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Research paper

DIGITAL TRANSFORMATION OF THE ARCHITECTURAL SECTOR IN SOUTHEAST EUROPE: BENEFITS AND CHALLENGES

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Abstract

This study examines the process of digital transformation within the Architecture, Engineering, and Construction (AEC) sector in Southeast Europe. The primary focus is placed on the role of Building Information Modeling (BIM) as an integrated methodology for information management and project coordination. The research analyzes the levels of BIM implementation and maturity across the region, while highlighting the role of OpenBIM standards in enhancing interoperability among stakeholders in the construction and investment process. The study explores the specific characteristics of the regional digital transition, characterized by fragmented design workflows, limited institutional integration, and uneven levels of digital maturity. Furthermore, it evaluates national digitalization policies, BIM adoption in both public and private sectors, and the role of higher education in architecture and engineering across selected Southeast European countries. The paper identifies the key benefits of BIM, such as improved coordination, design optimization, and more efficient building lifecycle management. Additionally, it addresses significant implementation challenges, including the lack of standardization, limited investment, and resistance to organizational change. Finally, future trends in BIM development are outlined, emphasizing the integration of Artificial Intelligence (AI), the Internet of Things (IoT), and Digital Twin technologies, as well as the growing significance of digital ecosystems for the sustainable development of the construction industry.

Key words: *Building Information Modeling (BIM), Digital Transformation, OpenBIM, Digital Twin, Artificial Intelligence (AI)*

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1. INTRODUCTION

Over the past two decades, the Architecture, Engineering, and Construction (AEC) sector has undergone an intensive digital transformation. The primary drivers of this process have been advancements in information technology and the increasing need for more efficient data management throughout the design and construction lifecycle. In this context, Building Information Modeling (BIM) has emerged as an integrated methodology for the creation, coordination, and management of information throughout a building's entire lifecycle [1]. BIM facilitates more effective interdisciplinary coordination, the optimization of design processes, and improved sustainability within architectural practice.

The growing importance of BIM is closely linked to the evolution of the OpenBIM approach, the adoption of international information management standards, and the integration of technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and Digital Twin systems [2]. In many developed European countries, BIM serves as the foundation for building integrated digital ecosystems and smart data management.

Against this backdrop, the countries of Southeast Europe present a unique context for digital transformation. The region is characterized by an uneven level of digitalization, limited institutional integration, and fragmented design processes [3]. This is further influenced by disparities in educational frameworks, management models, and the level of digital maturity. Consequently, the adoption of BIM in the region is progressing at varying speeds, remaining concentrated primarily within large design firms and public-sector projects.

The relevance of this study stems from the need to analyze digitalization processes and the extent of BIM implementation across Southeast Europe. The primary objective is to evaluate the current status, level of adoption, and future development prospects for BIM practices within a regional context.

2. LEVELS OF BIM IMPLEMENTATION AND MATURITY OF BIM PROCESSES. ANALYSIS OF SOUTHEAST EUROPE.

2.1. BIM Maturity Levels 0–3

The concept of BIM Maturity Levels describes the stages that organizations and the construction sector undergo during the implementation of digital modeling [4]. This typology serves as a framework for assessing the extent to which principles of collaboration, standardization, and information integration are applied within architectural design, as shown in Figure 1.

Level 0 (CAD environment): This stage is characterized by the use of traditional 2D CAD tools devoid of an integrated environment for information exchange or management. Data is exchanged primarily via electronic drawings; the absence of interdisciplinary coordination frequently results in inconsistencies and redundant work.

Level 1 (2D/3D CAD with a Common Data Environment): At this stage, partial standardization is introduced, alongside a Common Data Environment (CDE) for the

centralized management of files and documentation. While discipline-specific models remain separate, data exchange is conducted according to established protocols.

Level 2 (Collaborative 3D modeling and coordinated data): This level serves as the foundation for BIM as a collaborative process. Individual disciplinary models are federated into a unified information model, with data exchange facilitated through standardized formats such as IFC and COBie [5].

Level 3 (Integrated BIM – iBIM): This stage is defined by a fully integrated environment and real-time information exchange among all project stakeholders throughout the building's lifecycle. At this level, BIM evolves toward Digital Twin systems, cloud-based platforms, and automated data management leveraging Artificial Intelligence (AI) and adherence to international standards, such as ISO 19650 [6].

