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THE IMPACT OF BIM AND GIS ON THE EFFICIENCY OF IMPLEMENTING CONSTRUCTION PROJECTS

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ABSTRACT

The integration of building information modelling (BIM) and geographic information systems (GIS) plays a key role in modern civil engineering, improving the efficiency of construction project execution. This article focuses on specific aspects of this integration, such as spatial and engineering data management, spatial analysis, and optimisation of construction processes. Using the example of the Central Communication Port (*Centralny Port Komunikacyjny* – CPK) in Poland, it illustrates how BIM enables detailed digital representations of the physical characteristics of construction projects, supporting planning and management, while GIS provides tools for advanced spatial and environmental analyses. The integration of both technologies allows for precise representation of the spatial context, enhances resource management, reduces construction costs and risks, and supports interdisciplinary collaboration at various stages of the project. The article also discusses challenges, such as the lack of standardised data exchange procedures and the need for specialised training essential to acquire knowledge enabling full use of the potential of BIM and GIS. The aim of the work is to analyse the impact of BIM and GIS integration on construction project management, with particular emphasis on data management processes and spatial analyses.

Keywords: BIM, GIS, Central Communication Port, AI

INTRODUCTION

Contemporary civil engineering increasingly relies on advanced technologies and methodologies aimed at improving project execution efficiency. Two of the most important ones playing a crucial role in this process are building information modelling (BIM) and geographic information systems (GIS). BIM is a methodology for managing information about construction projects or structures throughout their entire lifecycle – from conception, through design and construction, to operation and demolition. BIM enables the creation and utilisation of digital representations of physical and functional characteristics, allowing for better planning, designing, building, and managing of constructions (Zawada, Rybak-Niedziółka, Donderewicz & Starzyk, 2024). Nonetheless, GIS technologies are used for collecting, analysing, and presenting geographic data. GIS allows for the integration of spatial data with other data types, enabling the creation of comprehensive models and maps that support decision-making processes in construction. GIS is used, among other things, for spatial analysis, urban planning, infrastructure management, and risk assessment (Sunny, 2024).

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The combination of BIM and GIS in construction projects brings numerous benefits. The integration of these methodological and technological solutions allows for the creation of more precise and comprehensive models that take into account various aspects such as architecture, linear and energy infrastructure, spatial context, and more. This enables better resource management, cost and time reduction, and minimisation of construction-related risk factors. One example of BIM and GIS integration is the ability to accurately plan construction material delivery routes, perform environmental impact analyses, and assess the accessibility of construction sites. Moreover, the use of BIM and GIS can increase the transparency of construction processes and facilitate communication among all project participants – from designers and contractors to developers. This, in turn, allows for more effective monitoring of project progress, quicker responses to emerging issues, and the implementation of necessary adjustments.

The article presents an analysis and case study illustrating how the integration of BIM and GIS impacts the efficiency of construction project execution (Fig. 1). It will analyse both the benefits of their use and the challenges that must be overcome to fully realise their potential (Wang, Pan & Luo, 2019; Borkowski & To Duc, 2024).

