

STRATEGY FOR INTRODUCING NEW TECHNOLOGIES IN CONSTRUCTION: HOW TO ENSURE BUSINESS COMPETITIVENESS

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Abstract. The urgent need for the introduction of modern technologies in construction companies underlines the importance of researching new strategies used by companies to increase their competitiveness and business efficiency, maintain their market share and achieve leadership. The use of BIM technologies in the construction and design industry makes it possible to comprehensively solve all current problems and identify possible problems related not only to the construction but also to the subsequent operation of buildings. The *purpose* of the research was to study the global experience of implementing a strategy for introducing new technologies in construction to ensure the competitiveness of enterprises. The *subject* of the study is strategies for introducing new technologies in construction to ensure the competitiveness of enterprises. The *methodology* is based on the methods of systematisation, analysis and generalisation of the key theoretical and practical foundations of the strategy for implementation of new technologies in construction. The author studies and summarises in detail the problems, economic effects and business strategies for implementing BIM technologies in construction. *Conclusion.* The use of modern technologies in construction leads to increased efficiency and resource saving in production, improved management of business processes, rational use of material resources, as well as the introduction of integrated approaches to life cycle management of construction projects and strategic planning. An analysis of global experience in the use of BIM technologies in construction has identified the main challenges faced by companies at various levels. The introduction of BIM technologies in construction leads to the following economic results: budget reduction due to the elimination of unforeseen changes by 40%; reduction of estimates by 80%; savings in contract costs by 10%; elimination of potential conflicts in interaction with customers; reduction of project implementation time by 7% and staff time and reduction of unit costs; ensuring timely completion of projects and improving their quality. In order to remain competitive, companies need to apply an integrated approach and strategic planning to introduce new technologies in construction, with government support and recognition of national and international standards being important factors. Based on a theoretical and practical study of the world experience in the implementation of BIM technologies in construction, the main problems of companies at the strategic, tactical and operational levels are systematised. In general, to ensure the competitiveness of companies in the implementation of BIM technologies, it is important to use a comprehensive approach and strategic planning for their integration into construction projects. The main factors for the successful implementation of such strategies are the joint support of the state and the recognition of global and national standards.

Key words: BIM technologies, construction, competitiveness of the construction industry, business strategies.

JEL Classification: O32, L74, M21

1. Introduction

In the context of digital transformation, Ukraine's construction industry needs new approaches and methods to ensure competitiveness based on innovative strategies. One of the problems that needs to be addressed is the lack of consistency

in the processes of technology integration, information creation and exchange (The Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Implementation of Building Information Modelling (BIM) Technologies in Ukraine and

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Approval of the Action Plan for its Implementation" of February 17, 2021, No. 152-p., 2023). The need to introduce modern technologies in construction companies makes it important to study new strategies used by companies to increase competitiveness, retain market share and ensure leadership.

With new technologies, construction companies are addressing a number of challenges related to digital transformation, legal requirements for sustainable business development, environmental sustainability and energy efficiency:

1. Resource and energy intensity of construction processes.

2. The need to improve the efficiency of management of key business processes: design, construction, operation as a result of problems with communication between stakeholders in these processes.

3. Inefficient use of material resources for construction, including the use of raw materials and related construction products that cannot be reused.

4. Outdated approaches to managing the life cycle of construction industry facilities as an integral complex are consistent in their stages and content: from the idea and concept of creation to the termination of operation, taking into account the reuse of elements for a new purpose.

5. Inconsistency of legislation with modern construction technologies.

6. Significant energy consumption in the sector, which is generated from non-renewable sources and leads to environmental pollution.

In economically developed countries, construction companies focus not on the processes of design, construction, and commissioning, but on the efficiency of planning the life cycle management of facilities. As a result, the industry as a whole is undergoing digital transformation and structural changes in the economy as a whole. Therefore, in the context of Ukraine's need to develop and reform the construction industry, ensure its efficiency and competitiveness as a link in the economy, it is advisable to study in detail the practice of implementing a strategy for introducing new technologies in construction on the basis of international experience.