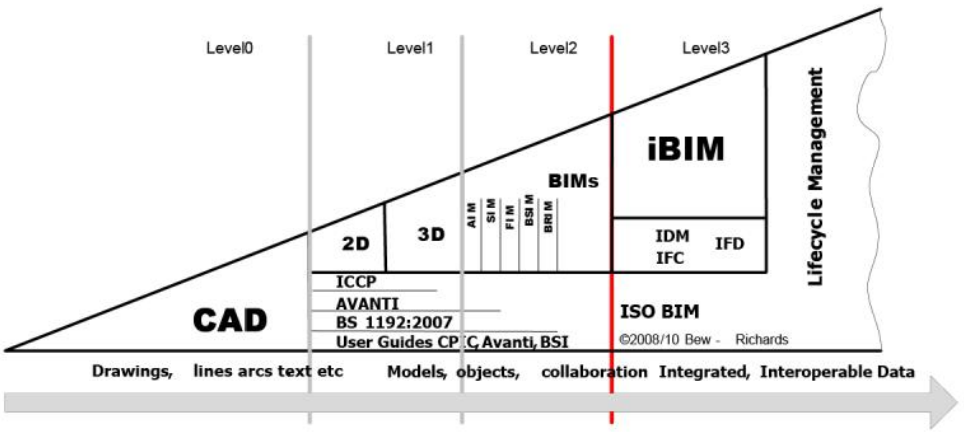


Figure 1. Bew–Richards BIM Maturity Model, Bew & Richards (2008) [4]

2.2. Analysis of Southeast Europe

Digital transformation in Southeastern Europe is characterized by uneven levels of digitalization, limited institutional integration, and varying degrees of BIM maturity across different countries and design organizations [3]. Across much of the region, clearly defined national BIM strategies and mandatory standards for public projects are still lacking, which hinders the systematic implementation of digital processes.

An additional challenge lies in the educational and professional preparation within the BIM field. In many cases, BIM training is still in the developmental stage, while professional practice remains focused primarily on traditional design methods, 3D modeling, and visualization [7].

A significant issue for the region remains the limited interoperability between various software environments and the absence of a common data environment (CDE). This fosters fragmented design practices and restricts effective coordination among stakeholders throughout the construction and investment process [5].

3. TECHNOLOGICAL TOOLS AND WORKFLOWS IN CONTEMPORARY BIM PRACTICE. OPENBIM

The current state of BIM in architectural practice is defined by the evolution of technological tools and workflows within the construction and investment process. Over the past two decades, BIM has established itself as the standard for modern design activities. The digital transformation of the architectural sector is driving the integration of various technologies into a unified information process.

Among the most widely used BIM platforms are Autodesk Revit, Graphisoft ArchiCAD, and Nemetschek Allplan. These tools enable the creation of intelligent information models containing geometric, parametric, and operational data. BIM environments are utilized not only for 3D modeling but also for project information coordination, documentation management, and tracking design changes throughout the process.

With the increasing use of diverse software platforms, the need for interoperability has become critical. It refers to the ability to achieve standardized information exchange between different BIM environments without loss of data or content. In multidisciplinary workflows, interoperability becomes a key factor for the coordination and effective management of project information.

In this context, the OpenBIM concept has gained strategic importance. Developed by buildingSMART International, it is based on the use of open standards such as IFC, BCF, and COBie [5]. These standards ensure sustainable information exchange between disparate software environments. The IFC format, in particular, is increasingly established as the primary standard for the structured description and exchange of building information [6], as illustrated in Figure 2.

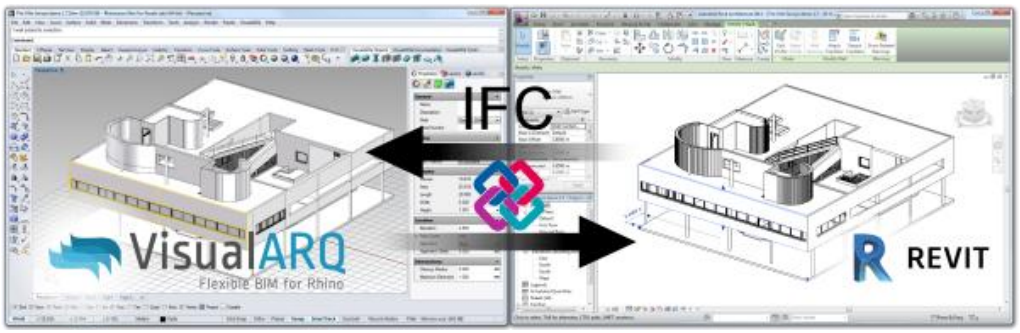


Figure 2.Exchanging models between Rhino and Revit through IFC, VisualARQ Official Website [12]

The OpenBIM approach enables more flexible collaboration among architects, engineers, investors, and contractors. At the same time, it reduces dependency on specific software vendors. This is particularly significant in the context of Southeastern Europe, where design teams often operate using various software systems and exhibit varying levels of digital maturity.

