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# EXPLORING THE BENEFITS OF OPENBIM STANDARDS FOR ENHANCED INTEROPERABILITY AND EFFICIENCY IN ARCHITECTURE, ENGINEERING, AND CONSTRUCTION PROJECTS

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## ABSTRACT

This article presents an analysis of the impact of openBIM standards on interoperability and efficiency in construction projects. The hypothesis put forward is that the coordinated use of openBIM standards and services, such as IFC, BCF, bSDD, IDS, IDM, and UCM, improves the quality of information and reduces the number of errors during interdisciplinary coordination. For this study, 'efficiency' is defined as a composite of: (1) data quality, (2) coordination efficiency, and (3) time/cost (person-hours and related costs). The methodology combines a literature review with a practical case study of a conceptual BIM model of a museum building. The results indicate that each standard plays a distinct role: IFC enables uniform model transfer, BCF facilitates issue tracking, bSDD provides standardised semantics, IDS allows automatic data verification, IDM clarifies the flow of information between process participants, and UCM enables capturing and reusing best practices. Together, these standards improve data exchange, enhance coordination, and reduce errors. Challenges include limited tool support and the need for user training. In conclusion, openBIM standards support collaboration and efficiency; there is also a need for further research on their practical implementation.

**Keywords:** architecture, design, openBIM, IFC, bSDD, IDS

## INTRODUCTION

The architecture, engineering, and construction (AEC) industry is complex and requires a collaborative approach. Nevertheless, project data is often fragmented across heterogeneous systems and processes. In many cases, building information remains detached, unstructured, and inconsistently represented across platforms and industries, making it difficult to exchange it effectively (Jiang et al., 2019a, 2019b). The insufficient unification of data exchange standards and methods contributes to information loss, misinterpretation, or inefficient manual repetition of activities, resulting in increased costs, delays, or errors. In response, the concept of openBIM has emerged as a holistic approach to digital collaboration based on open standards and transparent data workflows. Studies show that openBIM improves multidisciplinary coordination, enhances interoperability between different software, and ensures data consistency, thereby increasing overall project efficiency (Jiang et al., 2019a, 2019b; Gourabpasi, Jalaei & Ghobadi, 2025).

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At the core of openBIM is the Industry Foundation Classes (IFC) standard ISO 16739 (International Organization for Standardization [ISO], 2024), which is an open data schema for describing construction models. By providing a common data language, IFC enables the shared use of models across different software and disciplines, including architecture, engineering, mechanical, electrical, and plumbing (MEP), and various construction phases (Gourabpasi et al., 2025). Complementing IFC are other buildingSMART standards. The buildingSMART Data Dictionary (bSDD) provides a structured, multilingual classification of buildings and properties, ensuring semantic consistency and data quality that can be shared across different projects (Oraskari, 2021). The Information Delivery Specification (IDS) enables the expression of data requirements in machine-readable format (XML), which supports automated model validation. The Information Delivery Manual (IDM) outlines process maps and data exchanges between stakeholders, supporting the structured development of information models (Kim, Kwon, You & Lim, 2010). In addition, the Use Case Management (UCM) system serves as a collaborative platform to capture and share real-world BIM use cases, thereby supporting the standardisation and reuse of best practices. Together, these standards create a robust openBIM framework that governs data exchange throughout the asset lifecycle. Furthermore, initiatives such as the ISO/TC 59 Digitalisation Use Case underscore the growing importance of standardised digital workflows in the construction industry, highlighting the role of international standards in facilitating interoperable data exchange (Borgos, 2022). This highlights the crucial role of evolving openBIM standards in enabling efficient digital collaboration and process integration.

Although the benefits of open standards in BIM are increasingly acknowledged, the current literature lacks a comprehensive evaluation of their combined impact that highlights the benefits. Some studies have demonstrated the practical applications of openBIM, such as streamlining energy analysis workflows with the use of IFC, which significantly reduces preparation time and increases model reliability (Gourabpasi et al., 2025). Despite growing interest in openBIM, the integration and use of standards such as IFC, IDS, bSDD, IDM, and UCM remain underexplored.

This article aims to explore the benefits of applying openBIM standards – specifically, IFC, IDS, bSDD, IDM, and UCM – for improving data interoperability and project efficiency in the AEC industry. It hypothesises that the coordinated implementation of these standards enhances information quality, as well as reducing coordination errors and the time needed for their resolution, contributing to higher performance in construction projects. The study will examine both the functional scope and adoption challenges of these standards, as well as their potential to improve interdisciplinary collaboration across the construction value chain.

## MATERIAL AND METHODS

This study uses a multi-step methodology combining literature review, industry insight and a practical case study based on a BIM model. First, a narrative literature review was conducted to identify the documented benefits of openBIM standards, including IFC, bSDD, IDS, IDM, and UCM. Official materials from buildingSMART and academic papers were included.

A narrative review of technical papers, standards documentation and case studies was performed to extract the key advantages of each openBIM standard. Databases such as ScienceDirect and Google Scholar were utilised, with a focus on works published between 2020 and 2025 to ensure that the research aligns with the latest applications of openBIM. Resources from buildingSMART (technical specifications, guides and platform materials) were essential in identifying the role of open standards in improving data exchange, model reliability and multidisciplinary coordination (buildingSMART, n.d.-a; buildingSMART, n.d.-b; buildingSMART, n.d.-c; buildingSMART, n.d.-d; buildingSMART, n.d.-e).

These documents are essential for understanding the intended usage of openBIM standards. The above-mentioned documents have a practitioner-oriented character and can be perceived as promotional.

buildingSMART describes standards and recommended workflows, but its claimed benefits need confirmation from independent research and their usage in the case study.

Qualitative insights were also given from the author's practical, professional experience working in the construction industry as an employee of a general contractor. Although anonymised, this perspective provides a picture of the practical benefits and challenges observed in the implementation of openBIM standards in real-world conditions. These insights supplement the theoretical findings from the literature.

