http://doi.org/10.35784/iapgos.4261

received: 16.07.2023 | revised: 19.08.2023 | accepted: 22.10.2023 | available online: 20.12.2023

USE OF THE CDE ENVIRONMENT IN TEAM COLLABORATION IN BIM

Andrzej Szymon Borkowski, Jakub Brożyna, Joanna Litwin, Weronika Rączka, Aleksandra Szponarowicz

Warsaw University of Technology, Faculty of Geodesy and Cartography, Warsaw, Poland

Abstract. *In project processes, group collaboration and project documentation management are important aspects. In order for the cooperation of all project participants to be effective, it should be based first and foremost on adequate and effective communication. All project participants should use such solutions so that they can exchange, manage and combine information quickly and efficiently throughout the entire investment process, thus providing a complete picture of the situation. To this end, it is necessary to develop a catalogue of good practices supported by a variety of examples, as well as rules for group cooperation when using a CDE-type solution. The aim of this article was to show the advantages and benefits as well as the disadvantages and limitations in group collaboration when working on a single BIM model.*

Keywords: BIM, building information modelling, CDE, common data environment, team collaboration

WYKORZYSTANIE PLATFORMY CDE WE WSPÓŁPRACY ZESPOŁOWEJ W BIM

Streszczenie. *W procesach projektowych ważny aspekt stanowi współpraca grupowa oraz zarządzanie dokumentacją projektową. Aby współpraca wszystkich uczestników projektu była efektywna, powinna opierać się przede wszystkim na odpowiedniej i efektywnej komunikacji. Wszyscy uczestnicy projektu powinni używać takich rozwiązań, aby przez cały proces inwestycyjny mogli szybko i sprawnie wymieniać się informacjami, zarządzać nimi i łączyć je ze sobą, dostarczając w ten sposób kompletny obraz danej sytuacji. W tym celu konieczne jest opracowanie katalogu dobrych praktyk podpartych różnorodnymi przykładami oraz zasad współpracy grupowej przy stosowaniu rozwiązań typu CDE. Celem artykułu było pokazanie zalet i korzyści oraz wad i ograniczeń we współpracy grupowej podczas pracy na jednym modelu BIM.*

Słowa kluczowe: BIM, modelowanie informacji o budynku, CDE, wspólne środowisko danych, współpraca grupowa

Introduction

BIM (Building Information Modelling) is no longer new to the AEC (Architecture, Engineering, Construction) industry. With the rapid development of BIM, it has become apparent that the problem is not the use of BIM software that can be mastered, but collaboration between designers or trades [12]. Researchers and computer scientists have developed virtual and physical collaboration platforms for AEC and FM (Facility Management). Improved communication through the use of wireless and cloud technologies has been identified as an important factor in maintaining the quality of this collaboration. Interoperability and online storage of models is already widely used in BIM [11]. Holzer, in his 2014 reflections, notes that practitioners are well aware that the quality of BIM itself depends on a deeper understanding of the building construction process. There is a danger associated with the use of BIM by inexperienced designers, which can imply inefficiencies in the design process as well as in project delivery [4]. In addition to familiarity with BIM technology, it is crucial to develop critical thinking skills, openness and attentiveness to innovation, the ability to adapt to rapidly changing environments and to communicate and manage information efficiently within a multidisciplinary team. BIM, with the development of the software, has become a symbol of collaboration, but the adversarial nature of corporate branding and market dominance has led to a plethora of mutually incompatible BIM offering [18].

Let the multitude of problems (integration with GIS (Geographic Information System), macro to micro modelling of objects, insufficient interoperability, etc.) faced by researchers, computer scientists and practitioners [15] attest to how difficult group collaboration is. Designers use various workarounds to solve the problems because BIM is evolving all the time and the development of technology has not kept pace with the development of the methodology [5]. At this point, it is important to clarify what BIM is and what it is not. BIM is not software. BIM is not Revit, as some people claim. The BIM process is not about building stunning 3D models that will ultimately culminate in photorealistic exciting visualizations. BIM is a 'process' that completely changes the status quo in the construction industry. A new paradigm is emerging: BIM is a new way of organizing work throughout the construction project process. A BIM model is a collection of knowledge and information about a construction object that forms the basis for decision-making throughout the life cycle of that object. Eastman and his group define it as follows: Building Information Modelling (BIM) is a collaborative way of storing, sharing, exchanging and managing multidisciplinary information throughout the lifecycle of a construction project, including the planning, design, construction, operation, maintenance and demolition phases [3]. Eastman has repeatedly emphasized that BIM is about activity undertaken by people, not a model built by people. BIM is variously defined and understood by both established organizations and many researchers. According to the authors, BIM can be considered from two perspectives – a broader one and a narrower one. BIM *sensu largo* is a process based on the collaboration of people, IT systems, databases and software. In a much broader perspective, it can also include hardware, tangible and intangible resources or knowledge. BIM *sensu stricto* is the relational database of a building object accompanying it throughout its life cycle.