In modern architectural practice, BIM is gradually establishing itself as an integrated information environment that unifies design, coordination, and data management

throughout the entire building lifecycle [8]. In this process, OpenBIM plays a pivotal role in establishing sustainable and interoperable digital environments.

4. BENEFITS OF BIM IMPLEMENTATION IN ARCHITECTURAL PRACTICE

The implementation of BIM in architectural practice leads to significant benefits related to coordination, information management, and the optimization of design processes. In the context of Southeastern Europe, this is particularly critical due to the region's characteristic fragmented design practices and limited coordination among stakeholders in the construction and investment process. Through the creation of information models, design clashes can be identified during the design phase. This reduces the risk of errors and the necessity for subsequent changes during construction.

A key advantage of BIM is the potential for more effective exchange and management of project information among architects, engineers, investors, and contractors. Given the uneven digitalization and the use of diverse software environments, the BIM and OpenBIM approach facilitates interoperability and cross-disciplinary coordination [5]. This creates conditions for more effective communication, improved resource management, and higher traceability of project data.

BIM provides the capability for information management throughout the entire building lifecycle, from design to operation and maintenance. Of particular importance for Southeastern Europe are the opportunities for analyzing and optimizing the energy efficiency of buildings, given the challenges of high summer temperatures and the need for heating during the winter season. Through parametric modeling, energy simulations, and the monitoring of operational data, energy costs, resource efficiency, and the functional performance of buildings can be optimized [8]. This creates the prerequisites for more sustainable design and a gradual transition toward more integrated digital environments in architectural practice.

BIM further facilitates energy modeling by linking building geometry and envelope properties with performance-related parameters such as U-values, infiltration rates, thermal bridges, and solar gain coefficients, thus enabling rapid scenario testing from the early design stages. Through the connection between parametric models and energy simulation environments, it becomes possible to assess heating and cooling loads, the impact of orientation and glazing ratios, shading performance, natural ventilation potential, and daylight availability. This supports more informed decisions regarding envelope optimization, HVAC system selection, and passive design strategies, ultimately reducing operational costs and lifecycle emissions. In addition, integrated digital workflows and automated rule-based checks can support compliance with national energy performance requirements and sustainability certification frameworks, while also improving the traceability of assumptions used in the design process.

In the context of Southeastern Europe, BIM also represents a still underutilized opportunity for improving building energy performance and supporting the transition toward a decarbonized built environment. In a region marked by aging building stock, uneven renovation practices, and pressure on energy infrastructure, BIM-based workflows enable more accurate Building Performance Simulation (BPS) from the

earliest stages of design. By incorporating thermal properties, solar orientation, and envelope-related performance data into the intelligent model, architects can evaluate building behavior under both summer overheating and winter heating conditions. As a result, energy optimization is no longer treated as a late-stage verification procedure, but as an integral and generative part of the design process, contributing to more effective retrofit strategies, reduced lifecycle carbon emissions, and stronger alignment with contemporary sustainability goals.

Overall, the benefits of BIM implementation can be summarized in four main directions, as illustrated in Figure 3: quality, related to improving the quality and accuracy of project documentation; saving, including optimization of costs, resources, and process efficiency; time, focused on reducing delays and optimizing the project life cycle; and functionality, associated with improved communication, visualization, and access to project information. This demonstrates that BIM is gradually emerging as an integrated informational and methodological framework that is transforming architectural practice and supporting the broader digital and sustainable transition of the AEC sector in Southeastern Europe.

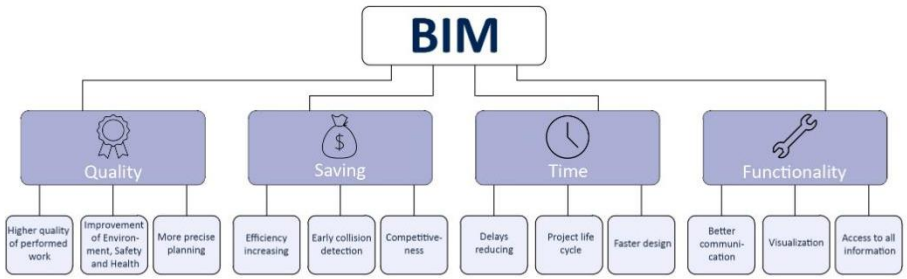


Figure 3. Main Benefits of BIM Implementation, Author's own work

5. CHALLENGES AND LIMITATIONS OF BIM IMPLEMENTATION

Despite the gradual development of BIM practices, its implementation in Southeastern Europe remains constrained by the lack of national BIM strategies, uneven digitalization, and limited institutional support. In many countries, the regulatory framework does not yet fully encompass BIM processes within the public sector, which hinders standardization and coordination among stakeholders in the construction and investment process [3].

