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**Research paper**

# BIM model for the operational phase based on available documentation

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**Abstract:** For several years, there has been an intensification of using BIM (Building Information Modeling) technology in the design and construction phases of building projects. However, it is rare to come across data regarding the implementation and subsequent verification of the utilization of BIM's capabilities in the longest phase of a building's life cycle – the operational phase. Currently, various property management systems and methods are applied during the operational phase of volumetric construction. However, these are often systems dedicated to specific types of activities (e.g., invoicing, electronic documentation approval), often requiring a significant amount of manual work. Additionally, current practices do not integrate the systems in use, and manual processing results in the manager receiving scattered and unformatted data that is difficult to use in daily operations. The aim of this article is to present the potential benefits of implementing BIM technology during the operational phase of a facility. The article outlines the possibilities of using the information introduced into the BIM model during the operational phase of a building. It also presents a proposed approach for creating a BIM model for the operational phase. In a subsequent article, the authors will focus on presenting an example of its implementation.

**Keywords:** building information modelling (BIM), maintenance, facility management, operation phase, data exchange, digital twin

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# 1. Introduction

The operation and maintenance phase is the longest phase in the life cycle of buildings. Therefore, it is essential to take conscious actions related to activities that enable the building to be used for as long as possible in the best possible condition while minimizing maintenance costs. The operation of buildings [1] involves a series of activities that allow for the systematic collection of data concerning the technical and functional condition of the facility. These activities are typically planned and coordinated by the owner or property manager. The property manager is responsible for tasks such as regularly updating the Building Log Book (BLB) and ensuring that ongoing repairs and maintenance are carried out within the facility [2]. However, these actions have traditionally required significant involvement from the property manager, who must monitor the facility's condition, oversee regular inspections of structures and installations, verify warranties for individual equipment, plan actions related to necessary ongoing repairs, gather information on user reports of any irregularities and faults in the facility. Additionally, these activities necessitate the creation of a substantial amount of documentation, both in paper and electronic form, in the form of protocols, notes, and photographic documentation. They also require effective scheduling of maintenance and operational tasks. Therefore, it is worthwhile to seek solutions that streamline and reduce the number of actions required for the proper, long-term operation of facilities [2].

For over a decade, we have witnessed a pronounced surge in technological advancements within the construction industry. An array of methods and tools aimed at facilitating various facets of the construction sector has emerged. This period has seen marked growth in the construction materials market, advancements in construction technologies through increased automation of tasks, as well as the digitization of the entire construction process. Commencing with the creation of electronic documentation for planned construction projects, submission of building permit applications through online platforms, and subsequently managing construction activities through electronic construction diaries, the process has been progressively digitized. Furthermore, digitalization has extended into successive phases of the building lifecycle [2–4] exemplified by the introduction of electronic Building Log Book (BLB). Moreover, in recent years, the development of software for designing and managing the construction process has catalyzed a revolution in the construction industry. The creation of Building Information Models (BIM) for designed structures has substantially expedited the execution of construction investments [5]. The evolution of BIM technology has ushered in vast opportunities within the hitherto less digitized construction sector. Presently, thanks to the modeling of building information, it is feasible to devise various scenarios, encompassing design, implementation, operational, and even dismantling phases [6, 7]. It is conceivable to input comprehensive information pertaining to a structure, foster cross-industry integration, enhance on-site monitoring during construction, and fortify subsequent phases of the lifecycle.

Moreover, in recent years, there has been an upsurge in scholarly literature exploring the capabilities and potential applications of BIM technology, predominantly concentrating on the design and execution phases of investments. However, there is a dearth of publications that illuminate the extensive potential of employing BIM technology in the latter stages of a building's lifecycle – a focal point of the authors in this article.

The article will outline the advantages and disadvantages of implementing BIM in the operational phase of buildings, while in the subsequent article, the authors will present the challenges of its implementation using a selected example (Fig. 1, Fig. 2).

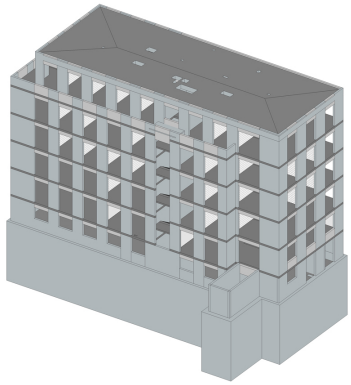


Fig. 1. Axonometry of the BIM model of the D3 building

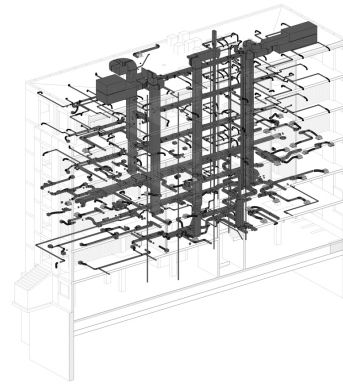


Fig. 2. BIM model of the existing AGH building – D3 – ventilations

## 2. Property management requirements

Objects constructed with building permits mostly require the continuation of current documentation during the operational phase. A significant exception to this rule is single-family homes, which, despite requiring construction diaries during their construction, do not have a requirement for maintaining a building log book (BLB) or regular construction inspections once they are put into use. However, this article focuses on buildings that necessitate the documentation of activities throughout their entire lifecycle. In such structures, the successor to the construction diary, after the object is put into use, is the BLB, in which all events occurring within the structure must be recorded. Among these events, we can distinguish the following categories:

- regular, legally required building inspections and reviews, including annual and five-year assessments of both the structural condition and all installations within it,
- activities related to ongoing maintenance and repairs,
- activities related to all types of renovation, modernization, as well as planned work such as reconstruction, expansion, and extension.

