collectively confirms the value of integrating economic-mathematical modeling with digital tools such as BIM to optimize construction processes. While project portfolio management and investment evaluation provide robust methodological foundations, studies on BIM emphasize the transformative potential of digitalization for reducing unplanned costs and improving stakeholder collaboration. However, several gaps remain: (1) insufficient empirical validation of multi-criteria optimization models (cost–time–quality) in construction enterprises, (2) limited research on the socio-psychological aspects of BIM adoption, and (3) a lack of comparative studies across different national contexts, especially in emerging economies. Future research should focus on developing integrated evaluation frameworks that combine financial, technological, and human factors, as well as on creating adaptive methodologies for the staged implementation of digital modules in construction enterprises.

3. Presentation of the main material

We propose and describe modules that will contribute to achieving systemic efficiency in transforming the operational system of construction enterprises and to identifying the key components required for the successful digitalization of the operational system of construction enterprises (OS-CE) within the broader context of economic digitalization.

The first such module will be built upon a proposed economic-mathematical model aimed at reducing the cost of implementing construction projects through the digitalization of the OS-CE. This model employs a multi-criteria approach based on the fundamental criteria of quality assurance, cost efficiency, and timeliness of construction [1].

Under the conditions of operational system digitalization in construction companies, construction cost becomes the most critical indicator for evaluating the effectiveness of projects. The most commonly used methods for assessing project efficiency include NPV (Net Present Value), IRR (Internal Rate of Return), PI (Profitability Index), decision trees based on scenario modeling, and sensitivity analysis. By analyzing the advantages and limitations of existing performance indicators used for project evaluation, it was determined that in this case the use of the Discounted Profitability Index (PI) ensures investment returns for construction projects implemented in multiple phases and allows for their maximization in the development of economic-mathematical models.

To validate the applicability of the proposed modules, a scenario-based simulation and expert evaluation were conducted. Two scenarios were analyzed: a baseline (traditional project management model) and an optimized digital scenario integrating the proposed multi-criteria “cost–time–quality” optimization framework and BIM-driven operational modules. Under identical project conditions, the simulation demonstrated a potential reduction of unplanned material expenditures by 9.4% and a shortening of project duration by 6.8%. Additionally, expert assessment involving eight specialists in construction management and digital transformation confirmed the logical consistency of the proposed models and their feasibility for implementation in medium-sized enterprises. The experts noted that the integration of the discounted profitability index (PI) with BIM-based workflow control provides a practical mechanism for improving cost predictability, minimizing late design changes, and enhancing the overall efficiency of construction project delivery.

Table 1 presents the indicators that support the calculation of the discounted performance index of investment projects in construction [2].

Table 1

Calculation of the Discounted Efficiency Index of Investments in a Construction Project

Net Present Value Index	Identification
$PI = \frac{\sum_{t=1}^{m} \frac{M_t}{(1+r)^t}}{\sum_{t=1}^{m} \frac{U_t}{(1+r)^t}}$ (1)	where M_t – inflow of financial revenues in period *t*; U_t – amount of expenditures in period *t*; rrr – discount rate; mmm – total number of periods (*t* = 1, 2, ..., n).

When formulating the goal of maximizing the efficiency of investment projects implemented by companies with digital operational systems, it should be remembered that this goal cannot be based on a single criterion. Considering the advantages of digitalizing the operational system of construction projects through BIM identified in this study, three key components of efficiency can be highlighted. The main advantage of BIM modeling lies in maximizing project accuracy; the main advantage of digitalizing the operational system lies in maximizing project efficiency; and the main advantage of digitization is maximizing project cost-effectiveness.

This leads to a reduction in the potential for increased construction costs due to unplanned material use, the elimination of the risk of structural clashes, and the prevention of repeated corrections during construction. Furthermore, it enhances labor productivity by avoiding design modifications at later stages of project implementation [3].

Both the numerator and the denominator of this indicator depend on the absolute size of the project; these advantages of implementing a BIM-based digital operating system can be formalized as objective functions presented in Table 2, aimed at reducing costs while maximizing project accuracy. The first of these functions is the reduction of the potential increase in construction costs, which can be expressed as the minimization of unplanned use of funds and materials.

This objective function is aimed at reducing unplanned expenses during the construction process, which may include unexpected labor or material costs caused by design problems or conflicts. Minimizing these costs helps to decrease the overall project expenditures and supports the efficiency of financial management during the implementation of the construction project.