A significant issue for the region remains the limited digital maturity of design organizations. In many cases, BIM is primarily utilized for 3D modeling and visualization, lacking established Common Data Environments (CDE) and coordinated information exchange protocols. This sustains fragmented design practices and limits effective interoperability between individual disciplines [5].

An additional challenge is the limited BIM training within architectural and engineering education. The lack of practical experience and systemic professional training often leads to partial implementation of BIM processes and inefficient management of project information.

The transition toward integrated digital processes in Southeastern Europe often proceeds at a slower pace compared to other European countries. This is attributable not only to limited institutional support and uneven digitalization but also to more conservative professional attitudes and deeply entrenched traditional working models within design practice [10].

6. CURRENT STATE OF BIM PRACTICE IN SOUTHEAST EUROPE

The development of BIM in the countries of Southeastern Europe is characterized by an uneven degree of digitalization, varying levels of institutional support, and limited regulatory integration within the public sector [3]. Although BIM has gradually established itself as part of architectural and engineering practice over the last decade, the region remains in a transitional stage between traditional design processes and the integrated digital environments characteristic of higher levels of BIM maturity.

The general trend indicates that the development of BIM in Southeastern Europe is being gradually stimulated by national digitalization policies, institutional initiatives, and the implementation of BIM in large-scale public and infrastructure projects [9]. Concurrently, there is a gradual integration of BIM into architectural and engineering education, although in most countries, training remains concentrated primarily on 3D modeling and basic coordination.

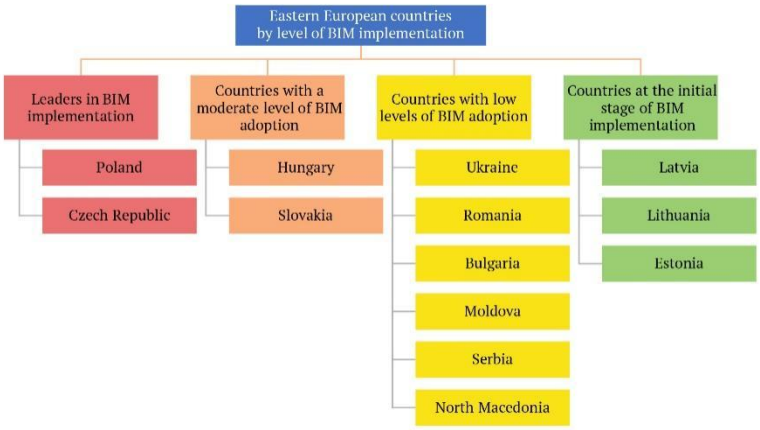


Figure 4. Classification of Eastern European countries by the level of BIM implementation, Ihor Mysak, Pavlo Mysak [3]

Figure 4 presents a summarized distribution of the countries in Eastern Europe according to their level of BIM implementation and digital integration. Although the broader comparative framework draws on Eastern Europe, the present study focuses specifically on Southeastern Europe due to the subregion's shared institutional, educational, and market-related conditions affecting BIM adoption. The majority of countries in the region are still in an early or transitional stage of BIM integration. This overall pattern highlights the uneven pace of digital transformation across the region and justifies the need for a more detailed comparative assessment. Since a significant share of the analyzed countries fall into the "Low levels of BIM adoption" category, the

next part of the research is aimed at a more in-depth analysis of selected cases. To address this gap, Table 1 presents a comprehensive comparative analysis developed by the authors, evaluating the institutional framework, private sector integration, and educational landscape across selected regional markets. The main focus of the study is divided into three key areas: state and institutional support, the level of BIM implementation in the private sector, and the integration of BIM training into architectural and engineering education.