Entries in the BLB can be made by any authorized person, who may or may not have the necessary construction knowledge for this purpose. However, inspections and tasks, especially those requiring project development and relevant calculations, should be carried out by individuals with the appropriate qualifications, technical knowledge, and skills.

Managing existing real estate requires a series of activities that must be adequately documented, for example, through the preparation of reports and notes. These tasks have traditionally been performed in the form of paper documentation stored in binders. Required regular technical inspections as well as incidental actions resulting from the need for ongoing

repairs and maintenance are also documented in paper form. When needed or necessary, finding a specific document becomes a tedious task for the property manager, who often has to go through hundreds of documents to locate the correct one, if it has been prepared and archived properly at all. So far, managing this vast amount of documentation has been improved by arranging and sorting them by years and, possibly, creating tables of contents for the documents contained in each volume. Additionally, the property manager must continuously review and monitor activities related to legally required inspections, which are most often entered into the calendar or previously prepared tables.

# 3. Improve building management with BIM

## 3.1. Introduction

BIM technology enables data exchange among multiple stakeholders at every stage of a building's lifecycle [8]. Depending on the needs in the process of creating a BIM building model, several stages can be distinguished, including industry-specific divisions, as well as several levels of detail contained in the building information model, most often defined in the Level of Development (LOD) document. Subsequently, the model created by architects will be used in subsequent phases by industry-specific designers (architects, structural engineers, installers), the execution team (estimators, site managers, and construction engineers), followed by individuals involved in finishing works in the building, as well as inspectors and building supervisors. Furthermore, during the operational phase, it will be used by the property management team, which will manage the property over the coming years.
It is important to note that at each of the mentioned stages, stakeholders may have different requirements regarding the data they need. Thus, supporting operational activities may involve:

- maintaining the efficiency of installations by monitoring them for various user needs,
- conducting inspections and organizing servicing,
- planning and prioritizing necessary renovation work,
- planning and designing work related to expansion, extension, or changes in usage,
- organizing disassembly work, e.g., for temporary structures.

For objects where the model is already created in the design phase of the life cycle, it is much easier to create a digital twin that takes into account stakeholders' needs in subsequent phases. This is due not only to the increasing awareness among designers and constructors of the undeniable benefits of creating a digital representation of the object in the early stages of the building's life cycle but also to the ability to meet increasingly challenging challenges and legal requirements in legislation.

Regardless, the information gathered by multiple teams during the creation of the BIM model must have a common database. In whole or in part, during the operational phase, the building management should have access to this database for both viewing and editing necessary data. Companies that need to manage a large amount of information will greatly benefit from integrating project information into the BIM models. BIM tools allow the use of cost and resistance factors to predict the expense of the entire construction project process

and help designers select the most cost-effective and resistant design [9]. Providing access to stakeholders associated with the object will enable real-time input of building information into a database, from which subsequent investment managers can benefit. Such an approach will allow for continuous exchange of building data taking place in one shared digital database accessible to all stakeholders.

## 3.2. Data contained in BIM models

A model created using BIM tools is a three-dimensional building model that contains information about every element of the building, including details regarding its geometry, material properties, installations, LME costs, schedules, as well as information about the construction process and building operation [10]. This model can be utilized throughout the entire lifecycle of the building, starting from the planning phase, through design and construction, up to the operational phase, and concluding with decommissioning and waste management planning. During the operational phase, different needs often arise, thus requiring different information than during the design or construction phase of the facility.

In the case of building operation, a BIM model enables the efficient execution of various tasks, including:

- Building Information Management: The BIM model contains information about building elements, such as installations, equipment, and technical documentation. This information will be necessary to create a building database, which is valuable for building management, technical inspections, and ongoing maintenance and upkeep.
- Condition Monitoring of the Facility: The BIM model allows for easy tracking of the building's and its elements' condition. It enables the quick identification of issues and needs that arise during the long operational phase, as well as efficient planning of legally required technical inspections. Additionally, it allows users (by granting them limited access within the model) to efficiently report detected faults, ultimately resulting in faster corrective actions.
- Maintenance of System Efficiency: Easily control installations for purposes such as variable weather conditions (e.g., cooling selected zones while simultaneously heating others).
- Cost Management: The BIM model contains information about the costs of individual building components. For the multi-year operation phase, it is also necessary to include information about servicing costs, inspections, and repairs, which facilitates budget planning and expense control associated with building operation.
- Planning Work and Tasks: The BIM model enables coordinated planning and scheduling of maintenance, modernization, and repair work, ensuring effective and efficient building operation. Different scenarios for planned work can be easily created, allowing for the selection of the most ergonomic option.
- Energy Efficiency Analysis: The BIM model allows for an analysis of the building's energy efficiency, facilitating the detection of issues and the planning of actions to improve energy efficiency.

