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Enhancing BIM quality through information validation

Exploring the effectiveness of Information Delivery Specification (IDS) in the Swedish construction industry

Master's thesis in Design and Construction Project Management ACEX30

Clara Frendberg och Linn Pusa

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

CHALMERS UNIVERSITY OF TECHNOLOGY

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Abstract

The full potential of BIM is rarely fulfilled, due to the information gap between the design and construction phases and the design and management. To increase the reliability of BIM models, buildingSMART created the Information Delivery Specification (IDS), a standard to structure and specify information requirements. The full potential of IDS has not yet been demonstrated due to limited knowledge, awareness, and adaptation, highlighting the need to investigate how IDS can be implemented to obtain higher-quality BIM models. Drawing on qualitative data from interviews and observations from testing IDS in old projects, conclusions on advantages, challenges, and potential improvements associated with the use of IDS have been determined. The results show that current methods of validating information requirements are incomplete as many requirements are not fulfilled. The findings show that IDS is an effective tool to automatically validate information requirements and achieve a higher quality of BIM data. This supports the use of the BIM model during the building's whole lifecycle. The study also shows the need for increased knowledge and awareness of the benefits of IDS to support broader adoption in the industry. Standardized requirement specifications and classification are also necessary for smoother implementation.

Keywords: Information Delivery Specification (IDS), Building Information Modeling (BIM), information requirements, model checking.

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Clara Frendberg & Linn Pusa, Gothenburg, May 2025

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

AEC	Architecture, Engineering & Construction
AIR	Asset Information Requirements
API	Application Programming Interfaces
BCF	BIM Collaboration Format
bSDD	buildingSMART Data Dictionary
BIM	Building Information Modeling
CDE	Common Data Environment
IDS	Information Delivery Specification
IFC	Industry Foundation Classes
ISO	International Organization for Standardization
LOD	Level of Development
LOD	Level of Detail
MMI	Model Maturity Index
MVD	Model View Definitions

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1
Introduction

The Swedish Architecture, Engineering, and Construction (AEC) industry is often identified as reactive, conservative, and resistant to change (Szentes & Eriksson, 2013). For a long time, Building Information Modeling (BIM) has been seen as a digital solution with the potential to revolutionize the industry (Klint & Stand, n.d.). Despite this, the industry is still relatively low in its digital maturity. The information gap between the design and construction phases and the design and management is a recurring problem. These gaps often arise due to insufficiently specified and validated information requirements, leading to inefficiency and lack of interoperability between different actors and software systems (Klint & Stand, n.d.). The requirements are often incomplete, too general, unclear, and applied at the wrong level of detail (LOD). The lack of clear requirements and their validation in model-based projects is a major obstacle for clients and designers to fully benefit from all the opportunities of BIM (Cavka et al., 2017). Studies have shown that poor work with the requirements often leads to significant cost overruns and schedule delays (Wheatcraft, 2011). Projects that do not take effective actions to ensure good and fulfilled requirements are three times more likely to fail. Incomplete or incorrect information in BIM models can also result in performance shortfalls, where the final product does not meet the intended needs or expectations.

The most common way of handling information requirements is through text-based documents, which has been proven to be a problem in BIM practices, as it can not be transferred to software automatically (Tomczak et al., 2022). To solve this and improve the reliability of BIM models, buildingSMART created Information Delivery Specification (IDS) (buildingSMART, n.d.-c). IDS is a standard, with version 1.0 published in June 2024, aiming to structure and specify information requirements to be delivered between different project actors and phases (Bigai & Santos, n.d.). The standard focuses on automated validation of information requirements to help reduce errors and information gaps throughout the project lifecycle (de Marco et al., 2024). The potential of IDS is sustainable information management throughout the life cycle of the building, contributing to resource-efficient, climate-smart, and socially sustainable buildings. However, several challenges remain for effective implementation. Studies confirm that the full potential of IDS has not yet been demonstrated due to limited knowledge, awareness, and adaptation (de Marco et al., 2024). This highlights a need to further investigate how IDS can be implemented and exploited to obtain higher-quality BIM models.

1.1 Aim

This thesis aims to explore and analyze the possibility of obtaining higher quality BIM models with the implementation of IDS within the AEC industry. By investigating how IDS can be employed to enhance information management and ensure compliance with information requirements, this study seeks to identify the advantages, challenges, and potential improvements associated with the use of IDS.

1.2 Research questions

1. Is there a need for more effective methods to validate information requirements in BIM models within the Swedish construction industry?
2. How can the implementation of IDS contribute to enhancing the quality of BIM models?
3. What adaptations and improvements are required to facilitate broader adoption of IDS within the Swedish construction industry?

1.3 Limitations

The study is limited to construction projects in Sweden and adheres to Swedish industry standards. The scope is further restricted to projects for which WSP has been able to provide data, both in terms of selection and volume, which inherently limits the generalizability of the findings. Furthermore, the study specifically addresses information requirements applicable to the investigated projects, without encompassing a broader analysis of information requirements in other types of construction projects or industries.

Furthermore, the project was conducted within a limited time frame, which limited the depth of analysis and excluded the observation of long-term impacts associated with the implementation of IDS.

The interview study involved a limited number of experts and industry professionals, due to the time limit, and to gain in-depth insights into their experiences and perceptions regarding IDS.

Moreover, only a limited number of software tools were analyzed and utilized within the study. This was also due to the time limit.

2
Methodology

The methodology employed in this study is a mixed-methods approach combining qualitative and quantitative methods. This method has been used to gain a comprehensive understanding of IDS's role in improving BIM information quality.

2.1 Research

2.1.1 Technical background and literature study

A comprehensive information gathering process was conducted to acquire relevant knowledge and context in accordance with the objectives of this study. The technical background section presents essential information related to the creation, structure, and understanding of IDS. In the literature study, previous research within the industry was gathered and examined to establish a theoretical foundation. Academic databases such as Scopus and Google Scholar, as well as general search tools like Google, were used to identify relevant articles, publications, and websites. All references were systematically managed using the reference management software Mendeley. Keywords that have been used include, for instance "IDS", "Information Delivery Specifications", "IDS in the Swedish construction industry", "BIM", "BIM in the Swedish construction industry", "OpenBIM workflow", "IFC", "BIM requirements", "Information requirements".

2.1.2 Comparative study of IDS software

A comparative study was conducted to investigate how various tools and softwares support the creation of IDS specifications and the validation of IFC models using IDS. A simple BIM model was created in Autodesk Revit, consisting of a limited number of objects with input properties. This ensured that all tools worked with the same dataset. Based on this model, three identical IDS specifications were created using the following tools: IDS-Editor.com, Solibri IDS Editor, and usBIM.ids. Subsequently, these IDS files were validated against the IFC file, exported from the model, using two software applications: Solibri Office and BonsaiBIM. These tools and software were tested as they were the most common or recommended by industry experts. To evaluate each tool and software, specific criteria were developed, and divided into two categories: tools for creating IDS specifications and software for validating IDS files. Table 2.1 presents the developed criteria for IDS creation tools, and Table 2.2 present the developed criteria for IDS validation software, along with explanations.

Table 2.1: Criteria for the IDS tools

Criteria	**Explanation**
Intuitive interface	How easy it is to understand and navigate the tool without extensive instructions or previous experience.
Support for different IFC versions	Whether the tool supports different IFC versions
License	If the tool is open source, it is considered an advantage from a transparency and customization perspective
User-friendliness	How easy the tool is to use, including workflow, clarity, and available features.
Flexibility in requirement specification	The tool's ability to handle complex requirement formulations

Table 2.2: Criteria for the IDS validation software

Criteria	**Explanation**
Feedback on validation	How clearly the program reports back which requirements have been met or not, and why.
Result export	Ability to save or export validation results in a readable form.
License	Whether the software is free to use or requires a license, which affects availability and cost.
User-friendliness	How easy the tool is to use, including workflow, clarity, and available features.

Each criteria was evaluated based on a five-point scale. The results from each tool were documented and compiled in comparative tables.

Another part of the study aimed to investigate whether the tested IDS tools and validation software support the use of entities higher up in the IFC hierarchy. The use of general entities can simplify the specification process by allowing for a more general definition without the need to specify each subordinate entity, such as IfcWall, IfcBeam, IfcColumn, etc., individually. This can be particularly advantageous in stages where requirements do not need to be detailed at the entity level. To test this, three separate IDS files were created with different entity levels: IfcProduct, IfcElement, and IfcBuildingElement. Each IDS file contained a simple requirement definition without real significance, solely to ensure that the file itself could be validated without errors related to the content of the requirement. The purpose was to test the applicability of the different entities.

These three IDS files were created in all three IDS creation tools. Each file was then validated against the same IFC model as before, using both Solibri Office and BonsaiBIM. If the validation failed at the entity level of IfcProduct, a new IDS file was created with the entity one step lower in the hierarchy, IfcElement, and the process was repeated. If this also failed, IfcBuildingElement was instead tested. This method enabled a systematic mapping of the support each tool has for different levels of entity application according to the IFC hierarchy. The results were documented in a separate table.

2.1.3 Case studies for IDS validation

The purpose of the case studies was to investigate the efficiency and effectiveness of using IDS to validate information requirements in digital building models. To achieve this, several case studies were conducted on completed projects and their associated digital models. The materials used in the studies include, for instance, requirement specifications and BIM models, which were obtained from WSP. The material were obtained from completed construction projects.

Based on the obtained requirement specifications, an IDS file was created for each discipline. The work was carried out using a tool that supports the creation and editing of IDS. The information requirements were formulated in a structured and machine-readable manner according to the IDS standard. The IDS files were then used to validate the corresponding IFC models in a software that supports IDS validation. The validation process involves automatically checking the model against the requirements defined in the IDS file. The results of the validation were exported in the form of a validation report, clearly indicating which requirements have been met and which have not.

The results of the validation reports were subsequently analyzed to assess how well the models meet the specified information requirements, the extent to which the IDS files allow for clear control of the information requirements, and any patterns or recurring deficiencies in the information deliveries. Additionally, the time and effort required for the IDS creation were evaluated.

2.1.4 Interview study

An interview study was conducted to gather information on the attitudes, knowledge, and expectations of the industry for IDS. The interviewees were selected to provide a broad perspective and included a PhD student involved in the development of the standard, an information strategist representing the client side, a BIM developer that has used IDS in real projects, and a manager of information modeling.

The interviews were conducted in a semi-structured way to allow space for additional questions and reflections during the discussions. The questions were tailored to each interviewee, taking into account differences in expertise and areas of knowledge, and can be found in Appendix A. All interviews were recorded and transcribed using the AI-powered transcription feature integrated into Microsoft Teams.

2.2 Ethical considerations

Ethical considerations are important to this study, both to ensure responsible research and the rights and privacy of interview participants. As the study involves handling of project data, including potentially sensitive or proprietary information from a real construction project, it is essential to ensure confidentiality, responsible data management, and transparency.

Interview participants were contacted via email and informed about the purpose and subject of the study, as well as how their participation would contribute. Before the interview, they received the questions in advance to help them feel prepared and informed about what to expect. At the beginning of each interview, verbal consent was obtained to record the conversation to facilitate transcription and ensure accurate representation of the content. Participants were informed that both the audio recordings and transcriptions would not be published, and that their identities would be anonymized in the final report. They were also informed of their right to revise or withdraw any statements at any time. Before publication, participants will be allowed to review and approve the content in which they are part.

All material containing sensitive information from WSP has been anonymized in the report. This material was processed manually, without the use of AI tools, to ensure secure handling. Once no longer necessary for the study, such material was permanently deleted.

AI tools were used in a responsible manner throughout the study, primarily for brainstorming, translation, language refinement, and article searches via Scopus AI. No sensitive or personally identifiable information was processed using AI.

Critical source evaluation was applied throughout the process of data collection and analysis, including the interpretation of interview data. This was done to ensure the credibility, transparency, and reliability of the study's findings and conclusions.

3
Technical background

3.1 Building Information Modeling

Over the past decades, BIM has become a central technology in the AEC industry (Azhar, 2011). It is used to create, manage, and analyze digital representations of a building's physical and functional characteristics and serves as an integrated platform that facilitates collaboration between various stakeholders (Yang & Liao, 2016). This reduces errors and supports decision making, thus improving efficiency throughout the lifecycle of the building.