Table 1. Comparative Analysis of BIM Adoption in Bulgaria, Romania, Croatia, Greece and Slovenia, Author's own work

Country	Public procurement frameworks and national policies	Private sector	Education
Bulgaria	The National Strategy for Digital Transformation of the Construction Sector 2030 envisages a phased implementation of BIM Level 2 in public procurement.	BIM is primarily used in large design firms, international companies, and infrastructure projects.	Limited BIM training, focused primarily on 3D modeling and basic coordination. Gradual development of BIM training, organized by EDIHs and supported by European digitalization programs.
Romania	There is a lack of mandatory national implementation. BIM is primarily promoted through European infrastructure programs.	In private projects, BIM is mainly used for industrial, logistics, and infrastructure projects with international participation.	Primarily 3D BIM training, with a gradual introduction of 4D and 5D concepts.
Croatia	There is no mandatory national BIM strategy, although there is active participation in European BIM initiatives.	BIM is mainly used for infrastructure, tourism, and international projects.	Focus primarily on 3D modeling and basic interdisciplinary coordination.
Greece	There is no clearly defined national BIM strategy. Digitalization is driven mainly by European infrastructure programs and the modernization of the construction sector.	BIM is primarily used in large-scale private investments, hospitality projects, and transport infrastructure with international involvement.	BIM integration in education remains limited, focusing primarily on 3D modeling and visualization.
Slovenia	The public sector has adopted BIM via the 'Action Plan for the Introduction of Digitalization for the Built Environment.' From 2025, BIM becomes mandatory for nationally significant projects, with policies further bolstered by the 'Digital Slovenia 2030' strategy.	BIM is widely adopted in both architectural and engineering practice, including public and infrastructure projects.	BIM is integrated at an advanced level, including 4D and 5D processes, supported by the activities of siBIM and buildingSMART Slovenia.

7. PERSPECTIVES FOR THE DEVELOPMENT OF BIM PRACTICE

The future development of BIM practice is characterized by a gradual transition from digital modeling to integrated environments for managing data, processes, and building operational performance. In this context, BIM is increasingly viewed not merely as a design tool, but as a foundation for building a comprehensive digital ecosystem. This environment integrates design, construction, operation, and the management of the building's life cycle.

A crucial factor for the advancement of BIM in the coming years will be the expansion of the regulatory and institutional framework related to the digitalization of the construction sector. A gradual introduction of BIM requirements in public procurement and a wider application of international standards, such as ISO 19650, is expected [6]. Within the context of Southeastern Europe, such policies could help overcome the fragmented design process and enhance the digital maturity of the sector.

The next stage in the evolution of BIM is linked to the integration of Artificial Intelligence (AI), the Internet of Things (IoT), and Digital Twin technologies. By connecting BIM models with operational data and automated systems, conditions are created for more efficient building management, resource optimization, and the development of more sustainable architectural solutions.

In a number of developed European countries, BIM is already being integrated with AI, IoT, and Digital Twin technologies as part of a broader digital transformation of the construction sector [13]. Compared to these trends, the countries of Southeastern Europe are still in an earlier stage of digital integration. BIM is primarily used for 3D coordination and documentation, while the implementation of AI and Digital Twin technologies remains limited mostly to large-scale international and infrastructure projects.

The future evolution of BIM practice can be envisioned as a transition from a digital modeling environment to an intelligent information infrastructure. This infrastructure unifies the design, analysis, operation, and management of the built environment. In this process, BIM, OpenBIM, AI, and Digital Twin technologies are gradually forming the foundation of the next generation of architectural and engineering practice.

8. CONCLUSION

This study examines BIM not merely as a digital modeling technology, but as an integrated information and organizational methodology that transforms the processes of design, coordination, and data management in architectural and construction practice. The analysis indicates that effective BIM implementation is linked not only to the use of specialized software but also to the establishment of standardized processes, interoperability, and a sustainable environment for information exchange.

The research on BIM maturity and the OpenBIM approach demonstrates that the countries of Southeastern Europe are in a transitional stage between traditional design practices and higher levels of digital integration. Despite the gradual development of

BIM in the region, there is still a limited regulatory framework, uneven digital maturity, and insufficient coordination among the various stakeholders in the construction and investment process.

In parallel, the development of AI, IoT, and Digital Twin technologies outlines the next stage in the evolution of BIM processes. BIM is gradually transforming from an environment for coordinating project information into an integrated digital infrastructure linked to data management, automation, and real-time analysis.

In the context of Southeastern Europe, successful digital transformation will depend not only on technological development but also on the ability of institutions, the educational system, and professional practice to build a shared digital culture, standardized processes, and effective mechanisms for information management. In this process, BIM, OpenBIM, and Digital Twin technologies are gradually forming the foundation of the next generation of architectural and engineering practice.

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