– Feasibility Analysis and Variant Selection for Renovation, Expansion, Modernization, or Change of Building Use: The BIM model contains all the information needed to conduct efficient calculations related to planned changes and to verify whether the facility can undergo the chosen actions. In later stages, it is also possible to estimate the costs of their implementation and select the most favorable option.

All these BIM model functions are particularly useful in building operation because they enable easy information management, problem identification, maintenance needs recognition, and coordinated and efficient action planning [11]. As a result, building operation becomes more effective and cost-effective, while also enhancing user comfort. Data access is centralized, and checking information and making updates is as simple as opening the relevant model and adding the necessary parameters to the corresponding building elements. Data in all linked views and applications are updated in real-time.

# 4. Creating a BIM model for an existing facility

## 4.1. 2D and 3D object documentation

In the case of new buildings currently in the design or construction phase, transitioning to BIM-based facility management is a relatively straightforward and streamlined process. The investor can purchase a BIM model from the designers or receive it – if provided for in the contract, and then supplement it with necessary information that was not previously included in the model. It will be somewhat different for an existing building, whether there is paper documentation or not, often incomplete or deviating from the actual state. In this case, one must be prepared for additional costs associated with creating a BIM model for operational purposes. At this juncture, a financial calculation of the cost-effectiveness of such actions should be conducted in this scenario [12]. A specialist who is familiar with BIM tools and can convert 2D documentation into 3D, add the appropriate parameters, create views, and integrate the BIM model with building management applications can create a BIM model for operational needs. However, it is worth considering that the model being developed during the operational phase of the facility may not need to include certain information that was essential in preceding stages of the life cycle.

Currently, in the IT services market for the construction industry, there are many tools available that allow for the creation of a digital twin, significantly enhancing property management. These tools, modeling software, and management platforms enable the linkage of a digital model with parameters describing specific property elements. Displaying changes for building management can be done in a user-friendly and comprehensible manner, often requiring only a web browser, without the need for in-depth knowledge of computer software. Examples of applications that support the building operation process may include:

– ThingWorx – Integration with real building systems, such as HVAC and lighting, allows real-time monitoring of their condition and efficiency, which is crucial for building life cycle management.

- IBM Maximo – Advanced asset management features enable not only monitoring but also predicting maintenance and replacement of various building components. Integration with the BIM model can assist in automatically assigning maintenance tasks.
- Autodesk Tandem – This is a "digital twin" solution that combines data from the entire building life cycle into one dynamic digital counterpart, providing users with insights into the latest operational data.
- Archibus – One of the most comprehensive real estate management tools available, it can use BIM model data for space and resource management, optimizing space utilization and cost management.
- FM:Systems – Similar to Archibus, it focuses on space management but offers more flexible solutions for different types of spaces (offices, warehouses, etc.). It works well with BIM models, facilitating space planning and asset management.
- Planon – Offers versatile features, from real estate management to service management. Integrated with the BIM model, it can automatically update management and maintenance plans based on the actual building condition.
- Dalux FM – Enables the collection and sharing of technical information in one place. This makes it easy to create connections between FM information, allowing work with digital twins.

These applications can significantly enhance the supervision of building operations in the BIM model through various functions such as real-time monitoring, asset management, space optimization, and maintenance forecasting. The choice among them depends on specific needs and expectations regarding facility management, as well as the financial capabilities of the property owner.

## 4.2. Data required in the BIM model for the operated facility

In the previous points, we could familiarize with the possibilities that using BIM provides in the operational phase. It is worth remembering that a BIM model created at the design and construction stage usually does not cover all the needs related to its use for FM purposes. It requires adaptation and supplementation with information necessary in the operational phase (Table 1).

In models created for the design and construction phase, there are many pieces of information that are not useful during the operational phase (e.g., certain construction details, architectural descriptions, element groups). Therefore, before supplementing the BIM model with operational data, it is worthwhile to remove or hide information that is not relevant for the FM phase [8]. In the case of a building for which a digital twin is being created only during the operational phase, it is important to establish the essential data from the property management perspective. Particularly labor-intensive will be the introduction of changes in the existing management approach for a facility that has been managed solely based on paper documentation. Finding a solution to reduce the costs of transitioning to a new management approach is important in this case. Minimizing the costs of creating a digital representation of the building is possible e.g. by identifying the data needed during the operation phase, which can be achieved by gathering requirements from stakeholders who use the facility. To do this, it is necessary to establish data that has been used in the facility management process with the