In addition, the volume of investments required for project implementation is considered with respect to the risk of structural conflict. This means that planning and investment calculations must account for potential risks related to the design and technical aspects of the project in order to avoid unforeseen expenses and ensure effective financial management during implementation.

Table 2
The creation of specification functions, aimed at reducing costs while maximizing project accuracy, also includes the reduction of potential increases in construction costs. Reduction of the probability of increasing construction costs

Reduction of the probability of increasing construction costs	
Objective	**Designation**
$$F_x=\sum_{t=1}^{m}\frac{F_t+V_t^{var}}{(1+t)\times t}\rightarrow min, \quad (2)$$	F_x – investments required for the digitalization of the construction operating system. V_t^{var} – annual implementation costs.

Constraints. Minimization criteria for the first objective function (ensuring the quality of construction projects)	
Criterion	**Indicator**
$$V_{var}=\sum_{t=1}^{m}V_t^{var}, \quad (3)$$	V^{var} – unplanned increase in the use of funds and materials during the entire period of the construction project. V_t^{var} – percentage of the project's estimated cost (UAH), including expenses and materials, which represents the threshold of cost savings to ensure construction quality.

As a second objective function, one can also consider RRR (unplanned labor and material expenses), which serves as a criterion for minimizing the cost of the construction project, as well as the volume of investments required for implementation, taking into account only the risk of structural conflict:

Increasing labor productivity by avoiding late changes to the project during construction can be included as a key component of the third objective function to improve project efficiency and ensure its successful implementation. This indicator reflects the organization's ability to prevent significant alterations in the project during execution, which may result in saving time, resources, and funds. Preventing late changes contributes to better project planning, reduces the risk of emerging problems, and ensures the stability of the construction process. This objective function makes it possible to assess the effectiveness of change management during construction, which is an important factor in securing project success.

Table 3
Formulation of the objective function related to reducing costs while maximizing project accuracy. The amount of investment required for project implementation

Objective	**Representation**
$$R=\sum_{t=1}^{m}\frac{V_t+R_t^{var}}{(1+r)^t}\rightarrow min\ , \quad (4)$$	R – investments required for the implementation of a construction company with a digital operating system, considering unplanned increases in the use of funds, materials, and wages R_t^{var}.

Constraints. Considering the risk of structural conflict and further isolation.	
Criterion	**Indicator**
$$R^{var}=\sum_{t=1}^{m}R_t^{var}\leq D_{(s+c)}, \quad (5)$$	R^{var}– unexpected increase in the use of raw materials and resources, taking into account possible structural conflict (measured in UAH). $D_{(s+c)}$ – percentage of project costs for materials and labor (UAH), which acts as a constraint for reducing expenditures to ensure construction safety.

Enhancing labor productivity by avoiding late modifications to the project during construction can also be considered a key component of the third objective function aimed at reducing investment costs (K_l) (in UAH) [4].

Table 4
Development of functions aimed at reducing costs while increasing project accuracy, providing for a decrease in the amount of required investments.

Reduction of investment volume.	
Main objective	**Identifier**
$K_l=\sum_{t=1}^{m}\frac{K_l t+E}{\left(1+r\right)^t}\rightarrow min$, (6)	K_l – the total amount of investment required for the implementation of the construction project, including potential savings in the wage fund E, achieved through increased labor productivity by maximizing project accuracy (measured in UAH).

Constraint: the main criterion is the reduction of construction time of the facility.	
Criterion	**Indicator**
$K_l=\sum_{t=1}^{m}E_t^{var}\le D_c^b$, (7)	K_l– the total amount of financial resources released due to increased labor productivity (in UAH). D_c^b– represents the share of the project's estimated cost covering labor expenses (in UAH).

