



## EXTENSION OF THE INFORMATION DELIVERY SPECIFICATION FOR BIM-BASED CHECKING IN DATA-DRIVEN BUILDING PERMIT

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### Abstract

Recent research has increasingly focused on the automated checking of building permits, either in very limited application areas, using isolated standards, or using completely new approaches. This work presents a holistic approach to data-driven building permits, including BIM-based collision checking and calculation, combining the international standards IFC and an extension of the IDS format, as well as the national standard XPlanung. While the holistic approach offers the possibility of broad use and flexible extension with other approaches, the combination of open standards within a model checking process demonstrates their wide range of applications in automating and supporting checks.

### Introduction

Digital transformation has also had a significant impact on the public sector in Germany. The Online Access Act (Federal Ministry of the Interior and Community, 2024), which forms the legal basis for the digital modernisation of the Federal Republic of Germany, has led to an increase in the provision of administrative services in machine-readable form and via electronic platforms. An important development in this context is the Digital Building Permit (DBP), which digitally processes the state's permission for the construction of buildings. This enables a more efficient, data-driven and automated review of building permits. In this context, the digital document-based building permit in PDF format represents only the first phase (Bloch and Fauth, 2023). The advent of digital building permit platforms, which are now increasingly being used in practice (Hartmann et al., 2024), has also enabled the use of machine-readable formats and the extraction of data from unstructured proofs or plans. This also means that Building Information Modelling (BIM) can be used in the context of building permission to enable digital information management and automation. With BIM and the Industry Foundation Classes (IFC) format, modern data formats are available to facilitate the digital verification of building models (Eichler et al., 2023). BIM represents a central method for creating detailed three-dimensional building models that contain all relevant building information. The IFC format, in turn, facilitates

the uniform exchange of data between different software applications, thus ensuring the seamless transfer of information relevant to the issuing of building permits. In addition to BIM and IFC, other international standards, such as the Information Delivery Specification (IDS) format developed by buildingSMART International (Eichler et al., 2023), offer new opportunities for automating and standardising the building permit process. The IDS format facilitates the automated evaluation of IFC data for pertinent information, thereby ensuring the incorporation of BIM models within the building permit process. This development paves the way for rule-based validation of BIM-based building models, ensuring the quality of submitted data through the use of machine-readable standards. Furthermore, in Germany the XPlanung format (Krause and Munske, 2016) standardises the exchange of georeferenced urban planning data and enables the integration of digital land use plans and geodata into permit processes.

The present work is based on a design science approach that includes the artefact of a concept for data-driven permit of building applications to address the research gap of handling different inputs in DBP. In iterative cycles of analysis, development, demonstration and evaluation, an overall framework is developed, and, as part of it, a BIM-based review process using the combination of IFC, IDS and XPlanung is developed to provide a robust basis for optimising the building permit process. It enables a data-driven, automated and standardised process that ensures seamless data transfer and meets the increasing demands of the construction industry.

### State of the art

#### Digital building permit

The advancement of digital building permit procedures is being propelled by networks such as EUNet4DBP (European Network for Digital Building Permits, 2024) and different national and international research projects. The EU project BRISE is investigating the potential of BIM, augmented reality and artificial intelligence (AI), with a particular focus on natural language processing, for the automation of building permit procedures in Vienna (Urban et al., 2024). Another European research project called EuroSDR GeoBIM has proposed a harmonised

workflow using geographic information and BIM data to automate the building permit process (Noardo et al., 2020). In Germany, digital methods based on 2D data are increasingly available at the state level (Hartmann et al., 2024) and studies have already been carried out to integrate BIM into the building permit process (Tulke et al., 2021). Research is currently being conducted in Germany to integrate AI into the building permitting process (AI Building Permit Application, 2024). In addition, national standards such as XPlanung facilitate the structured exchange of geo-referenced data and digital building application documents. These standards form the basis for a seamless process chain. After the progressive harmonisation and enabling of the exchange of building data and requirements, the process of automated validation of regulations using BIM is the focus of current research.