Project work in a group should be based on communication – unfortunately equipment often fails or problems arise at other levels. Many times a single channel of communication is not enough to exchange information - it is important to bear in mind that reporting problems and trying to resolve them can be done using traditional communication channels e.g. email, chat, instant messaging or telephone contact. However, in a mature level two BIM approach (according to the Bew-Richards wedge), one works using the CDE (Common Data Environment) platform, which should be the only communication channel [17].

1. Structure of the Common Data Environment

The CDE platform is a tool that specifically influences the collaboration of all those involved in a project. It acts as a virtual place where the exchange of information about a construction project takes place. They include not only the BIM model and the elements created in this environment, but also documentation, graphic resources and various components collected during the design process [9]. Using one common source of information and updating it systematically improves collaboration and reduces errors, and duplication. This is crucial for project delivery, collaboration efficiency, model hygiene and work culture. Conduct within the use of the BIM environment is structured by the ISO 19650 standard, which consists of six parts (four of which are published). It defines a unified framework for the collaborative and effective management of a facility throughout its life cycle. Importantly, there is freedom to create your own requirements as to ISO 19650 and CDE, an example being the Victorian Digital Asset Strategy (VDAS) in Victoria [10].

The operation of the CDE platform is concentrated in the four working areas [8] shown in the diagram (figure 1).

From the point of view of the owner and the implementation of a CDE project, the control functions are strengthened and this ultimately has the effect of reducing costs, increasing quality (while maintaining all necessary parameters) and reducing time delays [12]. The CDE environment allows information to be collected from a wide range of industries involved in the design, implementation, and subsequent use, these include architectural, structural, building, infrastructure, landscape, electrical or plumbing data.

One example of multi-discipline collaboration is the Pan Borneo Highway project, which connects two states: Malaysia, Sabah and Sarawak, with Brunei and the Kalimantan Region in Indonesia [1]. In the course of this implementation, it was crucial to provide a suitable workspace for engineers or entrepreneurs dispersed around the world. This meant, among other things, integrating various data, files and knowledge, as well as optimizing costs and working times, which were important for such a large investment Implementing a CDE for infrastructure projects provides a measurable return on investment (ROI), such as saving time for searching, validation and accessing project information.

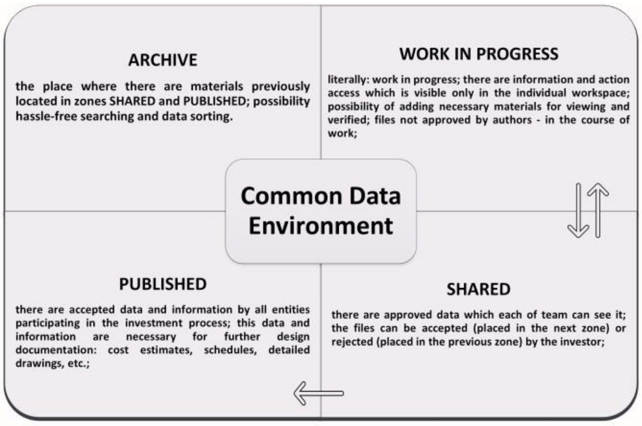

Fig. 1. Diagram illustrating the functioning of the data sharing environment (CDE) structure

2. The practical implementation of CDE

The CDE platform plays a key role in the management of information and documentation in BIM-based projects, which contributes to a more efficient flow of data between project participants. In practice, CDE platforms, such as Bentley ProjectWise or Autodesk BIM 360, support the delivery of diverse construction and engineering projects by enabling the centralization of data and resources and close collaboration across trades. Group collaboration enables a project team to work continuously using one common model (not necessarily one file). Effective group collaboration is not only about software that allows people to work on the same project, but also about properly defining the standards, stages, goals and ways of this collaboration [6]. Examples of the use of the CDE platform include the Crossrail project (Elizabeth Line) in the UK. However, the CDE platform can also have a more common application, which is its use in smaller-scale projects, such as the development of residential structures or construction projects requiring extensive interprofessional collaboration.

