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Model-Based Public Participation Using Open Data Exchange Formats

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Abstract: Public participation in planning processes is often limited by the reliance on two-dimensional technical drawings, which can be difficult for non-experts to interpret. Building Information Modeling (BIM) offers the potential to present complex planning information in a structured, model-based format. This study presents the design, prototypical implementation, and validation of a model-based public participation approach using open data exchange standards, specifically the Industry Foundation Classes (IFC) and the BIM Collaboration Format (BCF). The approach includes a coordination model for public participation and story points as supporting visualization elements. These were implemented using a Common Data Environment (CDE) and a BIM-based participation platform. Validation through focus group workshops with professionals from road and rail infrastructure administrations indicates that the approach improves the comprehensibility and transparency of planning information. From a safety and reliability perspective, clearer model-based visualizations can reduce human interpretation errors when assessing complex infrastructure plans. By supporting a more consistent understanding of planning data among stakeholders, the approach contributes to more reliable decision-making under uncertainty. At the same time, challenges such as accessibility barriers, potential information overload, and limitations in representing certain planning aspects were identified.

Keywords: Public Participation, Planning Documents, Building Information Modeling (BIM), Common Data Environment (CDE), Industry Foundation Classes (IFC), BIM Collaboration Format (BCF)

1. Introduction

1.1. *Initial Situation*

Public participation refers to the involvement of citizens and stakeholders in planning, decision-making, and approval processes (Arbter et al. 2005). The aim of such participation procedures is to provide information, enable the submission of feedback, and thus support transparent and comprehensible decision-making (Kallenbach-Herbert et al. 2008). The degree of actual influence varies depending on the specific design of the process (Lauria and Slotterback 2021).

From a democratic perspective, public participation is particularly understood as a means of legitimizing political and planning decisions (Trénel et al. 2001). Albrecht et al. (2013) identify this legitimizing function as a central objective of formal participation procedures (Albrecht et al. 2013). An improved level of public information can contribute to

increased trust in planning processes and responsible institutions. Consequently, public participation is considered an essential element of a pluralistic democracy (Damer and Hague 1971).

In the context of planning and approval procedures, the public display of planning documents represents a core component of public participation. During a defined period, citizens are given the opportunity to review relevant documents, assess their personal stake in the project, and submit objections. However, the documents provided are predominantly technical, two-dimensional drawings, which are often difficult for non-experts to interpret (Spieker et al. 2017). From a human factors perspective, such limitations in information representation can increase the likelihood of misinterpretation and misunderstandings during participation processes. This results in delays in planning and approval procedures and thus more uncertainty. Against the backdrop of increasing digitalization in planning processes, the use of digital tools and methods offers new opportunities for more illustrative and comprehensible presentation of planning information. In particular, Building Information Modeling (BIM) offers the potential to represent complex planning information in a model-based manner. The use of BIM model data for public participation purposes is therefore considered a promising approach (Spieker et al. 2017; Matthei et al. 2025), but it requires the development, prototypical implementation, and validation of suitable methods. In this context, improved visualization and structured information exchange can contribute to reducing human interpretation errors and increasing the reliability and transparency of participation processes in infrastructure planning.

1.2. *Research Aim and Procedure*

The aim of this study is the design, prototypical implementation, and subsequent validation of an approach for model-based public participation. The focus is on the use of open data exchange standards, specifically the Industry Foundation Classes (IFC) and the BIM Collaboration Format (BCF).

Initially, the theoretical foundations are outlined (*Section 2*). Subsequently, a concept for model-based public participation, including two central components, is presented (*Section 3*). The concept builds on the findings of Matthei et al. (2025), which propose a BIM-based participation platform as the central software system for presenting complex planning information (Matthei et al. 2025). The BIM-based participation platform provides an interface to a Common Data Environment (CDE), which supplies model data and information relevant to the participation process.

The prototypical implementation of the developed concept for model-based public participation is described in *Section 4*. The implementation is based on the BIM-based participation platform developed within the research project BIM4People (funded by the German Federal Ministry of Transport, project 19FS2057A). For this purpose, a road construction project from a German road administration was made available.