Moreover, the case study was presented to illustrate the potential, practical implementation, and mutual integration of a wide range of openBIM standards in a project managed using BIM. The BIM model concerned a conceptual museum building located on the Vistula riverbank in Warsaw. The project comprised two levels (one underground and a ground floor with mezzanines in the exhibition space), modelled at the level of detail (LOD) 300, which is sufficient for design coordination and information validation tasks. The architectural model was created in ArchiCAD, and the structural model in Revit. The combined model was exported in IFC 4 format and included both architectural and structural elements. Disciplines covered are architecture, structure, and mechanical systems. This scope provides a representative scale for testing the practical integration of IFC, IDS, bSDD, BCF and related workflows.

## Literature review – openBIM standards overview

OpenBIM emerged from IAI/buildingSMART initiatives in the mid-1990s and has since evolved into several vendor-neutral standards and tools enabling data exchange (Steinmann, 2024). Jiang et al. (2019a, 2019b) provided a broad review up to 2019. More recent work highlights practical advances: Information Delivery Specification (IDS) enables machine-readable information requirements and automated checks (buildingSMART International, 2023). IFC 4.3 extends IFC's scope, including infrastructure use cases, and was formalised in recent updates (buildingSMART International, 2024). Recent research (since 2020) finds openBIM mainly in large and infrastructure projects, with limited evidence for smaller ones (Jin & Li, 2023; Fischer et al., 2024).

A broad overview of the possibilities derived from openBIM was published in 2019 (Jiang et al., 2019a, 2019b). The paper thoroughly discusses the topic of openBIM standards and services, including IFC, IDM, MVD, COBie, LandXML, ifcOWL, IFD, BCF, and bSDD. The results show that from January 2000 to October 2019, the IFC was the topic of approximately 78% of all publications related to these standards. The paper highlights that the USA was the leading country in the number of publications, followed by Germany and China. The article also highlights and describes platforms that utilise open standards in BIM, as well as tools supporting open standards that can be implemented in both native and IFC software. It also addresses the topic of information exchange through openBIM participation, demonstrating how openBIM can be utilised in various phases of the construction process. Finally, it identifies research gaps and future directions. One of these is the complexity of defining rules using tools based on Model View Definitions (MVD). It turns out that the answer to this problem is partially the IDS standard, which allows, in an accessible way, to determine what information should be delivered, in what form, and at what stage. The second challenge pointed out is the development of the IFC ontology, which is also being addressed through successive versions of IFC to respond to existing gaps. Considering the above, and taking into account that six years have passed since the publication of this study, it is worth once again summarising the current state of open standards and the benefits resulting from their implementation.

Recent studies confirm the relevance of observations by Jiang et al. (2019a, 2019b) and offer updates on standards and implementation challenges. It is highlighted that openBIM enables a neutral and open environment for exchanging building information, improving interoperability and enabling process integration across disciplines. It is stated that openBIM practices reduce dependency on paid software and enhance collaboration efficiency in project teams working from different locations (Jin & Li, 2023). Similarly, Fischer et al. (2024) examine the practical adoption of IDS, demonstrating the potential of simplifying the specification of information requirements for regulatory compliance, particularly in permitting workflows. They show that IDS not only addresses the limitations previously associated with MVD but also supports automatic checking, thereby reducing manual review errors. OpenBIM standards collectively contribute to facilitating interoperability throughout the building lifecycle. In particular, a standard IFC model can serve multiple use cases, eliminating the need for separate proprietary formats (Gourabpasi et al., 2025). These research works underline the continuous progress and deepening integration of openBIM standards, emphasising the growing maturity of the ecosystem, as well as the benefits in the AEC sector.

This article discusses key openBIM standards and services, summarising reported benefits and noting challenges or limitations identified in the literature, covering the period of 2020–2025.

*Industry Foundation Classes – IFC*

IFC is the key BIM data model standard that codifies geometric and non-geometric information about building elements, processes, and stakeholders in a single schema (Yu et al., 2023). Given that it is an ISO standard – ISO 16739 (ISO, 2024) – IFC is supported by most BIM software and viewers, thereby enabling multidisciplinary data exchange without loss of information. Research emphasises that the rich schema of IFC and its ability to work with older versions allow the same model to be used across different phases and disciplines (Yu et al., 2023; Gourabpasi et al., 2025). IFC codifies the identity and semantics (name, unique identifier, building type), characteristics (material, thermal properties), and relationships (locations, ownership) of buildings, processes, and people, creating a consolidated data repository. In practice, the utilisation of IFC enables the connection of design applications with analysis tools, facilitating tasks such as energy simulation by providing an exchangeable format (Yu, Kim, Jeon & Koo, 2023; Gourabpasi et al., 2025). Summarising, IFC enables the use of a standard model and its exchange between disciplines, as well as supporting long-term data reuse.

Despite its benefits, IFC faces notable limitations. Its schema is highly complex, which can lead to inconsistent implementation. Researchers have documented that IFC's underlying EXPRESS-based format (IFC 1.x, 2x2, 2x3, 4.0, 4.1, 4.2) seems to be rigid and not easily adapted to modern data technologies (Yu et al., 2023). It is pointed out that the reliance on EXPRESS reduces IFC's flexibility for partial updates or dynamic data filtering (Yu et al., 2023). It is worth noting that not all software applications fully support the latest IFC schemas (e.g. IFC 4), which can result in interoperability gaps. Furthermore, some domain-specific information (e.g. infrastructure or advanced structural elements) has been missing, requiring extensions or workarounds. This challenge is addressed by the development of IFC 5 and related efforts, which introduce a modular schema and are compatible with XML, JSON, and other formats (Yu et al., 2023). As van Berlo et al. (2021) highlight, IFC 5 aims to modernise the standard by moving away from the rigid EXPRESS syntax and introducing more flexible, modular formats such as JSON and XML, which are more compatible with contemporary IT systems and enable easier integration and partial model updates. Until such updates are widely adopted, project teams may still encounter issues such as incomplete data translations and discrepancies in property set mappings, which hinder the use of IFC, particularly in complex projects.