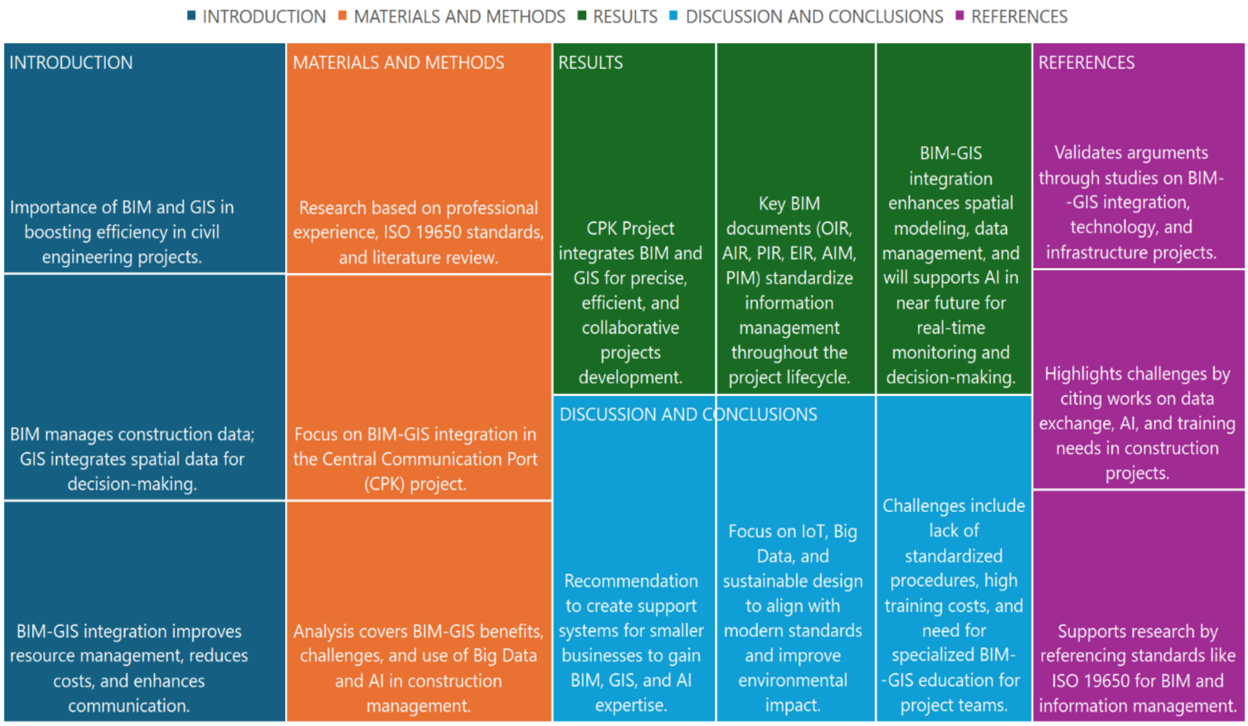

Fig. 1. Article flowchart

Source: own work.

MATERIAL AND METHODS

In the preparation of this article, the authors drew upon their professional experience and practical knowledge. Additionally, the research approach employed to examine the integration of BIM and GIS in construction projects, with a particular focus on the Central Communication Port (CPK) in Poland, is discussed.

The research methodology is based on three main elements (Fig. 2): (1) professional experience; (2) ISO 19650 standards; (3) literature review and critique. It is important to emphasise the significance of the research team's expertise in BIM and GIS, which provided an opportunity for practical evaluation and insights regarding the application of these technologies in real projects. Subsequently, an analysis of the ISO 19650 standards (British Standards Institution [BSI], 2018a, 2018b, 2020a, 2020b, 2022), which pertain to information exchange in construction processes in the context of BIM, was conducted to formulate observations related to the integration of BIM and GIS (BS EN ISO 19650-1:2018; BS EN ISO 19650-2:2018; BS EN ISO 19650-3:2020; BS EN ISO 19650-5:2020; BS EN ISO 19650-4:2022). This qualitative data helps to understand the operational landscape and the effectiveness of these technologies in managing projects in the digital world. Finally, a comprehensive literature review was conducted, which allowed for identifying trends within the context of existing research. This review highlighted the benefits and challenges associated with the integration of BIM and GIS. Database search engines used included ResearchGate, Web of Science, Google Scholar, Scopus, the Acta Scientiarum Polonorum archive, and the Knowledge Base of the Warsaw University of Life Sciences (SGGW). An attempt was made to extract publication topics using the following criteria: research conducted exclusively in Polish or English, carried out between 2018 and 2024, utilising keywords related to the subject of this study. Subsequently, the material was gradually narrowed down to refine the scope. It is believed that this methodology enabled the identification of the most important issues related to the topic, while also addressing aspects of big data, data science, and artificial intelligence (AI) in the construction project management process.

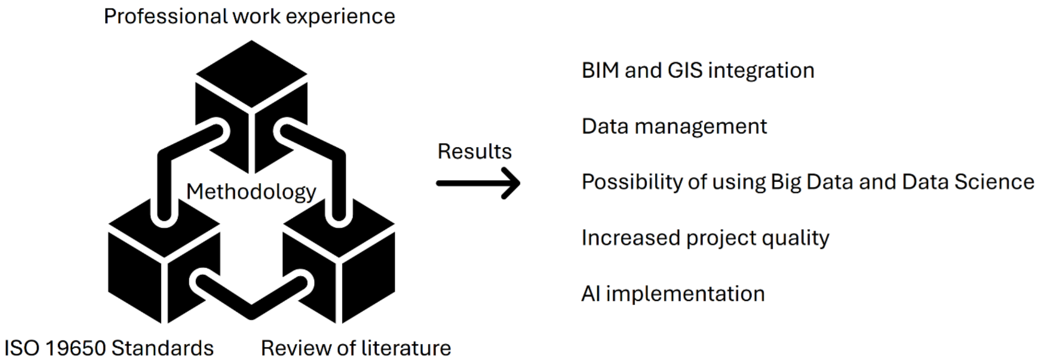

Fig. 2. Research methodology diagram

Source: own work.