### **Information Delivery Specification (IDS)**

IDS is increasingly used in the context of BIM to ensure data quality and accuracy. While initially used primarily for quality assurance in the design phase, semi-automated compliance checks based on BIM models are now being applied (Noardo et al., 2022). These checks offer benefits such as improved design quality and reduced processing time for building applications (Eastman et al., 2009). However, automated checks require that the necessary information is available in the BIM models. The definition and processing of this information in the BIM workflow have been investigated in numerous studies (Tomczak et al., 2022). Despite their limitations, text-based documents such as PDFs are often used to define information requirements (Tomczak et al., 2022). However, the manual transfer of this information into BIM software remains a significant drawback. The IDS standard addresses this gap by providing a machine-readable structure for alphanumeric information requirements. IDS supports two main use cases in the BIM workflow: defining information requirements and checking IFC models for compliance with these requirements (Eichler et al., 2023). This reduces manual effort and promotes automation. IDS is increasingly being used in practice and integrated into software solutions such as Plannerly, BIMQ and Solibri. In research and practice, IDS is used in various applications such as the specification of data for circularity (Tomczak et al., 2024) and digital building permits (De Marco et al., 2024). The first version of IDS targets basic information and relationships in the IFC. Complex information requirements are not currently covered by IDS. However, research is already underway to extend the IDS format, for example, to define the information needed to analyse escape routes and check compliance with fire resistance regulations (Fischer et al., 2024) or an IDS extension to use dynamic links to integrate external calculation services into the verification process (Kremer and Beetz, 2023). In addition to the further development of IDS for use in complex validations, the new development of approaches such as OpenBIMRL (Stepien et al., 2023)

represents a solution. This graph-based rule language defines a dynamically extensible interface for the transparent representation of geometric and semantic inspection rules. Despite technological advances, challenges remain, particularly in the integration of different standards and tools, and the acceptance of new technologies by authorities and designers. Most approaches focus only on the use of BIM models and the rule-based checks and calculations within specific software without any standardisation and thus transferability and exchangeability. However, digital models are still not available for most building applications, which are still plan- and document-based or even file-based. The use, processing and visualisation of information and data from these other sources is still unexplored. Other research is already looking at extending the IDS format due to its limited functionality for performing complex checks.

Two key research questions emerged and are addressed in this paper:

- How can a holistic approach to data-driven building permit combine multiple types of input information using digital tools and standards?
- What is the potential of IDS for compliance verification?

## **Methodology**

### **Data-driven building permit**

Based on a design science approach this work has developed a concept of data-driven building permits which represents the next step after digital document permitting towards a digital information management and automated system (Bloch and Fauth, 2023). Based on the previous analysis of the current digital and BIM-based permitting processes, the need for an overarching data-driven system and a BIM-based review using open standards is identified as an artefact. This is followed by the development of the artefact through the design of an integrated system for a comprehensive data-driven building permit and, as a component, BIM-based verification through the combined use of standardised data formats such as IFC, IDS and XPlanung. As this data is machine-readable, it can be used for automated checking and analysis. The inclusion of unstructured and other structured data in this approach is generally feasible, although it requires the use of more sophisticated digital methods to extract and process this type of data.

Figure 1 illustrates the data-driven building permit as a central, data-based and multi-layered system that integrates disparate data sources and perspectives, thereby facilitating a comprehensive examination of building permits through a variety of lenses.

The structure can be divided into different layers: the data core, the data checks, the regular and BIM data views, and the data rules. These can be used to underpin specific application views, including the permit view, fire protection view, climate view, and resource view. At the

centre is the data core, which acts as a central repository for all relevant structured and unstructured data for the building permit. This core brings together all the necessary information and data models of the heterogeneous database for the digital building permit and provides a system for storage and management. This central repository ensures data consistency and provides a consistent basis for all subsequent checks and calculations.