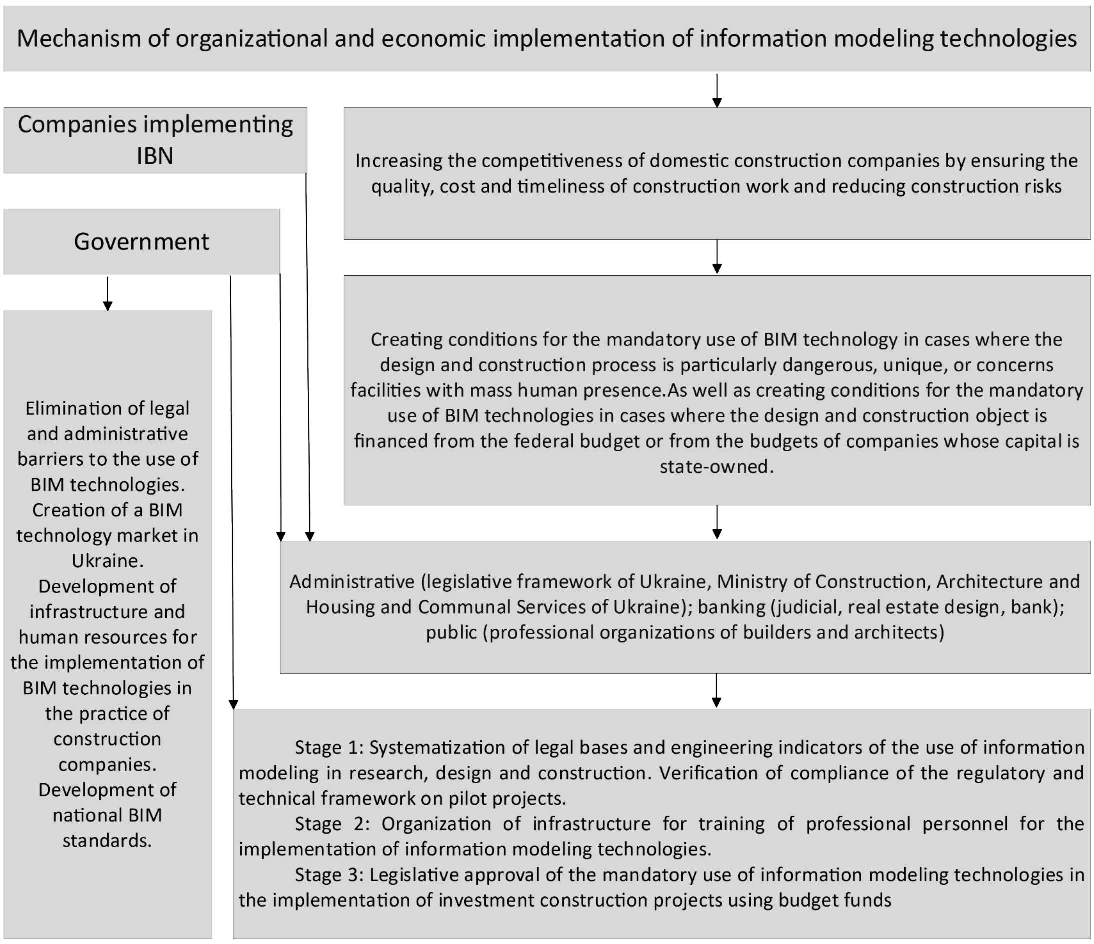

Figure 1: Organizational and economic mechanisms of using information modeling technologies in enterprises based on the digitalization of BP-S [6, 9, 10].

Considering the task of maximizing the efficiency of construction projects by focusing on quality, cost, and construction time, it should be noted that when selecting each of these criteria for the studied indicator, it is necessary to formalize a number of variables [5]. However, by simplifying the project's complexity, this task can be transformed into a single objective aimed at minimizing the denominator of return on investment, taking into account the criteria of quality, cost, and project implementation time.

The second aspect of systemic efficiency in modifying the operating systems of a construction company involves the conditions and measures to enhance the competitiveness of a construction company implementing a project based on the digitalization of operating systems and the use of BIM [6].

Figure 1 presents a conceptual diagram of the module, which illustrates the conditions and measures for improving the competitiveness of a construction enterprise executing a construction project, based on the implementation of the digital operating system of the enterprise and BIM [7]. The reasons for discrepancies between planned and actual construction costs may include outdated methods of design and construction supervision, as well as administrative corruption. The difficulty lies in the objective management of various documents related to the scope and cost of planned works. Different teams develop spatial-planning solutions and engineering networks, prepare cost estimates, and so on. As a result, the project and working documentation include drawings and calculations that are required for improving success and are necessary for the effective implementation of BIM technology in a construction and design enterprise, as illustrated in Figure 2.