*BIM Collaboration Format – BCF*

BCF is a standard for issue tracking and communication across BIM applications. It enables the generation of problem reports, including views, comments, and checkpoints, in a neutral format that can be used by clash detection and model-checking applications (Khemlani, 2021). BCF was developed to streamline reporting clashes and issues to designers without losing context. Its integration with a wide range of BIM software contributes to the interoperability between multidisciplinary project teams, enabling them to resolve problems rather than communicate them via email correspondence.

BCF's limitations are mostly practical. Regarding the standardisation of usage, different teams may have different workflows for creating BCF reports, leading to potential inconsistencies in how issues are recorded or resolved. Moreover, large and complex projects generating a vast number of BCF issues may cause them to become unwieldy without proper filtering and management tools. Additionally, it should be noted that BCF itself does not contain the model geometry or building data; instead, it includes textual information, screenshots, comments, the location of the issue within the model, and other metadata necessary for coordination among project participants. Therefore, BCF must be used in conjunction with a BIM model, whether in IFC format or a native one.

*buildingSMART Data Dictionary – bSDD*

bSDD offers industry-specific terminology in a structured format, enabling the linkage of IFC entities to a consistent "classification" or ontology (Yu et al., 2023). The bSDD is a centralised repository of building industry terms: definitions of classes, properties and property sets intended to standardise semantics across projects. By mapping buildings to standardised IFC terms, bSDD enables the BIM data to be consistent and machine-readable (buildingSMART, n.d.-d). By using bSDD, a BIM element can be linked to a unique concept ID, ensuring that it is recognised as the same element type regardless of the software used. Consequently, misunderstandings from synonyms or local codes are eliminated. Moreover, IDS can reference the bSDD dictionary to ensure that requirement definitions align with commonly understood terms (Yu et al., 2023). In this way, bSDD creates a common language for elements, materials, and attributes, enhancing interoperability.

Despite the potential of bSDD, not all software supports automatic linking to bSDD or might only partially integrate it. While bSDD is multilingual and covers many domains, specialised terms or local classifications may not yet exist in the dictionary (Yu et al., 2023). Based on practice-based observations, construction companies often utilise their own classifications during the model creation process and may develop their own Business Support Decision Dictionaries. There is a risk that, instead of linking their classes and properties to existing IFC entities and properties, they may duplicate this data due to naming conventions that differ from those already established in IFC, which is not aligned with the concept of the buildingSMART Data Dictionary.

*Information Delivery Specification – IDS*

IDS is a standard that specifies information requirements in a machine-readable format. It enables the definition of data that should be delivered by IFC models within a specific development stage and form, thereby contributing to more consistent and verifiable BIM models. The standard represents a significant advancement in formalising and digitising information requirements, addressing previous shortcomings where such requirements were often inconsistent or documented using spreadsheets or PDFs (Tomczak et al., 2022). IDS develops IDM/MVD concepts but packages them into an XML schema to enable automated requirements validation. In practice, using the IDS file enables tagging or validating the IFC export against an IDS and potentially detecting missing data at an early stage. The IDS framework was utilised in recent work to define the minimum data requirements for BIM-to-energy modelling, ensuring the presence of necessary information for simulation tools (Gourabpasi et al., 2025). Fischer et al. (2024) note that IDS is already being used by building authorities for automated code compliance checking and that even small extensions to the IDS schema can expand its applicability. IDS provides the benefit of precise, standardised information delivery, ensuring that the necessary information is included in the BIM model, enabling efficient, error-free data exchange (Fischer et al., 2024).

Being a relatively new buildingSMART standard, it faces some implementation challenges. Defining an IDS for a project requires effort to identify data needs. Additionally, its value depends on the consistent use of classification in the BIM model. The effective use of IDS depends on broader process maturity and integration with tools (Tomczak et al., 2022). The standard still cannot cover specialised use cases – for example, Fischer et al. (2024) found that existing IDS filters were insufficient for certain building permit checks. Having the potential to be implemented in building permit processes, IDS seems to need schema extensions. Limited awareness of IDS among BIM users, along with a lack of familiarity with supporting software, hinders its deployment in the building industry.

*Information Delivery Manual – IDM*

IDM provides a formal methodology (ISO 29481-1) for capturing and documenting processes and information flows in projects (buildingSMART, n.d.-b). By mapping BIM uses to data requirements, IDM clarifies roles and information needed to be delivered at a particular stage of the construction process. BuildingSMART states that IDM creates a "common understanding" by documenting BIM objectives, use cases, and information exchange requirements. As a benefit, it enhances process coordination, reduces the risk of miscommunication about data responsibilities, and ensures that each exchange follows a consistent structure by clearly defining who should deliver which information, when, and in what format. When combined with the IDS standard, an IDM has the potential to enhance data quality and minimise errors during information transfer. IDM has been successfully utilised to support structured asset data exchanges, for example, in workflows linking BIM to asset management (Farghaly, Abanda, Vidalakis & Wood, 2020). It has also been adapted for prefabricated timber construction, where it helped define process-specific property sets and stakeholder responsibilities (Rojas Wettling, 2023). Recent studies emphasise IDM's ability to map complex post-construction information exchanges, such as those related to existing structures or post-disaster scenarios (Musella et al., 2025).

Although the development of IDM began as early as 2006–2007, the standard remains significantly underutilised in practice, especially when compared to the growing adoption of IDS. Defining an IDM requires substantial early-stage process analysis, which demands both time and commitment at the outset of a project. As a result, many project standards and procedures continue to be documented in informal or unstructured ways, rather than through formalised IDM documentation. It should be noted that IDM often involves modelling processes with specialised software or diagram tools, which can pose an adoption barrier.