The article is aimed at studying the world experience of implementing a strategy for introducing new technologies in construction to ensure the competitiveness of enterprises.

To achieve this aim, the following tasks have been outlined:

1. To systematise the theoretical and practical foundations for implementing a strategy for introducing new technologies in construction.

2. To consider the main and summarise the problems of implementing BIM technologies in construction.

3. To analyse the economic effects of implementing BIM technologies in construction.

4. To describe the most effective business strategies for implementing BIM technologies in construction.

2. Theoretical and Practical Bases of Implementation of the Strategy for the Introduction of New Technologies in Construction

The essence of BIM technologies is the development and sharing of a building information model of a construction object (BIM model of an object), which is a set of structured and unstructured information containers (data sets) within an integrated information system containing the necessary geometric, physical, functional and other characteristics of the object, on the basis of which documentation accompanying the life cycle of the object (design and estimate documentation, operating recommendations) is developed.

The introduction of BIM technology contributes to the dynamic ongoing changes in the construction industry, with fundamental changes occurring in the context of solving problems of optimising business operations, i.e., at the operational level, and problems of using technology in general, i.e. at the strategic level (Wu and Issa, 2014).

The global experience of implementing advanced technologies in the construction industry confirms the high efficiency of BIM technology, a construction information modelling technology that ensures the use of modern approaches and integrated system strategies at various levels of management (national, regional, local) to manage digital information (Arayici et al., 2011; Wu and Issa, 2014; Warner and Wäger, 2019; Zhou, Yang and Yang, 2019; Ma et al. 2020; Al-Ashmori et al. 2020).

BIM technologies are based on the use of digital representation of objects in the design, construction, and operation processes for reliable decision-making. In 2021, the global BIM market

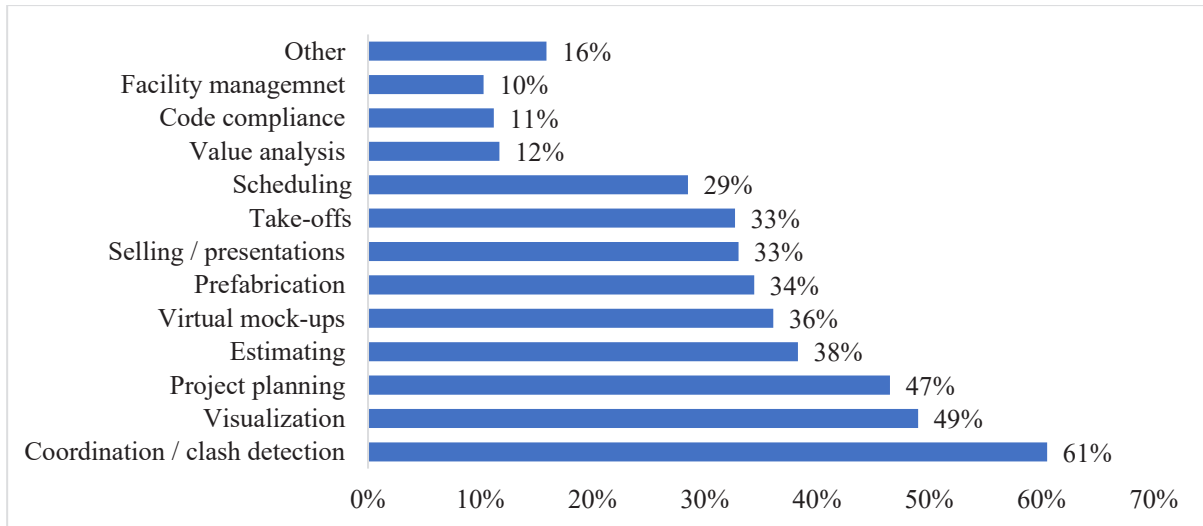


Figure 1. Purpose of building information modeling in the construction sector in the United States as of 2019