By utilizing BIM, cost and time aspects can be considered early in the construction process, enabling the creation of 4D and 5D models, where the fourth and fifth dimensions, representing cost and time, are linked to the 3D representation of the building (Bernard et al., 2013). BIM also enables real-time updates and automated calculations, contributing to improved resource allocation and project management.

However, BIM implementation comes with challenges (Azhar, 2011). As different stakeholders and projects may use various software solutions, the need for uniform standards becomes crucial. Without such standardization, efficient collaboration and seamless information exchange may be hindered. Implementing BIM also entails high initial costs for software acquisition and competence development. Organizations must also adapt their internal processes to ensure that all involved parties possess the necessary expertise to handle the technology efficiently. Interoperability is another key aspect, as different BIM platforms may have limited capabilities in interpreting and sharing data consistently, potentially leading to information loss and reduced productivity if not optimized (Yang & Liao, 2016). To mitigate this, the IFC (Industry Foundation Classes) standard has been developed to enhance compatibility between different software solutions.

3.2 Industry Foundation Classes

IFC is a standardized data model that enables interoperability between different software applications in the construction sector (Laakso & Kiviniemi, 2012). In 1994, the organization Industry Alliance for Interoperability (IAI), now known as buildingSMART, initiated the development of IFC, which was formally launched in 1995. Today, IFC is an international standard for information exchange in the construction industry. By providing a common structure for BIM models, IFC facilitates more efficient data exchange across disciplines, enabling a more integrated workflow while reducing the risk of information loss and minimizing the need for manual data translation (Venugopal et al., 2012). IFC has been formally adopted by the International Organization for Standardization (ISO), an independent international standards organization (Borrmann et al., 2018). The standard is designated as ISO 16739, defining the IFC data model and its application within construction and facility management.

The primary purpose of IFC is to facilitate information exchange across all phases of a construction project (Venugopal et al., 2012). During the design and planning phase, IFC allows engineers and architects to share BIM models between different software applications without losing semantic or geometric information. Furthermore, IFC enables the use of BIM models in various technical analyses, such as structural analysis, energy calculations, and fire protection simulations (Venugopal et al., 2012). Collaboration between different software solutions can also be enhanced through Model View Definitions (MVD), which allow specific portions of an IFC model to be customized for particular needs during the construction process (Borrmann et al., 2018). By restricting the data types and objects included in a specific exchange, compatibility and efficiency in information flows between software applications are improved.

During the production phase, IFC serves as a bridge between design and production by conveying detailed information about building components, thereby reducing the risk of errors in production and increasing precision (Klusmann et al., 2020). Moreover, IFC models can be integrated with scheduling and logistics through 4D and 5D BIM models, enabling better process control during construction. IFC is also applicable in building operation and maintenance, facilitating the exchange and management of building information such as structural conditions, installation dates, warranties, and service history (Borrmann et al., 2018). This supports maintenance planning and repairs. As various software applications and functions support IFC as an open standard, building data remains accessible and usable even as new software or technologies are developed and implemented. This ensures long-term access to digital information, independent of proprietary file formats.

Depending on specific needs and applications, IFC can be stored in multiple data formats (Borrmann et al., 2018). The most common format is IFC-SPF (Step Physical File, ISO 10303-21), which is used for exchanging large BIM models. IFC-XML (ISO 10303-8), an XML-based version with a larger file size than IFC-SPF, is primarily used in web-based applications. To reduce file size and facilitate sharing, IFC-ZIP is employed as a compressed version of either IFC-SPF or IFC-XML. Another format, IFC-BIN, is a binary format optimized for faster file access and processing.

3.2.1 Inheritance hierarchy

The inheritance hierarchy plays a significant role in IFC files, as it defines which classes can inherit from others (Borrmann et al., 2018). At the top of this hierarchy is the IfcRoot class. Figure 3.1 illustrates the hierarchy structure and how the various classes are related through inheritance. This structure ensures that attributes and relationships are defined in higher-level classes and systematically reused by more specific subclasses.

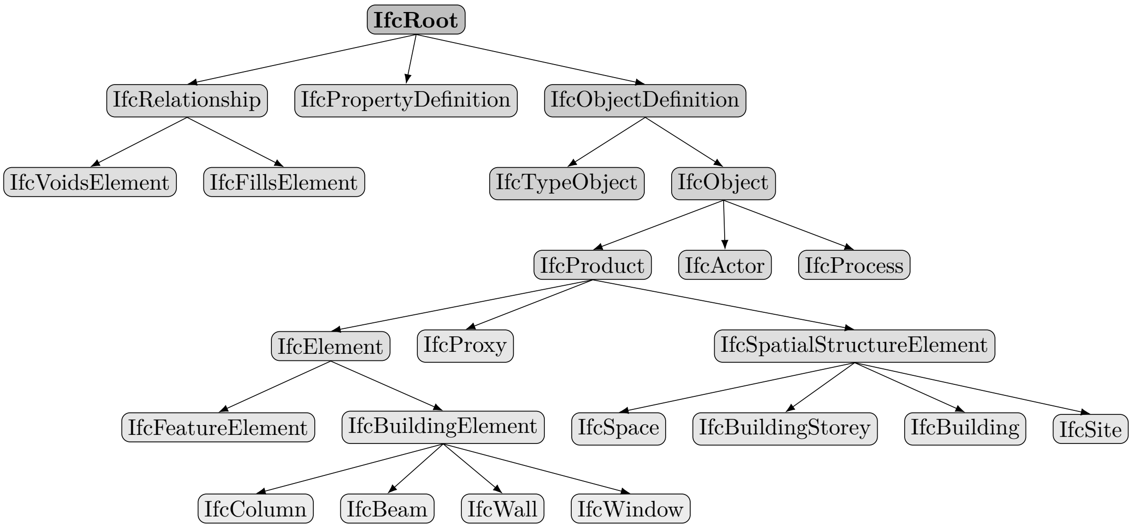


Figure 3.1: Inheritance hierarchy in IFC

3.2.2 Object relationship in IFC

The IFC schema incorporates the concept of objectified relationships (Borrmann et al., 2018). This means that relationships between objects are represented as separate entities, rather than as simple attributes embedded within the objects themselves. For example, if a wall contains an opening for a window, a distinct relationship entity is created to represent this connection. This relationship is modeled as an independent object with its own set of attributes, allowing detailed descriptions of how the wall and the window interact, for instance, how the opening affects thermal insulation or fire safety (Figure 3.2).

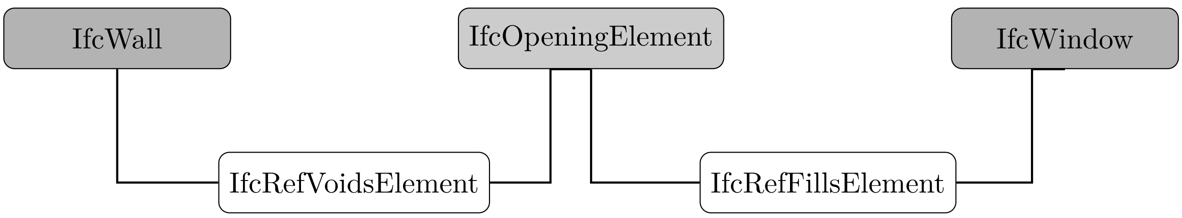


Figure 3.2: Example object relationship in IFC

This approach allows for greater flexibility and semantic accuracy, as the relationship can convey more complex information than a direct association (Borrmann et al., 2018). It also enables navigation in both directions: from the wall to the window and from the window to the wall.

3.3 Standard levels

Within BIM, there are several methods for specifying information, including Level of detail (LOD), Level of development (LOD), and Model Maturity Index (MMI)(Abualdenien & Borrmann, 2022; Hansen et al., 2021). These standardized levels are used to define various aspects of information management and modeling throughout the BIM process.

3.3.1 Level of detail

Level of detail defines the level of detail in BIM models and specifies the amount of information to be included at different stages of the construction process (Karlapudi et al., 2021). To determine the appropriate level of information, various standardized levels are established, representing the degree of detail for objects within the model (GP-Radar, n.d.). These levels encompass both geometric accuracy and non-geometric data, such as properties, materials, and connections to other building components. By ensuring that the right information is used at the right time, LOD helps reduce the risk of misunderstandings and inefficiencies in construction projects (Sampaio, 2021).

The different standard LOD levels are summarized in Table 3.1 below:

Table 3.1: Overview of Level of detail levels (GP-Radar, n.d.)

LOD level	Description
LOD 100	Represents rough shapes and volumes. The model is symbolic and used in early project stages.
LOD 200	Includes simplified geometric objects with approximate shapes, sizes, positions, and orientations.
LOD 300	Provides more precise geometry, with defined shapes, positions, and quantities. The higher level of detail allows for more accurate analyses.
LOD 400	Incorporates realistic and highly detailed information regarding materials, geometry, and quantities. The model can be used for fabrication and installation.
LOD 500	The most detailed level, representing the as-built conditions. All objects are verified against reality, enabling use in facility management and operations.

3.3.2 Level of development

Level of development defines the degree of development within a BIM model and is used to indicate the reliability of the information in the model at different stages of a project (Latiffi et al., 2015). The LOD framework consists of six different levels presented in Table 3.2, where each specifies the extent of detail and accuracy within the model (Abualdenien & Borrmann, 2022).

Table 3.2: Overview of Level of development levels (Abualdenien & Borrmann, 2022)

LOD level	Description
LOD 100	A generic representation of the building, without specific shape information or geometric definition.
LOD 200	The model includes approximate geometry and basic information.
LOD 300	All elements are modeled with their actual quantity, size, shape, placement, and orientation.
LOD 350	Includes relationships between building components, providing additional coordination details.
LOD 400	Contains detailed information regarding assembly, manufacturing, and installation.
LOD 500	Represents the as-built condition of the structure, including data for facility management.

3.3.3 Model Maturity Index

The Model Maturity Index describes the overall maturity level of a BIM model and serves as a framework for communicating, planning, and controlling the development of the model throughout the design process (Hansen et al., 2021). The use of MMI has been shown to improve coordination between different disciplines and reduce the risk of design errors. Similarly to the Level of development, MMI consists of six standardized levels, each representing a specific stage of model maturity.

Table 3.3: Overview of Model Maturity Index levels (Hansen et al., 2021)

MMI level	Description
MMI 100	The proposed design solutions are in an early conceptual stage and may still be subject to significant revisions.
MMI 200	The design solutions are established, and modifications that impact other disciplines are no longer permitted. Objects are suggested at this stage.
MMI 300	The model is prepared for cross-disciplinary validation, with objects having accurate geometry and placement.
MMI 350	The model is fully coordinated across all disciplines.
MMI 400	The model is finalized and approved for use in production.
MMI 500	The model contains verified as-built information, reflecting the actual construction.

3.4 Information requirement

Information requirement is the specific information needed throughout a project to make informed decisions and achieve project objectives (Filardo et al., 2023). In the context of BIM, information requirements specify what data should be delivered in the BIM model and how it should be delivered. They are crucial for controlling BIM data and ensuring that the model meets the needs of various stakeholders. Information requirements include detailed specifications of building components, spatial relationships, and design requirements. The information required in a BIM model varies between different phases of the building life cycle, including different design phases, and construction phases (Hort et al., 2020). Therefore, all requirements must be clarified in detail before modeling at each level.

ISO 19650 is an international standard for managing the information over the whole life cycle of a built asset using BIM (Scheffer et al., 2018). It provides a framework for effective information management and collaboration in construction projects. It describes how information is created, organized, shared, and stored in a structured and efficient way throughout the life cycle of a building or facility. The main purpose of the standard is to improve collaboration with stakeholders and to ensure the right information is available at the right time and in the right way.

3.5 BIM manual

A BIM manual is a document containing information on how to implement and use BIM in a company or in a specific project (Asma et al., 2016). It serves as a comprehensive guide that outlines the standards, responsibilities, and protocols necessary for a successful implementation of BIM throughout a construction project. It is essential to create a well-structured BIM manual before starting the project, to make sure every stakeholder knows what is expected of them and the project.

The BIM manual includes a lot of information, including:

- Guidelines for how data within BIM files should be created, managed, documented, and shared. Definition of roles and responsibilities for the BIM process.
- Key deliverables, essential project milestones, and specific uses of BIM for the project.
- Plans specifying when information will be produced, who is responsible for each task, and which protocols and procedures will be followed.
- How the information requirements should be fulfilled, including the level of development and collaboration protocols.
- Detailed working procedures, including file naming conventions, software requirements, and a standardized set of annotations, abbreviations, and symbols to be used throughout the BIM process (Asma et al., 2016).

