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BIM-BASED NOISE PROTECTION PLANNING IN RAILWAY INFRASTRUCTURE

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ABSTRACT

Building Information Modeling (BIM) enables collaborative planning by integrating geospatial, technical and lifecycle data into a unified digital model. In railway infrastructure, BIM significantly enhances noise protection planning by linking spatial sound analysis with project visualization. The EAV-Infra research project exemplifies this approach by using BIM to integrate sound propagation calculations into the overall project model. The BIM model, derived from geodata in Germany, incorporates terrain, urban and cadastral data, enabling precise noise evaluations. Train assignments and track routing enrich the model for emission calculations under various scenarios. In a case study scenario with and without noise barriers were compared. The results, visualized as isophones, grid maps and evaluated facade points of buildings, demonstrated the barriers' effectiveness in reducing sound pressure levels. These findings, embedded in the BIM model, streamline variant analysis and stakeholder engagement. By integrating sound planning into BIM workflows, the project accelerates approvals, improves model quality, and fosters acceptance, showcasing BIM transformative potential for railway infrastructure development.

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1. INTRODUCTION

Building Information Modeling (BIM) has established itself as a transformative methodology in infrastructure planning by enabling the integration of diverse data sources into a unified digital environment. Particularly in railway infrastructure projects, the integration of geospatial, technical, and regulatory information within BIM models supports more efficient and transparent planning processes.

Noise protection planning presents a complex challenge in infrastructure development, requiring precise spatial and acoustic analysis, iterative scenario evaluation, and communication with stakeholders and regulatory bodies. Traditionally, noise calculations and mitigation planning are performed in isolated workflows. This fragmentation limits collaboration and slows down the decision-making process.

To overcome these limitations, our approach embeds parametric noise protection planning directly within the BIM model. Large-scale inventory models are generated by combining geospatial datasets, including terrain models, cadastral information, and urban features. Railway and roadway alignments are incorporated from linear referencing systems or design files, forming the basis for modeling noise emission sources. From this integrated model, we simulate noise propagation using standardized methods such as *Schall 03* [1] and ISO 9613-2 [2], and evaluate the effectiveness of noise barriers across different scenarios.

The BIM model was automatically generated using the software platform KorFin®, developed and distributed by A+S Consult GmbH, which enables a fully digital and parametric infrastructure model in an integrated workflow. This paper demonstrates how the integration of acoustic simulation into the BIM environment enables precise visualization of sound propagation effects, such as isophone maps and facade sound pressure evaluations. The case study from the EAV-Infra [3] research project highlights how this approach facilitates early-phase planning, variant comparison, and stakeholder engagement, ultimately accelerating approval processes and improving overall planning quality.

2. CURRENT STATE OF NOISE PROTECTION PLANNING

Noise protection planning in railway infrastructure projects in Germany is currently characterized by a fragmented tool landscape and disjointed workflows. At DB InfraGO AG, the planning process typically involves a set of dedicated software tools that are used independently from the central infrastructure model. Acoustic analyses and barrier dimensioning are performed in external specialist applications, based on exported terrain models, track geometries, and building data. This results in so-called media breaks, manual handovers and conversions of data between incompatible formats, which increase the risk of data loss, misalignment, and inconsistency.

Another major limitation lies in the lack of parametric integration between alignment planning and noise protection design. Track alignments, stations, and topographical data are not linked dynamically within a common model. As a consequence, any changes to the track layout or project geometry require manual updates in the acoustic model, which slows down the iteration process and reduces the responsiveness to planning changes. Furthermore, station-specific requirements, such as platform edge heights or structural interferences, cannot be considered automatically in the noise protection layout.

In order to evaluate and discuss different planning scenarios or mitigation strategies, large coordination efforts are required between multiple contractors and stakeholders. Software pipelines must be set up for each planning phase, often involving manual exchanges of data packages and time-consuming validation processes. This not only delays the schedule but also increases the cost of project execution.

Ultimately, the lack of integrated digital workflows for noise protection planning hinders early-phase decision-making and stakeholder involvement. Changes in design, particularly those affecting alignments or terrain models, propagate slowly across the planning tools. This reduces transparency and limits the potential for optimizing noise protection measures in a holistic, scenario-driven way.

3. PARAMETRIC NOISE PROTECTION PLANNING WITHIN A BIM MODEL

In the research project EAV-Infra, a fully model-based planning approach using BIM was developed and tested for railway noise protection. As a demonstrator, a representative digital twin of the DESAG rail network in the federal state of Brandenburg was created. This BIM model was automatically generated using the software platform KorFin® [4], which enabled a fully digital and parametric infrastructure model in an integrated workflow.

The model comprises a digital terrain model, a 3D city model with Level of Detail 2 (LoD2) buildings, and a fully parameterized track alignment including conceptual substructure and superstructure elements. The alignment geometry and structural components are directly linked to semantic infrastructure objects, allowing automated derivation of planning-relevant quantities such as stationing and object relationships.

To ensure accurate acoustic analysis, key objects in the environment—particularly near the Wutike station were manually refined in 3d modelling software and integrated (see Figure 1). This step was especially important for validating sound reflection paths within complex spatial surroundings. Figure 2 shows the model-based reflection paths up to the third order at an example site. By integrating the acoustic propagation paths directly into the BIM model, the transparency, traceability, and overall communicability of the results are significantly improved for both planners and stakeholders.