Source: Statista (2023b)

in the construction industry was worth 3.320 billion USD, and is projected to reach 11.773 billion USD by 2030, with an average annual growth rate of 15.1% in 2022–2030 (Statista, 2023a). As shown in Figure 1, construction companies are implementing BIM for several purposes: to effectively coordinate and identify contradictions, to visualise and plan projects, to conduct estimates, build virtual mock-ups, presentations and sales, hold meetings, plan and analyse project costs, and manage facilities. As of July 2019, 49% of US companies used BIM in their own companies for visualisation.

The introduction of BIM technologies contributes to the digitalisation of the construction sector, providing economic, social and environmental competitive advantages for various stakeholders. For example, it improves work efficiency and optimises the price-quality ratio, which is the driving force behind competitiveness. Digital transformation is defined as the use of new digital technologies (mobile, cloud, artificial intelligence, blockchain and the Internet of Things (IoT)) to drive business growth and improve customer service, optimise operations or create new technology-based business models, resulting in a transformation of the strategy and organisational structure of companies (Warner and Wäger, 2019). Digital transformation is a continuous process of using digital technologies in an organisation, in which flexibility is the main mechanism of strategic renewal: 1) the organisation's business model;

2) the approach to cooperation, and 3) the corporate culture (Warner and Wäger, 2019).

3. Problems of Implementing BIM Technologies in Construction

The global experience in implementing BIM technologies in construction allows to systematise the main problems of companies at the strategic, tactical and operational levels. The paper by Arayici et al. (2011) highlights the problems of BIM integration based on the analysis of the practice of construction companies in the UK:

1. Human factor and staff resistance to technological change, which arises as a result of the need for training in the use of new technologies, awareness of the value and potential of 3D modelling compared to 2D drawings. Finding specialists with the skills to use new technologies and training staff, which requires financial costs. Wu and Issa (2014) also argue that the main constraint to digital transformation and the integration of BIM technologies is the lack of competent professionals in this field (Wu and Issa, 2014). According to an empirical study by Al-Ashmori et al. (2020) on the implementation of BIM technologies in Malaysia, in general, in different regions of the country, a low level of employee awareness of BIM technologies was found – 56%, which, accordingly, requires training programmes, seminars and other professional development activities. The study by Al-Ashmori et al. (2020) also found that time, cost, productivity,

conflict, and communication were among the most significant issues for managers to address during implementation. On the other hand, the driving factors for technology implementation were respect, trust, commitment, and knowledge (Al-Ashmori et al. 2020).

Liao and Ai Lin Teo (2018) identified human resource management as a key point in the implementation and integration of BIM technologies in Singapore, which requires both the use of certain types of strategies and organisational changes (changing the roles of individual employees, corporate culture, organisational structure). The following obstacles arise in the process of technology implementation: lack of knowledge, resistance to change, negative attitudes towards possible risks and problems in the use of BIM by staff (Liao and Ai Lin Teo, 2018).

2. The need to use strategies for adapting existing, well-established business processes to new processes related to the use of BIM technologies. The effective implementation of BIM technologies requires significant changes at every level of the construction process, given the requirements not only to learn new software applications, but also to train staff and redistribute responsibilities in view of the innovations in object modelling (Arayici et al., 2011). In the UK, for example, most companies are addressing the fundamental challenges associated with digital change and technology adoption in construction, particularly at the organisational level.

3. The need to understand the networking and high-performance hardware resources required to run BIM software.

4. Increased cooperation, interaction and integration between structural engineers/designers and external stakeholders (BIM technology providers).

5. Clear division of responsibilities of stakeholders in new processes in the construction industry (Arayici et al., 2011).