Building on this, the developed approach is validated (*Section 5*). In this context, four focus group workshops with a total of 25 participants were conducted. The validation first provides a detailed description of the methodological procedure, followed by a presentation of the results. The study concludes with a summary and an outlook on future research (*Section 6*).

2. Theoretical Foundation

2.1. Building Information Modeling (BIM)

In recent years, the Building Information Modeling (BIM) method has become increasingly important (Hartung et al. 2020). As a result, the BIM method is being used more and more frequently in pilot projects for the planning and execution of infrastructure projects (Matthei et al. 2023). The methodology is based on the idea of continuously using digital building models throughout the entire life cycle, from the planning of a structure through the construction phase to management and possible demolition (Borrmann et al. 2018b). In this regard, BIM differs from conventional paper-based or 2D drawing-based workflows (Eastman 2011).

2.2. *Common Data Environment*

At the core of a successful application of BIM methods lies a Common Data Environment (CDE). A CDE can be defined as a shared digital project space that provides structured access

areas for different project stakeholders, together with clearly defined information states and a robust workflow governing data exchange, review, and approval processes (Preidel et al. 2018). The CDE serves as a central, interdisciplinary platform for collaboration and data exchange, ensuring data consistency and transparency while reducing redundancies between project participants (Baumgärtel et al. 2020). In line with the single source of truth (SSOT) principle, the consistent use of the CDE forms the basis for model-based information management within a project (Schönbach et al. 2021).

2.3. *Data Exchange Formats*

Data exchange formats are essential for using the BIM method, which requires cooperation between different project participants. A fundamental distinction can be made between proprietary, software-dependent formats and vendor-neutral formats. Proprietary formats are typically tied to specific software solutions, limiting interoperability across platforms. (Borrmann et al. 2018a).

To address this limitation, the Industry Foundation Classes (IFC) were developed by the International Alliance for Interoperability, later renamed buildingSMART, as a vendor-neutral standard for the comprehensive description of digital building models. IFC enables the representation of both geometric and semantic information by structuring buildings into components and their relationships, thereby supporting interoperable data exchange across different software environments (Borrmann et al. 2018a). Complementing IFC, the BIM Collaboration Format (BCF) provides a standardized mechanism for model-based communication (Schapke et al. 2018). BCF is used to exchange comments, issues, and tasks linked directly to elements within an IFC model, enabling structured coordination and traceable documentation (Preidel et al. 2018). Together, IFC and BCF form a widely established framework for collaborative, model-based workflows (buildingSMART 2026).

2.4. *Model-based Collaboration*

n BIM projects, specialist planners create discipline-specific partial models that are merged into a coordination model within the CDE at defined exchange points (Baumgärtel et al. 2020). The coordination model consolidates these partial models and serves as the central basis for model-based coordination and communication (Schapke et al. 2018). Besides the main goal of checking that the individual partial models match up with each other, the coordination model serves as a starting point for communication.

In German federal road projects, partial models are structured into discipline models and sub models in accordance with the BIM Master Plan for Federal Highways. Each discipline model contains the elements of a specific planning domain and is the responsibility of the respective specialist planner (BMV 2021; Preidel et al. 2018). Discipline models may consist of several sub models representing specific aspects of a discipline, such as digital terrain or explosive ordnance within the environment discipline, or alignment and earthworks within the traffic facility discipline (BMV 2021).

3. The Concept of Model-based Public Participation

The approach of model-based public participation primarily addresses the limited comprehensibility of conventional planning documents. In addition, it aims to enhance transparency and traceability of planning decisions for the public. Central elements are a coordination model for public participation and the storypoints derived from it. The implementation builds on open and established data exchange formats, which are described in the following subchapters.

3.1. *Coordination model for public participation*

The coordination model for public participation comprises a thematically focused selection of discipline models and sub-models that are considered relevant for public disclosure and, consequently, for informing the public. Depending on the specific characteristics of a project, the coordination model is assembled from the corresponding discipline and sub-models and serves as the basis for an enhanced visual representation within participation procedures.

In the context of federal highway construction projects, typically nine different

discipline models are regarded as relevant (BMV 2021). Each discipline model is based on a set of associated sub-models. These sub-models can be consolidated into discipline models and, subsequently, aggregated into a project-specific coordination model.