3.6 Information Delivery Specification

IDS is an open standard from buildingSMART, used in the context of BIM, to define and manage the information requirements in construction projects (buildingSMART, n.d.-c). The standard was approved in version 1.0 in June 2024. It is designed to be both easily readable by humans and can be interpreted by computers. IDS aims to improve the efficiency and accuracy of information delivery by providing a structured and automated approach to specifying and verifying information requirements. According to buildingSMART (n.d.-c), IDS was developed as a solution to requirements previously being specified in unstructured documents and not readable by computers, leading to misunderstandings and a lot of manual work.

IDS is specially adapted to define information according to the IFC structure (buildingSMART, n.d.-c). An IDS is an XML file with the file extension .ids, making it possible to integrate IDS into various digital workflows and BIM software. The XML file can be read by both humans and computers, and some specific viewers visualise the IDS in a way that humans can more easily understand. It is also possible to add instructions that clarify the requirements to a human, as there will be cases where humans need to add information to the BIM dataset, even if IDS can be read by computers. The purpose of using interoperable platforms and non-proprietary formats like IFC and XML is to ensure that IDS does not limit competition between technology suppliers and supports a broader adoption.

The IDS file consists of one or more specifications, divided into two main parts: a description with the title, purpose, and version, for human understanding, and specifications for computer interpretation (Smart Build Environment, n.d.). The specification includes an applicability that defines what object you intend to specify in the model and a requirement specifying what information those objects should have. Applicability and requirements are described based on IFC aspects and can specify information requirements for properties, attributes, classifications, materials, entity types, and object dependency.

3.7 Softwares

3.7.1 Revit

Autodesk Revit is a BIM software used to design and document building structures (Autodesk, n.d.-a). The software allows the import of 2D drawings as a basis for creating detailed 3D models of buildings. As a modeling tool, Revit enables users to define each building component with realistic attributes such as material properties, weight, and geometry (Autodesk, n.d.-b). Furthermore, Revit supports multidisciplinary collaboration and coordination, allowing data from various disciplines to be integrated within a single model (Autodesk, n.d.-a). Access to Autodesk Revit requires a valid software license.

3.7.2 Solibri Office

Solibri Office is a software application designed for the verification, quality assurance, and coordination of BIM models within the AEC industry (Nordic BIM Group, n.d.-c). As Solibri is based on the standardized IFC interface, it supports the import of models from the most commonly used modeling tools (Solibri, n.d.-a). The primary purpose of the software is to review and validate models in terms of compliance with regulations, quality standards, and interdisciplinary coordination (Nordic BIM Group, n.d.-c). A valid license is required to operate Solibri Office (Solibri, n.d.-b).

3.7.3 BonsaiBIM

BonsaiBIM, formerly known as the BlenderBIM Add-on, is a free and open-source tool for creating, editing, and analyzing BIM data in the IFC format (BonsaiBIM, n.d.). BonsaiBIM functions as an add-on to Blender and is built on top of IfcOpenShell. It provides a workflow for OpenBIM that aligns with international ISO standards. BonsaiBIM is not owned by any company, it has been developed by the Blender community, which anyone is free to join or support through financial contributions.

3.7.4 usBIM

usBIM is a cloud-based platform developed by ACCA Software (ACCA Software, n.d.-a). It supports openBIM workflows, as it complies with standards such as EN ISO 19650. The software is compatible with file formats like IFC and RVT, which can be accessed and used directly in a web browser, without the need for additional application installation. usBIM offers certain features free of charge, including 10 GB of cloud storage and basic tools for filtering and collaboration, such as the usBIM IDS editor (ACCA Software, n.d.-b). However, access to more advanced functionalities—such as clash detection, 4D scheduling, and IFC editing—requires a paid subscription.

3.7.5 IDS-Editor.com

IDS-Editor.com is a free, online platform to define and create information requirements in IDS (LastBIM, n.d.). The IDS editor is designed by LastBIM, a German software company specializing in BIM solutions. The IDS editor adheres to international standards and supports IDS 1.0, IFC2x3, IFC4, and IFC4x3.

3.8 Systems for structuring building information

When working with BIM and digital information management, it is essential to use shared terminology and standardized classifications to ensure that all stakeholders speak the same language (BIM Alliance, n.d.-b). It is important to have a structure or a standard for sorting, naming, and grouping information in a consistent way, making the information searchable, comparable, and reusable. Various systems are used within BIM, each offering different methods of organizing and structuring data. Among them are, for instance, Building Information Properties (BIP), BSAB 96, CoClass, and the buildingSMART Data Dictionary (bSDD).

3.8.1 BIP

BIP is a Swedish free database and standard for properties used in BIM (Svensk Byggtjänst, n.d.-a). The purpose of BIP is to create consistent and structured terminology for information linked to building components in digital models, such as fire rating for doors or U-value for windows. BIP is used so that everyone uses common designations and codes for objects within BIM.

3.8.2 BSAB 96

BSAB 96 is a Swedish standard for the classification and structuring of information throughout the construction process, maintained by Svensk Byggtjänst (Svensk Byggtjänst, n.d.-b). The system comprises tables with codes for construction works, spaces, building elements, and production results, enabling consistent information management from design and planning to production and facility management

3.8.3 CoClass

CoClass is a classification system for the built environment, published by Svensk Byggtjänst (BIM Alliance, n.d.-a). CoClass consists of standardized classes, terms, and concepts, and its purpose is to manage information from a lifecycle perspective. An object classified with CoClass retains the same meaning across different software platforms and throughout all phases of its lifecycle. It is possible to access the basic tables in CoClass for free, but to access full tables, a paid subscription is required.

3.8.4 bSDD

bSDD is a database with standardized definitions and concepts for the built environment (buildingSMART, n.d.-a). The data dictionary is free and provided by buildingSMART to enable a common understanding between different actors and software, and to get everyone to agree on consistent terms. bSDD contains standardised properties and classes and can also link relations and map between them.

The primary method for accessing the bSDD is through its APIs (Application Programming Interfaces), allowing BIM software and other applications to use the data stored in the bSDD (buildingSMART, n.d.-b). There is also a search webpage where the data can be accessed manually. bSdd can be used to enrich BIM models with easy access to standards and data. It can also be used to reference in IDS and IFC, and to validate the quality of BIM data.

4
Literature study

4.1 Issues related to information requirements

In the present time, BIM continues to develop and become more important within the construction industry to increase productivity (Heaton & Parlikad, 2020). Although BIM has shown many advantages, especially in the design and construction phase, there are still limitations to its adoption within the operational phase. One of the challenges is to develop information requirements that support the BIM process. BIM requirements are often incomplete, too general, unclear, and applied at the wrong level of detail (Heaton & Parlikad, 2020). Studies have shown that poor requirements often lead to significant cost overruns and schedule delays (Wheatcraft, 2011). Projects that do not take effective actions to ensure good requirements are three times more likely to fail. Incomplete or incorrect requirements can also result in performance shortfalls, where the final product does not meet the intended needs or expectations. The requirements must be clarified in detail before modeling at each level. An identified problem with setting requirements is that clients often do not know what modeling requirements should be set due to lack of knowledge (Hort et al., 2020). Another major problem with information requirements, according to Filardo et al. (2023), is that they are usually handled in a paper-based manner, through PDF, for example.

4.2 IDS in practice

The most common way of handling information requirements today is through text-based documents, that can not be transferred to software automatically (Tomczak et al., 2022). According to a study by Tomczak et al. (2022) where several initiatives and workflows were compared, IDS was identified as the most advantageous method for validating alphanumerical information requirements in digital construction projects. de Marco et al. (2024) confirms that IDS facilitates importing requirements into BIM software and performing automated compliance checks. This significantly improves workflow efficiency and reduces the manual effort required for information exchange. It also enhances interoperability among stakeholders and improves the quality and efficiency of BIM models from early design stages. As the use of IDS helps in aligning BIM models with specific project requirements, it is also crucial for maintaining high-quality deliverables. The use of IDS and other information standards has been shown to reduce the complexity and cost of communication data within supply chains.

According to Smart Build Environment (n.d.), IDS is initially used to document the requirements established for a project and forms part of the contractor's specification. Before a model is submitted, an automated verification against the IDS can be performed to identify any deviations. Similarly, the IDS can be used to verify that the delivered model contains the requested information. This automated verification process reduces the risk of human error and enhances the quality of project deliverables. However, it remains essential to clearly define the information requirements before delivery to ensure the effectiveness of the process. For information requirements to be machine-readable, the language must be formally defined and structured, which can make IDS files challenging to write or interpret manually. The use of appropriate software tools facilitates this process, and the development within this area is active, with an increasing range of tools available for creating, editing, and reading IDS files. A study by Kremer and Beetz (n.d.) also confirms that IDS can be used as a tool to support energy performance calculations. IDS makes it possible to formulate and document the data needed for the energy calculation and facilitates the automatic verification of whether the IFC model contains the specified information. This reduces the amount of information that must be manually entered into energy simulation tools.

Research by de Marco et al. (2024) has found that the IDS standards' full potential has not yet been realized, due to limited knowledge, awareness, and adoption. Another challenge proved to be integrating the IDS methodology into established industry workflows, as it requires a shift in the cultural practices of digital engineering. Another limitation identified in a study by Filardo et al. (2024) is that IDS uses facet types from IFC, which can make it difficult to use IDS in contexts where other data models are used. IDS is also dependent on the information being correctly structured in IFC, which can lead to problems if the information does not exactly follow the standard. Experiments have also revealed compatibility issues among different IDS file-creation tools on the market (Owerko et al., 2024). This incompatibility is because the IDS format is still relatively new, and many suppliers have not yet had time to fully adapt their products. One of the most important limitations identified in the study by Tomczak et al. (2022) is that IDS is limited to alphanumeric requirements and can not be used to define geometric requirements. IDS can specify that a wall should have a certain fire class, but can not specify how it should be modeled or what level of detail is required.

4.2.1 Integration of bsDD with IDS

Research demonstrates that integrating bSDD with IDS enables the standardization of properties, classifications, and other data elements in a way that ensures both clarity and machine-readability (Kładź & Borkowski, 2025). This approach significantly reduces the risk of misunderstandings and misinterpretations during requirements specification, as users select predefined attributes directly from a digital dictionary rather than manually entering them. One of the key advantages of incorporating bSDD into IDS files lies in the fact that both tools are developed as openBIM solutions, independent of any specific software vendors, thereby enhancing interoperability across various phases of a project. The study by Kładź and

Borkowski (2025) also shows that this integration minimizes duplication of effort and inconsistencies in information requirements, as bSDD provides a shared, centralized set of definitions that can be reused throughout different stages and projects.

4.3 BIM workflow in Sweden

BIM has become a central tool in the AEC industry due to its capacity to support a building's entire lifecycle (Boverket, 2023). In the early planning stages, BIM is primarily utilized to generate 3D visualizations of the proposed structure, enabling the evaluation of various design alternatives before the commencement of detailed design work. This facilitates more informed decision-making and fosters a shared understanding among stakeholders regarding the project's prerequisites. Furthermore, geographic data and detailed development plans are often integrated into the model (Nordic BIM Group, n.d.-b). This provides a broader contextual foundation for the design and enhances the relationship between the building and its surrounding environment.

As the project transitions into the design phase, the BIM model is progressively enriched with greater levels of detail (Nordic BIM Group, n.d.-b). It is employed for quantity take-offs, material planning, and cost estimation. Multiple stakeholders, including architects, engineers, cost estimators, and project managers, collaborate within the model environment and participate in regular coordination meetings. This interdisciplinary collaboration enables early identification of potential conflicts, resulting in more efficient design processes and a reduction in construction-phase errors. During the design phase, BIM also serves as a platform for clash detection, quantity extraction, and the visual planning of construction activities (Boverket, 2023). The information embedded within the model is leveraged to produce schedules, conduct cost analyses, and simulate workflow through 4D scheduling

On-site, the model is frequently accessed via digital devices such as tablets, ensuring that all parties have real-time access to the most current project information (Boverket, 2023). In projects involving prefabricated modules or pre-cut components, these can be specified directly within the model and ordered in advance, thereby improving logistics and reducing lead times (Nordic BIM Group, n.d.-b).