RESULTS

Integration of BIM and GIS: A case study of the Central Communication Port

The Central Communication Port (CPK) is one of the most significant infrastructure projects in Poland in recent years. This project includes the construction of a new international airport as well as the development of a railway and road network (Uchwała Nr 201 Rady Ministrów z dnia 24 października 2023 r.). To execute this massive undertaking, CPK is adopting modern approaches and technologies such as BIM and GIS (Centralny Port Komunikacyjny, n.d.). The integration of BIM and GIS plays a crucial role in ensuring efficiency, precision, and collaboration among various project teams. Further, we discuss the aspects of integrating these two technologies, based on CPK's internal documents concerning information requirements. Within the BIM methodology, several key documents play an essential role in managing information across different stages of the project – from planning, through all phases of the design process, to demolition. These documents assist in standardising processes, managing data, and facilitating collaboration among different teams. All guidelines and project files are located in a single, central data repository, which is the Common Data Environment (CDE) Bentley ProjectWise platform (Fig. 3).

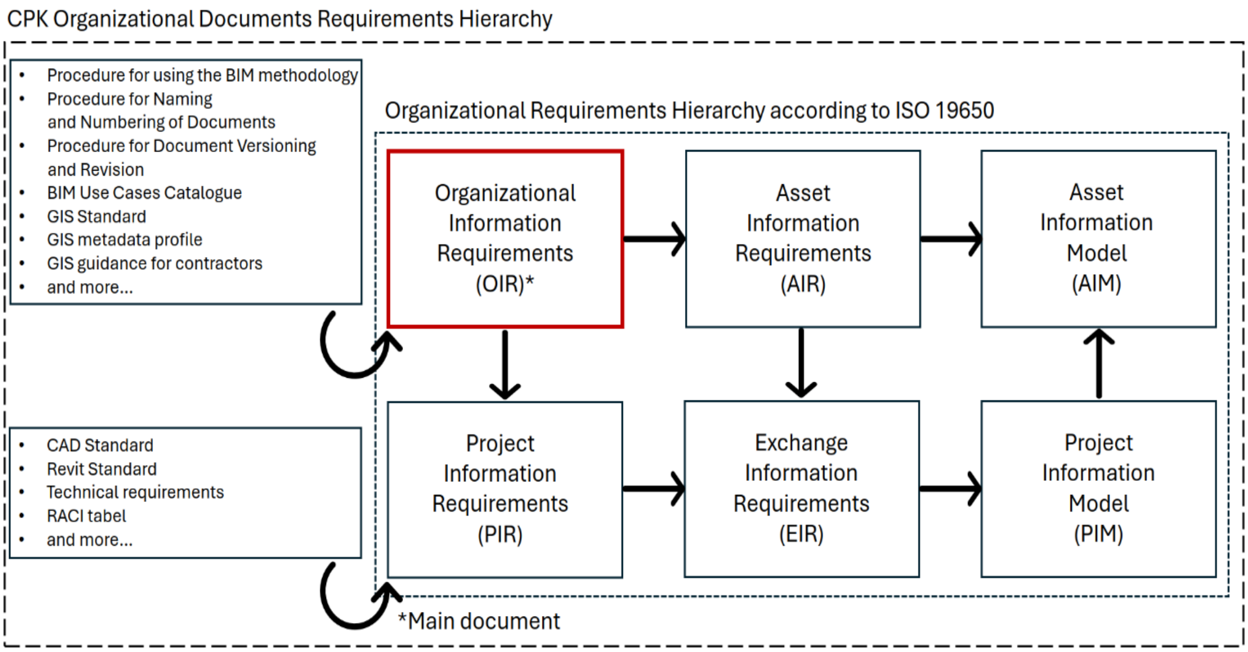

Fig. 3. Central Communication Port (CPK) organisational documents requirements hierarchy

Source: own work based on ISO 19650 and BIM and GIS Central Communication Port (CPK) procedures.

The organisational information requirements (OIR) is a document that specifies the information needs of an organisation at a strategic level. The OIR define the necessary information for effective management, monitoring, and achievement of organisational goals throughout the project lifecycle. It is a crucial document that ensures all organisational actions align with its long-term strategy and objectives. Another document is the asset information requirements (AIR), which outlines the information needs related to managed organisational assets, such as buildings, infrastructure, or equipment. The AIR is essential to ensure that all asset information is accurate, up-to-date, and available when needed. The asset information model (AIM) is an integrated model that contains all data and information related to asset management. The AIM collects and processes information throughout the asset lifecycle, from planning and construction to operation and eventual decommissioning. With the AIM, organisations can effectively manage their assets and make informed decisions. The project information requirements (PIR) is a document that specifies specific information needs for individual projects. The PIR considers technical, operational, and managerial requirements, ensuring that all necessary project information is collected and processed to enable effective project management. Based on the PIR, the employer's information requirements (EIR) are prepared. The EIR is document created by the employer, defining information expectations and requirements for contractors and suppliers. The EIR ensures that all project participants have clear and understandable guidelines regarding the employer's information expectations, helping to avoid misunderstandings and ensuring that the project is executed according to its requirements. The project information model (PIM) is a detailed model containing all information collected and processed during the execution of a construction project. The PIM is a key tool in project management, allowing efficient gathering, analysis, and sharing of information at all project stages, from planning through execution to completion. Thanks to the PIM, all stakeholders have access to current and accurate information, facilitating collaboration and coordination (Godager, Mohn, Merschbrock, Klakegg & Huang, 2022).

