

The Impact of Integrated Management Information Systems on Cost Control Efficiency in Large Construction and Engineering Projects

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Abstract: This article examines the impact of integrated management information systems, such as Enterprise Resource Planning (ERP), Project Management Information Systems (PMIS), Building Information Modeling (BIM), and Business Intelligence (BI), on the efficiency of cost management in large construction and engineering projects. It explores the role of these systems in automating financial processes, enhancing data transparency, and minimizing the risks of budget overruns. The article discusses the application of various technologies for planning, monitoring, and analyzing costs, as well as their integration for comprehensive project management.

Keywords: integrated management information systems, cost management, construction projects, Enterprise Resource Planning (ERP), Project Management Information Systems (PMIS), Building Information Modeling (BIM), Business Intelligence (BI).

I. INTRODUCTION

Modern construction and engineering projects are characterized through excessive complexity, numerous stakeholders, and sizable financial investments. In an environment of growing opposition and stricter regulatory requirements, making sure transparency and accuracy in fee management has emerge as one of the primary elements for undertaking fulfillment. Integrated management information systems, such as Enterprise Resource Planning (ERP) or Project Management Information Systems (PMIS), offer unique opportunities for data synchronization, process optimization, and risk minimization. However, the successful implementation of these technologies requires not only their adoption but also a deep understanding of their impact on critical aspects of project management.

The application of integrated management information systems in the construction industry unlocks new opportunities for optimizing cost management processes. These technologies enable the automation of routine tasks and provide real-time access to data, significantly improving the quality of managerial decision-making. Particular emphasis is placed on their role in enhancing transparency and efficiency in budgeting during the planning and execution phases of large-scale projects. The purpose of this study is to examine the impact of integrated management information systems on the efficiency of cost control in large construction and engineering projects.

II. THEORETICAL ASPECTS OF INTEGRATING MANAGEMENT INFORMATION SYSTEMS IN CONSTRUCTION

An integrated management information system is one important tool needed to manage modern construction projects in terms of their complexity and scale. It is a system that seeks to integrate processes, data, and analytical tools into one unified and centralized system to manage projects. Integration in the construction sector will guarantee consistency, accuracy, and access to information to stakeholders involved.

Integrated systems have a common characteristic of integration of data from procurement, finance, project schedule, and quality control. This could be further understood at a couple of levels: Data integration at the database level provides consistency; Application integration allows for seamless communications between tools, while process integration makes the workflow far more efficient. The integration of management systems helps to overcome the fragmentation of information often observed in large-scale construction projects, where various stakeholders rely on separate tools and platforms [1].

Core management information systems, including ERP, PMIS, Building Information Modeling (BIM), and Business Intelligence (BI), collectively demonstrate the transformative potential of integration in construction projects. Each system contributes to addressing specific project management needs, from financial oversight and resource allocation to spatial modeling and advanced analytics. Through implementing these technologies, construction organizations can unify fragmented processes, facilitate seamless data flow, and enhance decision-making. This collective approach fosters greater collaboration, transparency, and efficiency, ensuring that project objectives are met in a coordinated and cost-effective manner [2].

Theoretical models of integration highlight its role in reducing redundancies and streamlining operations. By aligning technology with organizational goals, integrated systems allow for better synchronization between processes and data. Integrating BIM and PMIS with ERP ensures that financial data aligns with project progress, while BI tools enhance decision-making by analyzing trends and deviations.

The challenges of integration are also significant and include compatibility issues, organizational resistance, and the complexity of merging legacy systems with modern platforms. However, theoretical frameworks, such as digital ecosystems and cloud-based integration, provide practical approaches to overcoming these challenges, enabling construction projects to leverage the full potential of integrated management information systems.

Integrated management systems, therefore, serve as a foundation for addressing the high degree of uncertainty and complexity inherent in construction projects. By providing a unified information environment, they enable faster decision-making, improve stakeholder collaboration, and contribute to the successful execution of large-scale projects.

III. COST MANAGEMENT SYSTEMS IN LARGE CONSTRUCTION PROJECTS

Effective cost management is one of the key challenges in implementing large construction projects. To address this challenge, various management systems are utilized, including ERP, PMIS, BIM, BI, and specialized cost management systems. These technologies enable the optimization of financial processes while ensuring their transparency and accuracy.