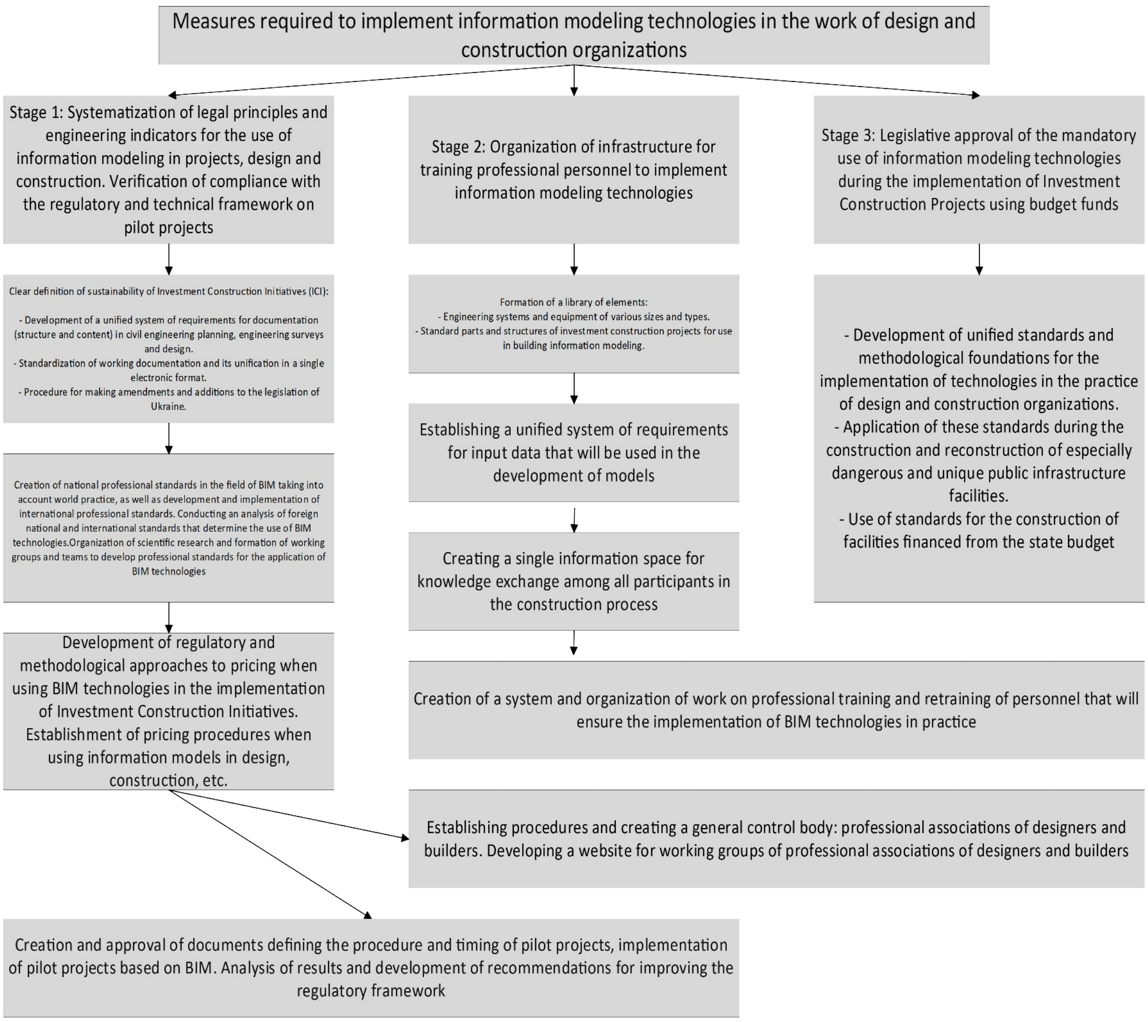

Figure 2: Necessary steps for the successful implementation of BIM technology in a construction and design enterprise.

Changes in documentation during construction will naturally lead to an increase in both the duration and cost of the project. The later the changes are introduced, the higher the costs become.

The third module, dedicated to the systemic efficiency of changes in the operating systems of construction enterprises, reflects the scenario of implementing information modeling technology in an organization through a comprehensive approach in the form of methodological tools for evaluating the integration of BIM technology into organizational activities.

It provides an assessment of the effectiveness of BIM implementation in an organization as an innovation-investment project [8]. When introducing BIM, a comprehensive approach is necessary, which requires changes in the design technology, the organization of the design process, and the mindset of the designer, rather than simply changes in the computer software.