Based on a mapping of the problems associated with the integration of BIM technologies, Zhou, Yang and Yang (2019) identified six key barriers to the implementation of Chinese construction companies' strategies in this area: organisational challenges, high cost of integration and use, insufficient management by company management, legal issues, insufficient external motivation, human factors and resistance to

change by staff (Zhou, Yang and Yang, 2019). Another classification of risk factors for the adoption of BIM technologies is proposed by Chien, Wu and Huang (2014), where the authors identify technical, managerial, human, financial and legal aspects of technology adoption in Taiwan. According to Khosrowshahi and Arayici (2012), there are a number of issues at the strategic and operational levels of construction companies in the UK that need to be addressed through the development of structured strategies and models. The latter should include the following components: information management, organisational culture, training and education (Khosrowshahi and Arayici, 2012).

4. Economic Effects of Implementing BIM Technologies in Construction

To ensure the company's competitiveness in implementing BIM technologies, companies use a holistic approach and strategic planning to integrate them into facility construction projects. The planning and development methodology proposes the implementation of BIM projects based on clearly defined guidelines and a standardised workflow for the strategic implementation of BIM to improve productivity, efficiency, quality and sustainability in construction.

The use of BIM technologies and the implementation of projects based on them provides construction companies with a number of competitive advantages. Stanford University's Centre for Integrated Building Design analysed 32 large projects and identified the following benefits of using BIM technologies: cost planning helps to eliminate up to 40% of unforeseen budget changes with an estimation accuracy of 3%; companies reduce the volume of estimates by up to 80% and save up to 10% of contract costs by identifying potential contradictions during interaction with customers; project implementation time is reduced by up to 7% (Chiu, Tzeng and Li, 2010).

Based on a survey of 105 respondents to the National BIM Standardisation Committee of the National Institute of Building Sciences, Suermann (2009) systemises the following factors of BIM technologies' impact on construction: 76% of respondents claimed a reduction in labour hours due to the technology; 70% of respondents reported

a reduction in unit costs; 84% reported a reduction in project costs due to BIM; 90% reported timely completion of projects; and 95% reported high quality.

Kaner et al. (2008), based on four cases of quality improvement in engineering design, found that BIM technologies have a positive impact on the productivity and quality of engineers' work by eliminating drawing errors at the design stage. Barlish and Sullivan (2012) argue that there is a high potential for realising the benefits of BIM technologies, particularly in the context of positive impacts on order scheduling, cost savings and possible conflicts between stakeholders. Giel and Issa (2013), based on case studies, found a significant level of fluctuation in the return on investment in BIM: from 16% to 1654%. The authors also found a 34%, 68%, and 43% reduction in the total number of information requests in projects involving small sloping walls, a three-storey residential building, and a mid-rise commercial condominium, respectively, and a 40%, 48%, and 37% reduction in the number of change orders, respectively (Giel & Issa, 2016).

Coates et al. (2010) systematised the main stages of BIM technology implementation

on the example of John McCall's Architects (JMA's) (Table 1), highlighting the key short- and medium-term benefits. It is worth noting that at the final stage of implementing BIM technologies, they are integrated into the company's strategic plan.

5. Business Strategies for the Implementation of BIM Technologies in Construction

Despite the above discussion of obstacles, challenges and problems in technology adoption, the literature also discusses significant successes in implementing integration strategies in a number of countries, with North America, the Scandinavian countries and the UK leading the way. Coordinated government support and leadership are the most important factors for companies to implement their strategies for using new technologies. Global and national BIM standards, legal protocols for certification, distribution of powers and responsibilities, training and educational programmes, and the economic and technical justification of BIM are recognised as important strategies for BIM integration (Smith, 2014). Ma et al. (2020) also identify leadership strategy as a driving force in