*Use Case Management – UCM*

UCM is a buildingSMART service that integrates best practices and "use cases" across the BIM workflow (buildingSMART, n.d.-e). No peer-reviewed studies from 2020 to 2025 were found that focus solely on UCM; its role is currently documented by buildingSMART documentation, but not addressed in academic literature. UCM utilises the IDM methodology to define and share standardised use cases, processes, and information requirements for tasks from the design to the operational phase. By providing a library of validated use-case templates, UCM supports projects to leverage industry knowledge and accelerates BIM implementation. It supports the openBIM core workflow by reducing the effort required to reinvent process templates and exchange formats for each new project. Instead, it conveys the information about what should happen in each BIM use case, promoting consistency and efficiency across organisations.

As a relatively new initiative, UCM is gaining popularity and acceptance gradually. It depends on active contribution and updating of use cases by the BIM community. Early adopters may appreciate the platform's main features, but widespread adoption requires training and awareness. The practical challenge is to ensure that the use cases remain relevant as the IFC standard evolves. It is worth noting that teams must adapt the published use cases to their specific context. Since UCM is built on IDM, it shares IDM's complexity – creating or selecting the proper use cases requires a deep understanding of project requirements.

Taking into account the research from 2020–2025, IFC is the most thoroughly researched openBIM standard, with extensive analysis and real-world applications. IDS and bSDD are moderately well-studied, whereas BCF and IDM receive less attention, and UCM appears to be the least examined in the academic literature. The existing research proves that openBIM standards and services provide clear benefits in promoting interoperability, data consistency, and coordination across the AEC industry (Yu et al., 2023; Gourabpasi et al., 2025). Each standard or service brings advantages: IFC – comprehensive schema, BCF – issue tracking, bSDD – standard semantics, IDS – specification of deliverables, IDM – clarity of the process, and UCM – use-cases templates. However, the literature from 2020–2025 also highlights challenges, including the technical limitations of schemas (IFC), the evolving implementation of newer tools (IDS, UCM), and the need for organisational change to leverage these standards fully. By understanding these benefits and hurdles, practitioners can better integrate openBIM into projects for more efficient and reliable data exchange.

## RESULTS AND DISCUSSION

### Results – case study

In this case study, we demonstrate the practical implementation and integration of openBIM standards using a BIM model for a conceptual museum building based in Warsaw, Poland. The model included architecture, structure, and ventilation systems, which allowed for the demonstration of interdisciplinary collaboration between architect, structural engineer, and MEP engineer within an openBIM workflow. The architectural model was created in ArchiCAD, exported to the IFC 4 format, and then processed in the Blender application, using the Bonsai extension. The aim was to apply and verify the use of the openBIM standards: IFC, BCF, bSDD, IDS, IDM, and UCM. For the purposes of this case study, a demonstration was performed in the IfcWall class. The same properties and validation logic presented below could be analogously applied to other IFC entities; these were not repeated to avoid redundancy.

*Step 1: Creation of the classification as a bSDD dictionary*

At the beginning, the custom classification for the building was created as a dictionary (in JSON format), based on the buildingSMART Data Dictionary (bSDD) with the usage of usBIM.bSDDeditor from ACCA. This platform allows the creation of a JSON file without knowing programming languages.

The bSDD service enables the user to search for a dictionary. The published *Construction Process Dictionary*, where the demonstration class (‘Wall’) is mapped to the ‘ifcWall’ entity, and the property sets contain attributes relevant throughout the entire construction process. The properties are grouped into the following property sets: ‘01_Identification Data’, ‘02_Quantity Data’, ‘03_Location Data’, ‘04_Common Element Properties’, ‘05_Phase Data’, ‘06_Execution Data’, ‘07_Maintenance Data’, ‘08_Sustainability Data’, and ‘09_Demolition Data’. Then the bSDD was downloaded from the platform in a JSON file and uploaded to the bSDD service using the buildingSMART manage platform.

*Step 2: Importing the IFC model and applying bSDD classification in Blender*

The architectural model of the museum building was exported to IFC format and imported into the Blender application. The Bonsai extension was used to manage classification and property sets in compliance with the openBIM methodology. The custom classification dictionary (in JSON format) based on the buildingSMART Data Dictionary was loaded into Blender using the Bonsai interface (Fig. 1). Then, a wall element (IfcWall) was selected. The corresponding bSDD class (Wall) was assigned, thereby automatically assigning all properties and property sets previously defined in the bSDD with references to standardised names, codes, and data types. Subsequently, the values of the above-mentioned parameters were filled in (Fig. 2).

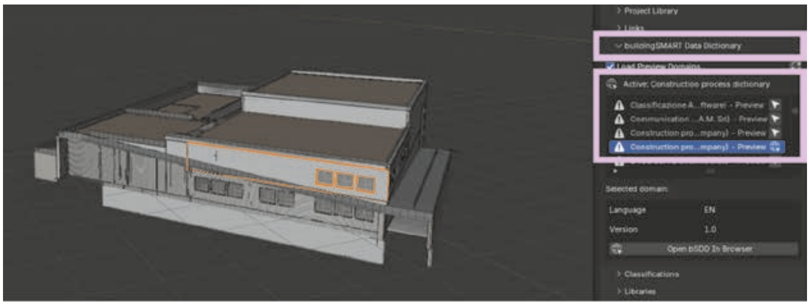


**Fig. 1.** Loading the bSDD dictionary into the Blender application with the usage of the Bonsai plug-in

Source: own work.