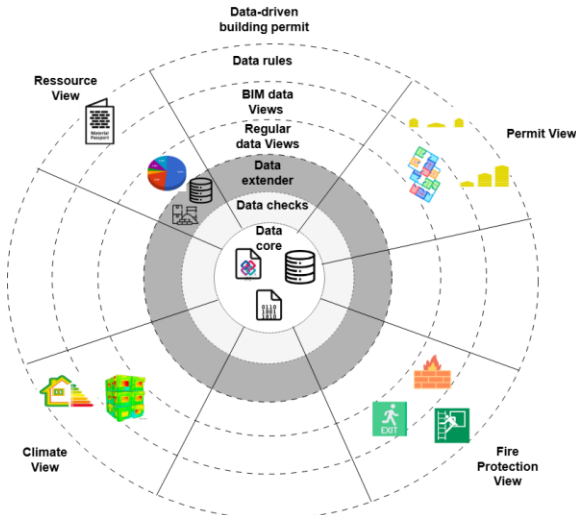


Figure 1: Structure of the data-driven building permit

The next level of the platform consists of data checks that ensure the quality and consistency of the IFC-based building models stored in the data core. These automated checks, based on the IDS format, allow the data to be checked for completeness and compliance with defined specifications to ensure subsequent functionalities such as building code checks. Such checks are essential for the reliable and rapid processing of planning applications, ensuring that all data is compliant before it is used in specific use cases.

The data extender extends the data core with additional data that may be required for specific analyses or checks, but is not part of the original building permit information. This enables a deeper and more detailed analysis of the submitted planning applications. The Data Extender can add such missing data by enriching it with external data sources such as geospatial data, environmental information or specific building codes.

The third level consists of data views, which are divided into two categories: regular data views and BIM data views. Regular data views are based on all data relevant to the building permit, but not specifically available in BIM formats. This includes general building data, additional technical descriptions and design details that may be stored in specific databases or included in supporting documents and plans. These data views complement the BIM views, providing a more comprehensive perspective that can provide initial insights into the building for a range of review requirements. Regular data views are particularly important when it comes to reviewing information that

cannot be directly represented in the Building Information Model, such as legal information, ownership data or building-related analytics. BIM data views relate to the use of BIM. These data views provide a detailed and structured representation of the building model, including geometric and semantic information. BIM data includes all available information about the structure, such as materials, building structure, technical installations and more. In the context of building permits, this makes it possible to visually check specific building codes and standards against the BIM data and ensure compliance, so that the proposed structure meets legal requirements. Data rules are an essential component of rule-based checking of building models. These rules determine the legal and technical requirements that apply to the building. For example, data rules can define building codes, safety regulations and environmental requirements that are automatically applied in the checking process. The rules are machine-readable and enable automated checking and validation to ensure the functionality of the building.

The different layers and their digital methods are used in specific application views that focus on specific areas of review in order to support and automate the process. Examples are the following:

- **Permit View:** This view focuses on permitting requirements and ensures that all necessary documents and data comply with building codes and construction requirements.
- **Fire Protection View:** This view focuses on fire safety requirements and checks that all necessary documents and data comply with the applicable fire safety regulations.
- **Climate View:** This view deals with the energy requirements and aspects of the building. It is designed to check requirements for thermal insulation and energy performance certificates.
- **Resource View:** This view focuses on the sustainability of the building in terms of the use of resources and the choice of materials in the construction process. It is used to analyse the impact of the building on the environment and to ensure compliance with environmental and sustainability legislation.

The combination of BIM-based data checks, views, rules enables comprehensive and automated data checking. The platform can therefore make the permit process efficient and compliant, while minimising the amount of checking required. The clear structure and use of machine-readable data formats enables reliable, standardised and automated building permits that meet the needs of the modern construction industry.