Table 1. Simplified scheme for creating a digital building model

| **Type of Information** | **Design Phase** | **Construction Phase** | **FM Phase** |
|---|---|---|---|
| Object Geometry | Modeling of the object in architectural and construction branches | Modeling based on construction documentation, 3D visualizations, simulation of works | Modeling considering existing elements and measurements, simulation of people flow, space planning |
| Material Data | Information about designed building materials, their parameters, properties, suppliers | Update of data on installed materials, supply management, quality control | Monitoring material status, forecasting necessary supplies of consumable materials (e.g., filters), waste management, environmental impact assessment |
| Technical Data | Information about object's technical parameters, specifications, guidelines, standards | Update of specifications, project change management, execution quality control | Monitoring technical parameters, equipment diagnostics, maintenance and inspection schedules |
| Equipment Data | Only in the conceptual phase | Information about equipment, specifications, warranty conditions, operating instructions | Monitoring equipment status, procurement planning, warranties, maintenance and repair schedules |
| Installation Data | MEP | Information about completed installations, schematics, layouts, technical documentation, and photography | Installation diagnostics, energy consumption monitoring, warranties, required maintenance, and repair schedules |
| Construction Schedules | Planning of works, schedules, construction stages, human and material resources | Update of schedules, progress monitoring, task and resource management. | Monitoring of operational processes, maintenance and repair schedules, modernization planning |
| Cost Information | Cost estimates, budget planning | Cost control, variance analysis, fund management | Monitoring operating costs, maintenance budget planning, cost optimization |
| Sustainable Development Data | Material data related to carbon footprint during their production | Location of construction sites, management of pollution minimization during construction (e.g., dust, noise) | Energy consumption monitoring, environmental impact assessment, emission reporting |
| Property Management Data | – | – | Lease contract management, rental analysis, modernization planning, financial reporting |

owner and/or manager [13]. Additionally, it is worth considering the needs of users who may not have access to a lot of data related to the facility but can, through digitizing documentation and collecting data about the facility in one model, report and thus support efficient management.

In the process of determining stakeholder requirements, it is necessary to select data about the facility. This data should be based on existing as-built project documentation and an inventory to update geometric data and the technical condition of individual components. Next, it is essential to identify the existing procedures that have taken place during the management of the specified property, with a focus on the data contained in documents and/or notes prepared after these procedures. The final step is to gather stakeholder requirements, which they consider necessary to improve property management and which have not been implemented for various reasons thus far.

Determination of stakeholder requirements will allow for the introduction of necessary data about the elements and components of the existing building. The requirements that will serve as a kind of standard in building properties for efficient management will include data concerning:

- properties of individual elements and components, such as their characteristic parameters (e.g., thermal insulation will primarily have a assigned heat transfer coefficient),
- manufacturer's warranties for specific solutions,
- frequency and timing of required inspections mandated by regulations,
- the durability of individual solutions along with information about their current usage time
- current technical condition (as observed on the day of the inventory and subsequently during inspections, i.e., wear and tear),
- observed defects/flaws in individual elements, components, and/or equipment.

Based on the BIM model created by the authors for a selected facility located at the university for management purposes, data were compiled in consultation with its users (Table 2).

The data introduced into the BIM model can be continuously updated through parameters, filters, or external scripts set earlier [14]. The model allows for the observation of the maintenance history of individual elements, components, equipment, or entire spaces, with the visible data being the most current. Such data can also be exported to external databases, such as Excel files. Individuals interested in checking current or archival information will not need specialized software.

The final management using the BIM model in the context of building operation primarily requires precise determination of the data needed by various stakeholders. These pieces of information can be diverse and dependent on management needs, which will affect the efficiency and purposefulness of the operation. An essential aspect of this process is the ability to continuously update the data entered into the BIM model.

Furthermore, BIM models propose implementing access roles (permissions) that will filter data access for different users. Several access levels can be distinguished, including property manager/owner, technical staff (inspectors), facility management coordinators, administrators, building users (office employees), tenants, and external contractors performing maintenance or repair work.

Table 2. The information identified as necessary for managing existing real estate by stakeholders of the facility

| **The technical sector of the university** | **Building administrator** | **Building staff (e.g., porter)** | **Building users (e.g., lecturers)** |
|---|---|---|---|
| – Inventory identification of individual building components (e.g., QR codes) along with their location<br>– Information regarding the necessity of technical inspections<br>– Information about the need for repairs and renovations<br>– Costs of performing any actions in the facility<br>– Ability to prioritize actions taken during operation<br>– Information, including photographic, about the technical condition of individual elements<br>– Characteristics of solutions used in the building (e.g., material parameters)<br>– Geometry of rooms and components within them<br>– Verification of work execution by individual workers (e.g., cleaning) | – Information about warranty periods and maintenance of elements and devices,<br>– Schedule of periodic inspections,<br>– Information from the BMS regarding necessary maintenance actions, e.g., filter replacement,<br>– Information from building and/or equipment monitoring about occurring issues (e.g., malfunctioning filter),<br>– Ability to directly send information about occurring events requiring action, e.g., repairs | – The ability to report faults and breakdowns. The ability for easy communication with technical staff of the facility | – The ability to report faults and breakdowns without having to wonder who they should be directed to.<br>– The ability to report any observed malfunctioning of equipment.<br>– The ability to report the absence of basic working tools in the equipment inventory (such as pens).<br>– The ability to control the temperature and humidity in office spaces |

Data filtering and access roles in the BIM model are crucial for effective facility management. Properly configured permissions enable relevant individuals to access necessary information while safeguarding other data against unauthorized access. Access levels can be finely defined, from property managers or owners to technical staff and end users. In this way, facility management becomes more flexible and tailored to real operational needs [15].