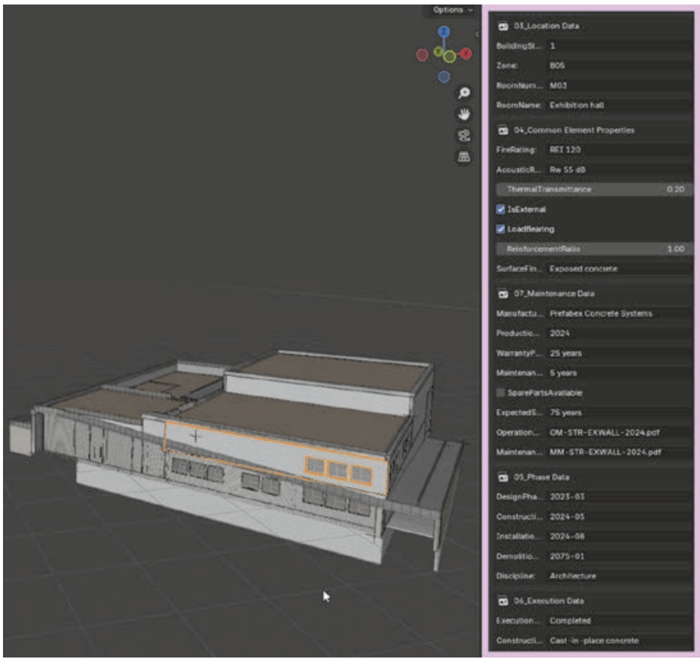


**Fig. 2.** Property sets and properties defined in bSDD are filled in with proper values

Source: own work.

*Step 3: Creating IDS specifications for model validation*

A single IDS file (in XML format) was created to validate multiple information requirements for a selected wall element. This step aimed to validate whether the information requirements defined in the bSDD file were correctly fulfilled within the IFC file. The IDS specification was created using IDS Maker by Datacomp IT, which enables the creation of IDS specifications without requiring programming skills. First, the metadata was defined. The file included three specifications: validation rules aimed at checking property presence, correct data types, and value formatting, as detailed below. The IDS file targeted the 'IfcWall' entity and includes a filter, restricting validation to a single element based on its GlobalId 2MHs2GzN5FdhzT1r$zhAjO, which was defined in the 'Applicability' section of each of the specifications. Then, the 'Requirements' sections were described, aimed at performing the following checks:

1. Presence and data type validation: for the property 'BuildingStorey' within the property set '03_Location Data'. The requirement ensures that the selected wall contains the Building Storey property and that its value is represented as a string.
2. Controlled vocabulary and data type validation: for the property 'FireRating' within the property set '04_Common Element Properties'. The property value is expected to follow the official REI fire resistance rating system (e.g. REI 30, REI 60, REI 90, REI 120, REI 180), represented as a string. Values that deviate from this convention are considered invalid. The specification lists the allowed values as an enumeration and requires formatting with a space (e.g. REI 120).
3. Pattern-based validation: for the property 'AcousticRating' within the property set '04_Common Element Properties'. The requirement enforces that the property value is of IfcLabel type and must conform to a specific text format: 'Rw XX dB', where XX represents a two-digit number. This format is validated using a regular expression pattern: '^Rw\s\d{2}\sdB$'. The pattern checks that the value starts with 'Rw', followed by a space, two digits, another space, and ends with 'dB'. This ensures standardised acoustic rating syntax across the model.

*Step 4: Validating the model using IDS in Blender*

As a final step, the IDS file (in XML format) was downloaded from the platform and imported into Blender via the Bonsai interface using the 'Quality and Coordination' and 'IFC Tester' panels (Fig. 3).

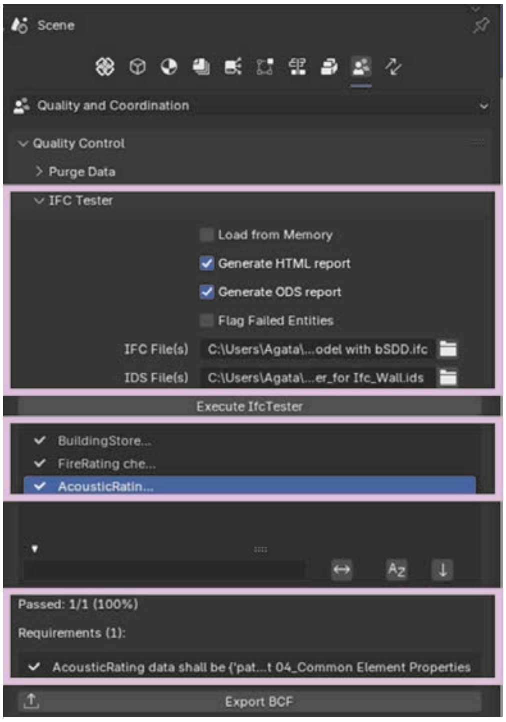


**Fig. 3.** The museum BIM model classification validation with the usage of the IDS file – the model successfully passed the verification process

Source: own work.

The model passed all three validation checks defined in the IDS file. The model confirmed the presence and correct typing of 'BuildingStorey', compliance with the REI fire rating list in 'FireRating', and proper formatting of 'AcousticRating' according to the expected regular expression pattern. Additionally, an HTML report was created that included detailed information about the validation. This step demonstrates the practical capability of IDS to automatically validate data consistency and regulatory compliance directly within an openBIM environment.

*Step 5: Creating and exporting a BCF file*

Had the model contained validation errors – such as a missing required property or a value that did not conform to the expected format – a BCF file could have been created directly within Blender using the Bonsai interface, directly after the IDS file validation (Fig. 3). In the case study, the BCF export was presented as a theoretical example, as the validation files created for the demonstration did not contain errors. The resulting BCF file would typically include: metadata such as the author of the comment, issue status and priority level, a screenshot capturing the specific model view where the issue is visible, and a markup file containing the issue description, comments, and the reference to the relevant building using its GlobalId. Such a BCF file could then be shared with the project team via a Common Data Environment (CDE) platform or BIM coordination platform. This would enable structured, transparent issue tracking and resolution, independent of the software used. Even though the discussed model passed all IDS-based validation checks successfully, this method shows how BCF supports openBIM-based workflows when data inconsistencies are detected in Step 4.