Upon project completion, the BIM model plays a critical role in the handover to facility management (Boverket, 2023). It contains comprehensive documentation on building components, technical systems, user manuals, and warranties, enabling facility managers to efficiently locate systems and plan maintenance based on actual needs. Furthermore, integration with digital twin technologies allows for more proactive maintenance strategies, using sensor data to optimize indoor climate conditions and energy consumption (Nordic BIM Group, n.d.-b).

Even in the later stages of the lifecycle of a building, such as renovation or demolition, BIM continues to generate value (Boverket, 2023). The model provides traceability regarding the materials used and the structural configuration, thereby facilitating disassembly and promoting the reuse of components. In this way, BIM supports the transition to a more circular economy by conserving resources and minimizing waste.

4.4 OpenBIM workflow

OpenBIM is a seamless methodology for collaboration among various disciplines within the construction process, based on open standards and workflows that facilitate the use of BIM (Nordic BIM Group, n.d.-a). Developed by buildingSMART, this approach provides a universal solution primarily focusing on interoperability between different BIM software.

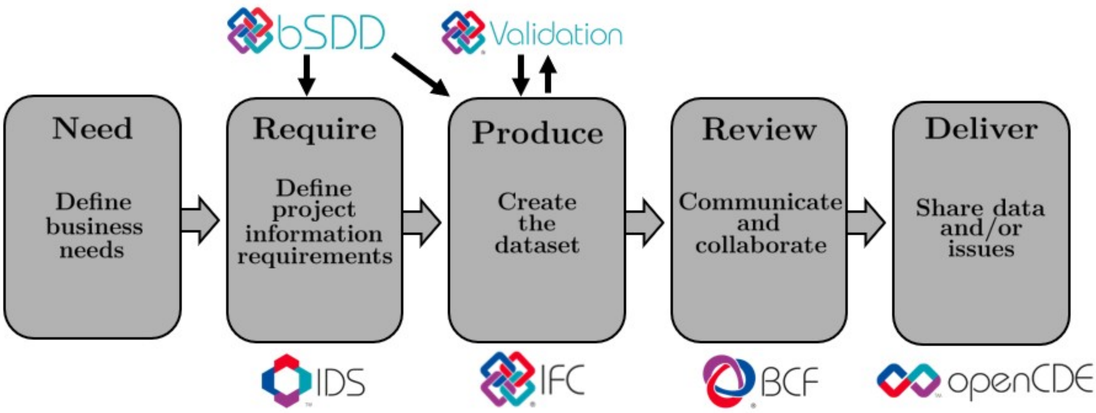


Figure 4.1: OpenBIM workflow

The OpenBIM workflow can be divided into five key stages according to buildingSMART: needs analysis, requirements specification, information creation, validation and verification, and information sharing (Knoop & Norberg, 2024). The first stage, needs analysis, involves identifying the information requirements within the organization and the project (Smart Built Environment, n.d.). Conducting a needs analysis is a crucial step in establishing a unified understanding of information requirements while ensuring efficient and clear communication between disciplines. The second stage, requirements specification, entails defining explicit information delivery requirements set by the client. At this stage, IDS can be used to describe and verify the information requirements, which are managed in a structured manner through IFC. A common language and standardized definitions are essential for effective requirements specification, and bSDD can facilitate this process.

The next step in the workflow involves creating the required information (Smart Built Environment, n.d.). The appointed contractor develops a BIM model based on the specified requirements, structuring the model's information according to IDS specifications. Throughout the model development process, continuous validation is performed to ensure compliance with the specified requirements and correct data placement. Once finalized, the model is exported via IFC.

Following model completion, verification ensures that the model meets the established requirements (Smart Built Environment, n.d.). In this stage, IDS plays a crucial role by enabling the automatic verification of information, ensuring accuracy and completeness. Additionally, the BIM Collaboration Format (BCF) can be utilized to communicate any discrepancies and necessary corrections.

Once the model has been validated and all information is confirmed to be correct, it is shared within a common data environment (CDE), granting all involved disciplines access to the latest validated version of the model (Smart Built Environment, n.d.).

4.5 IDS as a proposed standard in Sweden

As part of a government mandate, Boverket has produced a final report aimed at promoting the transition to a circular economy within the construction and real estate sectors, identifying digitalization as a key enabler for change (Boverket, 2024). Boverket was tasked with investigating how digitalization can support and facilitate the transition to a circular economy and proposing measures within the construction and real estate sectors. Boverket concludes that digitalization supports the circular economy by enabling the sharing and reuse of building information throughout its lifecycle. Boverket mentions that a major challenge in today's construction sector is that information is often locked in proprietary file formats, developed and owned by specific companies, where the information in the file can only be fully read or edited with the company's software, making sharing between actors and software difficult. This reduces the incentives to spend time producing high-quality and detailed building information since it cannot be effectively reused.

In the report, Boverket mentions a solution to this problem being the open and free standard IFC, which allows information to be created, shared, edited, and reused by various compatible systems (Boverket, 2024). However, some information may be lost when exporting from proprietary formats to IFC. To support information sharing and transparency in the industry, the use of open standards and file formats should be encouraged. According to Boverket, this is particularly important for government agencies and public projects to maintain competitive neutrality and reduce duplication of work.

Boverket (2024) also proposes measures to promote the use of open, non-proprietary standards and file formats for digital building information. The proposal includes, among other things, that IFC should be the standard used to deliver digital building information to authorities, and that IDS should be used to enable automated validation of IFC models. Boverket will develop guidelines and instructional videos showing how digital models are built and validated according to IDS.

Boverket's final report was submitted to Regeringskansliet in February 2025. Before taking a position on the proposal, it has been sent out for consultation to relevant authorities, organizations, municipalities, and other stakeholders (Regeringskansliet, 2025). This is done to find out what the concerned parties think about the proposal and what support it has, which will be included in the basis for the decisions that follow after the consultation. While the report is out for consultation, and until Regeringskansliet decides on any further work, Boverket has no or very limited resources to work on the proposals (Martin Wiss, personal communication, March 12, 2025).

4.6 BIM practices in Norway

Norway has established itself as a leading actor in the implementation of BIM, mostly due to the early and proactive involvement of the state-owned agency Statsbygg, which serves as the government's property developer (Agacad, 2021). In 2010, Statsbygg introduced a mandatory BIM requirement for all public procurement processes. Since then, the Norwegian government has required the use of BIM in major public construction projects for over a decade.

In 2019, the SIMBA framework was introduced as a comprehensive term encompassing Statsbygg's BIM requirements from that year onward (Statsbygg, n.d.). SIMBA stands for Statsbygg, Information, Model, Construction, Buildings, and Assets. The system is built on machine-readable requirement sets, enabling the validation of BIM models against defined criteria using open standards. The IFC format is used for the BIM models, while mvdXML and IDS are employed for the specification of requirements. The BCF is used for reporting any deviations.

The decision by the Norwegian government, through Statsbygg, to mandate the use of BIM in public construction projects has led to a substantial increase in BIM adoption across the entire Norwegian construction industry (Bui, 2020). Usage has expanded beyond public sector projects, as companies have adapted to the requirements and invested in building BIM competence. The development of a regulatory framework for BIM has further facilitated the standardization of BIM practices, ensuring consistent and efficient data exchange throughout all stages of the project lifecycle.

5

Comparative study of IDS software

An evaluation of various software programs has been conducted to identify the best support for creating, validating, and presenting results from IDS files from a user perspective. The investigation also examines which IDS tools offer support for using entities higher up in the IFC hierarchy. These evaluations included three different IDS tools: IDS-Editor.com, Solibri IDS Editor, and usBIM IDS Editor, as well as two different validation tools: Solibri Office and Bonsai BIM.

5.1 Result of software comparison

Table 5.1: Result of criterias for IDS tools

Criterias	**IDS-Editor.com**	**Solibri IDS Editor**	**usBIM IDS Editor**	**Comment**
Intuitive interface	5	5	2	usBIM has a more complex interface compared to the others.
Support for different IFC versions	5	5	5	All support IFC4 IFC2x3 and 4X3.
License	No	No	No	All are free.
User-friendliness	5	1	4	IDS-Editor.com was perceived as the easiest to use.
Flexibility in requirement specification	3	4	5	Possible to set more complex requirements in usBIM.

The result indicates IDS-Editor.com as the most intuitive and user-friendly tool (Table 5.1). Its open-source and clear interface makes it easy to use, even for users with limited prior experience. In addition, IDS-Editor.com offers the possibility of multiple people working on the same file.

Solibri IDS Editor, while functional, was considered less user-friendly due to limitations in editing. Specifically, once an applicability section has been defined, it cannot be changed without all associated requirements being deleted. This means that even small changes to the entity applicability require the user to recreate the entire set of requirements

usBIM IDS Editor offers a wider range of functionalities and allows for the creation of more complex requirements, particularly through its integration with bSDD. However, the interface appears more complex compared to the other tools and requires more time to manage effectively.

Table 5.2: Result of criterias for IDS validation software

Criterias	**Solibri Office**	**BonsaiBIM**	**Comment**
Feedback on validation	5	3	Both tools provide clear feedback, but Solibri is more visual.
Result export	2	5	Export to html works in Bonsai BIM, not in solibri.
License	Yes	No	BonsaiBIM is free of charge, Solibri requires license.
User-friendliness	3	3	Both were perceived as equal.

Solibri Office excels in its visual presentation and provides clear and structured feedback during validation, enabling users to identify which objects failed. The primary limitation of Solibri lies in its report export functionality. While Solibri allows the creation of various result reports in XLSX, the report considered the clearest is illustrated in Figure 5.2. However, this type of report is not as clear as the HTML report that can be generated in BonsaiBIM. Another limitation is the licensing model of Solibri Office, which necessitates a paid subscription. Another limitation is the licensing model of Solibri Office, which requires a paid subscription.

Bonsai BIM, on the other hand, is freely accessible and offers a straightforward way to validate IDS files against IFC models. The main advantage of Bonsai BIM is its ability to export validation results to an HTML report. Figure 5.1 shows an excerpt illustrating the layout of such a report; a full image of the report can be found in Appendix B. This report presents the percentage of requirements fulfilled, identifies which objects have passed or failed the validation, and provides explanations for each failed requirement. The structured and transparent format makes it easy to interpret and communicate the outcome of the validation process.

The results show that IDS-Editor.com and Bonsai BIM are the most effective and user-friendly tools for creating and validating IDS files.