## 4.3. Creating a BIM model for an existing facility

Building a model of an existing facility that is currently in operation and lacks digital BIM documentation can be developed based on the existing technical as-built documentation, typically presented in the form of 2D drawings, along with a comprehensive survey of

the facility. After gathering the necessary documentation, the next step is to proceed with creating a digital model. BIM provides a process for consistent sharing of information for improved collaboration and management across the project's life cycle, encompassing the design, construction and operational phases [16]. The first step is to select suitable software that allows for easy input of new information about the building's elements and their browsing, for example, in the web version of the program, is user-friendly, and can be used by individuals who may not necessarily have an engineering background. The subsequent steps of creating a digital twin along with preparing the database for its construction (Fig. 3 Part 1) can be illustrated similarly to Part 2 of Fig. 3.

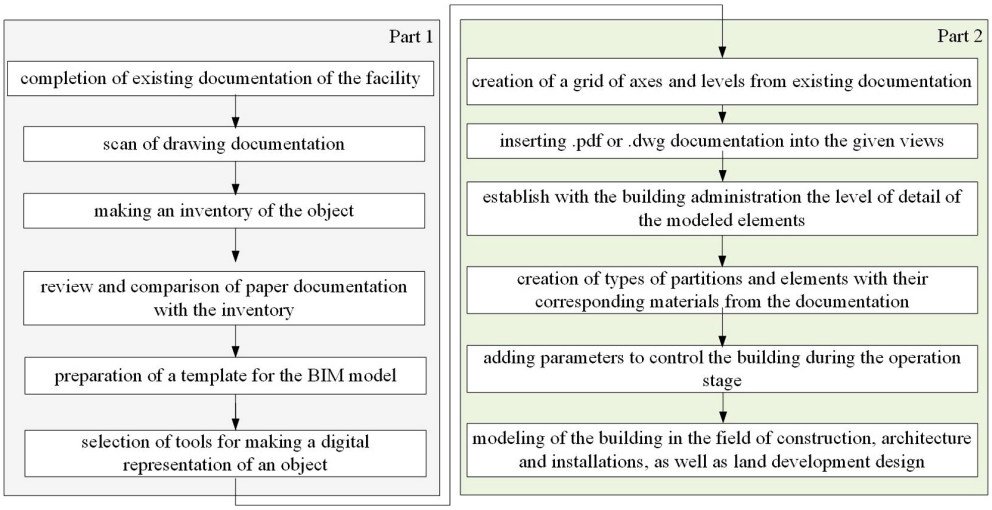



Fig. 3. Simplified scheme for creating a digital building model

The modeling of the digital object begins with creating levels and axes and inserting documentation into the appropriate views (floor plans, elevations, sections). The structural framework of the building is established based on previously prepared types of partitions in the model (foundations, walls, floors, beams, columns, stairs). Horizontal and vertical openings are then inserted. Partitions, finishes, the geometry of doors, windows, curtain walls, and other detailed solutions in the building are modeled. The scope of other disciplines is also modeled, including water supply and sewage systems, ventilation, air conditioning, electrical systems, and site development design.

After creating a correct model from the technical documentation, the next step involves adding appropriate information to the elements in the created parameters in the BIM model, especially the data necessary for the management process during the operational phase [17]. The number of parameters that can be assigned to elements is flexible, and it's essential to consider which information will be useful during property management. Examples of parameters may include:

– warranty end date,
– last service date,

– URL link to the warranty card,
– element symbol from technical documentation.

Creating a BIM model for an existing building, it's important to consider the need for adding information different from previous stages. Choosing software for modeling that allows gathering various information and flexible expansion of the database according to needs is crucial. Among the information particularly useful in the operational phase (dimension 7D BIM) that will improve building property management are:

– Information about installations, such as warranty periods, dates of periodic inspections, maintenance schedules for individual building components (e.g., filter replacements, pipe cleaning, technical inspections of installations). This allows for regular and coordinated maintenance planning and execution. Additionally, assigning a unique identification/registration number to each component, for example, by using QR codes, which will also be placed on the devices in the actual building, is crucial. There is an increasing trend of integrating the ability to connect with device software for continuous monitoring and immediate response to any anomalies.
– Information about building elements, focusing on projected periods of use and necessary maintenance actions to prevent deterioration and ensure early response to any defects.
– Cost information incurred during repairs, renovations, and upgrades to monitor the budget and plan future maintenance work.
– Technical condition information of individual components at the time of their inventory for creating a digital twin of the property. This includes details about material condition, usage, and observed defects.
– Information about spaces available in the building, such as area, height, and shape of rooms. This data can be useful for planning new interior arrangements or changes in room layouts.

The information stored in the BIM model will enable effective and efficient building management during its operation, leading to increased user comfort and cost savings in building operation.