*Step 6: Representing information flows using IDM*

In this step, the IDM was conceptually applied to define who creates and delivers which openBIM files – such as IFC models for geometry and data, IDS for validation requirements, BCF for issue tracking, and bSDD-based property definitions – at each stage of the coordination workflow. The IDM mapping explicitly reflected interactions between the Architect, Structural Engineer, MEP Engineer, and BIM coordinator, illustrating the collaborative workflow rather than a purely theoretical structure. Specifically, IDM principles were used to identify the responsibilities of each discipline – architect, structural engineer, and engineer – during the design development stage. Each discipline is responsible for providing correct IFC models, including classification and performance properties, according to the buildingSMART Data Dictionary, previously prepared by the BIM coordinator. Although IDM is not a software tool, it provides a clear structure that helps organise the information flow by defining what data needs to be shared, by whom, and when. This conceptual structure guided the development of the Business Process Model and Notation (BPMN) process diagram, which represents the part of the openBIM flow described in the case study. The BPMN process (Fig. 4) visually represents the coordination workflow for validating IFC models against IDS files. These IDS files reference bSDD-defined properties to ensure that all required attributes are correctly delivered. Each participant (architect, structural engineer, MEP) first prepares and exports their IFC model, which is then uploaded to the CDE platform. Secondly, the BIM coordinator uses the IDS to validate each discipline's IFC model. If validation fails, a BCF issue is generated and sent to the responsible discipline for correction, ensuring traceability. The corrected model is then re-validated in a loop until all information meets the defined requirements. If no issues are found, the process ends. In this way, IDM provides the foundation for the logical structure and responsibilities embedded in the BPMN workflow. The process map illustrates the practical application of IDM principles utilising interoperable openBIM standards and services, in alignment with buildingSMART recommendations. This contributes to both data consistency and multidisciplinary interoperable coordination, enhancing efficiency throughout the design process.

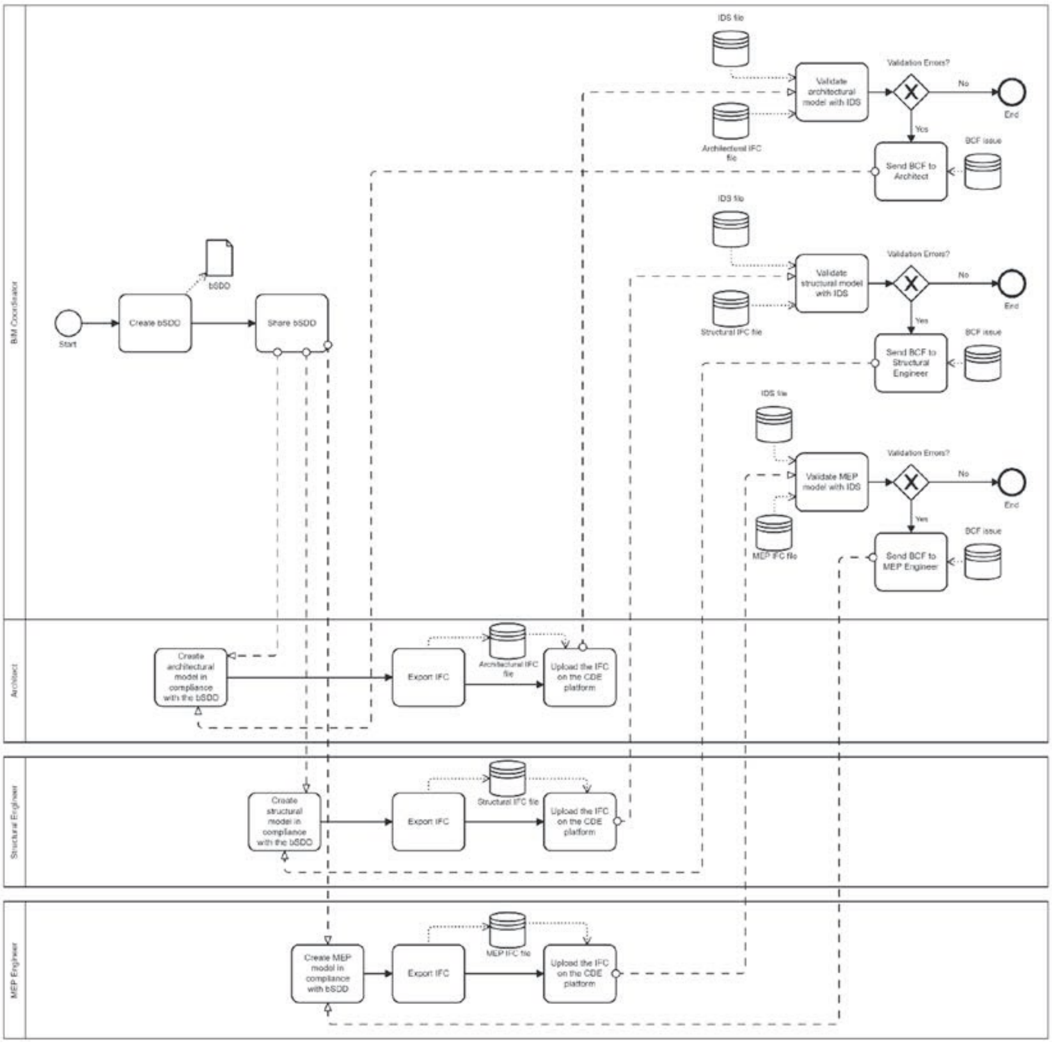


**Fig. 4.** BPMN process map for BIM model validation and coordination based on IDM principles

Source: own work.