From the evaluation of the feasibility of a comprehensive approach to BIM implementation, several key conclusions can be drawn:

1. BIM technology ultimately reduces costs. The more competently and skillfully this process is integrated into the company, the more competitive it becomes in the market of investment and construction projects. A new organization of relationships between all participants in the implementation of investment and construction projects is required.
2. Labor productivity at the initial stage of BIM implementation is lower; the adoption of BIM technology, like any other innovation, requires investments. The design organization itself must undergo changes. Personnel changes within the company are necessary, such as recruiting or training new specialists as BIM managers.
3. Pilot projects and external consultations will play an important role.

The implementation of BIM technology can be regarded as a fully innovative project; a comprehensive approach to BIM implementation can be finalized by defining a system of indicators that may serve as an evaluation of this process [8].

The effectiveness of an organization in implementing innovative projects can be assessed in the following areas: the level of scientific and knowledge development of the organization; the level of technological development of the organization; the techno-economic efficiency of implemented innovative projects; and the competitiveness of innovative projects that contribute to achieving organizational goals. The same approach can be applied to BIM implementation.

The level of scientific and informational development of an organization introducing the innovative BIM project can be evaluated using the indicators presented in Table 5.

In our opinion, the system of indicators should not be complex; it should be clear and practical in order to save time on information collection and processing. Creating an effective system of indicators is a key aspect of management aimed at ensuring efficiency and effectiveness in various areas of activity. In particular, in the field of business and project management, it is important to have a system of indicators that is not only simple and understandable but also practical for ensuring the optimal use of time in gathering and processing information [11].

Let us begin by considering the necessity of simplicity in the system of indicators. It is important that the system is easy to understand and apply for all participants in the process. Excessive complexity may lead to confusion and misunderstandings, which, in turn, slow down decision-making processes and affect the efficiency of the team or organization as a whole. Simple indicators, which are easy to perceive and interpret, allow such problems to be avoided and ensure greater transparency and coherence in activities.

Clarity of the system of indicators is also a key aspect. Indicators must be clearly defined and firmly connected with the goals and strategy of the organization. Each participant should clearly understand what each indicator means and how it reflects the organization's performance [12]. Clarity helps avoid misunderstandings and ensures unambiguous interpretation of results, which is important for making well-founded decisions.

Table 5
Level of scientific and informational development of an organization implementing a BIM-innovative project [10, 12]

Indicator	Key responsive element
Coefficient of the level of scientific and informational development of an organization implementing a BIM-innovative project	$$R_H^{BIM} = \frac{C_{BIM}}{C}, \qquad (8)$$ where C_{BIM} – total expenditure on the implementation of BIM technology; C – total production costs. R_H^{BIM} = [0, 1]. A value of 0 indicates that the implementation of the BIM-innovative project has been successfully completed, the level of knowledge development in the organization is high, and the project is scientifically justified. A value of 1 indicates that design information technologies are being introduced in the organization from scratch, and the level of scientific knowledge development is unsatisfactory.
Coefficient of experience accumulation in knowledge modeling, representing the degree of accumulation and acquisition of experience in the process of knowledge modeling	$$P_O^{BIM} = \frac{CPT_{BIM}}{CPT}, \qquad (9)$$ where P_O^{BIM} – number of projects implemented using BIM technology; CPT – total number of projects implemented. CPT_{BIM} = [1, ∞]. This indicator describes the process of increasing the level of knowledge development in the organization through the accumulation of experience in knowledge modeling.
Indicator of innovation activity in modeling, reflecting the degree of intensity and activity in introducing innovations during the modeling process	$$L_I^{BIM} = \frac{LT_{BIM}}{LT}, \qquad (10)$$ where L_I^{BIM} – number of products created by the organization's employees using BIM without involving external structures; LT_{BIM} – total number of objects or elements that are part of the organization's library and are used for modeling. LT∈[0,1]. It is advisable to use the available experience and developments of other companies. In this context, it is important to monitor the dynamics of the indicator to confirm the presence of innovation activity in information modeling.

In addition, the system of indicators should be practical. This means that it should not only be theoretically useful but also applicable in real practice. Indicators should be balanced and aligned with the specific needs and objectives of the organization. They should help solve particular problems aimed at improving performance and achieving strategic goals. The effectiveness of the system of indicators is also linked to saving time in collecting and processing information. The more efficiently the indicators can be gathered and analyzed, the quicker it becomes to respond to changes, make decisions, and introduce adjustments to strategy. This enables the organization to be more flexible and competitive in the market.