## 5. Building a digital model for a selected existing object

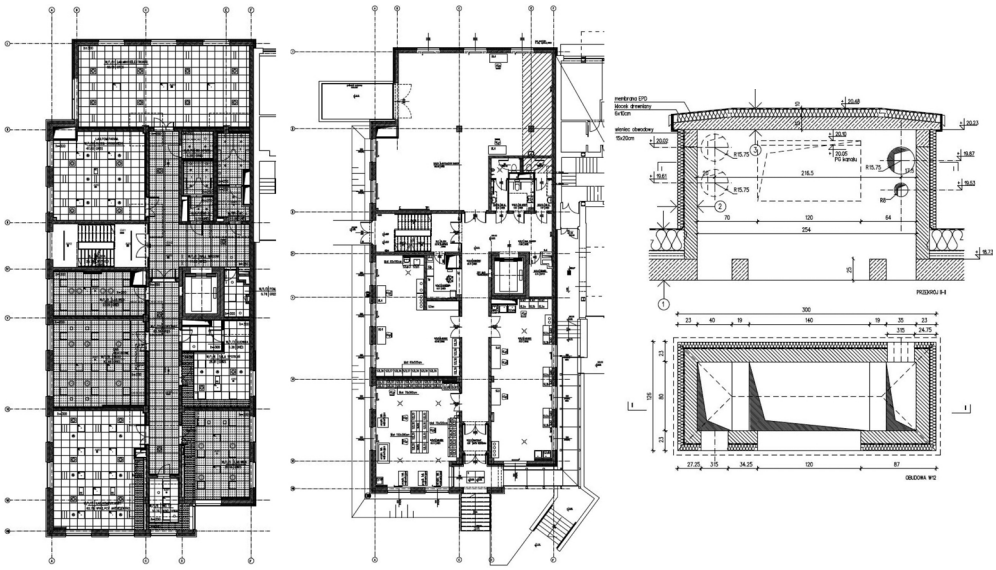
The building for which a digital building model was created is a public utility facility located on the campus of the AGH University of Science and Technology in Krakow (Fig. 4). The object model was created using the Revit software based on the as-built documentation provided by the Technical Sector of the AGH University of Science and Technology.

The provided as-built documentation was created in AutoCAD with the .dwg file extension. The supplied drawing documentation was compared and verified against the actual state of the building by the investor's supervisory inspector. The creation of the object model was supported by photographic documentation and an on-site visit conducted by the authors. The building was put into use in the year 2019. The subsequent steps of modeling the prototype of the digital representation of the building are shown in 8. Enabling changes to be made in the BIM model using an Excel program.

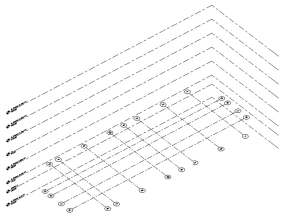
Fig. 4. Current appearance of the building, 8.12.2022 (authors' archive)

In subsequent publications, the authors presented attempts to implement property management using digital representations of the object.

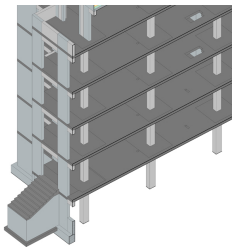
1. Preparing a template for standardizing the input of information about the facility based on the provided technical documentation (in the figures, sample floor plans and cross-sections from the provided documentation)



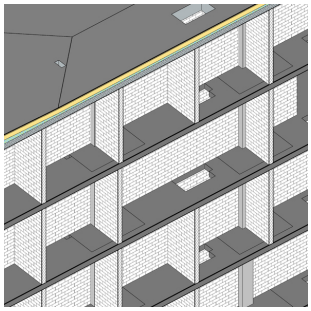
2. Adding axes and levels from the technical documentation



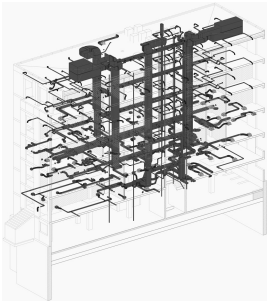
3. Creating structural elements



4. Creating architectural elements



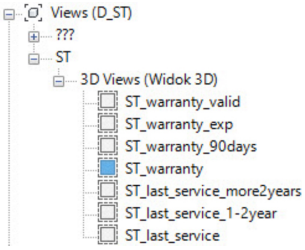
5. Creating installation elements



6. Example data regarding individual elements constituting the object, taking into account operational needs, including warranties and servicing

| Data | |
|---|---|
| ST_documentation_URL | D:\PROJECTS\2301_AGH_D... |
| ST_last_service | 20220915 |
| ST_warranty | 20230901 |
| ST_documentation_symbol | AT-01 |

7. Creating appropriate filtering views to display the object based on the parameters introduced for operation




8. Enabling changes to be made in the BIM model using an Excel program

Fig. 5. Modeling the object based on paper documentation and inventory

# 6. Summary

Managing a building can be a complex process, but the use of BIM greatly simplifies and streamlines it. The constructed model, enriched with various data input by stakeholders, becomes an invaluable tool in many aspects of property management. It allows for the

centralization and efficient management of all building-related information, from plans and drawings to technical data, documents, and photographs.