*Step 7: Applying UCM to structure information validation and coordination*

In the final step of the case study, the UCM framework developed by buildingSMART was applied to structure and document the information flows, responsibilities, and validation logic already established in the previous steps using IDM and BPMN. As mentioned, UCM provides a framework to formalise project objectives and outcomes by aligning them with standard, reusable, openBIM workflows. Instead of creating a fully custom UCM, this step adopted the existing use case, *BCF & Issue Management from Building Owners* (buildingSMART International, 2023), available on the buildingSMART UCM platform. This existing use case reflects the process described in Step 6: IFC model validation using the IDS file, with a special focus on issues that are communicated through BCF for resolution. This approach supports the UCM's fundamental goal of reusing well-established, community-validated workflows to ensure implementation efficiency.

The selected UCM use case highlights the use of BCF for managing and communicating issues. It illustrates how BCF facilitates transparent issue tracking and resolution among project stakeholders. The advantages of referencing this UCM use case include a better understanding of how BCF supports communication, documentation, and resolution of issues, as well as clarification of responsibilities related to issue management and alignment of the project workflow with an established example of BCF usage. This example illustrates the practical application of BCF within the broader openBIM framework, enhancing collaboration and interoperability.

Table 1 summarises the practical steps applied in the case study and illustrates how each openBIM standard contributes to the overall workflow. The sequential integration of bSDD, IFC, IDS, BCF, IDM, and UCM demonstrates not only their individual benefits but also their cumulative effect on improving interoperability, ensuring data quality, and enhancing interdisciplinary coordination.

**Table 1.** Case study stages and highlighted benefits

| Stage | Description | Benefits |
|---|---|---|
| 1. bSDD classification | Creation of a custom classification dictionary in compliance with the buildingSMART Data Dictionary and its application to IFC entities. | Ensures semantic consistency, standardised terminology, and machine-readability of BIM data. |
| 2. IFC model import | Import of the architectural model into Blender and assignment of bSDD-based classifications and properties. | Enables open, vendor-neutral model transfer and unified data environment. |
| 3. IDS specification | Preparation of IDS rules in XML format to check the presence, types, and formatting of required attributes. | Allows automated validation of model data, ensuring completeness and compliance with requirements. |
| 4. IDS-based validation | Execution of validation rules on the IFC model using Blender's Bonsai extension. | Detects inconsistencies early, reduces errors, and generates structured validation reports. |
| 5. BCF export | Generation of BCF issue reports in case of non-compliance detected during validation. | Facilitates transparent communication and efficient issue tracking between stakeholders. |
| 6. IDM workflow | Definition of roles, responsibilities, and information flows using IDM principles and BPMN diagrams. | Provides clarity of process, reduces miscommunication, and structures interdisciplinary collaboration. |
| 7. UCM use case | Adoption of a standardised UCM template reflecting issue management workflows. | Supports reuse of best practices, accelerates BIM implementation, and ensures alignment with industry standards. |

Source: own work.

In the presented case study, the UCM framework was applied at a conceptual level to structure and document information validation and coordination tasks. Although the project was not realised, the adoption of existing UCM templates, such as *BCF & Issue Management from Building Owners*, demonstrates how openBIM use cases can be standardised and reused across projects. In a realised design process, UCM would serve as a bridge between theoretical process mapping (IDM) and practical project execution by providing templates that clarify responsibilities, define data exchanges, and guide the resolution of issues at each stage. For example, during detailed design or construction design phases, UCM templates could support clash detection workflows by standardising the way BCF reports are created, shared, and resolved among disciplines. This illustrates the potential of UCM not only to document best practices but also to formalise interdisciplinary collaboration, making the workflow repeatable and transferable to different project contexts.

In the Polish context, legal and implementation issues continue to pose a significant challenge to openBIM adoption. Although BIM is increasingly promoted through governmental and industry initiatives, there is still no binding national regulation that mandates the use of open standards such as IFC or IDS. Current public procurement law allows BIM to be required in tenders; however, in practice, these requirements are often formulated in diverse and inconsistent ways, sometimes tied to proprietary formats rather than open ones. This creates uncertainty for contractors and designers, limiting the comparability of deliverables. Furthermore, the lack of official national guidelines on openBIM workflows means that implementation depends mainly on the policies of individual organisations and their level of digital maturity. As a result, although technical solutions are available, Poland's legal frameworks and procurement practices still need to evolve to support the systematic and large-scale use of openBIM.

## CONCLUSIONS

OpenBIM standards collectively enhance interoperability and project efficiency by providing a unified framework for data exchange (Ren, Zhang & Müller, 2025). The literature emphasises that IFC-enabled model federation reduces data fragmentation across disciplines (Jiang et al., 2019a, 2019b), while BCF supports issue tracking (Khemlani, 2021). The usage of bSDD ensures semantic consistency (Oraskari, 2021), and IDS has the potential to formalise project requirements for automated validation (Fischer et al., 2024; Gourabpasi et al., 2025). IDM clarifies workflows and exchange requirements (Kim et al., 2010; Rojas Wettling, 2023), while UCM promotes the reuse of proven coordination workflows (Musella et al., 2020). The presented case study confirmed these benefits in practice. An IFC model, enhanced with bSDD-based classification, served as an information-rich asset that could be exchanged among different stakeholders throughout the construction process due to its open, non-proprietary format. IDS-based validation rules automatically checked required properties, and any discrepancies were documented in BCF issue reports and could be resolved within a workflow defined in IDM. Finally, the use of UCM demonstrated the feasibility of formalising and reusing standardised use cases, thereby supporting the consistent implementation of openBIM practices across projects. The case study as a whole shows how the coordinated use of openBIM standards and services enhanced model quality and interdisciplinary collaboration, ultimately reducing errors and facilitating the acceleration of information exchange throughout the project lifecycle. In addition to the technical aspects demonstrated in the case study, organisational barriers remain a key challenge for the wider adoption of openBIM. The need for clear allocation of responsibilities, appropriate contractual frameworks, and investment in user training shows that efficiency gains depend not only on interoperable standards but also on organisational readiness to implement them.