Crossrail (Elizabeth Line) represents one of the largest construction projects in Europe, which aimed to meet London's future transport needs and support the UK's continued economic growth. The project involved the construction of 118 km of rail line, including 21 km through tunnels under central London, leading to Shenfield and Abbey Wood in the east. The complexity of this project required the use of an integrated design environment to enable the project to be delivered. The company behind the Crossrail project has created an intelligent 3D model with linked databases managing the associated design data, meaning the project is largely compliant with the UK GCS BIM Level 2 requirements set out in 2016. The Government Construction Strategy (GCS) is the BIM technology implementation strategy implemented by the UK government. It shows that all government projects drawn up after 2016 require the use of BIM technology at maturity level two, which is based on collaboration between project teams, the sharing of information in both 2D and 3D formats, and the use of a common data environment – the CDE – to manage project documentation. The CDE-based working model has contributed to improved management and increased project quality through the use of the 3D model. The creation of a consistent and complete 'as-built' BIM model has also helped to maximize the benefits, as it has been handed over to the railway operator, who can carry out inspections and maintenance based on it [14].

3. The challenges encountered in collaborative work on a shared model

Group collaboration on a single model is intended as a response to common problems encountered during the 'traditional' design process. Such challenges include: lack of ongoing updating of the model, which results in designing based on outdated data and, consequently, the need to repeat the completed work. Lack of workflow – this is particularly significant when multi-discipline teams are working together, where a minor modification to the design of one trade can make the design of another trade immensely easier or provide the opportunity to introduce a much more efficient solution. Other challenges are the loss of information and the need to recreate it, which can lead to errors and discrepancies, the difficult use of the results of other team members' work, resulting in designers from different branches having to enter the same data multiple times. The last and greatest challenge in group collaboration, reduced by group collaboration on a single model, are problems in the coordination of the model, design, collision or quantity statements, which can carry the uncertainty of generating up-to-date design documentation when they need to be delivered to the construction of drawings while still in the design process [6].

Group work on a single model is intended to improve the efficiency of collaboration between project participants and the quality of the final product. In the context of information management and data exchange within the CDE, it solves one of the major challenges of keeping project documentation consistent and up-to-date. In the case of the implementation of construction projects, such as roads or residential buildings, it is important to adapt the standards and formats of data exchange to the specifics of the local construction market, which may require government intervention to standardize this environment. For example, in the Czech Republic, where road projects are subject to a complex legislative system, frequently changing regulations and a complex decision-making structure of local authorities, a properly defined CDE environment can contribute to making projects more resilient to changes in the external environment [13].

4. Georeferencing of the BIM model

The correct positioning of the BIM model in GIS space enables reliable analyses and simulations. The integration of BIM and GIS is an important technological and scientific trend [2]. In the near future, it can be seen as one of the biggest challenges for the construction industry, in order to use the vast amount of data more efficiently and achieve synergies. Integration can be considered at the application, process and data level. From the project team's point of view, integration at the application level is the easiest. Typically, users of BIM modelling software look for specific functionality in the application that allows them to import GIS data. Unfortunately, in many cases such functionalities are either not present at all or are limited to only loading web map services (Web Map Service).

Many popular BIM software packages have certain limitations when working with GIS data. These limitations often affect or prevent the georeferencing of BIM models. The Autodesk Revit application has a maximum distance limit from its internal datum of 10 miles (over 16 kilometers). Once this limit is exceeded, the graphical representation of the components used becomes less reliable and less accurate. This limitation applies to geometry directly created in Autodesk Revit, as well as geometry derived from an import or link. As databases, city models and planning tools are developed in GIS-enabled software such as ArcGIS or QGIS, they are often geographically referenced and located very far from the origin of the BIM models. Directly importing this information, or entering the coordinates manually into Autodesk Revit, often results in a 'Geometry in file is greater than 10 miles (16 km)' error. So the workspace is limited in both directions – a total of 20 miles (more than 32 km), and the designer must otherwise establish the coordinates of the survey point (x,y,z) and give the appropriate GIS coordinate system.