### BIM-based checking

Figure 2 shows the concept of BIM-based checking in the context of data-driven building permits. This approach aims to further improve the efficiency and automation of the building permit process through the use of BIM and open digital standards. (Klooster et al., 2019). The process

encompasses three consecutive stages: data verification, BIM data views and data rules. It employs the Building Smart IDS to facilitate a systematic examination of building applications based on predefined rules.

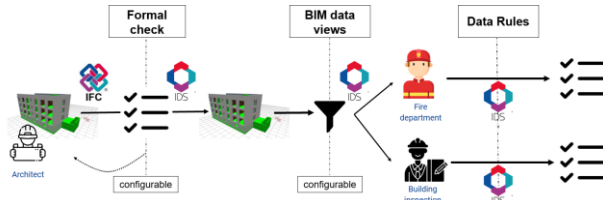


Figure 2: Concept of BIM-based testing

The process starts with the designer creating a BIM model of the planned building project. This model is uploaded to the DBP platform in a standardised IFC format. During the upload, a formal check is performed using the IDS format, which checks the basic data requirements of the model. This check verifies that the model contains all the necessary data and that it meets the formal requirements before proceeding to the detailed check and that the model is complete and correct in a machine-readable format and that it meets the input criteria. If data is missing or incorrect, detailed feedback is provided to the designer via either an html-based report or the BIM Collaboration Format prior to successful submission.

Once the formal verification process is complete, the model is then subjected to further analysis within the BIM data views. These views provide the specific information about the model required for the various checks. The use of BIM data views allows the selective filtering and viewing of specific aspects of the building model, including structural elements, fire protection components and spatial data. The data views facilitate the targeted investigation of specific construction industry specialisms and the extraction of data relevant to specific areas of inspection. The use of the IDS format and an IFC viewer developed for BIM data views within a DBP platform enables the dynamic generation and combination of BIM data views. The developed BIM data views are based on the IDS format and can be created, displayed and executed in the same way. In addition, most of the IDS rules used for formal check can be used in a similar way to generate BIM data views.

The rule-based review is based on the specific data rules, which contain predefined criteria and requirements that the building or its components must meet. These rules are configurable and can cover different requirements for various inspection areas, such as fire protection and building inspection.

In the initial phase, the standard IDS functions are used, which include a basic check. The aim is to check the values of attributes when they are single instances in IFC data. The above checks are relatively simple and relate to individual attributes, without complicated dependencies. The limitations of such checks are given by the very complex normative rules and therefore allow the control

of basic properties of the model. The IDS format is an effective way of checking simple, attribute-based requirements for IFC data. The current version of the IDS format is not yet able to satisfy more complicated checking requirements.

The next stage of development, the extension of IDS, builds on the existing validation capabilities of the IDS format to incorporate geometric and logical checks that go beyond simple attribute-based assessments. To this end, the IDS format has been extended to facilitate the implementation of checks, particularly in the area of collision control and logic. This includes both enhancements to the IDS format and its underlying schema, designed to accommodate the storage of appropriate rules, and the inclusion of libraries that perform the actual checks.

In the third stage, the integration of XPlanung data is incorporated into the extension of the IDS format. XPlanung represents a standardised approach to the modelling and provision of geodata for urban planning and development processes in Germany. The combination of IDS and XPlanung enables the incorporation of additional semantic and spatial requirements from XPlanung into the verification process. This signifies that the verification process can now encompass specific location data, thereby facilitating a more exacting examination of conformity with local planning regulations. In order to facilitate the processing of XPlanung data with the common programming libraries, it is first necessary to convert the data from XPlanung into an IFC format. The focus here is on the `xplan:BP_UeberbaubareGrundstuecksFlaeche` of the XPlanung data set, which defines the buildable property area and other information such as the minimum and maximum number of storeys. For this purpose, these are converted into `IfcSpace` elements of the IFC format.