Key strengths include improved data consistency, increased access to project information, and faster issue resolution through automated validation. However, challenges emerged: many tools still lack full support for newer standards (Yu et al., 2023), requiring manual workarounds and user training. Some technical limitations persist, e.g. complex elements are not fully supported in IFC (Ren et al., 2025). These observations align with reviews noting that openBIM adoption is hindered by schema complexity and evolving toolchains (Tomczak et al., 2022). Future research could test these integrated workflows across broader project phases, from design through operation. Integrating openBIM with digital twins, GIS, and other systems will also be crucial (Ren et al., 2025). As a roadmap for future work, further testing in real-life projects is planned, including the application of IFC 4.3, developing domain-specific extensions or MVDs, and improving support for IDS and UCM (van Berlo et al., 2021; Yu et al., 2023). These steps will facilitate the adoption of openBIM and enhance data integration throughout the project lifecycle.

A limitation of the present research is that the case study was based on a conceptual, not realised, design. This allowed us to test interoperability and data validation mechanisms in a controlled environment, but did not include the full scope of the design and construction process. Consequently, while the study demonstrates improvements in interdisciplinary collaboration and clash detection at the design stage, it cannot fully address later phases such as detailed design, implementation, and operation. Future research should therefore apply the integrated openBIM workflow (IFC, bSDD, IDS, BCF, IDM, UCM) to realised projects, in order to evaluate their impact across the entire lifecycle. Such studies would enable a realistic assessment of how openBIM services improve coordination, support clash detection, and facilitate data exchange under practical project conditions, thereby providing stronger evidence for the hypothesis formulated in this paper.

The case study illustrates that the integration of openBIM standards brings measurable improvements in model quality, coordination, and communication. In particular, bSDD and IDS ensured consistency and completeness of information before coordination meetings, reducing the likelihood of misinterpretation. The possibility of automatically validating properties such as fire resistance or acoustic rating shows how rule-based checks can substitute time-consuming manual reviews. Although the presented project was conceptual, the workflow proved that even at early design stages, structured classification and validation significantly reduce potential coordination issues.

A key added value was the demonstration of interoperability: architectural, structural, and MEP models created in different authoring tools were combined in IFC format, without data loss. This confirms the role of IFC as a neutral backbone for cross-disciplinary collaboration. Moreover, the complementary use of IDS and BCF illustrated how information requirements and issue management can be tightly connected, creating a closed feedback loop between validation and correction. Such integration addresses one of the most common pain points in practice – the fragmentation of information across emails, spreadsheets, and proprietary tools.

Nevertheless, the case study also revealed current limitations. The practical use of IDS and UCM requires higher process maturity and tool support than is currently available in many organisations. While the theoretical benefits are clear, their full potential depends on awareness, training, and wider adoption across the AEC industry.

The study does not focus on implementation costs; however, for clarity, typical cost categories that affect openBIM adoption should be outlined: setup costs (software licenses, hardware upgrades, initial consultancy, configuration), training and competence development, per-project modelling and validation effort (person-hours), CDE/subscription fees, and ongoing maintenance. At the same time, openBIM can reduce costs compared to native solutions, since expensive commercial model viewers are not required, and several IFC-based viewers are available free of charge. Future studies should report costs and compare them to estimated savings from reduced work, fewer coordination efforts and automation of checks.

While openBIM standards can be applied across a variety of project types, their benefits are most pronounced in large-scale and complex projects, particularly under design-and-build contracts, where multidisciplinary coordination and consistent data exchange are critical. Future research could also address the applicability and value of openBIM in smaller projects.

The coordinated use of openBIM standards in the case study confirmed that information consistency and automated validation directly improve collaboration and reduce the risk of errors. The added discussion highlights that the benefits are most visible in interdisciplinary coordination, where common classification, automated checks, and structured issue management accelerate the resolution of conflicts and enhance trust in shared models.

Although based on a conceptual project, the presented workflow demonstrates a repeatable methodology that can be adapted to realised projects. Therefore, the findings provide not only theoretical insights but also practical guidelines for practitioners aiming to implement openBIM in design coordination. With further development of tools and wider industry training, the tested approach has the potential to significantly improve efficiency and data reliability throughout the building lifecycle.

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## BADANIE KORZYŚCI PŁYNĄCYCH ZE STANDARDÓW openBIM W ZAKRESIE ZWIĘKSZONEJ INTEROPERACYJNOŚCI I EFEKTYWNOŚCI W PROJEKTACH ARCHITEKTONICZNO-BUDOWLANYCH

### STRESZCZENIE

W artykule przeanalizowano wpływ standardów openBIM na interoperacyjność i efektywność w projektach budowlanych. Przyjęto hipotezę, że skoordynowane zastosowanie standardów i usług openBIM, takich jak: IFC, BCF, bSDD, IDS, IDM i UCM, poprawi jakość informacji oraz zmniejszy liczbę błędów podczas koordynacji międzybranżowej. Metodologia łączy przegląd literatury z praktycznym studium przypadku koncepcyjnego modelu BIM budynku muzeum. Wyniki wskazują, że każdy standard odgrywa odrębną rolę: IFC umożliwia jednolity transfer modeli, BCF ułatwia rejestrowanie problemów, bSDD zapewnia ustandaryzowaną semantykę, IDS umożliwia automatyczną weryfikację danych, IDM usprawnia przepływ informacji między stronami procesu, a UCM pozwala utrwalać i ponownie wykorzystywać dobre praktyki. Wspólnie wymienione standardy usprawniają wymianę danych, poprawiają koordynację i zmniejszają liczbę błędów. Do wyzwań należą: ograniczone wsparcie narzędziowe i potrzeba szkolenia użytkowników. Podsumowując, standardy openBIM wspierają współpracę i efektywność; istnieje również potrzeba dalszych badań nad ich praktyczną implementacją.

**Słowa kluczowe:** architektura, projekt, openBIM, IFC, bSDD, IDS