The .rvt project file with fixed X,Y,Z coordinates of the base point should be loaded in ESRI ArcGIS Pro, which supports both GIS and BIM data. Pre-connecting the ESRI ArcGIS GeoBIM service with Autodesk Construction Cloud Services will provide the ability to directly load BIM data into a local or global scene in GIS. To geo-reference the BIM model, load any GIS reference data in the desired coordinate system (e.g. 2000 lane 7 system), then load the BIM model and move it to the anticipated location. Once the coordinate system is correctly assigned, the .rvt file receives two additional companion files with extensions .prj and .wld3. The .prj file is a text file containing information defining the coordinate system, data and map projection. A projection file with the same name as the BIM or CAD file is used to define the coordinate system of this file (<filename>.prj). The .prj file is sometimes referred to as a universal projection file. The .wld3 file, on the other hand, is often referred to as the 'world file' (world file). Using this file to store control points is a best practice for sharing and reusing links in other projects and map documents. ArcGIS Pro uses the file name and its location to associate the .wld3 file with a specific CAD dataset or BIM model (.rvt or .ifc). This file is similar to a world file, but contains coordinates so that the file can be placed in the correct x,y,z location. Correct geo-referencing of the BIM model enables it to be further used by the designer to produce their model or disseminated more widely e.g. to tradesmen. This then facilitates the federation (together) of industry models into a whole. Team members' access to the CDE provides access to the model files with the correct geo-referencing.

5. Object of research

The subject of the study was a BIM model of a two-story building with an office function (figure 2). The building was surrounded on all sides by paved surfaces in the form of a car park (figure 3). The ground floor comprised rooms such as a storage room, three bathrooms, an office and a conference room. The rooms comprising the first floor included an office, two bathrooms and a rest room. Space was also designated for a lift and a staircase. The first floor was laid out with a corridor providing access to each room. The main intention of the project was to test the CDE platform by converting/adapting the aforementioned office function of the building into residential, while at the same time increasing the biologically active area of the surrounding space. It is worth mentioning that the work was carried out on a previously provided finished model. All modifications and tests of the functioning of the CDE environment were experimental and carried out in a controlled environment.

Fig. 2. Office building

Fig. 3. Office building with immediate surroundings

6. Group cooperation on a central model

In the case study presented here, the main focus of the group collaboration on the central model was to change the function of the site from office to residential. To this end, the interior of the building and its surroundings were redesigned to meet the requirements of the newly assigned function. The scope of work included, among other things, changing the site's surface and landscaping, as well as adapting the building by modifying the layout and interior finishes. Two teams of three people worked on the project simultaneously: one team worked on the interior of the building and the other on the exterior. In the CDE environment, each user used a local version of the model, which was a 'branch' of the central model. Therefore, during the process of updating the model, version continuity is maintained and, as a result of combining data from both models, the new version shows the changes made. Such a solution streamlines the work by reducing the need to send the updated files to the other team members themselves and reducing the risk of data inconsistency [16].

Nevertheless, some difficulties were encountered during the collaboration. During the project, each team member worked on a local copy of the central model and uploaded their changes to the central model. However, the synchronization process was not performed automatically in real time, so after each work step, a two-step synchronization had to be performed manually by clicking on two different synchronization icons in the BIM design software and then publishing the changes made. The synchronized model did not immediately appear to the other users. For this reason, they had to update their model first by selecting the icon to reload the latest changes in order to see the effects of the other team members' work (figures 4 and 5). Such asynchronous working has its strengths and weaknesses.

Fig. 4. View of the synchronized model from the user making the changes

Fig. 5. View of the non-synchronized model from the non-synchronized user level

When making changes, it proved convenient for this type of collaboration to be able to use components uploaded to the project by other users. As a result, project consistency was easily maintained without having to send separate family files to each other. In addition, the option to modify changes made to the project by other users also optimized and accelerated the work. This made it possible, for example, to move furniture inserted by another user without having to send an edit request for the object in question.