BIM documentation in the Central Communication Port

The scope and purpose of key documents according to ISO 19650 are presented in Table 1. These documents standardise information exchange between individual projects at all stages of the entire project process, such as for the CPK. It's important to note that all these documents are interconnected, and their provisions complement each other rather than exclude one another (Anger, Łaguna & Zamara, 2021; Kasznia, Magiera & Wierzowiecki, 2022).

Table 1. Contents and targets for basic BIM documents

Document	Content	Target
OIR	Key objectives of the organisation and their impact on information needs.	Ensuring that the information needed for decision-making at the strategic level is available, accurate, and up to date.
	Requirements for data collection and processing.	
	Information management standards and procedures.	Facilitating effective information management at all stages of the project.
	Tools and technologies supporting information management.	
AIR	Specifications of information about resources needed to manage them throughout their lifecycle.	Ensuring that information about resources is complete, accurate, and accessible throughout their entire period of use.
	Requirements for data related to maintenance, operations, and resource utilisation.	Supporting effective resource management and decision-making regarding their exploitation.
	Standards and procedures for collecting and processing information about resources.	
AIM	Geometric data, attributes, and technical properties of resources.	Enabling central storage and management of resource information.
	Information on maintenance, operations, and resource utilisation.	Supporting decisions regarding maintenance, modernisation, and resource management.
	History of changes and updates to resources.	
PIR	Detailed requirements for the data needed to implement the project.	Ensuring that all project teams have access to the necessary information that complies with organisational and project standards.
	Guidelines for 3D modelling, interbranch coordination, and data management.	Facilitating effective collaboration and coordination of activities within the project.
	Requirements for reporting and data reviews.	
EIR	The client's expectations regarding the scope, format, and quality of information provided by the contractors.	Ensuring that contractors provide information in accordance with the requirements of the contracting authority.
	Requirements for BIM standards, procedures, and tools.	Facilitating the client's monitoring and management of the project.
	Guidelines for reviewing and approving provided information.	

Source: own work based on ISO 19650.

In the CPK, in addition to the above-mentioned documentation, we also distinguish:

(A) – The document revision and versioning procedure. It is crucial for maintaining the accuracy and relevance of information in the CPK project. According to this procedure, every change in documentation must be meticulously tracked, versioned, and approved. This process ensures that all teams have access to the latest and verified information, minimising the risk of errors and misunderstandings.

(B) – The document naming and numbering procedure, which signifies standardised naming and numbering of documents, is essential for maintaining order and transparency in a large project like the CPK. This procedure defines clear rules for naming and numbering, facilitating identification, search, and documentation management. As a result, all teams can quickly and easily find the necessary information.

(C) – The GIS standard, a document aimed at describing the requirements of the GIS ordering party, in which the principles of creating GIS data, basic data formats (vector, raster, databases, attribute data, layer styles, map compositions), technical requirements, and rules for GIS data naming are specified. The standard is closely related to the OIR document, ensuring effective integration with BIM.

(D) – Other BIM documents and standards refer to documentation created dynamically with the increase in the number of projects in the airport and railway subprograms of the CPK. This is due to the stages and specificity of projects that cover all industries. The entire documentation is created by the central BIM team and reviewed by industry experts the company employs.

Each of the mentioned components plays a crucial role within BIM and GIS, providing the structure, standards, and procedures necessary for effective information management in construction projects. They ensure consistency, quality, and accessibility of data, which translates into the efficiency of project execution and management at every stage of the project lifecycle (Centralny Port Komunikacyjny, n.d.).

The possibilities offered by the integration of BIM and GIS in management methods

Integration of BIM and GIS in the CPK project brings numerous benefits, including improved planning, spatial analysis and data management (Sani & Abdul Rahman, 2018; Syed Mustorpha & Wan Mohd, 2019; Shi, 2024). The main aspects of this integration are detailed in the next subchapters.

Integrated spatial modelling

This concept integrates detailed BIM models with GIS data, allowing for a more precise and realistic representation of the built environment. This integration enables:

- Localisation and contextualisation of projects: BIM models can be embedded in real geographic locations, facilitating planning and analysis.
- Spatial analysis: Integration with GIS allows for advanced spatial analyses (such as the visual impact on the landscape, visibility analysis of the building from various key observation points, and hazard assessment) as well as environmental impact evaluation.
- Digital terrain models (DTM): These models enable detailed analysis and visualisation of the topography, supporting accurate spatial planning and natural resource management. They also facilitate the prediction of environmental hazards, such as floods or landslides, through terrain modelling and analysis of its properties.