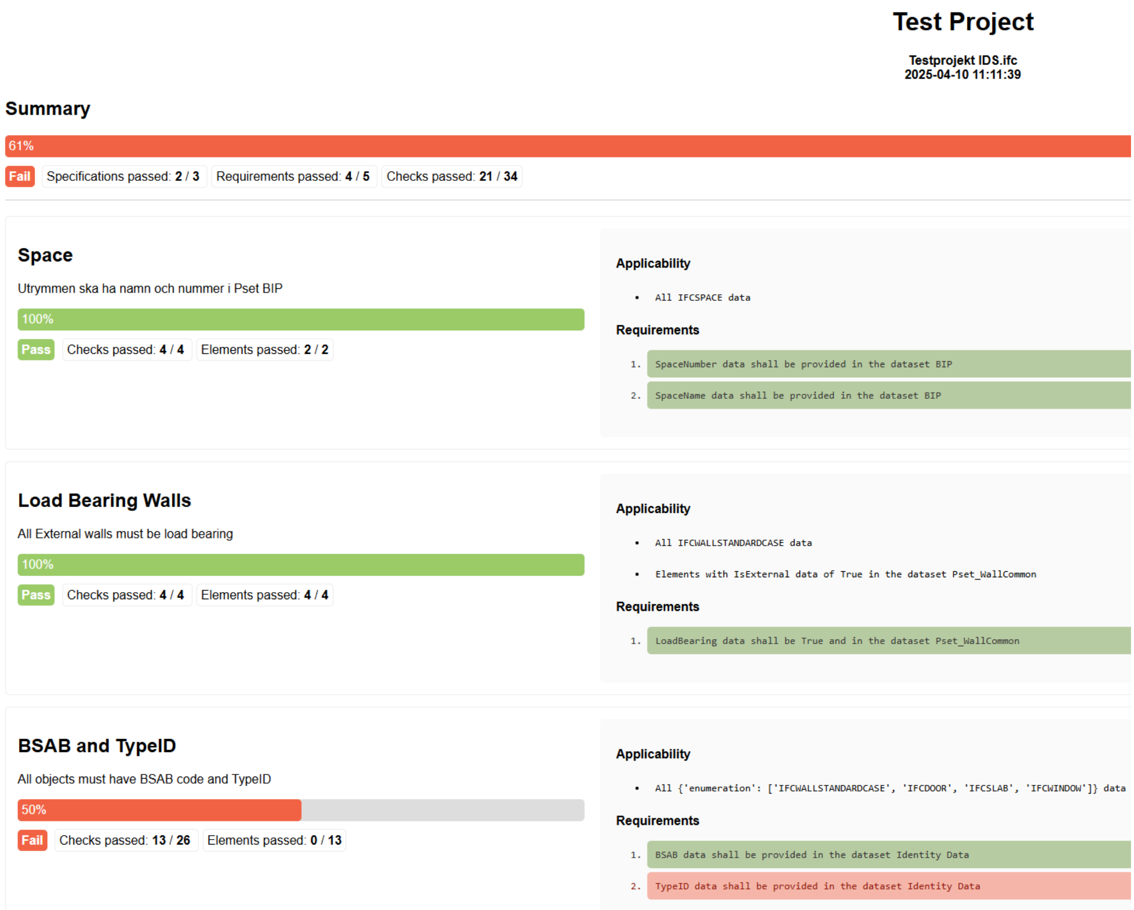
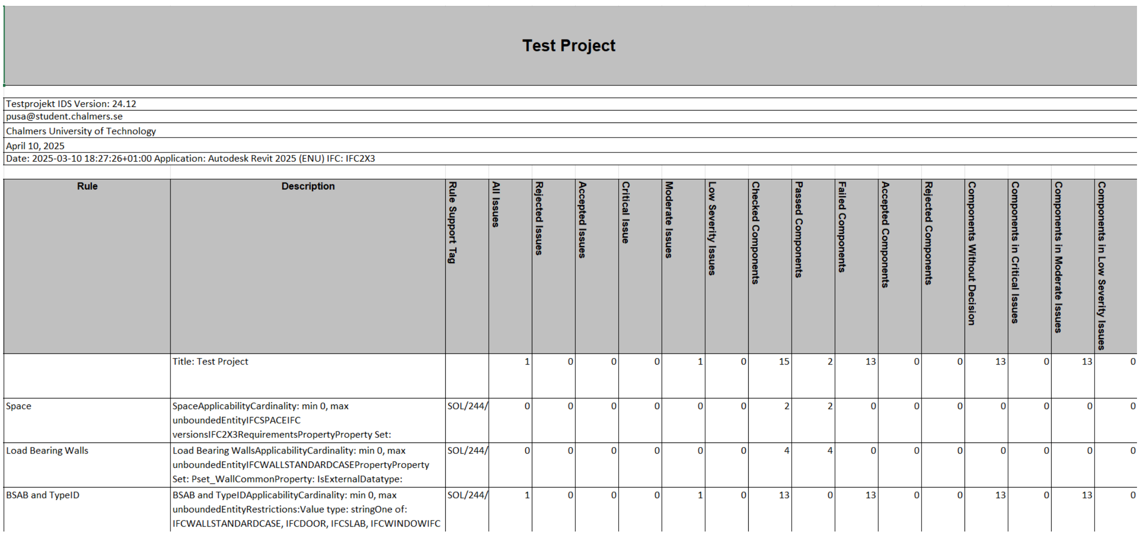


Figure 5.1: Result export to HTML report in Bonsai BIM



Test Project

Testprojekt IDS Version: 24.12
pusa@student.chalmers.se
Chalmers University of Technology
April 10, 2025
Date: 2025-03-10 18:27:26+01:00 Application: Autodesk Revit 2025 (ENU) IFC: IFC2X3

Rule	Description	Rule Support Tag	All Issues	Rejected Issues	Accepted Issues	Critical Issue	Moderate Issues	Low Severity Issues	Checked Components	Passed Components	Failed Components	Accepted Components	Rejected Components	Components Without Decision	Components in Critical Issues	Components in Moderate Issues	Components in Low Severity Issues
	Title: Test Project		1	0	0	0	1	0	15	2	13	0	0	13	0	13	0
Space	SpaceApplicabilityCardinality: min 0, max unboundedEntityIFCSPACEIFC versionsIFC2X3RequirementsPropertyProperty Set:	SOL/244/	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0
Load Bearing Walls	Load Bearing WallsApplicabilityCardinality: min 0, max unboundedEntityIFCWALLSTANDARDCASEPropertyProperty Set: Pset_WallCommonProperty: IsExternalDatatype:	SOL/244/	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0
BSAB and TypeID	BSAB and TypeIDApplicabilityCardinality: min 0, max unboundedEntityRestrictions:Value type: stringOne of: IFCWALLSTANDARDCASE, IFCDOOR, IFCSLAB, IFCWINDOWIFC	SOL/244/	1	0	0	0	1	0	13	0	13	0	0	13	0	13	0

Figure 5.2: Result export to XLSX report in Solibri Office

5.1.1 IFC hierarchy

The results shows that none of the IDS tools or validation tools support the use of IfcProduct, IfcElement, or IfcBuildingElement as general IfcEntity definitions in an IDS file (Table 5.3). All tools required specific subclasses to be specified for the validation to function correctly, which means that the tools do not utilize the hierarchy in the IFC model in a way that allows the use of more general entities in the specification.

Table 5.3: Result of IFC hierarchy experiment

	IFCProduct	**IfcElement**	**IfcBuildingElement**
Validated in Solibri			
IDS Editor	No	No	No
Solibri IDS Editor	No	No	No
usBIM	No	No	No
Validated in Bonsai BIM			
IDS-Editor.com	No	No	No
Solibri IDS Editor	No	No	No
usBIM IDS Editor	No	No	No

6

Case studies for IDS validation

6.1 Case 1

Case 1 is a hospital project in Sweden that was completed in 2024. The hospital consists of several buildings and, in this case study, two of them have been examined, Building 1 and Building 2. The case study materials, provided by WSP, include a BIM manual and two Excel files, one from the contractor and one from the client, with the requirement specification. As-built documents in IFC format have been supplied from various disciplines: architecture (A), construction (K), ventilation (V), sprinkler (SPR), heating and sanitation (W), and electricity (E). According to the BIM manual, these files should be in LOD500, representing the final model post-project planning. The materials are consistent for both buildings. The Excel file includes both general and object-specific requirements for all BIM models in the project. These requirements form the foundation of the IDS specification.

Table 6.1: Compiled relevant information from the BIM manual.

Information requrement	Filled in parameters according to the requirement specification
Exchange format	IFC2x3
Quality control	Self-checks where each discipline is responsible for ensuring the quality and information quantity in the model before each delivery
Property sets	Requirements from the client should be in one specific property set and requirements from the contractor should be in another specific property set

To develop the IDS specification based on the established requirement, the IDS-Editor has been used and Bonsai BIM has been used to validate the IFC files against the IDS files. The softwares are based on the result of the comparative study of IDS softwares.

6.1.1 Structure of the IDS

To ensure that the requirements are applied only to the correct objects in the IFC model, the applicability entity has been used in the IDS specification. This means that each requirement has been linked to one or more specific IFC entities, depending on which object the information requirement pertains to. To define the information requirements, the requirement property has been used, where the IFC entity must contain a property of a specific type (label, text, etc.), with the name and property set specified. For each discipline, a separate IDS was created, specifying the requirements for each relevant object. Each IDS includes detailed specifications for individual objects, defining all requirements for each object to ensure accurate and structured information.

Table 6.2 presents an excerpt from the requirement specification, where all objects must have a property set named CoClass with a property name ccClassCode. Figure 6.1 illustrates the IDS construction for this requirement applied to all doors in the model.

Table 6.2: Example of a general requirement

Category	Property name	Property set	Explanation
Generall	ccClassCode	CoClass	BSABe

```
  <ids:specifications>
    <ids:specification ifcVersion="IFC2X3" name="Doors">
      <ids:applicability minOccurs="0" maxOccurs="unbounded">
        <ids:entity>
          <ids:name>
            <ids:simpleValue>IFCDOOR</ids:simpleValue>
          </ids:name>
        </ids:entity>
      </ids:applicability>
      <ids:requirements>
        <ids:property dataType="IFCLABEL">
          <ids:propertySet>
            <ids:simpleValue>CoClass</ids:simpleValue>
          </ids:propertySet>
          <ids:baseName>
            <ids:simpleValue>ccClassCode</ids:simpleValue>
          </ids:baseName>
        </ids:property>
      </ids:requirements>
    </ids:specification>
  </ids:specifications>
</ids:ids>
```

Figure 6.1: IDS Structure for the general requirement applied to IFCDoor.

The study on fire doors further investigates how IDS can be most efficiently designed for requirements that do not apply to all objects within an IFC entity.

6.1.2 Case fire doors

As an in-depth analysis, the fire doors in the A-models have been examined. The requirements for fire doors differ from those for other doors. Therefore, it is necessary to distinguish between doors and fire doors in the IDS specification. Both fire doors and other doors fall under the entity IfcDoor, so to apply the requirements exclusively to fire doors in the IDS, an additional applicability must be established to differentiate them. This study investigates two different methods to achieve this:

1. In the requirement specification, it is stated that all fire doors must have the property ccFireRating, which distinguishes fire doors from other doors. To make this distinction in the IDS, an additional applicability filter is used, where the doors in this specification must also be sorted by having a Property Set named CoClass with the property ccFireRating.
2. In the requirement specification, it is stated that all objects must have the property ccClassCodeFunctionalSystem, containing class code according to the CoClass table functional systems. According to the CoClass table,is the classification code for fire doors FME, which distinguishes them from other doors. To make this distinction in the IDS, an additional applicability filter is used, where the doors in this specification must also be sorted by having a Property Set named CoClass with the property ccClassCodeFunctionalSystem, with the value FME.

6.1.3 Result Building 1

The validation results of all models in Building 1 are presented in Figure 6.2. The Figure show the percentage of the specified requirements that have passed the validation.

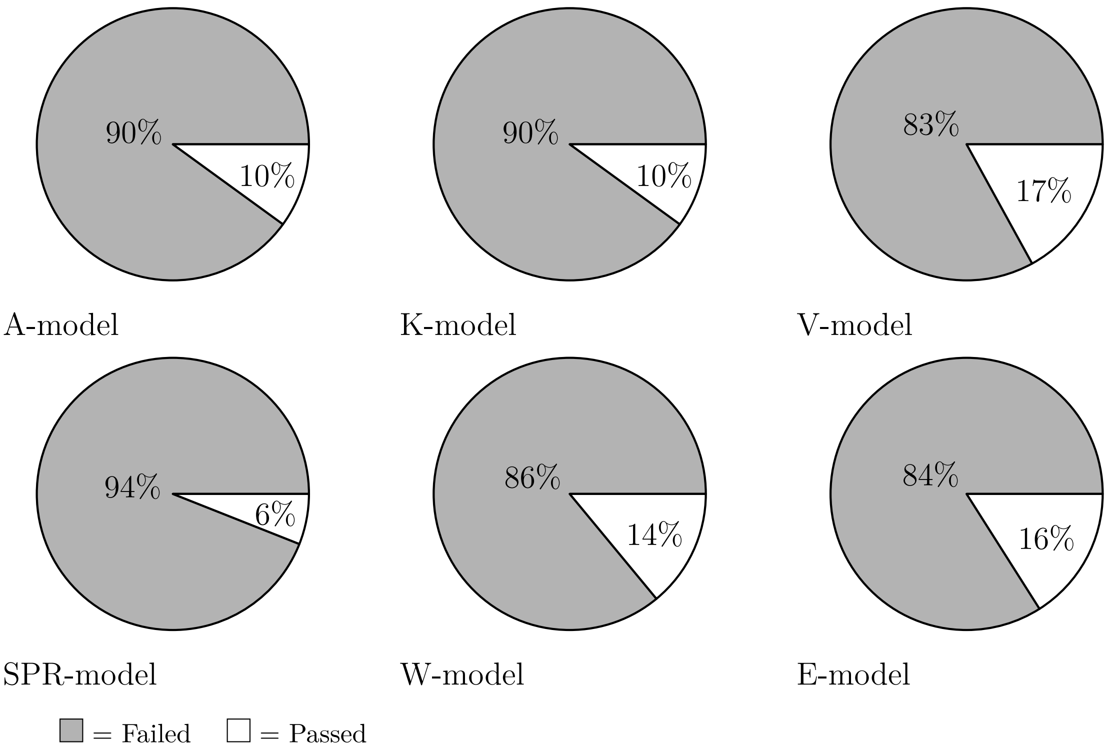


Figure 6.2: Result validated models in Building 1

The result shows that the property set for the client requirements does not exist in none of the models. Observations in all models show that most of the properties were located in the wrong property set. To assess how much of the required information exists in the models but in the wrong property set, updated IDS files were created, testing the same requirements but using a different property set. The new results of Building 1 is presented in Figure 6.3. The results shows that all models contained more information than was apparent in the first validation.