For the integration and management of discipline models and sub-models, the use of a CDE is appropriate, as it represents a core element of BIM-based planning (see Section 2.2). The coordination model generated on this basis forms the foundation for an enhanced visual presentation of planning documents, using the open data exchange format IFC.

Figure 1 illustrates the exemplary composition of the coordination model for public participation based on the discipline models and sub-models commonly defined for road construction. The shown sub-models represent possible components and may vary depending on the project context and available data. Furthermore, not all models are necessarily represented by three-dimensional geometry (BMV 2021). The specific configuration of the coordination model for public participation therefore depends on project-specific characteristics and the available data basis.

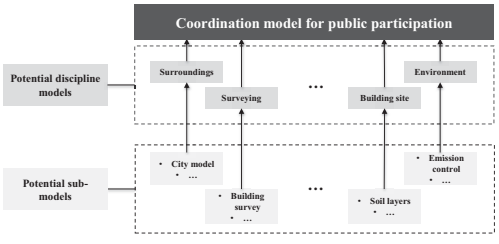

Fig. 1. Schematic composition of a coordination model for public participation

3.2. *Storypoints*

Storypoints represent selected, individual three-dimensional (3D) views within a coordination model for public participation, complemented by explanatory text. They are intended to convey complex information through the combined use of textual explanations and 3D visualizations and can be understood as supplementary elements to conventional planning documents.

The concept of storypoints is based on the structure of current BIM viewpoints, which represent specific views of a digital model (Neuville et al. 2019). Accordingly, storypoints are implemented using BCF, which provides a standardized, model-related structure. The attributes used to represent a storypoint and their functional roles are summarized in Table 1.

Table 1. Data structure of storypoints.

Relevant BCF Attribute	Functional description
Guid	Unique identifier of the storypoint within the project. Enables unambiguous referencing.
ProjectID	Assigns the storypoint to a specific project, ensuring the correct project context.
TopicType	Marks the BCF topic as a "Storypoint." Ensures clear differentiation from other BCF topic types.
TopicStatus	Represents the processing status of the storypoint, supporting workflow tracking.
Title	Short description of the storypoint. Provides orientation and content overview.
CreationDate	Timestamp of storypoint creation. Allows chronological tracking and traceability.
CreationAuthor	Name of the person who created the storypoint. Supports transparency and accountability.
ModifiedDate	Timestamp of the most recent modification. Enables change tracking.
ModifiedAuthor	Reference to the last person that saved a change to the topic.
AssignedTo	Optional assignment of the storypoint to a responsible person.
Description	Textual explanation of the represented content. Core attribute for conveying information in addition to the 3D view.
Stage	Assigns the storypoint to a project phase, enabling phase-specific organization.
DosumentReference	References additional documents, particularly conventional planning documents. Supports linking between digital and traditional documentation.
Comment	Allows supplementary comments to be added to the storypoint.
Viewpoints	Collection of viewpoints associated with the storypoint.
RelatedTopic	Links to other BCF topics, e.g., to thematically related storypoints.

4. Prototypical Implementation

The prototypical implementation is based on the concept by Matthei et al. (2025), which envisions a

BIM-based participation platform as the central medium for public engagement. This platform relies on a CDE as the underlying data source for providing planning documents and participation-related information (Figure 2).

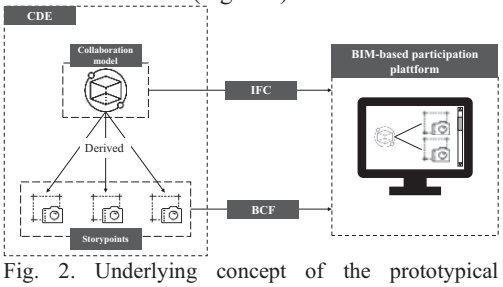

Fig. 2. Underlying concept of the prototypical implementation

The implementation initially involved the generation of a coordination model for public participation. Based on an available BIM-based road construction project, a total of 63 discipline models were provided for the prototype, which could be organized into five sub models.

Using the CDE, these models were consolidated into a coordination model for public participation. This was supplemented by the exemplary creation of story points. In addition, the traditional planning documents, which were available as PDF files, were provided via the CDE.