The primary objective of implementing management information systems in construction is to reduce time and financial costs by optimizing processes. Traditional cost control methods often involve fragmented tools, leading to data duplication, increased time consumption, and a higher likelihood of errors. The ERP systems enable the integration of data related to procurement, budgeting, and task execution, eliminating information redundancy and increasing data accuracy. The growing popularity of ERP systems is evident in their adoption within the construction industry and in global economic trends. According to forecast [3], revenue from ERP software is expected to reach nearly \$65,29 billion in 2029 (fig. 1).

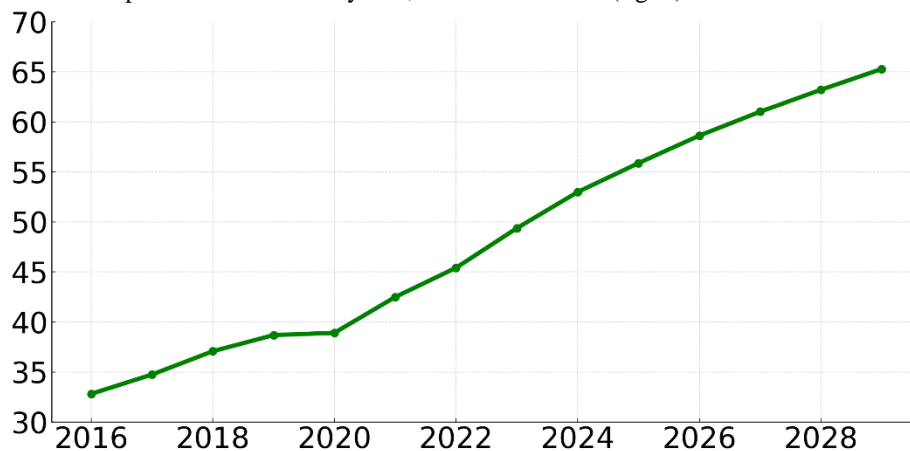


Fig. 1. Revenue of ERP software worldwide, billion dollars

These systems consolidate all aspects of financial management on a single platform, enabling automated expense tracking, cost analysis, and real-time reporting. The financial management module in ERP systems facilitate automatic comparison of actual expenses with planned budgets, identifying deviations. This simplifies the control process and reduces the need for manual data verification. ERP systems also significantly streamline the budgeting process, allowing companies to create detailed cost plans that account for current needs and for potential changes during project implementation.

Systems, such as PMIS, are designed to manage projects and budgets, offering functions for planning, monitoring, and cost analysis. These systems enable the integration of data from various sources, including ERP and BIM, for extensive analysis. It provides budget visualization, deviation analysis, and tools for prompt intervention when necessary. For example, PMIS solutions like Primavera P6 and Procore offer tools for managing financial metrics at all stages of a project [4]. They help create cost scenarios, forecast changes, and develop strategies to mitigate risks. Integration with ERP allows PMIS to synchronize data on resources and finances, ensuring accuracy and relevance of the information.

The BIM tools offer unique capabilities for cost management based on project data. These systems create three-dimensional models of structures, containing detailed information about materials, labor costs, and other

project aspects. BIM is used for cost estimation during the design phase and helps optimize decisions to reduce expenses [5]. Currently, companies such as Epicon actively employ BIM technologies to optimize their projects and reduce costs. For instance, during the design of a molasses processing workshop for a sugar factory, Epicon used BIM to create a detailed model that enabled precise calculations of material volumes, labor requirements, and construction costs [6].

Integrating BIM with ERP and PMIS allows project data to be utilized for automatic budget calculations and expense tracking. This can be notably valuable for large infrastructure projects, where the accuracy of material and resource data is important. According to a 2023 survey report of construction industry professionals [7], the two aforementioned systems have the potential to deliver the greatest overall return on investment (ROI), which explains their widespread adoption in the market. Despite a decline in these indicators in 2023, attributed to the adoption of innovative technologies such as artificial intelligence and virtual reality/augmented reality, BIM and PMIS systems remain leaders in the survey on potential ROI improvement. Together, they account for nearly half of all respondents' preferences, underscoring their continued relevance and effectiveness in large-scale construction and engineering projects (fig. 2).