Control over multiple document versions becomes easier, enabling comparisons between versions from different periods and monitoring any changes. This is particularly useful in the context of periodic technical inspections and maintenance. Parameters such as warranty dates and the technical condition are included in the model, facilitating more efficient planning of these activities.

During the operational phase, it is crucial to select relevant data from the perspective of property management and implement them into the model. If a model from the design and/or construction phase is used, unnecessary information for the operational phase should be removed (or hidden), thus creating a more user-friendly model. For objects where digital representation is created only during the operational phase, the first step is to familiarize oneself with the most current documentation, verify it through on-site inspection and inventory, and then identify and establish the needs of its users.

Observing the changing construction market, as well as the legal requirements adapting to it, it seems only a matter of time before property management through digital models and platforms becomes mandatory. In this case, it is worth noting that this solution has significantly more benefits and will be an essential improvement in property management processes in the future.

## References

[1] Ustawa z dnia 7 lipca 1994 r., "Prawo budowlane", no. 89, 2021.

[2] Rozporządzenie Ministra Rozwoju i Technologii z dnia 15 grudnia 2022 "W sprawie książki obiektu budowlanego oraz systemu Cyfrowa Książka Obiektu Budowlanego", 2022.

[3] J. Patacas, N. Dawood, and M. Kassem, "BIM for facilities management: A framework and a common data environment using open standards", *Automation in Construction*, vol. 120, 2020, doi: 10.1016/j.autcon.2020.103366.

[4] D. Ilter and E. Ergen, "BIM for building refurbishment and maintenance: current status and research directions", *Structural Survey*, vol. 33, no. 3, pp. 228–256, 2015, doi: 10.1108/SS-02-2015-0008.

[5] R. Kontrimovičius, L. Ustinovičius, C. Miedziałowski, and M. Vaišnoras, "The initial prototype BIM system for the optimization of integrated construction processes", *Archives of Civil Engineering*, vol. 68, no. 3, pp. 617–631, 2022, doi: 10.24425/ace.2022.141906.

[6] M. Condotta and C. Scanagatta, "BIM-based method to inform operation and maintenance phases through a simplified procedure", *Journal of Building Engineering*, vol. 65, art. no. 105730, 2023, doi: 10.1016/j.jobe.2022.105730.

[7] A. Radziejowska and A. Struś, "Diagnostics of objects in a bad technical condition in the context of safety of construction works", *Materiały Budowlane*, no. 10, pp. 64–67, 2022, doi: 10.15199/33.2022.10.16.

[8] O.H. Abdullah and W. A. Hatem, "The use of BIM to propose alternative construction methods to reduce the cost of energyfor the historic archeological building in Iraq", *Archives od Civil Engineering*, vol. 69, no. 2, pp. 535–549, 2023 doi: 10.24425/ace.2023.145283.

[9] X. Pereiro, M. Cabaleiro, B. Conde, and B. Riveiro, "BIM methodology for cost analysis, sustainability, and management of steel structures with reconfigurable joints for industrial structures", *Journal of Building Engineering*, vol. 77, art. no. 107443, 2023, doi: 10.1016/j.jobe.2023.107443.

[10] A. Arsiwala, F. Elghaish, and M. Zoher, "Digital twin with Machine learning for predictive monitoring of CO2 equivalent from existing buildings", *Energy and Buildings*, vol. 284, 2023, doi: 10.1016/j.enbuild.2023.112851.

[11] S. Honghong, Y. Gang, L. Haijiang, Z. Tian, and J. Annan, "Digital twin enhanced BIM to shape full life cycle digital transformation for bridge engineering", *Automation in Construction*, vol. 147, art. no. 104736, 2023, doi: 10.1016/j.autcon.2022.104736.

[12] G. Editors, et al., "From BIM to digital twins: a systematic review of the evolution of intelligent building representations in the AEC-FM industry", *ITcon, Journal of Information Technology in Construction, Spec. issue Next Gener. ICT – How distant is ubiquitous Computing,* vol. 26, no. 5, pp. 58–83, 2021, doi: 10.36680/j.itcon.2021.005.

[13] J. Du, Z. Zou, Y. Shi, and D. Zhao, "Simultaneous Data Exchange between BIM and VR for Collaborative Decision Making", in *Computing in Civil Engineering 2017: Sensing, Simulation, and Visualization*. ASCE, 2017, pp. 1–8, doi: 10.1061/9780784480830.001.

[14] S.M.E. Sepasgozar, et al., "Lean Practices Using Building Information Modeling (BIM) and Digital Twinning for Sustainable Construction", *Sustainability*, vol. 13, no. 1, 2021, doi: 10.3390/su13010161.

[15] R. Bortolini, N. Forcada, and M. Macarulla, "BIM for the integration of building maintenance management: A case study of a university campus", in *eWork and eBusiness in Architecture, Engineering and Construction: ECPPM 2016*. CRC Press, 2016, doi: 10.1201/9781315386904.

[16] Q. Lu, X. Xie, J. Heaton, A.K. Parlikad, and J. Schooling, "From BIM towards digital twin: Strategy and future development for smart asset management", in *Studies in Computational Intelligence*, vol. 853. Springer, 2020, pp. 392–404, doi: 10.1007/978-3-030-27477-1_30.