Figure 3 illustrates the CDE at the time of the plan display. The interface has been translated into English for the purpose of this publication.

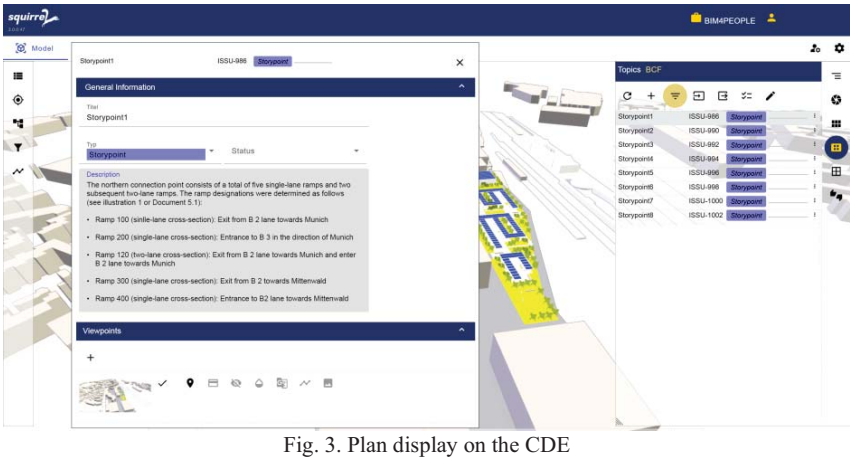

Fig. 3. Plan display on the CDE

Subsequently, the conventional planning documents were transferred as PDFs, the coordination model for public participation as IFC files, and the generated story points as BCF files to the BIM-based participation platform. The platform provides an IFC viewer for displaying the models. In this context, Cesium was used, which supports the visualization of open-source 3D graphics formats directly in the browser [24]

The following figure (Figure 4) shows a story point generated on the BIM-based participation platform. Each story point contains a three-dimensional view (right side) complemented by a textual description (left side), which was derived from the conventional planning documents.

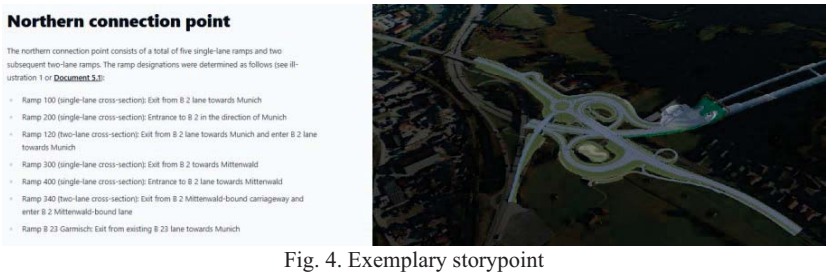

Fig. 4. Exemplary storypoint

6. Validation

6.1. *Methodology*

For validation purposes, focus group workshops were conducted as a qualitative research method involving guided group discussions. In contrast to individual interviews, focus groups are particularly suitable when the objective is to explore how participants discuss and reflect on an issue collectively, rather than solely from an individual perspective (Bryman 2016).

In total, 25 individuals participated in the focus group workshops. Twelve participants were project developers acting as initiators of public participation processes. Eleven participants represented planning approval authorities responsible for organizing and conducting public disclosure procedures within formal approval processes. In addition, two participants were employed by ITZBund, the central IT service provider for the German federal administration (Informations Technik Zentrum Bund n.d.). All participants were associated with rail or road infrastructure administrations at the federal and state levels in Germany.

As part of the focus group workshops, participants were given access to the BIM-based participation platform presenting the coordination model and the implemented storypoints. They first familiarized themselves with the content and then provided feedback using digital post-it notes on the online platform Miro (Miro o.J.).

The collection of feedback was guided by the central question: *"What strengths, weaknesses, opportunities, and risks do you see in this approach?"* This guiding question captured participants key assessments and structured them systematically. Participants initially responded to the question individually and subsequently discussed their inputs collectively.

The guiding question is conceptually aligned with a SWOT analysis, which categorizes internal and external factors as Strengths, Weaknesses, Opportunities, an Threats (Namugenyi et al. 2019).