Table 1
BIM Implementation Approach for JMA's Design Practice

Stage	Brief stage description
Stage 1: Detail Review and Analysis of Current Practice	Production of Current Process Flowcharts Soft System Analysis Review of IT systems Stakeholder Review and Analysis Identification of competitive advantages from BIM implementation
Stage 2: Identification of Efficiency gains from BIM implementation	Efficiency gains from BIM adoption: Short-term benefits (quality, speed and cost of services; automatic low-level corrections when changes are made to the design through the use of parametric relationships between objects; creation of accurate and consistent two-dimensional visualisations of the object design; creation of visualisations that allow to verify the idea and intent of the design; detection of design errors before construction). Medium-term benefits (information exchange, greater flexibility to satisfy customers, better financial control, simultaneous work across multiple disciplines).
Stage 3: Design of new business processes and technology adoption path	Production of detail strategies Documentation of Lean Process and Procedures Identification of Key Performance Indicators Documentation of BIM implementation plan
Stage 4: Implementation & roll-out of BIM	Piloting BIM on three different projects (past, current, and future) Training the JMA staff and stakeholders Devising and improving companywide capabilities Documentation and integration of process and procedures
Stage 5: Project review, dissemination and integration into strategy plan	Sustaining new products and processing offerings Evaluation and dissemination of the project

Source: (Coates et al., 2010)

the adoption of BIM technologies in construction, using construction projects in Singapore, Turkey and Nigeria as examples (Ma et al. 2020).

Ma et al. (2020) identify five best strategies for clear planning and implementation of BIM goals: financial support; identification of BIM capabilities and skills; availability and interoperability of engineering information and data; and alignment of project objective with BIM goals. The institutional environment and governance, technical conditions, resources and cooperation, and the ability to adapt to change are important for the implementation of a technology adoption strategy (Ma et al. 2020). Thus, strategies for integrating technologies in construction require a systematic approach and the development of strategies in the managerial and organisational, institutional, financial, technical, and resource subsystems of enterprises.

In the context of researching strategies for implementing BIM technology, let's look at the case of the construction company Turner. In its own operations, management uses the Integrated Building Solutions (IBS) strategy as a key core of its business strategy to meet client project requirements and ensure better project outcomes. The main components of the IBS-based strategy have been identified:

1. Integrated Project Delivery – IPD. The company uses IPD to ensure collaboration in the early stages of construction and optimise the use of BIM technologies through Lean production processes. Turner has defined the main formats for using IPD: (1) a traditional contract based on a partnership agreement with appropriate incentives for cooperation; (2) an integrated form of agreement.

2. Lean production. Turner relies on the lean manufacturing process to maximise customer value and minimise costs, eliminating business processes and activities that do not add value but are also costly.

3. BIM technology at an organisational level to enable effective design and collaboration for Turner.

4. Cloud and computing, social media and mobile devices: Turner uses social media, cloud and mobile computing in innovative ways.

5. Green building projects / LEED projects (leadership in energy and environmental design projects). Through the synergy of IBS elements, Turner achieves higher levels of performance and integrated sustainability in building projects.

6. Conclusions

The use of new technologies in construction contributes to an increase in resource and energy intensity of production, efficiency of management of key business processes, effectiveness of material resources use, implementation of holistic and integrated approaches to life cycle management of construction facilities and improvement of strategic planning. Based on a theoretical and practical study of the world experience in the implementation of BIM technologies in construction, the main problems of companies at the strategic, tactical and operational levels are systematised. The following problem areas are highlighted:

1. HR (staff resistance to technological changes, lack of competent specialists in this area, low level of employee awareness of BIM technologies; potential negative impact on productivity, conflicts and problems in communication and interaction).

2. Organisational (change in the roles of individual employees, corporate culture, organisational structure, cost, implementation time).

3. Strategic (adaptation at the strategic and operational levels, ensuring flexibility, using a leadership strategy).

4. Technical issues related to the launch of BIM software.

5. Financial.

6. Managerial (the need to change approaches to personnel and information management).

7. Legal.

8. Partnership (redistribution of stakeholder roles in new processes in the construction industry).

The article systematises the main economic effects of the implementation of BIM technologies in the construction industry: budget cuts due to the elimination of unforeseen changes by 40%; reduction of estimates by 80%; provision of contract cost savings of up to 10%; elimination of potential contradictions in interaction with clients; reduction of project implementation time by 7% and staff working hours; reduction of unit costs; timely completion of projects; ensuring high quality in project implementation. In general, to ensure the company's competitiveness in implementing BIM technologies, companies use a holistic approach and strategic planning to integrate them into facility construction projects.