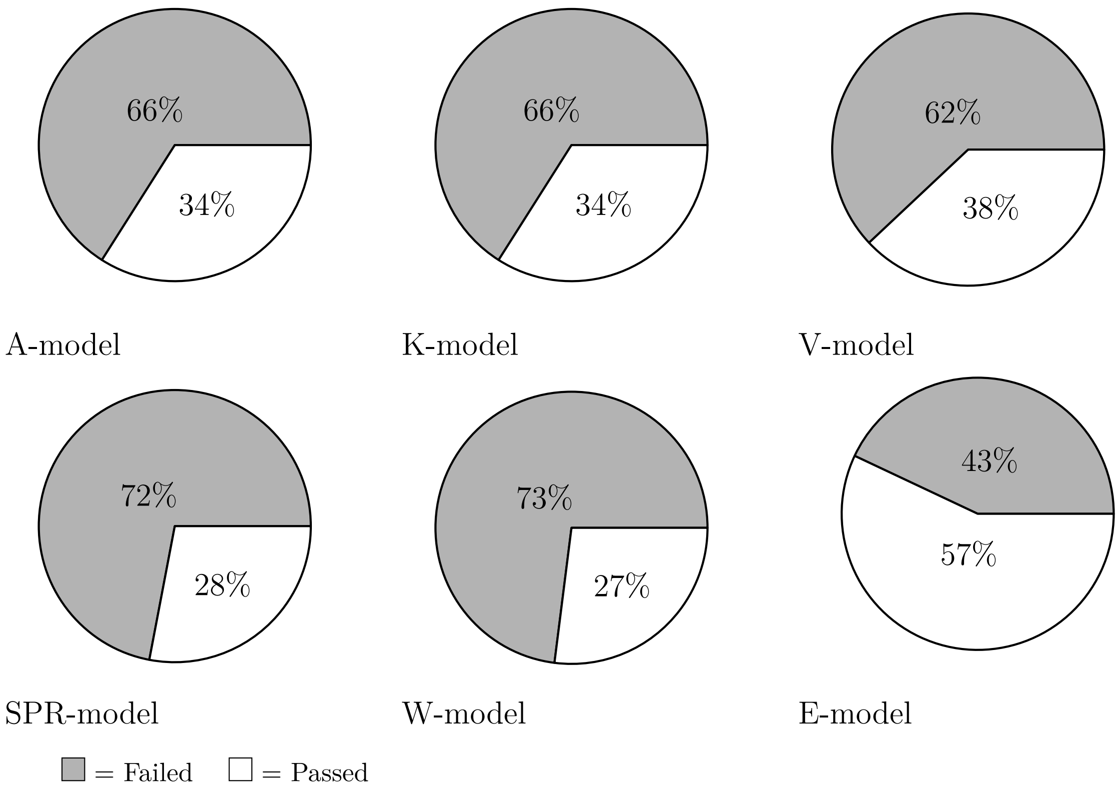


Figure 6.3: Result validated models in Building 1 when changed property set

6.1.4 Result Building 2

The validation results of all models in Building 1 are presented in Figure 6.4. The Figure shows the percentage of the specified requirements that have passed the validation.

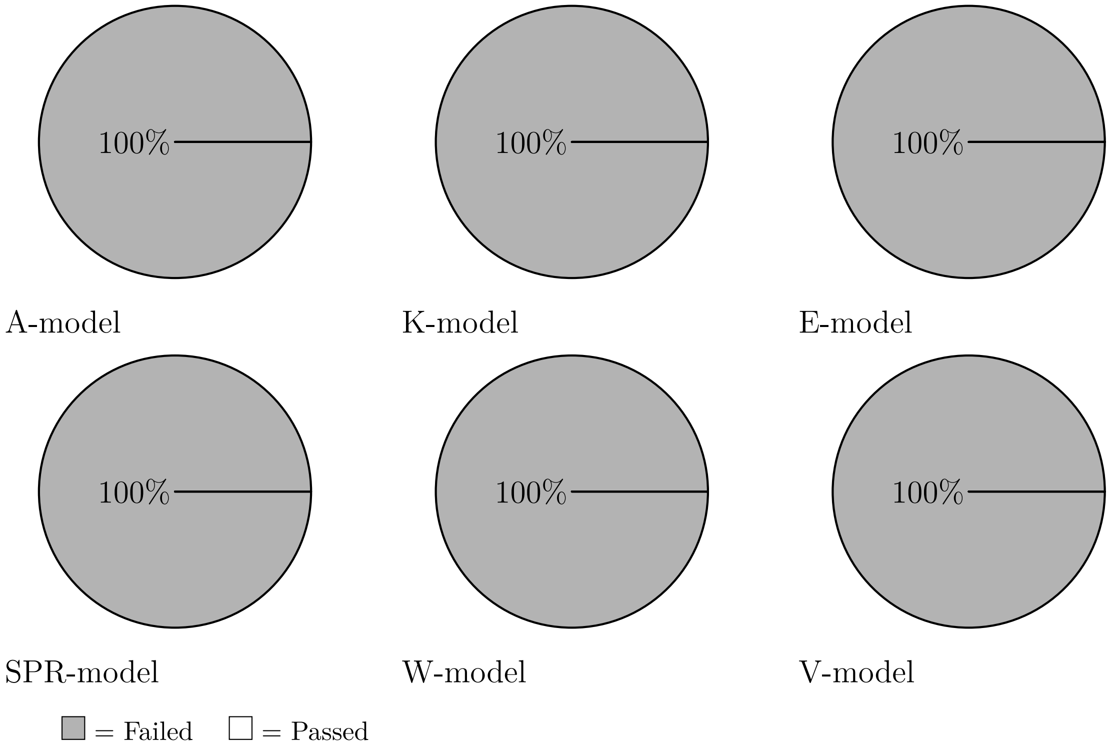


Figure 6.4: Result validated models in Building 2

The result shows that no requirements were met in any of the models. Observations in the models show that some properties that should be located in the property set CoClass are located in the Identity Data property set in the A-model. To assess how much of the required information exists in the A-model but in the wrong property set, an updated IDS was created, testing the same requirements but using a different property set. Instead of CoClass, the Identity Data property set was used, where the information was located. The new result of the A-model, shown in Figure 6.5, indicates that 2% of the established requirements are met, an improvement from the initial 0%.

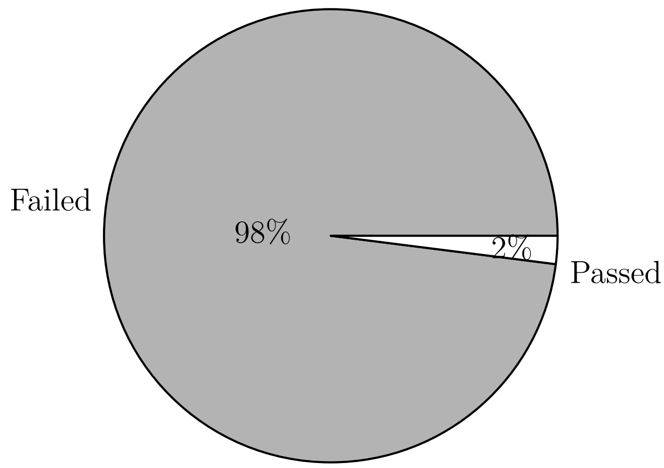


Figure 6.5: Result A-model Building 2 when chaned property set

6.1.5 Result case fire doors

Four IDS files were created, two for each model, based on the two proposed methods for distinguishing fire doors from other types of doors. The results show that all specifications are skipped, indicating that no fire doors could be identified in the models. Specifically, no doors in the buildings contained a property named ccFireRating, or a property named ccClassCodeFunctionalSystem with the value FME. Observations of the models further revealed that all doors were assigned the classification code QQC, which corresponds to a standard door. This indicates that the necessary information has not been correctly applied to the door objects, making it impossible to validate the remaining requirements related to fire doors.

6.2 Case 2

Case 2 is a campus project in Sweden scheduled for completion in 2027. The case study material provided by WSP includes the project BIM manual, a method sheet for IFC export of RVT files, and BIM models in RVT files from the disciplines of ventilation (V) and heating and sanitation (W), along with an export file for these models. The obtained models have been converted from Revit 2019 to Revit 2025 and exported to the IFC file format according to the instructions in the method sheet for IFC export of RVT files. The models are in the construction documentation. The BIM manual includes general requirements for all disciplines in PDF format. This study includes the general requirements for the V-model and W-model. The software tools used in this study is based on the results on the comparative study of IDS software and include IDS-Editor.com for creating the IDS files and Bonsai BIM for validating the IFC files against the IDS files. The structure of the IDS is the same as in case 1.

Table 6.3: Compiled relevant information from the BIM manual for case 2

Information requrement	Filled in parameters according to the BIM manual
Exchange format	IFC2x3, DWG, RVT
Quality control	Self-checks where each discipline is responsible for ensuring the quality and information quantity in the model before each delivery

6.2.1 Result case 2

The time required to create the IDS files for case 2 was significantly shorter compared to case 1. The validation results of the V-model indicate that 34% of the established requirements are met. The result of the W-model indicates that 38% of the established requirements are met (Figure 6.6).

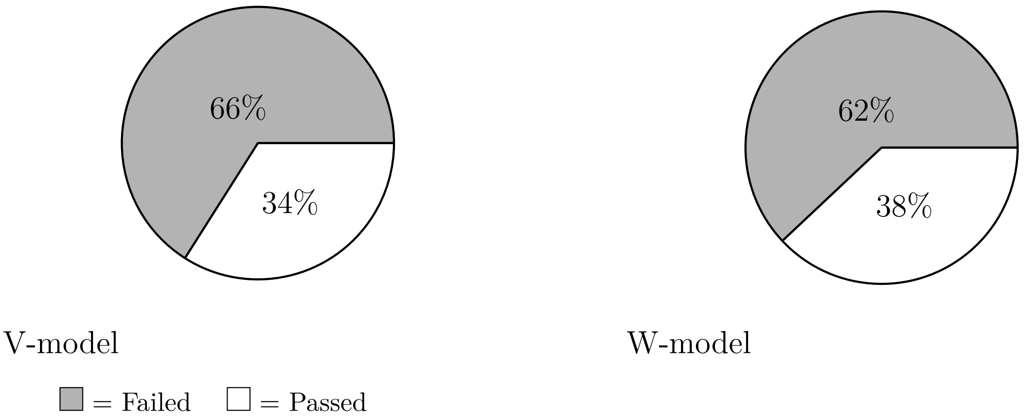


Figure 6.6: Result validated models in case 2

Observations in both models show that no information was located in the wrong property set.

7

Interview study

An interview study was conducted involving four professionals. The interview findings have been analyzed and presented according to four main categories, as summarized in this chapter.

7.1 Experiences and use of IDS

The PhD student has been actively involved in the development of IDS and has implemented it in various projects. He has participated in the IDS working group, contributing with feedback and improvements, although he has not been involved in making major decisions. He has also applied IDS practically in a large tunnel project, where he explained IDS proved to be highly valuable for automating and ensuring the accuracy of the information in the models.

The information strategist mentions that his company has not adopted IDS but is monitoring the issue and sees advantages in using it. However, he mentions that he is not familiar with how to use it. Currently, they use rulesets in Solibri to verify model deliveries against their BIM requirements, which he believes works very well. At the moment, he does not believe that IDS could replace their current methods.

The BIM developer learned about IDS in 2022 and began using it in a project to validate and structure the data. He observed that IDS made a significant difference in validating and structuring data and that it was much faster to meet the requirements compared to previous methods. He has continued to use IDS internally to organize the requirements and sees that it makes the process more efficient and clear.