Data management and collaboration

Integration of BIM and GIS supports better data management and collaboration between teams. Key elements include:

- Common data standards: These enable information exchange between different systems and tools, improving data efficiency and consistency.
- Data centralisation: All data is stored in a central repository, which facilitates accessibility and updates.

Using GIS in the operational phase

GIS also plays a crucial role in the operational phase of the CPK. Through integration with BIM, it enables:

– Monitoring and managing infrastructure: GIS allows for tracking the technical condition of buildings and infrastructure, which is essential for maintaining them in good condition using software such as ArcGIS or QGIS.
– Resource and operations management: GIS supports the management of resources such as energy, water, and waste, contributing to increased operational efficiency.

It is worth noting that preparations are underway for implementing AI to further enhance and expedite project management within the company. The task is being led by the co-author of this article, Karol Zawada, who serves as the BIM manager for projects in the airport subprogram. The plan involves integrating the CDE platform (Bentley ProjectWise), where all project documentation is stored, with Microsoft Power BI through a connector (Fig. 4). This integration will allow real-time monitoring of vast amounts of data, enabling trend observation, potential problem identification, carbon footprint management, and rapid decision-making.

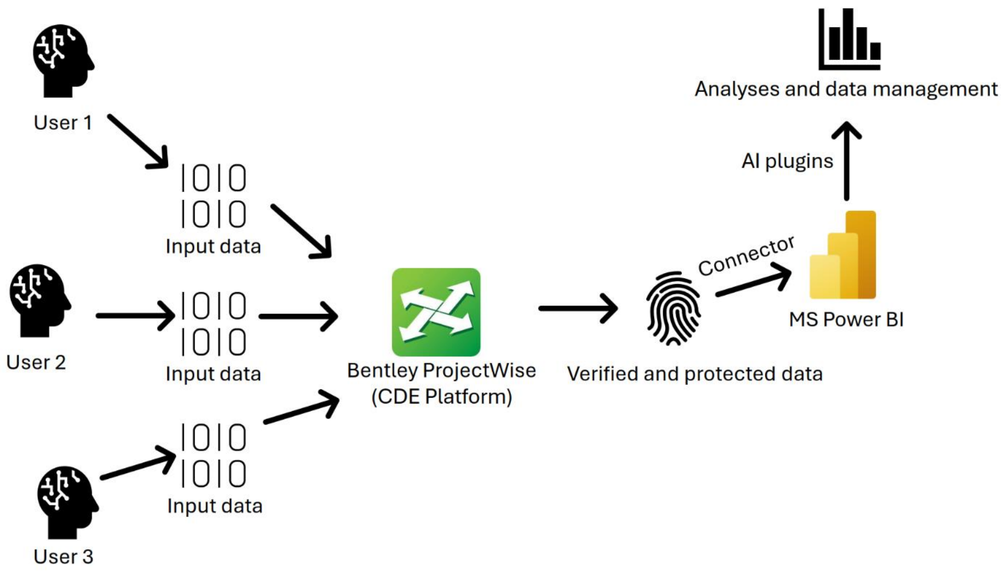

Fig. 4. Diagram of one of the future example strategies for implementing artificial intelligence in Central Communication Port (CPK) projects

Source: own work.

The implementation of AI in this context aims to automate data analysis and generate reports and forecasts, significantly increasing the efficiency of project teams. AI will, for example, predict delays, analyse costs and resources, and suggest optimal courses of action based on extensive data sets leveraging big data and data science. The system will also be able to recognise patterns in the data and propose adjustments to schedules and resource allocation, minimising the risk of errors and enhancing planning accuracy. With integration into Microsoft Power BI, data will be presented in the form of interactive dashboards, allowing managers quick access to key information. This solution has the potential to significantly improve transparency and communication within project teams, enabling better management at both strategic and operational levels (Chen et al., 2024; Starzyk et al., 2024).

The use of BIM methodology and integration with GIS in the CPK project brings numerous benefits, including improved planning, analysis, data management, and collaboration. Procedures related to information requirements, revision and versioning, as well as document naming and numbering provide a solid foundation for the effective implementation of these technologies. As a result, the CPK project has the potential to become a model for other large-scale infrastructure projects worldwide (Kurek, 2023).