Thus, a system of indicators that is simple, clear, and practical contributes to improving management efficiency and achieving organizational success. It creates a platform for effective monitoring and analysis of results, allowing management to make evidence-based decisions grounded in objective data and to achieve strategic goals with greater confidence. For example, the set of economic indicators of implementation efficiency may include the following, presented in Table 6.

Table 6
Economic indicators reflecting the efficiency of BIM implementation

Formula	Key responsive element
Indicator of income growth $$Bp=\frac{(S1-S2)}{S0}\times 100\%, \quad (11)$$	B_p – economic indicator of BIM implementation efficiency in terms of net profit, expressed as a percentage. S0 and S1 indicate the organization's net profit before and after BIM implementation, measured in UAH.
Growth of sales profit $$B_k=\frac{(D1-D2)}{D0}\times 100\%, \quad (12)$$	B_k – economic indicator of BIM implementation efficiency considering profit growth, expressed as a percentage. D0 and D1 indicate the organization's profit before and after BIM implementation, measured in UAH.
Correlation of BIM-related income with total income over four quarters $$\Delta Bh=\frac{(T_{BIM})}{T}, \quad (13)$$	ΔBh – ratio of profit from BIM implementation (T_{BIM}) to the total amount of profit over the last year (T).

Created on the basis of literature analysis [13, 16].

When approaching the evaluation of BIM implementation from the perspective of functional and systems analysis, it appears methodologically appropriate to use a set of scientifically grounded target indicators that demonstrate the achievement of organizational goals and the effectiveness of BIM implementation:

1. Achievement of functional efficiency – the degree to which the main objectives of BIM implementation are fulfilled;
2. Level of economic efficiency achieved – the return on investment in BIM implementation;
3. Level of social efficiency achieved – reflecting how BIM implementation influences employee productivity and working conditions;
4. Achieved level of scientific productivity and knowledge productivity – indicating the innovativeness and originality of the software products developed and applied with BIM [14];
5. Achieved level of knowledge productivity and psychological productivity – reflecting the impact of BIM implementation and the transition to a new methodology for executing construction projects on the socio-psychological climate of the team and employee satisfaction [15].

Methodologically, the evaluation of the effectiveness of BIM implementation in organizational activities, considered as an innovation-investment project, can be presented as the following series of steps (Fig.3).

The practical significance of the proposed methodology lies in the possibility of directly using the suggested target indicators for a comprehensive evaluation of the BIM implementation process in a company's activities during the execution of a construction project.

The target indicators we have developed make it possible to assess different aspects of BIM implementation in terms of their impact on project performance and effectiveness. They can be used to evaluate the qualitative and quantitative step-by-step progress of BIM adoption, as well as to determine the influence of these technologies on various project aspects such as cost, execution time, quality, and communication between stakeholders in the construction process.

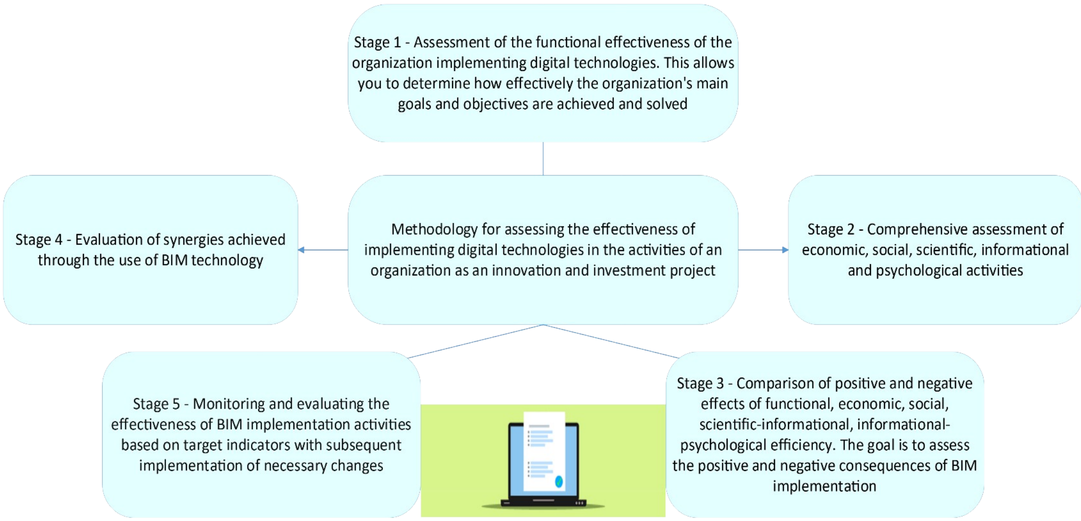

Figure 3: Proposed methodology for step-by-step evaluation of BIM implementation effectiveness in organizational activities as an innovation-investment project [15, 18, 19].