## Implementation

The implementation of BIM-based checking in the data-driven building permit is based on three fundamental components also shown in figure 3: a user interface, a Flask backend as a web server, and the `ifcTester` library for the actual validation. The user interface integrates the IFC Viewer with conventional functionalities and the IDS Viewer, which provides a human-readable representation of the IDS. The IFC Viewer and its associated functionality are based on the Open BIM Components library (That Open Company, 2024), whereas the IDS Viewer is based on more conventional implementations. Both implementations are realised with JavaScript and can be operated independently of any additional libraries within the framework of the user interface. In order to facilitate the interaction of IDS functionalities on the IFC viewer and also the validation of an IFC with an IDS using the Python library `ifcTester`, the user interface is integrated into a Flask-based web application. The user is able to upload IDS files via the IDS viewer and thereby initiate their execution and the subsequent validation of the IFC

model, which has previously been uploaded by the user, by selecting the corresponding buttons. Information regarding the specific IDS and its corresponding specification is transmitted to the Flask backend via an AJAX command, thereby initiating the execution of the validation process with the ifctester library. Following the completion of the model checking process with ifctester, the resulting data is transferred via Flask and an AJAX command back to the user interface. The IFC-viewer then displays the results, and additionally generates a report using the ifctester report template. This report can be downloaded by the user in HTML format.

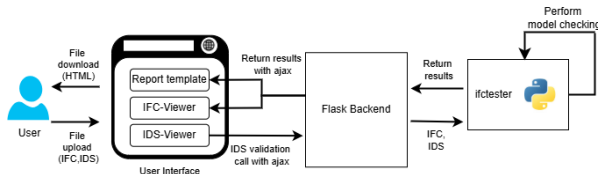


Figure 3: Implementation of model check process

### Rule-based testing with IDS

The following section outlines the extension of the IDS scheme, which are employed to conduct the extended test with IDS. Figure 4 provides a detailed illustration of the structure and function of an IDS-based rule check. The information section defines the fundamental information pertaining to the IDS (Eichler et al., 2023). The individual rules are ultimately recorded in individual specifications. The specifications are defined in accordance with the delineation of the applicability and the requirements. The applicability which consists of one or more applicability facets, is used to filter out specific elements of the model that are to be examined in the context of the specification. The aforementioned requirements are defined in requirement facets, which serve to ascertain compliance with similarly defined specifications with regard to individual aspects. A report is produced to document the test results for each specification and its defined requirements. The first extension is illustrated in figure 4 and refers to the applicability limitation.

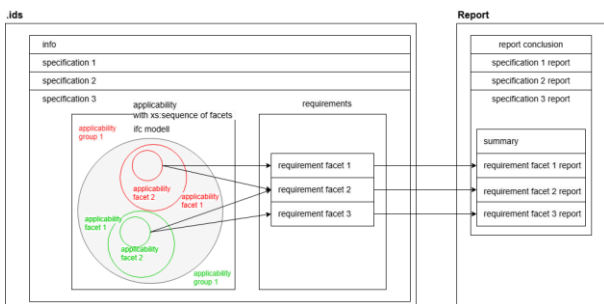


Figure 4: Extended applicability of IDS

The previous limitation of defining only a subset of the model within a specification is removed by the introduction of applicability groups. These allow the definition of several subsets of the model within a specification and their processing in different or the same requirement. The filtering of the elements of the groups is done identically by using one or more applicability facets.

The second part of the extension pertains to the development of two additional facets, namely the geometry facet and the mathOperation facet. In contrast to the six existing facets in the IDS schema, which can be employed in both the delineation of the applicability and the definition of the requirements, the two newly developed facets are solely utilized for the latter purpose. Figure 5 illustrates the incorporation of the two facets into the IDS schema.

The geometry facet is employed for the examination of geometrically colliding elements within a model specification, utilising two defined applicability groups. The following elements are included:

- **Type:** Determines the type of geometric clash control.
  - "Clash" type performs a geometric overlap check on elements belonging to the specified applicability groups.
  - "Contain" type performs a geometric containment check on elements belonging to the specified applicability groups within applicability group 0.