DISCUSSION AND CONCLUSIONS

An important recommendation would be to establish a regulatory system and support mechanisms for smaller businesses, allowing them to develop the necessary expertise at every stage of managing and executing engineering projects, not just those on the scale of CPK. It is believed that the integration of BIM methodology, GIS, and AI, with particular attention to the Internet of Things (IoT) and big data, will provide opportunities for more organised and effective professional training programs tailored to new problems and challenges in the future. This will create an opportunity to align with contemporary standards, design norms, and legal requirements while also focusing on ecological and sustainable design and considering the positive impact on the environment. These aspects are characterised as positive outcomes resulting from the implementation of improvements in integrating new technologies. Despite the benefits, the study highlights several challenges that need to be addressed. These include the lack of standardised procedures for data exchange between BIM and GIS and the need for specialised training for team members. These barriers may hinder the full utilisation of both technologies in construction projects, and further research aimed at minimising these obstacles will be valuable across multiple dimensions and can undoubtedly be considered essential (Sun & Kim, 2022; Saleh, Elhendawi, Darwish & Farrell, 2024).

The establishment of a multi-layered BIM framework in the CPK project exemplifies the implementation of contemporary construction standards. Considering the ongoing revolution driven by AI development, the proposed system aims to address both the threats and opportunities presented by this technology. The article outlines the various stages of project creation and the procedures designed to ensure the most efficient communication while maintaining transparency in decision-making processes. The demonstrated action plan is based on a multi-level competency configuration that, on the one hand, ensures the feasibility of the project and, on the other, provides a clear sequence for decision-making. Despite the complexity of the procedure, its advantage lies in the clearly defined decision-making structure. Overall, the development of a BIM-based system for designing and managing the CPK project offers a chance to create a universal model for handling such large-scale projects. The procedures developed through extensive consultations can serve as a foundation for managerial activities in large projects at every planning and execution stage. The educational aspect is crucial here. Greater awareness of the usefulness of the BIM environment in engineering and business processes is needed, as it represents not only a tool but also an opportunity to create a comprehensive decision-making process. The detail of the developed operational model should not intimidate potential participants but rather reassure them of the system's preparedness for most eventualities that might arise during the management of a large project. Creating such multi-layered procedures for large projects requires imagination combined with the experience of the entire management team. Given that BIM spacial operations will be increasingly driven by the need for detailed and continuous decision-making in engineering projects, the creation of competent teams is essential, with CPK serving as a good example. Thus, a training system that includes not only senior management but also mid-level executive teams is necessary. Such training should encompass the entire decision-making group involved in the project, providing a chance to develop skilled personnel ready for the challenges of demanding and large-scale projects. Unfortunately, these needs also come with associated risks. Currently, the most pressing issue is the lack of knowledge due to insufficient education. Equally important are the high costs, which can pose a significant problem in the financial accounting of large projects. The shortage of competent high and mid-level managers necessitates specialised training, which remains limited and expensive. The cost of acquiring these competencies can be a significant barrier to large project plans and implementations. Moreover, access to technology also incurs substantial financial demands. The software required for BIM management at various competency levels and for project creation still involves considerable financing. For large and very large projects with state or global developer teams, this can be a factor due to the high "return on competency". However, challenges arise for small or medium--sized capital projects. If there is a continuity of contracts, investment in team training is feasible. Yet, for projects with less frequent repetition, such actions may be uneconomical, leading to fragmented solutions that rely on cheaper and older technologies.

The authors recommend implementing the statutory use of BIM methodology in public procurement. A nationwide BIM standard should be developed, closely based on the solutions and documentation established in the CPK, due to the scale and complexity of this project, which encompasses all possible industries. This will enable the effective and efficient use of BIM in projects. A prime example of unsuccessful BIM implementation in an infrastructure project commissioned by the General Directorate for National Roads and Motorways (*Generalna Dyrekcja Dróg Krajowych i Autostrad* – GDDKiA) is the Zator bypass. The project was delayed by several years due to discrepancies in the project documentation, poorly executed 3D models with many clashes, metadata deficiencies, and inconsistencies between the 2D and 3D documentation (Karolak et al., 2018; Poznańskie Inwestycje Miejskie, 2024). However, BIM methodology was successfully implemented in the Hinkley Point C Nuclear Power Plant project, in which the co-author of this article, Karol Zawada, participated for two years as a structural designer's assistant, modelling reinforced concrete structures in the HL2-03 building that surrounded the nuclear reactor. The 2D documentation was generated from the 3D model only after all clashes were resolved, ensuring the transparency and accuracy of the project data (Zawada, 2023).

The limitations of the study include the lack of specific examples regarding the use and integration of BIM and GIS in large-scale projects. This article serves as an introduction to a series of publications concerning projects that are part of the CPK. The authors plan to write a paper on the program concept of roads (*koncepcja programowa dróg* – KPD) for the CPK, where the engineering challenges related to these technologies, the flow of all project documentation, the software used, the configuration of the CDE platform, and many other aspects will be described in detail.