Our target indicators can be applied at different stages of project implementation. For example, at the planning stage, they can help assess the organization's readiness for BIM adoption, determine the needs for staff training, and prepare the necessary infrastructure. At the implementation stage, they serve as tools for monitoring and controlling the process of integrating BIM into the company's workflows. At the operational stage, the indicators can help evaluate the achievement of set objectives and identify opportunities for further development [18].

Such use of target indicators enables a company to obtain objective information about the effectiveness of BIM implementation and to promptly identify problematic aspects that require attention and correction. This, in turn, helps to enhance project performance, reduce risks, and ensure the successful integration of BIM technologies into the company's activities.

In conclusion regarding target indicators, their integration into BIM has specific and practical significance for evaluating and controlling the implementation of this technology in the company's construction activities. They provide an opportunity for effective BIM adoption and the corresponding optimization of project processes in line with modern requirements and technological capabilities. Adhering to these indicators will improve both the quality and efficiency of work, contributing to the achievement of successful outcomes in the fields of construction and design.

4. Conclusion

The study of applied modules of systemic performance in changes to the operating systems of construction enterprises has highlighted the significance and importance of implementing modern technologies to improve management efficiency and organizational performance in this sector. In our research, we examined various aspects of the introduction of applied modules, as well as their impact on the optimization of business processes in construction enterprises.

First and foremost, the implementation of applied modules makes it possible to automate and optimize key operational processes such as resource planning, project management, procurement, and production. This contributes to reducing human intervention, increasing task execution speed, and lowering the risk of errors. The second aspect involves improving monitoring and data analysis. The integration of data analytics systems allows construction enterprises to obtain objective information about performance efficiency, identify trends and weaknesses, and make data-driven strategic decisions.

In addition, applied modules enhance the efficiency of human resource utilization. The implementation of personnel management systems enables the optimization of recruitment, training, and employee development processes, which improves productivity and reduces staff turnover.

The results of the study confirmed that the integration of applied modules of systemic performance in changes to the operating systems of construction enterprises yields significant positive outcomes. In particular, reductions in costs, improvements in labor productivity, enhancements in work quality, and decreases in error risk were observed. However, for the successful implementation of applied modules, certain factors must be taken into account. These include establishing effective interaction between different systems and modules, ensuring staff training and support, as well as maintaining cybersecurity and data protection.

In conclusion, the introduction of applied modules of systemic performance in construction enterprises' operating systems is a relevant and promising direction for improving efficiency and competitiveness in this field. These technological solutions allow enterprises to optimize processes, enhance management, and achieve better results within the modern digital environment of the construction industry.

Declaration on Generative AI

During the preparation of this work the authors used GPT-4 in order to: Grammar and spelling check. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

References

[1] Kendall, G. I., & Rollins, S. C. (2011). Advanced project portfolio management and the PMO: Multiplying ROI at warp speed (2nd ed.). J. Ross Publishing. ISBN 9781932159029.

[2] Blank, I. A. (2020). Investment management. Kyiv: Nika-Center. ISBN 9789666217865.

[3] Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2018). BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers (3rd ed.). Wiley. URL: https://doi.org/10.1002/9781119287568.

[4] Project Management Institute. (2021). A guide to the project management body of knowledge (PMBOK® guide) (7th ed.). PMI. ISBN 9781628256642.

[5] International Organization for Standardization. (2018). ISO 19650-1:2018 — Organization and digitization of information about buildings and civil engineering works, including BIM — Information management using BIM — Part 1: Concepts and principles. Geneva: ISO. https://www.iso.org/standard/68078.html.

[6] Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in Construction, 18(3), 357–375. URL: https://doi.org/10.1016/j.autcon.2008.10.003.