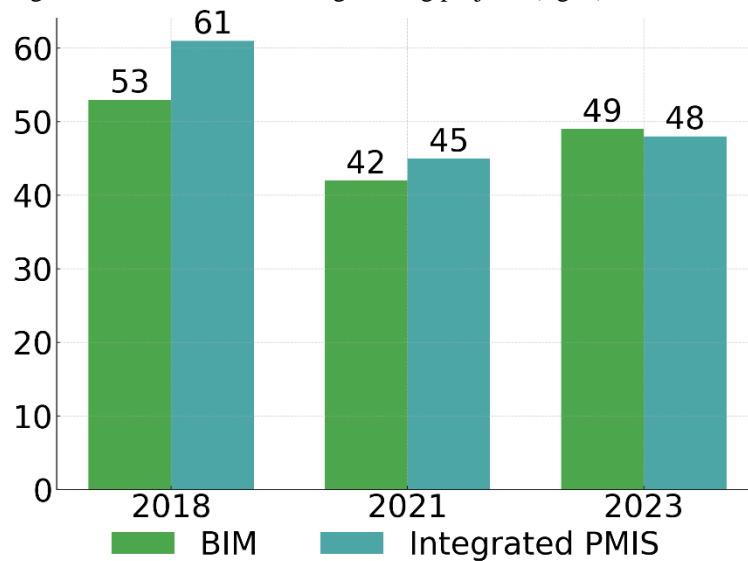


Fig. 2. Survey of technologies with the highest potential to deliver the greatest overall ROI, %

Various BI systems play an essential role in cost analysis and forecasting. These tools enable the collection, processing, and visualization of data, providing project managers with up-to-date information for decision-making. They help identify bottlenecks, analyze expenses in real-time, and generate cost forecasts based on historical data [8]. By way of illustration, BI tools like Tableau and Power BI integrate with ERP and PMIS to create analytical dashboards. This allows project managers to monitor key financial indicators, analyze deviations, and develop strategies to enhance efficiency.

Regardless of the system used, transparency and data standardization are essential aspects of cost management. ERP, PMIS, BIM, and BI provide centralized data storage, enabling all project participants to access up-to-date information. This fosters trust among clients, contractors, and other stakeholders while increasing accountability across the project team. The incorporation of ERP systems automate the process of generating reports for regulatory authorities, ensuring compliance with standards. PMIS and BIM complement this functionality by enabling the analysis of data within the context of project execution tasks. Each system plays a distinct role in cost reduction and process optimization, as they offer specialized functionalities tailored to different aspects of project management (table 1).

Table 1. Comparison of functionalities of ERP, PMIS, BIM, and BI systems [9]

System	Key functions	Examples of use	Main advantages
ERP	Financial management, resource management, procurement.	Automation of cost accounting, budget creation.	Centralized management, data accuracy.
PMIS	Planning, monitoring, cost analysis.	Managing schedules, controlling budgets.	Data visualization, prompt intervention.
BIM	Modeling, calculation of materials and labor costs.	Design and cost estimation at the planning stage.	3D visualization, decision optimization.
BI	Data analysis, cost forecasting.	Deviation analysis, forecast generation.	Analytical visualization, prediction capabilities.

Cost management systems such as ERP, PMIS, BIM, and BI play a vital role in the implementation of large-scale construction projects. ERP systems automate financial processes, PMIS assist in managing project budgets, BIM provides detailed cost information based on project data, and BI supports cost analysis and forecasting. Together, these technologies create an integrated approach to cost management, enhancing transparency, reducing risks, and ensuring the successful execution of projects.

IV. CONCLUSION

Integrated management information systems, such as ERP, PMIS, BIM, and BI, are an integral part of modern construction and engineering projects. Their use facilitates the automation of key processes, enhances transparency, and improves coordination among stakeholders, thereby minimizing the risks of budget overruns and delays. These technologies not only improve the accuracy of cost planning and control but also establish a resilient foundation for managing complex projects in the face of rapidly changing requirements and constraints. Looking ahead, their advancement and deeper integration with emerging technologies such as cloud computing and advanced data analytics promise to unlock new opportunities for improving the efficiency and sustainability of construction processes.

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