Authors' contributions

Conceptualisation: K.Z. and M.D. and A.G.; methodology: K.Z. and M.D.; validation: K.R.N. and A.G.; formal analysis: K.Z. and M.D. and K.R.N.; investigation: K.Z.; resources: K.Z. and A.G.; data curation: M.D.; writing – original draft preparation: K.Z. and M.D.; writing – review and editing: M.D. and K.R.N. and A.G.; visualisation: K.Z.; supervision: M.D. and K.R.N.; project administration: K.Z. and A.G.; funding acquisition: K.R.N.

All authors have read and agreed to the published version of the manuscript.

REFERENCES

Anger, A., Łaguna, P. & Zamara, B. (2021). *BIM dla managerów*. Warszawa: PWN.

Borkowski, A. S. & To Duc, A. (2024). Integration of BIM and GIS Data of a Heritage Building Using FME. *Civil and Environmental Engineering Reports*, *34* (2), 204–215. https://doi.org/10.59440/ceer/190231

British Standards Institution [BSI], (2018a). *Organization and Digitization of Information about Buildings and Civil Engineering Works, Including Building Information Modelling (BIM). Information Management Using Building Information Modelling Concepts and Principles* (BS EN ISO 19650-1:2018).

British Standards Institution [BSI], (2018b). *Organization and Digitization of Information about Buildings and Civil Engineering Works, Including Building Information Modelling (BIM). Information Management Using Building Information Modelling Delivery Phase of the Assets*. Vol. 2 (BS EN ISO 19650-2:2018).

British Standards Institution [BSI], (2020a). *Organization and Digitization of Information About Buildings and Civil Engineering Works, Including Building Information Modelling (BIM). Information Management Using Building Information Modelling*. Vol. 3 (BS EN ISO 19650-3:2020).

British Standards Institution [BSI], (2020b). *Organization and Digitization of Information about Buildings and Civil Engineering Works, Including Building Information Modelling (BIM). Information Management Using Building Information Modelling. Security-Minded Approach to Information Management.* Vol. 5 (BS EN ISO 19650-5:2020).

British Standards Institution [BSI], (2022). *Organization and Digitization of Information about Buildings and Civil Engineering Works, Including Building Information Modelling (BIM). Information Management Using Building Information Modelling Information Exchange.* Vol. 4 (BS EN ISO 19650-4:2022).

Centralny Port Komunikacyjny (n.d.). *BIM w CPK*. https://www.cpk.pl/pl/bim [accessed: 31.07.2024].

Chen, Z., Chen, L., Zhou, X., Huang, L., Sandanayake, M. & Yap, P-S. (2024). Recent Technological Advancements in BIM and LCA Integration for Sustainable Construction: A Review. *Sustainability*, *16* (3), 1340. https://doi.org/10.3390/su16031340

Godager, B., Mohn, K., Merschbrock, C., Klakegg, O. J. & Huang, L. (2022). Towards an improved framework for enterprise BIM: The role of ISO 19650. *Journal of Information Technology in Construction*, *27*, 1075–1103. https://doi.org/10.36680/j.itcon.2022.053

Karolak, M., Kasznia, D., Bohatkiewicz, J., Dudek, P., Gaweł, M., Magiera, J., Owerko, T., Rajchel, R., Salamak, M. & Wierzowiecki, P. (2018). Projekt pilotażowy zastosowania technologii BIM w GDDKiA przy projektowaniu i budowie obwodnicy Zatoru. *Autostrady*, *10*, 83–89.

Kasznia, D., Magiera, J. & Wierzowiecki, P. (2022). *BIM w praktyce: Standardy, wdrożenie, case study* (I-7 ed. reprint). Warszawa: Wydawnictwo Naukowe PWN.

Kurek, S. (2023, June 2). *BIM w Centralnym Porcie Komunikacyjnym*. Interview with Michał Latała. Builderpolska.pl.Retrieved from: https://builderpolska.pl/2023/06/02/bim-w-centralnym-porcie-komunikacyjnym [accessed: 31.07.2024].

Poznańskie Inwestycje Miejskie (2024). *Dokumentacja postępowania – postępowanie numer PIM/05/24/ZP20/2024-380*. Pim.poznan.pl. Retrieved from: https://pim.poznan.pl/dokumenty-zp/dokumentacja-postepowania-postepowanie-numer-pim0524zp202024-380?fbclid=IwY2xjawFlWT5leHRuA2FlbQIxMQABHf2YbeTKAvftNZI43Kb2wOVBI_mUg7kkktc92-rXVIRhoXTb3wL54Kdz_Q_aem_UDpIBA_BRMNUAfOqbOt5dw [accessed: 29.09.2024].