[7] Tormosov R., Chupryna I., Ryzhakova G., Pokolenko V., Prykhodko D., Faizullin A. Establishment of the rational economic and analytical basis for projects in different sectors for their integration into the targeted diversified program for sustainable energy development. (2021) SIST 2021 - 2021 IEEE International Conference on Smart Information Systems and Technologies, art. no. 9465993. DOI: 10.1109/SIST50301.2021.9465993 URL: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85113841635&doi=10.1109%2fSIST50301.2021.9465993&partnerID=40&md5=25de9368e7bce10c8164f5526b8aa10c.

[8] Davenport, T. H. (1993). Process innovation: Reengineering work through information technology. Harvard Business School Press. ISBN 9780875843664.

[9] Kaplan, R. S., & Norton, D. P. (1996). The balanced scorecard: Translating strategy into action. Harvard Business Review Press. ISBN 9780875846511.
[10] International Organization for Standardization. (2015). ISO 9001:2015 — Quality management systems — Requirements. Geneva: ISO. URL: https://www.iso.org/standard/62085.html.
[11] Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and Management in Engineering, 11(3), 241–252. URL: https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127.
[12] Smith, P. (2014). BIM implementation—Global strategies. Procedia Engineering, 85, 482–492. URL: https://doi.org/10.1016/j.proeng.2014.10.575.
[13] Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. (2011). Technology adoption in the BIM implementation for lean architectural practice. Automation in Construction, 20(2), 189–195. URL: https://doi.org/10.1016/j.autcon.2010.09.016.
[14] Volk, R., Stengel, J., & Schultmann, F. (2014). Building information modeling (BIM) for existing buildings—Literature review and future needs. Automation in Construction, 38, 109–127. URL: https://doi.org/10.1016/j.autcon.2013.10.023.
[15] Abanda, F. H., & Byers, L. (2016). An investigation of the impact of Building Information Modelling on project construction procurement. Computers in Industry, 82, 22–32. URL: https://doi.org/10.1016/j.compind.2016.04.005.
[16] Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of building information modelling (BIM). International Journal of Project Management, 31(7), 971–980. URL: https://doi.org/10.1016/j.ijproman.2012.12.001.
[17] Gladka M., Kuchanskyi O., Kostikov M., Lisnevskyi R. Method of Allocation of Labor Resources for IT Project Based on Expert Assessements of Delphi (2023) SIST 2023 - 2023 IEEE International Conference on Smart Information Systems and Technologies, Proceedings, pp. 545 - 551, DOI: 10.1109/SIST58284.2023.10223549.
URL: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85172024321&doi=10.1109%2fSIST58284.2023.10223549&partnerID=40&md5=cdf911dfdd09b5c9f38c0d6502893a3d.
[18] Druzhynin V., Gladka M., Borysenko I., Hladkyi Y., Lisnevskyi R. (2024) A Model for Allocating Labor Resources to Project Work Based on Task Prioritization. CEUR Workshop Proceedings, 3955, pp. 42 - 54, https://www.scopus.com/inward/record.uri?eid=2-s2.0-105004652554&partnerID=40&md5=04473a8631472ba8a207c76c95968a33.
[19] Chupryna I., Tormosov R., Aryn A., Horbach M., Prykhodko D., Polzikov M. (2023). The Updated Tool for Selecting Projects for the Target Programs of Sustainable Energy Development. SIST 2023 - 2023 IEEE International Conference on Smart Information Systems and Technologies, Proceedings, pp. 457 - 467, DOI: 10.1109/SIST58284.2023.10223492 URL: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85172033471&doi=10.1109%2fSIST58284.2023.10223492&partnerID=40&md5=71ff1a4e706d9c21234ebd0a7b218ddb.
[20] International Organization for Standardization. ISO 19650:2018 Organization and Digitization of Information about Buildings and Civil Engineering Works. Geneva : ISO, 2018.
[21] Tormosov R., Chupryna I., Ryzhakova G., Pokolenko V., Prykhodko D., Faizullin A. Economic and analytical framework for multi-sector project integration in sustainable energy programs // Proceedings of the IEEE International Conference on Smart Information Systems and Technologies (SIST). 2021.
[22] Chupryna I., Tormosov R., Aryn A., Horbach M., Prykhodko D., Polzikov M. Decision-support tools for project selection in sustainable energy initiatives // Proceedings of the IEEE International Conference on Smart Information Systems and Technologies (SIST). 2023.