The manager of information modeling currently possesses limited hands-on experience with IDS, but is familiar with the concept. He reports that his knowledge is sufficient to appreciate IDS as a promising and valuable tool, even though it has not yet been implemented into the organization's standard workflows. At the moment, the team relies on internally developed tools to validate the information in Revit models, complemented by manual checks using Information Takeoff in Solibri. Additionally, rule-based validation in Solibri is employed when project schedules allow.

7.2 Advantages of IDS

All interviewees recognize several advantages of IDS. The PhD student believes that the primary advantage is that IDS improves data quality by enabling better control over the information. He notes that previously, each model was structured differently, making it difficult to know what to expect, but with IDS, it becomes easier to verify and ensure the accuracy of the information. Additionally, he mentions that IDS automates the process of verifying models, saving time and reducing the risk of errors. Furthermore, in a large tunnel project he was involved in, they could immediately see what was missing or what did not meet the requirements with the help of IDS. Another advantage he mentions is that IDS provides a standardized method for verifying information in BIM models. This means that all tools implementing IDS yield the same results, preventing different companies from obtaining different results, and thereby ensuring that the standard is maintained.

The information strategist agrees that standardization is a significant advantage of IDS. He believes that IDS can standardize the way requirements are formulated at the property level, making it easier for project managers and other stakeholders to verify models. He also thinks that IDS can help avoid unnecessary requirements and make the process more efficient. Another advantage he mentions is that IDS could convey controls to project managers and other less knowledgeable stakeholders, making it easier for them to understand and follow up on the requirements.

The BIM developer also believes that IDS makes it clearer for designers and engineers to know what must be included in the models. IDS makes the requirements more specific and transparent, helping information recipients trust the data and facilitating the process for all parties involved in the project. When using it in their projects, they found that it was much faster to meet the requirements compared to the previous methods. Like the others, the BIM developer also agrees that standardization is a major advantage, making it easier to ensure that the information is accurate and meets the specified requirements.

The manager of information modeling identifies several advantages of IDS. One of the most important aspects is that it helps bring structure and clarity to handling model information, which in turn supports more efficient and cost-effective project delivery. IDS also enables automated validation of both the value and type of the data, reducing the need for manual checks. The manager of information modeling also sees IDS as a useful tool for designers, allowing them to check their models before delivery, which would improve quality and reduce the need for revisions.

7.3 Challenges with implementing IDS

The PhD student identifies several challenges with implementing IDS. He believes that one of the biggest challenges is that many projects are not mature enough to know exactly what they should specify. This means they cannot detail their information needs, making it difficult to use IDS effectively. Another challenge he mentions is the learning curve that must be overcome to use IDS effectively. Although the available software is good with user-friendly interfaces, it simplifies the process if one can use IDS correctly. He also notes that IDS requires projects to be very specific about how they want the information structured and what they want to achieve. This can be challenging for projects that previously focused solely on having a nice 3D geometry without specific information requirements. Implementing

IDS in practice can be both technically and organizationally challenging, as it can be difficult to do this without experience, and taking the first step can be particularly daunting.

The information strategist also sees several challenges with implementing IDS. He believes that a major challenge is that IDS is based on the IFC structure, while his company uses BIP codes, requiring them to learn how to work with the IFC structure. He explains that BIP codes are largely mapped to the IFC structure, which facilitates the process, but it would be even smoother if it were fully mapped, allowing the same "language" to continue being used. Although IDS can simplify certain aspects, he believes that handling the complexity of software like Solibri remains a challenge. He mentions that Solibri is complex software and hopes that IDS can improve this aspect. Implementing a new approach like IDS in the organization can be challenging, requiring the creation of IDS files and having the right tools and knowledge to do so.

The BIM developer sees the biggest challenge with IDS as ensuring that the requirements are properly specified. Previously, one could simply throw properties into Excel and attach it to the BIM manual, but with IDS, a more thorough requirements work is necessary. Working with requirements against the IFC structure can be challenging, requiring careful consideration of how the information will be used and having a clear picture of the information needs. Another challenge he mentions is that the IDS file is difficult to read compared to traditional Excel files. Furthermore, he explains that handling and verifying requirements can be time-consuming even with IDS, requiring the right data and significant effort to ensure the information is accurate.

According to the manager of information modeling, one of the main challenges with IDS is that it is still not widely known or used in the industry. While there is growing interest, awareness remains low. Another challenge is that many stakeholders do not yet know what requirements to set, which makes it difficult to apply IDS effectively. He also points out that there is often resistance to changing established workflows, especially in projects with tight schedules.

7.4 The future of IDS

The PhD student holds an optimistic view regarding the future of IDS, expressing hope that the majority of the market and companies will begin to adopt it. He envisions that many projects will implement IDS in practice, leading to improvements and the reuse of the same IDS to determine what works and what is excessive. He also believes that it would help the implementation if authorities start using and recommending IDS. The PhD student also believes that IDS will evolve and improve over time, potentially becoming more integrated with the next version of IFC. While this may not result in significant changes for users, it will represent a technical advancement that enhances the structuring of information.

The information strategist also foresees a positive future for IDS, hoping that it will become an integrated part of the BIM process and standardize requirements. Similar to the PhD student, he acknowledges that IDS is still very new and hopes that more organizations will implement it in the future. He believes that IDS will complement existing processes and aid in conveying property requirements in a standardized manner.

The BIM developer shares the belief that IDS will become a crucial component of future construction processes. He sees the potential for IDS to replace current Excel-based requirement lists, thereby making the process more efficient. He also anticipates that IDS will be incorporated into the pricing of projects in the future. The BIM developer highlights the issue of incorrect models being submitted without detection, noting that this is a prevalent problem in the construction industry, where information recipients are expected to validate all data, which is unsustainable. His vision is that IDS will ensure all information in models is accurate and validated before being forwarded. He mentions that a dream scenario would be that the models are automatically validated during submission and that it is not possible to deliver a model unless all requirements are fulfilled. Additionally, he expresses a desire for IDS to be integrated into design software such as Revit.

The manager of information modeling is optimistic about the future of IDS and believes it is likely to gain widespread adoption. A long-term vision involves integrating IDS directly into design platforms, enabling real-time feedback and correction during the modeling process. This would reduce the need for manual coordination and significantly improve the quality of final deliverables. The interviewee also sees potential in offering IDS-based validation services to contractors, which could evolve into a new business model. As a source of inspiration, the manager of information modeling points to Norway, where authorities have, in some cases, prohibited the submission of traditional drawings and instead require digital information delivery. He suggests that a similar initiative in Sweden, such as Boverket requiring data delivery through IFC, could have a comparable impact, raising the baseline standard across the industry. However, he realizes this vision will require greater engagement from both industry professionals and clients, as well as a generational shift that embraces new digital practices.

8

Discussion

8.1 IDS implementation

The interview study reveals that implementing IDS in real-world projects is a highly effective method for ensuring the accuracy of information in models, as both the PhD student and the BIM developer have experienced that. The BIM developer noted that he continued to use IDS internally as it made the validation process both faster and easier, compared to other methods. This demonstrates that IDS is an effective method for validating information requirements in digital construction projects, enabling automatic validation and improved data quality.

However, studies by de Marco et al. (2024) have shown that the full potential of IDS is not being utilized due to insufficient implementation and a lack of knowledge and awareness. The study also indicates that integrating a new methodology into an established workflow is challenging. In the interview study, the PhD student mentioned that a significant challenge in effectively utilizing IDS is overcoming the learning curve. However, he noted that there are many user-friendly software applications with simple interfaces, which significantly ease the learning process.

From the comparative software analysis, it is evident that there is a difference in user-friendliness among various software, with some being more complex than others. The results show that the export of the IDS results varies significantly across different software, with some being more difficult to interpret, such as Solibri's export. The information strategist mentioned that they wish to continue using the same software they currently use, which is Solibri, for potential IDS implementation. This poses a challenge as it may limit the ability to utilize IDS fully, and a more complex interface extends the learning curve. However, the PhD student argued that overcoming the learning curve is not particularly difficult, as it requires starting from scratch in the first project. In subsequent projects, the process becomes easier, and the same IDS file can be used and modified for the specific project. He also mentioned that the initial project is not particularly challenging either. During the case studies, a marked difference in complexity and time consumption was noted between the first case and the later cases, indicating that the learning curve for using IDS is not very steep.

The interview study reveal that there are prejudices and a lack of knowledge within the industry regarding IDS. The information strategist expressed that he had heard of IDS but did not fully understand its functions and how it can be used. His perception was that it is more complicated to develop and use IDS than Solibri rulesets. This indicates a need for more knowledge about IDS and how it can be used to achieve broader implementation in the industry. Another barrier to broader implementation in the industry is the difficulty of changing established workflows (Marco et al., 2024). If the proposal from Boverket is approved, it would contribute to greater awareness of IDS, as it would become a recommended and standardized methodology. Both the PhD student and the manager of information modeling argued that it would be advantageous if government authorities advocated for IDS, as this would accelerate its broader implementation. According to the proposal, Boverket would provide instructional videos and guidelines regarding IDS, which would increase the level of knowledge and make the information more accessible in the industry. A similar strategy has already been implemented in Norway, where Statsbygg has mandated the use of BIM and open standards. The manager of information modeling suggested that Sweden could greatly benefit from following Norway's example by requiring the use of IFC for all project deliveries. By compelling the industry to transition to open standards, it would be possible to establish the foundation for more unified and transparent information management in construction projects.

As energy performance certificates are required for buildings in Sweden, there is likely to be increased pressure on digital information management, especially to ensure that more precise and structured information is available within BIM models. As demonstrated in the study by Kremer and Beetz (2023), IDS is an effective tool to ensure that all necessary data is present for conducting energy simulations, essential for generating reliable energy performance certificates. Such regulatory developments could accelerate a broader adoption of IDS in Sweden, as there is a bigger need for validated models containing accurate and complete information. According to the PhD-student and the manager of information modelling, regulatory change is also perceived as a significant driver for the widespread knowledge and implementation of industry standards like IDS.

Another important point raised by the manager of information modeling was the role of generational shifts in enabling the adoption of new technologies in the construction industry. As older employees retire and younger professionals enter the field, established routines are increasingly questioned, creating space for innovation. This is especially relevant for IDS, where openness to change and a willingness to adopt new methods are important. Such generational change can act as a catalyst for more efficient and digitally integrated ways of working.

A challenge with current workflows identified by the BIM developer is that BIM models are often submitted for delivery without undergoing adequate quality control. The models are typically reviewed and validated only upon reaching the recipient, who is often a coordinator or a project management representative. Consequently, the responsibility for ensuring that all requirements are met is transferred to the receiving party, rather than being distributed among the various disciplines responsible for modeling and delivering the information. This approach is perceived as inefficient and counterproductive, as it places the burden of compliance on those verifying the models rather than on those producing them.

A potential improvement of the workflow is to allow each discipline to easily perform self-checks with IDS before the model is submitted for delivery. According to the BIM developer who tested this, it has proven to be significantly more time-efficient and resulted in higher quality data being transferred. Additionally, the HTML report provides a clear validation outcome, making it easily understandable for all parties involved. An even more efficient workflow, described by the BIM developer as a future aspiration, would be to make it technically impossible to submit a model that does not meet all requirements. In this scenario, the model would be automatically validated through an IDS check at the time of delivery. If the validation of the model fails, the delivery would be blocked, and the responsible designer needs to address the deficiencies before the model can be accepted into the project's coordination platform. This type of automated quality control would create an incentive to work correctly from the beginning and reduce the need for costly and time-consuming adjustments in later stages.

Another point raised by the manager of information modeling is the potential of using IDS as a service aimed at contractors. By using IDS to validate information requirements before delivery, designers could ensure that what is handed over is accurate, complete, and aligned with agreed specifications. This would not only improve the quality of deliverables but also add value for contractors, who could place greater trust in the information they receive. In the long term, he envisions IDS becoming an integrated part of the delivery process, where validation occurs before the model moves into production, contributing to a smoother transition from design to construction and reducing the need for costly revisions.