References:

- Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. M., Sabah, S. A., Rafindadi, A. D. U., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams Engineering Journal*, 11(4), 1013–1019.
- 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.
- Barlish, K., & Sullivan, K. (2012). How to measure the benefits of BIM – A case study approach. *Automation in Construction*, 24, 149–159.
- Chien, K. F., Wu, Z. H., & Huang, S. C. (2014). Identifying and assessing critical risk factors for BIM projects: Empirical study. *Automation in Construction*, 45, 1–15.
- Chiu, W. Y., Tzeng, G. H., & Li, H. L. (2010, December). Improving the e-store business model for satisfying customers' needs using a hybrid MCDM combined DANP with grey relational model. In *Advances in intelligent decision technologies: Proceedings of the second KES international symposium IDT 2010* (pp. 113–121). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Coates, P., Arayici, Y., Koskela, K., Kagioglou, M., Usher, C., & O'Reilly, K. (2010, June). The key performance indicators of the BIM implementation process. *The International Conference on Computing in Civil and Building Engineering*, vol. 30. Nottingham UK.
- Giel, B. K., & Issa, R. R. (2013). Return on Investment Analysis of Using Building Information Modeling in Construction. *Journal of Computing in Civil Engineering*, 27(5), 511–521.
- Giel, B., & Issa, R. R. (2016). Framework for Evaluating the BIM Competencies of Facility Owners. *Journal of Management in Engineering*, 32(1), 04015024.
- Kaner, I., Sacks, R., Kassian, W., & Quitt, T. (2008). Case studies of BIM adoption for precast concrete design by mid-sized structural engineering firms. *Journal of Information Technology in Construction (ITcon)*, 13(21), 303–323.
- Khosrowshahi, F., & Arayici, Y. (2012). Roadmap for implementation of BIM in the UK construction industry. *Engineering, construction and architectural management*, 19(6), 610–635.
- Liao, L., & Ai Lin Teo, E. (2018). Organizational Change Perspective on People Management in BIM Implementation in Building Projects. *Journal of Management in Engineering*, 34(3), 04018008.
- Ma, X., Chan, A. P., Li, Y., Zhang, B., & Xiong, F. (2020). Critical strategies for enhancing BIM implementation in AEC projects: perspectives from Chinese practitioners. *Journal of Construction Engineering and Management*, 146(2), 05019019.
- Smith, P. (2014). BIM Implementation – Global Strategies. *Procedia Engineering*, 85, 482–492.
- Statista (2023). Straits research. BIM in Construction Market. Available at: <https://straitresearch.com/report/bim-in-construction-market>
- Statista (2023b). Purpose of building information modeling in the construction sector in the United States as of 2019. Available at: <https://www.statista.com/statistics/1020765/uses-bim-construction-sector-us/>
- Suermann, P. C. (2009). *Evaluating the impact of building information modeling (BIM) on construction*. University of Florida.
- Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long range planning*, 52(3), 326–349.
- Wu, W., & Issa, R. R. (2014). Key issues in workforce planning and adaptation strategies for BIM implementation in construction industry. *Construction Research Congress 2014: Construction in a Global Network*, pp. 847–856.
- Zhou, Y., Yang, Y., & Yang, J. B. (2019). Barriers to BIM implementation strategies in China. *Engineering, Construction and Architectural Management*, 26(3), 554–574.
- The Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Implementation of Building Information Modelling (BIM) Technologies in Ukraine and Approval of the Action Plan for its Implementation" of February 17, 2021, No. 152-p. Available at: <https://ips.ligazakon.net/document/KR210152?an=1>

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