- **Accuracy:** denotes the degree of precision that is applicable to the geometric examination. This could be exemplified by a tolerance specification.
- **ApplicabilityGroupAssignment:** determines which groups of the model are encompassed within the geometric inspection.

```
<xs:complexType name="mathOperationType">
  <xs:sequence>
    <xs:element name="type" type="ids:idsValue" minOccurs="1"/>
    <xs:element name="property" type="ids:propertyType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="value" type="ids:idsValue" minOccurs="1" maxOccurs="unbounded"/>
    <xs:element name="applicabilityGroupAssignment" type="ids:applicabilityGroupAssignmentType" minOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="geometryType">
  <xs:sequence>
    <xs:element name="type" type="ids:idsValue" minOccurs="1"/>
    <xs:element name="accuracy" type="ids:idsValue" minOccurs="1"/>
    <xs:element name="applicabilityGroupAssignment" type="ids:applicabilityGroupAssignmentType" minOccurs="1"/>
  </xs:sequence>
</xs:complexType>
```

Figure 5: Development of the MathOperation and Geometry Facets in the IDS schema

The mathOperation facet is employed for the purpose of verifying the values that emerge from the preceding calculation of multiple elements. The following elements are included:

- **Type:** defines the type of mathematical operation that is to be applied. For example, this could be the sum, totalNumber, or quotient.
- **Property:** indicates the specific property to which the mathematical operation is to be applied using a property facet. This determines which property within the model is included in the operation.
- **Value:** defines the value to be adhered to. For example by means of upper and lower limit values
- **ApplicabilityGroupAssignment:** determines which groups of the model are included in the calculation.

The next phase involves referencing the XPlanung data in IFC format within the IDS. To achieve this, it is first necessary to record the representative buildable property area for the building in an applicability group of the specification. In addition to filtering the IFC spaces using an entity facet, followed by filtering the buildable property areas using a property facet, a final property facet is used to uniquely reference the corresponding buildable property via the GML:id. In a subsequent requirement facet, shown in figure 7 of the specification, a placeholder variable is defined via the value, which defines the value to be adhered to, and which refers to the corresponding property of the buildable property previously defined in applicability group 0. The placeholder is defined as a string using the following structure: The placeholder serves to distinguish it as such, while the subsequent XPlanung and ZMin represent the PropertySet and the property whose value is to be used as the limit.

```

<mathOperation>
  <type>
    <simpleValue>totalNumber</simpleValue>
  </type>
  <value>
    <xs:restriction base="xs:integer">
      <xs:minInclusive value="Placeholder_XPlanung_Zmin"/>
    </xs:restriction>
  </value>
  <applicabilityGroupAssignment>
    <name>
      <simpleValue>1</simpleValue>
    </name>
  </applicabilityGroupAssignment>
</mathOperation>

```

Figure 7: Using XPlanung data of IFC in mathOperation facet in IDS

In addition to utilising the semantic information from the XPlanung as a basis for the development, the geometry data can also be employed in conjunction with the geometry facet to ascertain whether the proposed construction project is consistent with the buildable area of the property.

### Demonstration

The developed system is demonstrated in a prototype workflow using the example of a 3-storey apartment building with one residential unit on each floor. In Germany, buildings in this building class are subject to medium requirements for fire protection and evacuation, so the building class must first be checked separately. Figure 8 illustrates the developed user interface, which comprises the IFC and IDS viewer and the BIM data view that has already been completed.