7. The importance of CDE for group and interprofessional cooperation

The CDE platform is extremely important as it enables collaborative projects involving multiple designers, managers, investors and others involved in a project or development. The simultaneous, coordinated work of many people on a single model increases the efficiency of the BIM process, amplifying the benefits provided by building information modelling technology. Another advantage is the ability to enrich the model with user-added elements such as families. This makes the process of modifying objects more efficient, which, moreover, can also be edited by other users.

However, the use of the platform requires the observance of certain precautions. The CDE system provides a tool for coordinating work and sharing results easily. However, it is not a technology that allows simultaneous, real-time modifications to a single model file by several users. This therefore imposes the need for mutual time synchronization. In addition, a slightly cumbersome aspect of working with the platform is the need to approve changes by double synchronization of local files with the central model each time, resulting from the method of functioning of the Revit application tools designed for this purpose. Some problems with the transparency of the system were also identified, which relate to the system of informing the user about the validity of particular file versions. This is because newly introduced changes are not always marked as new versions of the project.

Fig. 6. Visualization of the external adaptation of the site for new functions

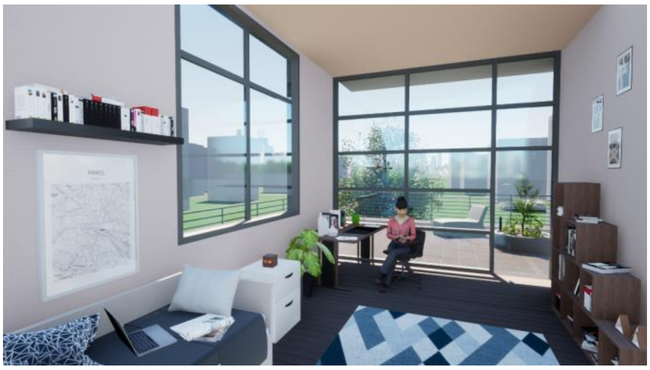

Fig. 7. Visualization of the interior after rearrangement for new functions

The visualizations produced (figures 6 and 7), showing the end result of the group collaboration on the model. By using the CDE platform, it was possible to achieve the main objective, the transformation of the original function of the building to residential. The coordinated collaboration between the different teams provided a practical demonstration of how the platform works. Group and interprofessional collaboration can be fraught, however, with risks due to a lack of communication and adherence to commonly agreed rules. Lack of these factors can result in duplicate content, working on erroneous files or failing to develop common and mutually acceptable solutions. The effectiveness and efficiency of using the CDE platform can be achieved by following basic rules such as: updating uploaded data systematically, using it as the only place to collect all content, from drawings to emails, which should only be corresponded to here. An important aspect is to assign specific roles to all those involved in the design process and give them the appropriate permissions in moving and operating within the CDE environment [9]. In summary: one of the most influential criteria when implementing CDE is data security and, on the other hand, the biggest obstacle to its use is the lack of collaboration between users and the lack of discipline [7].

8. Discussion

The use of the CDE platform in the management of construction and engineering projects brings numerous benefits that streamline the design and collaboration processes between the various project participants. It is a not inconsiderable improvement that represents a step towards completely moving all project phases to BIM technology. The use of the CDE platform meets the definition of BIM maturity at level 2 according to the Bew-Richards wedge (PAS 1192-2:2013). However, despite this huge pool of applications, the use of the CDE platform has both benefits and drawbacks.

In terms of the spatial localization of a project, ArcGIS GeoBIM enables it to be precisely located in a geographic information system (GIS), allowing spatial aspects to be analyzed and taken into account in project planning and implementation.

One of the key strengths of the CDE platform is the ability to modify changes made by other users, enabling dynamic collaboration and efficient management of different versions of documents and models. In addition, the system allows the use of families loaded into the project by other users, which provides access to updated components and speeds up the process of creating models.

Another key aspect of the CDE platform is the interoperability of .IFC files, which allows data to be exchanged between different applications and project management systems, regardless of the software used. This facilitates collaboration between specialists from different disciplines and increases the efficiency of project processes. The ability to view IFC files in free browsers also promotes the efficiency of the project team. In this way, all project participants, even those who do not have access to full versions of specialized tools, can verify and analyze models and adapt their activities to the current project requirements. As a result, the CDE platform provides an environment that fosters effective and flexible collaboration between teams and enhances the quality of projects (figure 8).