[17] C. Boje, A. Guerriero, S. Kubicki, and Y. Rezgui, "Towards a semantic Construction Digital Twin: Directions for future research", *Automation in Construction*, vol. 114, art. no. 103179, 2020, doi: 10.1016/j.autcon.2020.103179.

## Model BIM dla fazy eksploatacyjnej oparty na dostępnej dokumentacji

**Słowa kluczowe:** cyfrowy bliźniak, faza eksploatacji, modelowanie informacji o budynku (BIM), utrzymanie i użytkowanie, wymiana danych, zarządzanie nieruchomością,

### Streszczenie:

Eksploatacja jest najdłuższą fazą cyklu życia budynków. W związku z tym należy podejmować świadome działania związane z czynnościami, które pozwolą jak najdłużej użytkować obiekt w jak najlepszym stanie, przy jednoczesnej minimalizacji kosztów jego utrzymania. Eksploatacja obiektów [1] wymaga szeregu czynności, które pozwalają na systematyczne zbieranie danych dotyczących stanu technicznego i funkcjonalnego obiektu. Czynności te są najczęściej planowane i koordynowane przez osobę będącą właścicielem, bądź zarządcą nieruchomości. Zarządca m.in. dba o systematyczne uzupełnianie Książki Obiektu Budowlanego (KOB), jak również zapewnia wykonywanie bieżących napraw i remontów w obiekcie [2]. W artykule autorzy skupiają się na wykorzystaniu technologii BIM (Building Information Modeling – Modelowanie Informacji o Budynku) w fazie eksploatacji obiektów budowlanych. W ostatnich latach zauważalne jest znaczne zwiększenie popularności technologii BIM w fazach projektowania i budowy budynków, ale informacje dotyczące implementacji i weryfikacji jej wykorzystania w dłuższym okresie, tj. w fazie eksploatacji, pozostają stosunkowo rzadkie. W kontekście zarządzania budynkiem w fazie eksploatacji, autorzy podkreślają, że technologia BIM pozwala na centralizację i efektywne zarządzanie wszelkimi danymi związanymi z budynkiem. Model BIM może gromadzić informacje o różnych aspektach budynku, włącznie z planami, rysunkami, danymi technicznymi oraz dokumentacją fotograficzną. Model ten ułatwia kontrolę nad wieloma wersjami dokumentów, umożliwia porównywanie różnych wersji oraz monitorowanie wszelkich zmian. Jest to szczególnie przydatne w kontekście regularnych przeglądów technicznych i prac konserwacyjnych. W artykule podkreślane jest, że wykorzystanie technologii BIM może poprawić jakość zarządzania obiektami budowlanymi, przyczyniając się jednocześnie do oszczędności kosztów. Model BIM może być używany przez różnych interesariuszy obiektu w różnych fazach jego cyklu życia, począwszy od projektowania i budowy, aż po eksploatację i nawet rozbiórkę. Autorzy wskazują, że zbudowanie modelu BIM dla budynku istniejącego powinno uwzględniać także konieczność dostosowania go do konkretnych potrzeb

zarządców obiektu w fazie eksploatacji. Zgodnie z tym podejściem, model BIM może być aktualizowany poprzez parametry, filtry lub zewnętrzne skrypty, a dostęp do danych może być dostosowany do różnych użytkowników, w zależności od ich potrzeb. Budowanie modelu obiektu będącego w trakcie eksploatacji i nie posiadającego cyfrowej dokumentacji BIM, może zostać opracowany w oparciu o istniejącą dokumentację techniczną powykonawczą, najczęściej sporządzoną w formie płaskich rysunków oraz przeprowadzoną inwentaryzację obiektu. W procesie ustalania wymagań interesariuszy należy wybrać dane o obiekcie – sporządzone w oparciu o istniejącą dokumentację projektową powykonawczą oraz przeprowadzoną inwentaryzację w celu aktualizacji danych geometrycznych i stanu technicznego poszczególnych komponentów. Następnie należy ustalić dotychczasowe procedury, jakie miały miejsce podczas zarządzania wskazaną nieruchomością z ustaleniem danych zawartych w dokumentach i/lub notatkach sporządzanych po ich przeprowadzeniu. Ostatnim etapem jest zebranie wymagań interesariuszy, które uważają za potrzebne w celu usprawnienia zarządzania nieruchomością, a które dotychczas nie były realizowane z różnych przyczyn. Zarządzanie obiektem budowlanym może być złożonym procesem, ale wykorzystanie modelu BIM znacząco to upraszcza i usprawnia. Zbudowany model, bogaty w różnorodne dane zapisane przez interesariuszy, staje się nieocenionym narzędziem w wielu aspektach zarządzania nieruchomością. Umożliwia on centralizację i efektywne zarządzanie wszelkimi informacjami o budynku, od planów i rysunków, po dane techniczne, dokumenty i fotografie. Kontrola wielu wersji dokumentów staje się prostsza, umożliwiając porównanie wersji z różnych okresów i monitoring ewentualnych zmian. Jest to szczególnie przydatne w kontekście okresowych przeglądów technicznych i konserwacyjnych.

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