All forms of the test, including checks, views and rules, can be carried out individually in accordance with the specifications provided. To initiate a test, simply click on the play button, which is displayed in the IDS viewer next to each specification. The generated BIM data view displays two specifications of the fire protection view that have been carried out. The IFC-Space-FireExit-View presents all rooms that serve as escape routes in blue and rooms that do not serve as escape routes in green. The IFCWall-Fire Rating-View depicts walls with the fire rating F60 in neon green and walls with the fire rating F90

in grey. The repeatability of following tests requires the extension of the IDS schema and associated libraries as presented in the previous chapter

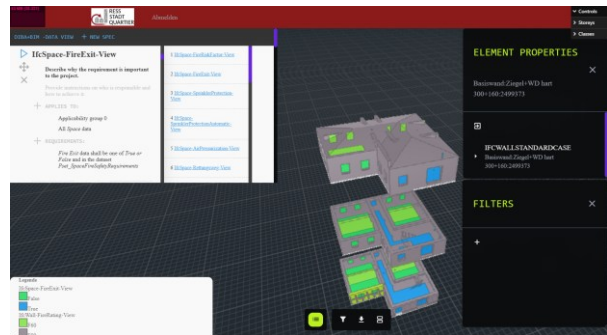


Figure 8: User interface with IFC- and IDS Viewer and an exemplary BIM data view facet in IDS

The following examples illustrate the utilisation of XPlanung data within an IDS, followed by the subsequent verification of an IFC model. Figure 9 on the left presents the human-readable form of the IDS implemented in figure 7.

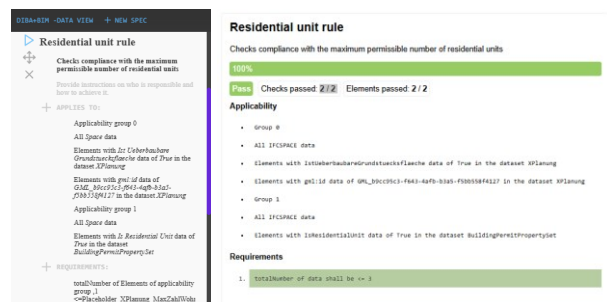


Figure 9: Using XPlanung data of IFC in mathOperation facet in IDS

The number of full storeys (IfcBuildingStorey with IstVollgeschoss) in applicability group 1 is determined and compared with the value of the XPlanung body determined in applicability group 0 with the property (minimum number of full storeys) and Z (maximum number of full storeys) in PropertySet XPlanung. This is achieved through the utilisation of the mathOperation facet of type totalNumber. The report on the right side of figure 9 illustrates the transfer of the placeholder values to the requirements.

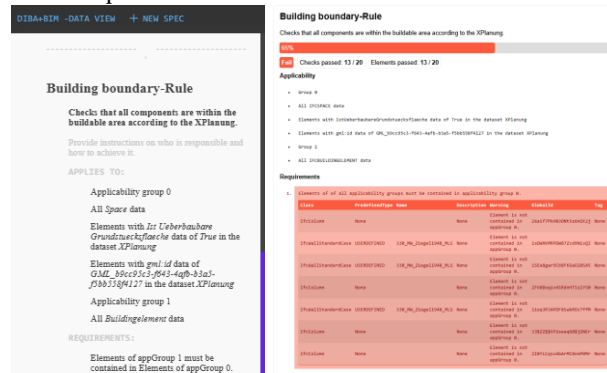


Figure 10: Using XPlanung data of IFC in geometry facet in IDS

Figure 10 illustrates the verification of compliance with the buildable area in accordance with the XPlanung. By employing all building elements within applicability group 1 and the XPlanung body determined in applicability group 0. The report lists all non-included components using the geometry facets of type contain.