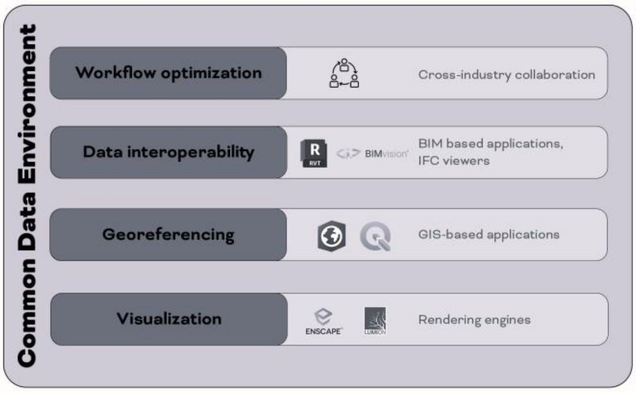

Fig. 8. Diagram showing the functionalities of the CDE platform

Despite the numerous advantages of the CDE platform, there are also some drawbacks that can affect the efficiency of collaboration and project delivery times. First and foremost, the need to work twice (message when synchronizing local files with the central model in Revit can be cumbersome and time-consuming for users. In addition, the software does not always recognize changes made as a new version of the project, which can lead to ambiguity in marking and tracking progress. The insufficient precision of the project location, given by address, compared to geographical coordinates, can make it difficult to accurately represent the project on the map in the Project Home tab. Collaboration in CDE can also be limited by the inability of several people to make changes at the same time, which affects the dynamics of project processes. In addition, the displayed changes only become visible after the project is closed and reopened, which can contribute to a delay in communication between project participants. Furthermore, when performing visualization with the Datasmith add-on in Twinmotion and visualization with Enscape, users may encounter problems with downloading and working on a model that is not available, as well as simplified solids of certain types of objects such as trees.

In terms of working with the .IFC format, familiarity with translators and IFC model building is required, which can be a barrier for some users. Standard import and export settings can lead to problems opening files, and the results of conversion to IFC can be asymmetrical in Archicad and Revit, causing unresolvable problems in one of these applications. Finally, the large file size of the .IFC format can be a limitation on the performance of systems and the transfer of data between users.

9. Conclusion

In summary, the CDE platform brings significant value to the management of construction and engineering projects, streamlining design processes and collaboration between participants. However, despite its numerous advantages, there are some limitations associated with the use of the platform, such as inefficient synchronization, ambiguity of designations or knowledge requirements on open data exchange standards. Nevertheless, the use of CDE is an important step towards the full application of BIM and the potential reduction of the risk of errors through more effective collaboration. In order to take full advantage of the CDE platform, its limitations must be taken into account and collaboration methods must be systematically improved to optimize the efficiency of construction and engineering projects.