8.2 Foundational requirements work

According to Wheatcraft (2011), a significant issue today is that many requirements are too general, unclear, and applied at the wrong Level of Detail, which has been proven to not support open BIM workflows and can lead to increased costs and project delays. This is reflected in the case study results, where a large portion of the requirements were not met. The same issue was raised during the interviews, where the PhD student mentioned that many projects today are not mature enough to understand exactly what requirements they need to set. The other interviewees emphasized the same problem and stressed the importance of understanding what requirements are being set and why. This indicates that there is often a lack of a clear connection between requirements and business needs, which in turn complicates both quality assurance and benefit realization. According to Hort et al. (2020), this is often due to the client not having sufficient knowledge to set relevant requirements.

To effectively use IDS, a fundamental requirements analysis is necessary to ensure that only essential requirements are set and that there is a clear understanding of how all information will be used. The BIM developer also highlighted that a common issue today is the tendency to focus on creating visually appealing 3D models while documenting numerous requirements in Excel spreadsheets, without specifying where the information should be located or how it should be structured. All interviewees emphasized that the use of IDS demands more detailed specifications regarding how information should be organized and what it should achieve. If the requirements are vague or contradictory, it becomes challenging to both meet and automatically validate the information content within the models, undermining the entire purpose of IDS. Overall, this underscores the importance of viewing requirement specification not merely as a technical formality but as a strategic activity that is crucial for realizing the value of BIM and effective digital information management.

The results of the case studies show that only a few requirements were fulfilled in the models, which could be a consequence of not clearly formulated requirements. However, the results also show that more information is present in the models but located in different places than specified. Thus, the problem is not the absence of information but rather its structure or placement not aligning with how the requirements are formulated in the specification. This suggests that the requirements were unclear formulated, particularly regarding the location of the information.

Another aspect that may have contributed to the results is the ambiguity regarding the data type of the requested information when creating the IDS files. For instance, some requirements expected a numerical value while the model contained the same information in text format, or vice versa. Since IDS relies on matching the specified data type, such deviations result in the requirement being marked as unmet. This underscores the importance of not only specifying what should be delivered but also how, in terms of both structure and type definitions.

In case 2, the requirements were better defined, and it was clearer in which property set the information should be located. This could be the reason for the better validation results compared to the other case. This reinforces the argument that a precise formulation of requirements is crucial for the effective use of IDS.

8.3 Standardization

In the interview, the information strategist explained that in Sweden, each client has different ways of setting and formulating requirements. He noted that before starting a new project, all stakeholders must familiarize themselves with the new requirement system, which can be time-consuming, lead to misinterpretations, and make work processes inefficient. According to the PhD student, one advantage of IDS is the ability to reuse and modify IDS files from project to project, saving time and resources. However, this lack of standardization in Sweden prevents this approach from being fully utilized.

All the interviewees mentioned that a future scenario could involve IDS being the standard method for delivering requirements, formulated in a standardized way. In such a system, stakeholders could quickly understand the requirements in a new project, without having to learn and interpret a new requirement format. Standardizing requirements could also contribute to the efficiency of the entire construction process. When requirements are delivered as an IDS, automated validation of the delivered information becomes accessible, enhancing quality assurance throughout the project's various stages. This ensures that the model is more reliable, which is crucial for the building's lifecycle perspective, where accurate and structured information, according to Boverket (2023), is essential for efficient operation, maintenance, and renovation. Once the model is validated against clear requirements, it can be used as a basis for decision-making throughout the building's lifecycle. This also creates conditions for a circular economy, where materials and components can be traced, analyzed, and reused in a resource-efficient way.

However, a barrier to completely replacing current Excel-based requirement specifications with IDS files, according to the BIM developer, is that IDS files are not as easy to open and read as Excel files. IDS is an XML file, making it significantly harder for someone without the right knowledge to interpret unless opened in specific IDS tools. This means that initially, IDS files may need to be supplemented with Excel files to ensure that everyone can easily read and understand the requirements.

A problem that became evident during the case studies was how to define more specific objects, such as distinguishing fire doors from regular doors, which was investigated in the fire door case study. The results show that objects can be differentiated by using an additional applicability in the IDS specification that refers to a classification system. A clear issue was that in the case project, the doors were not correctly classified according to either CoClass or fire rating, making it impossible to validate the requirements for fire doors. This method requires a high degree of accuracy in the classification work. If the objects are not correctly classified or if the classification is incomplete, the validation for the specific requirements fails as IDS cannot identify the objects. This highlights the importance of establishing clear guidelines for classification work early in the design phase and continuously checking these, which could be done using IDS.

One approach to distinguish objects in IDS files could be through the use of bSDD. By linking applicability directly to bSDD within the IDS specification, the process of creating IDS files becomes more streamlined, while also reducing the risk of duplicated efforts and contradictory requirements. Furthermore, bSDD includes translation capabilities, allowing for multilingual definitions that make information requirements more inclusive and unambiguous across international teams. Since bSDD is free to use and accessible via API integration directly within design tools, it facilitates a more efficient workflow and minimizes the potential for errors or inconsistencies, unlike systems such as CoClass, which often require manual switching between external databases. However, implementing bSDD require a shift in established workflows and routines, which could be a challenge for organizations accustomed to national or proprietary systems.

Boverket has proposed to Regeringskansliet that IFC should become the standard format for delivering digital building models and that IDS should become the standardized method for validating these models. This demonstrates an ambition to increase interoperability within the AEC sector and reduce dependence on specific supplier solutions. A current issue is that much data is locked in proprietary file formats, making it difficult to open, modify, or reuse information when a model transitions from one actor to another (Boverket, 2024). This can affect parts of the lifecycle where information needs to be consumed without access to the same software or licenses used in the design phase. According to the interviewees, a major advantage of IDS, and also IFC, is that they are completely open and non-proprietary standards. To support this even more, an openBIM workflow could be implemented where only open standards and workflows are used.

8.4 Limitations with IDS adoption

The results of the comparative study of IDS software indicate that IDS does not yet fully support the effective use of entities higher up in the IFC hierarchy. This can be a limitation when formulating general requirements applicable to a larger group of objects. Since IDS is based on and dependent on the IFC standard, it would be natural for these structures to also be utilized in IDS. This would ensure that general requirements can be applied broadly without the need to repeat them for each entity. The current inability to do this in practice limits the efficiency of working with IDS. This highlights the need to develop the standard based on actual application and user needs, which becomes possible as more people start using it, as noted by the PhD student.

Another limitation is that IDS only allows validation of numerical and semantic requirements and cannot be used to control geometric requirements. This means that different types of requirements must be handled in different ways, which, according to the information strategist, can reduce the perceived utility of IDS. To make IDS more effective in the digital review process, it would be desirable to explore how geometric requirements can be integrated, for example, through future versions of the IDS standard.

8.5 Guidelines and future research

To fully reach the potential of IDS, there are several areas for improvement and further development. One area of development, mentioned by both the BIM developer and the manager of information modelling, is to explore the possibility of implementing IDS closer to the designer, for instance, in Revit. Enabling validation during the design process would allow each discipline to ensure that all requirements are met during modeling. Another area for development could be the establishment of national standards for the specification and naming of objects in digital building models. If authorities or governmental agencies took the initiative to establish clear and uniform standards for this, it would streamline the construction process and facilitate a smoother implementation of IDS. Furthermore, the case studies revealed that IDS, in its current form, is limited to more specific objects within the IFC structure. Developing IDS to support entities higher up in the IFC hierarchy would enable more efficient validation, where requirements can be set at more general levels. For IDS to be established as an industry standard, broader implementation and increased usage within the construction sector are necessary. More stakeholders need to be willing to implement IDS and integrate it into their projects, despite the initial learning curve. To facilitate the use of IDS, improvements in some validation software are also necessary, Solibri for instance. These tools need further development to better support IDS specifications and enable clearer and more user-friendly result exports, for example, in the form of HTML reports.

Future research could explore the implications of implementing IDS in ongoing construction projects. By observing the process in real time, researchers would gain a deeper understanding of how IDS affects information flow, the quality of BIM models, and collaboration among project stakeholders. Such an approach would enable a more nuanced assessment of the practical benefits and challenges associated with IDS. It could also provide valuable insights into how IDS affects project efficiency, time management, and overall project costs. A study like this could also help identify the types of projects and organizations that are best positioned to benefit from IDS, as well as the adjustments required to successfully integrate the standard into existing workflows.

8.6 Review of method

Since IDS is a relatively new standard, there was limited access to literature and research on IDS, which posed challenges in collecting data for this work. However, there is some research existing, still in its early stages. Some of the literature used comes from countries where the construction industry differs from that in Sweden. Much of the information obtained from this literature is considered unaffected by this difference.

In the comparative study of IDS software, only a limited number of software were evaluated. More available software could have been evaluated to obtain more comprehensive results. The parameters could also have been developed and evaluated by industry experts to achieve more well-founded and nuanced results. The parameters developed were based on what is most suitable for the type of validation performed in the case studies.

In the case studies, three buildings were examined, two were from the same client with the same requirements. To obtain more nuanced results that reflect the industry, it would have been valuable to examine more buildings from different clients. To achieve even better results on how IDS can ensure accurate data in the models, an ongoing project could have been examined. This could provide insights on how effectively IDS ensures more requirements are met in BIM models compared to current methods in the industry.

In the interview study, a larger number of people could have been interviewed to gain more insights. However, the interviewees consisted of various industry stakeholders with different experiences of IDS, which provided a broader perspective. To gain an even broader perspective, more industry stakeholders could have been part of the interview study.

9 Conclusion

Conclusions are drawn based on the research questions that have guided this thesis. The aim has been to investigate the current state of information validation in BIM models and to explore the potential of IDS as a tool for improving data quality.

The findings show that there is a strong need for more effective methods to validate information requirements in BIM models in Sweden. The current practices are insufficient, and many requirements are not fulfilled. The implementation of IDS presents significant potential for enhancing the quality of BIM models by enabling structured and automated validation of information requirements. Through systematic identification of deviations from specifications, IDS facilitates the assurance of data accuracy and completeness within the BIM model. This strengthens both its reliability and its overall informational integrity.

To facilitate broader adoption of IDS within the Swedish construction industry, increased knowledge and awareness of IDS and its benefits are essential. Guidelines and information from authorities are crucial to accelerate and support the process of spreading knowledge and information within the industry. A more thorough requirements specification process is necessary, where requirements are structured and defined more clearly and according to the IDS standard. Standardization of requirement specifications and classification systems would further facilitate the use of IDS. The development of user-friendly software for both creating and validating IDS files is also important to support broader implementation.

By ensuring that the BIM model contains accurate and structured information, it can be utilized throughout the entire lifecycle of the building. This facilitates more efficient management of building information at all stages of the building's lifecycle, thereby contributing to increased resource efficiency and the development of more climate- and resource-efficient buildings.

In summary, this study demonstrates that IDS is a promising method for enhancing the quality of BIM models and supporting a circular economy. To fully realize the potential of IDS, increased knowledge, clearer requirements specifications, support from authorities, and resources for implementation, both financially and temporally, are necessary.

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A
Interview questions

Interviewquestions Phd-student

Tell us about yourself and what you work with?

What is your experience of IDS?

What do you see as the biggest opportunities with IDS?

What challenges do you see with IDS?

What challenges do you see with implementing IDS in practice?

How do you envision the future of IDS evolving?

Interview questions Information strategist

Can you briefly describe your role at the company and how you work with BIM-related matters?

What does your work look like when it comes to setting requirements and ensuring the quality of BIM models in projects?

How do you ensure that incoming models meet your requirements?

Do you think your current process works well? Why or why not?

Have you heard of IDS before?

How do you think IDS could help you in your work with requirements and quality assurance?

Do you see any obstacles or challenges in implementing IDS in your organization?

Interview questions BIM developer

Could you briefly tell us about yourself and what you are working with today?

What experience do you have with IDS?

What do you see as the greatest opportunities with IDS?

What challenges do you see with IDS?

What challenges have you encountered when implementing IDS?

What do you think the future of IDS looks like?

Interview questions Manager Information Modeling

Can you briefly describe your role at the company and how you work with BIM-related matters?

How do you currently validate the information requirements in BIM models?

Are there any challenges or recurring issues in the work of managing or validating information requirements?

What is your experience of IDS?

Which needs in your work do you think IDS could address?

What do you see as the main advantages and disadvantages of IDS?

What do you think could be challenging when implementing IDS, for example, in terms of competence, time, system support, or coordination?

What is your vision for how IDS could be used in the future within your organization?

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