## Results and discussion

The scientific contribution of this work lies in the integration and extension of the existing open standards IFC, IDS and XPlanung into a holistic, data-driven permitting system. This addresses the central problem of the lack of automation and transparency in the review of building applications in the construction industry. Compared to previous approaches, which often only cover isolated aspects such as purely BIM-based reviews (Tulke et al., 2021) or document-based procedures, this approach offers a holistic solution for different forms of DBP, including unstructured data using developed regular data views, while the use of BIM or data-based inputs is still not the norm (Hartmann et al., 2024). To incorporate digital, non-machine-readable building applications, it is necessary to extract data from unstructured documents such as proofs (Urban et al., 2024). In combination with Plan2Bim methods, such data can also be integrated into BIM. The BIM-based check based on the IDS extension provides the basic capability to perform a rule-based technical check. Similar existing tools for the BIM data view and data rules as part of commercial software use their own programming and storage functions with proprietary formats, so that no vendor-neutral exchange is possible. The evaluation of the approach is illustrated using the example of building class differentiation based on the model building code in Germany and is compared with the only open standard, OpenBIMRL. Building class differentiation is based on the following criteria: building height, number and total floor area of dwelling units, direct adjacency to neighbouring buildings and use for forestry and agriculture. In the IDS-based approach presented here, the ElevationWithFlooring property of the IfcSpaces, which are classified as living space by means of property, is used to check the building height. The MathOperation facet is used to determine the maximum of the height values of all selected rooms. In contrast, OpenBIMRL uses a geometric approach in which the coordinates of the individual rooms are determined and with the help of relations to associated storeys and floor superstructures the final building height is determined and then the maximum value is calculated. The IDS-based approach uses the totalNumber function of the MathOperation facet to determine the number of residential units, which calculates the number of units, after they have previously been selected in the applicability using an entity facet and property facets. OpenBIMRL equally first filters the relevant room objects and then calculates their total. In the IDS approach the living space area is checked by identifying the individual rooms belonging to usage units (IfcSpaces) using a PartOf facet, which determines the usage units using an entity

facet and a property facet. The total living space is calculated using a MathOperation facet of type sum in relation to the GrossFloorArea property of the individual room objects and then compared to the reference value. Both approaches use a property isDetached isLandOrForestUsage, which are attached to the IfcBuilding instance in order to check the direct adjacency to neighbouring buildings and the use for forestry and agriculture. While this is a realistic approach for controlling forestry and agricultural use, it is only an aid for controlling the adjacency of buildings, as existing, adjoining buildings are not modelled and therefore information is missing. This is where approaches to integrating the existing building stock, such as XPlanung, but also CityGML, can provide a solution. As a result of the comparison, it can be stated that both approaches allow the building class to be checked to the same depth of information, while they are based on different modelling. The limits result from the lack of information on the built environment. Compared to the graph-based approach (Stepien et al., 2023), the IDS-based approach is limited in the nesting of conditions by a schema, which limits the complexity of the controls. By integrating XPlanung, the presented approach opens up the possibility of including the planned built environment in the assessment, thus providing a solution to the information gap identified. From a scientific perspective, this work contributes to the advancement of knowledge in the field of the future digital transformation of DBP (Bloch and Fauth, 2023) and closes the research gap of handling different inputs in DBP within one framework with identical digital methods. By integrating existing research results (Noardo et al., 2022; Tulke et al., 2021) into overall concepts and extending them with other research approaches (Stepien et al., 2023)

## Conclusion and outlook

The work presented demonstrates that the integration of IFC, IDS and XPlanung has the potential to significantly advance the efficiency and transparency of building permit processes. Transferability to other countries is possible through the use of international standards IFC and IDS, and at the international level INSPIRE Planned Land Use (PLU) takes over the role of X-Planung (Benner, 2013). A key focus is the extension and refinement of IDS. New data views specifically tailored to individual permit views could further improve usability and facilitate adaptation to different use cases. In addition, extending the IDS format for specific checks, such as fire safety requirements or resource efficiency, is a key step in increasing the functionality and applicability of the platform. There are limitations to IDS evaluation, so approaches such as OpenBIMRL are also needed for very complex situations and need to be further explored. The use of AI in this area also represents another area of research to further automate and optimise validation processes in two ways. On the one hand, they are a key to unlocking unstructured data sources, such as documents and plans, for data-driven building permits through data

extraction and also for BIM-based approaches, for example using Plan2BIM approaches. On the other hand, a field of research for the use of artificial intelligence in the review of building permits itself arises.

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