In this context, however, the four categories were not used to conduct a comprehensive strategic analysis. Instead, they served solely as a means of structuring participant feedback in an orderly manner. Within this study, the categories are defined as follows: strengths and weaknesses describe direct effects of the approach and its application, while opportunities and risks refer to potential positive or negative developments arising from its use.

6.2. *Validation Results*

The following section presents the strengths, opportunities, weaknesses, and risks identified during the focus group workshops.

Strengths: A central strength of the model-based public approach was identified as its ability to enhance understanding as well as transparency. One workshop participant noted that even approval authorities often struggle to understand two-dimensional plans. The participants further emphasized that models and storypoints greatly improve comprehensibility compared to traditional plans.

The depoliticization of discussions was also mentioned as a strength. Although the visually enhanced approach does not aim to change firmly opposed stakeholders, increased understanding may help depolarize and depoliticize discussions regarding a project.

Opportunities: The model-based representation was seen as an excellent means of capturing stakeholder relevance more accurately, which could contribute to more effective conflict resolution. Participants noted that the approach enables answering questions from a citizen's perspective and in an ideal scenario may accelerate approval processes. The improved assessment of stakeholder relevance was attributed to a better spatial understanding of the project's location and extent.

According to the participants further opportunities include improved orientation through model-based visualization. Participants highlighted that road construction projects are already planned using models, making their use in public participation a logical step.

Weaknesses: Access for less digitally experienced users was noted as a limitation.

Limited access to suitable devices was mentioned as a barrier. Some aspects, such as plan justifications, cannot yet be represented, limiting the applicability of storypoints.

Risks: Participants warned that information overload and selective presentation within storypoints may obscure important details. They also noted that users may also get lost in details when interacting with complex visualizations. Potential issues with controlling or navigating the model view on the digital participation platform were also mentioned. However, one participant perceived few risks, emphasizing the predominantly positive effects of the approach.

7. Summary and Outlook

Current public participation processes are predominantly based on two-dimensional drawings, which are often difficult for non-experts to interpret. At the same time, Building Information Modeling (BIM) offers the potential to represent complex planning information in a model-based manner. Despite this potential, concrete approaches for the use of BIM model data in the context of public participation, as well as their systematic testing, have so far been lacking.

The aim of this study was the design, prototypical implementation, and subsequent validation of an approach for model-based public participation. The focus was on the use of open data exchange standards, specifically the Industry Foundation Classes (IFC) and the BIM Collaboration Format (BCF).

Building on the theoretical foundations, a concept for model-based public participation was developed, which includes a coordination model for public participation and derived storypoints. The coordination model comprises a thematically focused selection of discipline models and sub-models considered relevant for public disclosure. Storypoints represent selected individual three-dimensional (3D) views within the coordination model, complemented by explanatory text. For the structured representation of story points, the BCF structure was used.

The prototypical implementation applied the developed approaches using a Common Data Environment (CDE) and a BIM-based participation platform. Focus group results with 25 participants indicate that the approach enhances understanding and transparency, facilitates comprehension of complex planning information, and promotes fact-based discussion. Storypoints improve the interconnection of information. From a human reliability perspective, structured visualization can reduce misunderstandings among planners, authorities, and stakeholders, supporting more robust decision-making in complex, uncertain infrastructure projects.

Furthermore, the approach offers the potential to reduce conflicts through better identification of affected stakeholders, to accelerate planning procedures, and to improve the public image of administrative bodies. Identified weaknesses include limited accessibility for participants with low digital literacy or insufficient technical equipment, as well as the limited representation of certain planning aspects within the model. A key risk highlighted by participants is the potential for information overload within storypoints.

Overall, this study shows that BIM-based approaches enhance traditional public participation by making complex planning information more accessible. Improved information representation can also reduce human misinterpretation, supporting more reliable decision-making and addressing human factors in infrastructure planning under uncertainty. At the same time, the study highlights new challenges that may arise from the use of digital formats, including accessibility issues, potential information overload, and limitations in representing certain planning aspects. Future studies should investigate, from the citizens' point of view, the extent to which model-based visualizations improve the comprehensibility of planning documents, and how digital participation platforms can be made more inclusive for those with limited digital skills or resources.

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