References

[1] Akob Z. et al.: Coordination and Collaboration of Information for Pan Borneo Highway (Sarawak) via Common Data Environment (CDE). IOP Conference Series: Materials Science and Engineering, 2019, 12001.
[2] Borkowski A. Sz. et al.: Przegląd dotychczasowych rozwiązań na poziomie aplikacyjnym w zakresie integracji technologii BIM i GIS. Builder 305(12), 2022, 64–69.
[3] Eastman C. M. et al.: BIM handbook: A guide to building information modelling for owners, managers, designers, engineers and contractors. John Wiley & Sons, 2011.
[4] Holzer D.: BIM and parametric design as game changers. 19th International Conference on Computer Aided Architectural Design Research in Asia CAADRIA 2014, 379–388. 2014.
[5] Holzer D.: The BIM Manager's Handbook: Guidance for Professionals in Architecture, Engineering, and Construction. John Wiley & Sons, 2016.
[6] Kasznia D. et al.: BIM w praktyce – standardy – wdrożenie – case study. Wydawnictwo Naukowe PWN, Warszawa 2018.
[7] Lestari S. et al.: Application of common data environment (CDE) as a method of design review in construction project. Journal of Engineering Design and Technology 22(2), 2022, 103–109.
[8] Losev K. Yu.: The common data environment features from the building life cycle perspective. IOP Conference Series: Materials Science and Engineering, 2020, 42012.
[9] McPartland R.: What is the Common Data Environment (CDE)? Cooperate Website NBS for Specifiers, 2016 [https://www.thenbs.com/knowledge/what-is-the-common-data-environment-cde?fbclid=IwAR0jAXE6wF3pZ2PxKZ_3ct-oeZXBXOFeBOOFe7rUdsr1VmAhZXaH4nhnRD8].
[10] McPherson M.: The Ultimate Guide to the Common Data Environment (CDE) in 2023. 12d Synergy, 2022 [https://www.12dsynergy.com/common-data-environment-guide/?fbclid=IwAR0jyvJKXqkhubA22fvwI6wGFoVd3qpdVdaS-eIgpAePIVRAGFBie84bNB0].
[11] Park J. H., Nagakura T.: A Thousand BIM: A Rapid Value-Simulation Approach to Developing a BIM Tool for Supporting Collaboration during Schematic Design. International Journal of Architectural Computing 12(1), 2014, 47–60 [http://doi.org/10.1260/1478-0771.12.1.47].
[12] Race S.: BIM Demystified. RIBA Publishing, 2013.
[13] Radl J., Kaiser J.: Benefits of Implementation of Common Data Environment (CDE) into Construction Projects. IOP Conference Series: Materials Science and Engineering 471(2), 2019.
[14] Smith S.: Building information modelling – moving Crossrail, UK, forward. Management, Procurement and Law 167(3), 2014, 141–151 [http://doi.org/10.1680/mpal.13.00024].
[15] Song Y. et al.: Trends and Opportunities of BIM-GIS Integration in the Architecture, Engineering and Construction Industry: A Review from a Spatio-Temporal Statistical Perspective. ISPRS International Journal of Geo-Information 6(12), 2017, 397 [http://doi.org/10.3390/ijgi6120397].
[16] Tao X., et al.: Smart contract swarm and multi-branch structure for secure and efficient BIM versioning in blockchain-aided common data environment. Computers in Industry 149, 2023, 1–2 [http://doi.org/10.1016/j.compind.2023.103922].
[17] Vlasák P., Čerbák B.: BIM, structural analysis and communication using common data environment (CDE) in the field of water management. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2019, 93–94.
[18] Wierzbicki M. et al.: BIM - history and trends. CONVR2011– International Conference on Construction Applications of Virtual Reality, 2011.
[19] PAS 1192-2:2013; Specification for information management for the capital/delivery phase of construction projects using building information modelling; The British Standards Institution 2013, vii-viii.

Ph.D. Eng. Andrzej Szymon Borkowski
e-mail: Andrzej.borkowski@pw.edu.pl

Graduate of the Faculty of Geodesy and Cartography (Spatial Management) at the Warsaw University of Technology. Since 2019, he has been employed as an assistant professor. He specializes in BIM technology and its holistic use in urban planning. He conducts empirical and theoretical research in BIM applications in engineering design. Author of two books, co-author of 3 monographs and dozens of scientific articles.

http://orcid.org/0000-0002-7013-670X

Eng. Jakub Brożyna
e-mail: jakub.brozyna2@gmail.com

Graduate of Bachelor of Science in Engineering (diploma with honors) at the faculty of Geodesy and Cartography (Spatial Management) at the Warsaw University of Technology. Currently student at Master's program in Spatial Management at Warsaw University of Technology. Co-author of the poster at the 10th Ogólnopolska Konferencja Młodych Badaczy (Jagiellonian University) in Cracow, Poland.

http://orcid.org/0009-0006-7302-1197

Eng. Joanna Litwin
e-mail: asialitwin@onet.eu

Graduate of Bachelor of Science in Engineering in Spatial Management with a specialization in Urban Planning at the Faculty of Geodesy and Cartography, Warsaw University of Technology. Currently a MA student in the same course of study. Holder of a DAAD (German Academic Exchange Service) scholarship.

http://orcid.org/0009-0007-3896-2001

Eng. Weronika Rączka
e-mail: weronika.r@onet.pl

Graduate of the Faculty of Geodesy and Cartography (Spatial Management) at the Warsaw University of Technology. She designs fiber optic networks and she is interested in researching BIM technology in engineering design.

http://orcid.org/0009-0003-7294-6372

Aleksandra Szponarowicz
e-mail: aleksandra.szpnarowicz@gmail.com

A student of the Spatial Planning Bachelor of Engineering Course at Warsaw University of Technology with a specialization in Environmental Conditions in Spatial Planning.

http://orcid.org/0009-0009-2308-1839