Saleh, F., Elhendawi, A., Darwish, A. S. & Farrell, P. (2024). A Framework for Leveraging the Incorporation of AI, BIM, and IoT to Achieve Smart Sustainable Cities. *Journal of Intelligent Systems and Internet of Things*, *11* (2), 75–84. https://doi.org/10.54216/JISIoT.110207

Sani, M. J. & Abdul Rahman, A. (2018). GIS and BIM integration at data level: a review. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-4/W9*, 299–306. https://doi.org/10.5194/isprs-archives-XLII-4-W9-299-2018

Shi, J. (2024). Construction and Application of Three-dimensional Information Management System for Intelligent Buildings Integrating BIM and GIS Technologies. *Scalable Computing: Practice and Experience*, *25* (4), 2985–3000. https://doi.org/10.12694/scpe.v25i4.2939

Starzyk, A., Rybak-Niedziółka, K., Nowysz, A., Marchwiński, J., Kozarzewska, A., Koszewska, J., Piętocha, A., Vietrova, P., Łacek, P., Donderewicz, M., Langie, K., Walasek, K., Zawada, K., Voronkova, I., Francke, B. & Podlasek, A. (2024). New Zero-Carbon Wooden Building Concepts: A Review of Selected Criteria. Energies, *17* (17), 4502. https://doi.org/10.3390/en17174502

Sun, H. & Kim, I. (2022). Applying ai technology to recognize BIM objects and visible properties for achieving automated code compliance checking. *Journal of Civil Engineering and Management*, *28* (6), 497–508. https://doi.org/10.3846/jcem.2022.16994

Sunny, M. A. U. (2024). Unveiling spatial insights: Navigating the parameters of dynamic Geographic Information Systems (GIS) analysis. *International Journal of Science and Research Archive*, *11* (2), 1976–1985. https://doi.org/10.30574/ijsra.2024.11.2.0690

Syed Mustorpha, S. N. A. & Wan Mohd, W. M. N. (2019). A BIM oriented model to a 3D indoor GIS for space management – a requirement analysis. *IOP Conference Series: Earth and Environmental Science*, *385* (1), 012046. https://doi.org/10.1088/1755-1315/385/1/012046

Uchwała Nr 201 Rady Ministrów z dnia 24 października 2023 r. w sprawie ustanowienia programu wieloletniego – Program inwestycyjny Centralny Port Komunikacyjny. Etap II. 2024–2030. M.P. 2023 poz. 1258.

Wang, H., Pan, Y. & Luo, X. (2019). Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis. *Automation in Construction*, *103*, 41–52. https://doi.org/10.1016/j.autcon.2019.03.005

Zawada, K. (2023). Informatyzacja branż AEC przy zastosowaniu metodologii BIM, w oparciu o ISO 19650 z uwzględnieniem VR, AR, VDC oraz środowiska CDE. Szkoła Główna Gospodarstwa Wiejskiego, Warszawa [MSc thesis].

Zawada, K., Rybak-Niedziółka, K., Donderewicz, M. & Starzyk, A. (2024). Digitization of AEC Industries Based on BIM and 4.0 Technologies. *Buildings*, *14* (5), 1350. https://doi.org/10.3390/buildings14051350

WPŁYW BIM ORAZ GIS NA EFEKTYWNOŚĆ REALIZACJI PRZEDSIĘWZIĘĆ BUDOWLANYCH

STRESZCZENIE

Integracja modelowania informacji o budynku (BIM) oraz systemów informacji geograficznej (GIS) odgrywają kluczową rolę we współczesnej inżynierii lądowej, gdyż poprawiają efektywność realizacji projektów budowlanych. W artykule skupiono się na konkretnych aspektach tej integracji, takich jak: zarządzanie danymi przestrzennymi i inżynieryjnymi, analiza przestrzenna oraz optymalizacja procesów budowlanych. Na przykładzie Centralnego Portu Komunikacyjnego (CPK) w Polsce przedstawiono, jak BIM umożliwia szczegółowe cyfrowe odwzorowanie cech fizycznych obiektów budowlanych, co jest wykorzystywane w planowaniu i zarządzaniu przedsięwzięciami budowlanymi, a GIS zapewnia narzędzia do zaawansowanych analiz przestrzennych i środowiskowych. Integracja obu technologii pozwala na precyzyjną reprezentację kontekstu przestrzennego, usprawnia zarządzanie zasobami, redukuje koszty i ryzyko budowlane oraz wspiera współpracę międzybranżową na różnych etapach projektu. W artykule omówiono również wyzwania związane z wykorzystaniem BIS i GIS, m.in. brak ustandaryzowanych procedur BIM oraz konieczność szkoleń specjalistycznych niezbędnych do zdobycia wiedzy umożliwiającej pełne wykorzystanie potencjału obu technologii. Celem pracy jest analiza wpływu integracji BIM i GIS na zarządzanie przedsięwzięciami budowlanymi z uwzględnieniem procesów zarządzania danymi i analiz przestrzennych.

Słowa kluczowe: BIM, GIS, Centralny Port Komunikacyjny, AI