In addition to geometry and alignment, authoritative geodata from national sources were incorporated, including the Digital Landscape Model (ATKIS [5]) and the Digital Cadastral Map (ALKIS [6]). These datasets, compliant with the INSPIRE [7] directive, provide semantic attributes such as land use classification. Through spatial intersection of 3D building models and cadastral parcels, building types can be automatically identified and assigned to noise sensitivity categories according to the

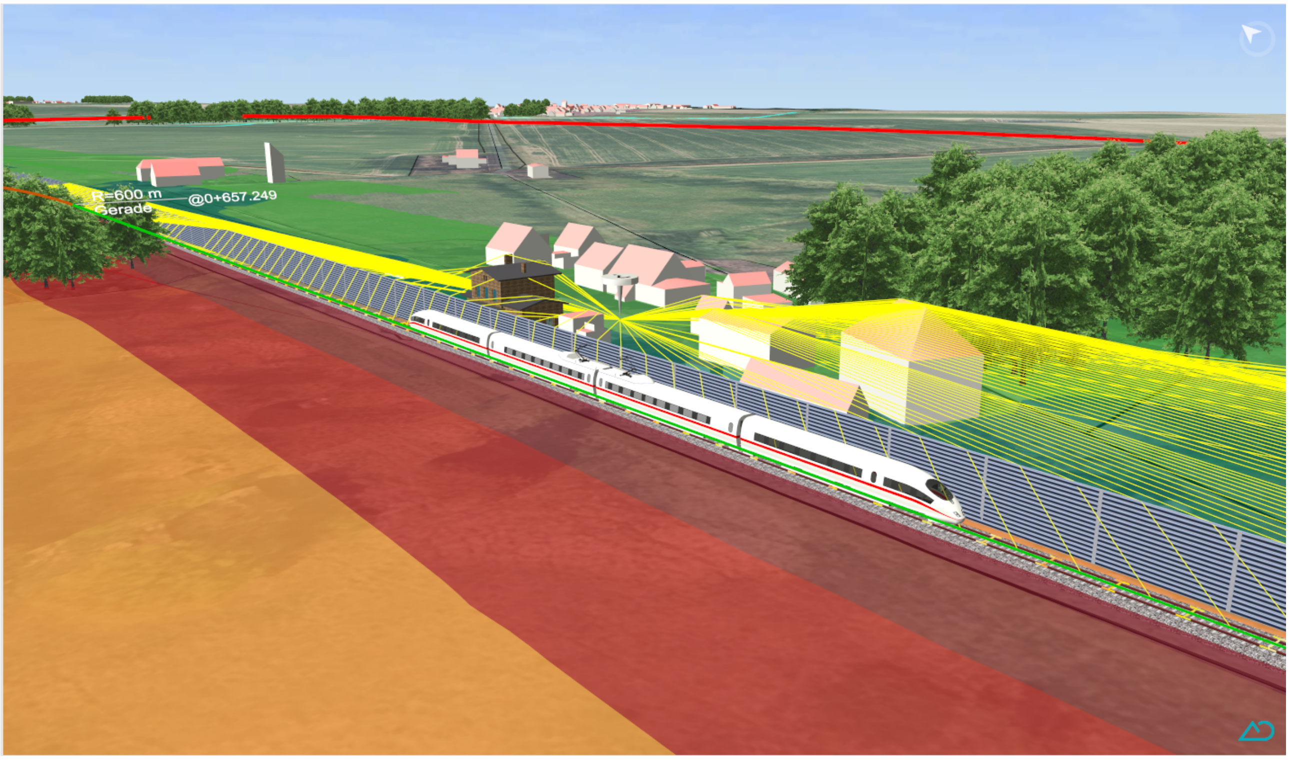

Figure 1. Noise calculation at the station of Wutike with a virtual 6-meter-high noise barriers, illustrating model-based sound propagation using a rubber band model.

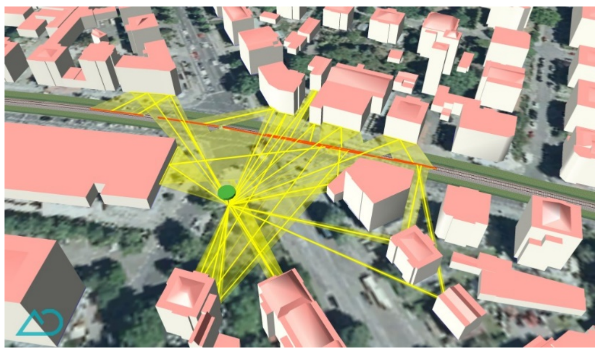

Figure 2. Evaluated reflection paths of third order within the BIM model

16th BImSchV [1], such as residential, commercial, or mixed-use zones.

An important feature of the integrated BIM workflow is the automated generation of facade evaluation points (Figure 3), which are derived for each relevant floor level of the affected buildings. These points serve as receivers for the noise immission calculation, enabling precise and vertically differentiated assessment of the sound pressure levels. The impact of noise mitigation measures, such as noise barriers, can thus be evaluated not only at ground level but also for each floor of multistory buildings.

Noise barriers required for the study were modeled step by step and integrated directly into the BIM environment. These objects were linked parametrically to the railway alignment by station and lateral offset values. A parametric example is shown in Figure 4. As a result, barrier geometry and position are not static objects but dynamically linked to the track layout, allowing for efficient variant design and quick adjustments when the track alignment changes.

The networked structure of the model ensures that technical data from different disciplines, such as civil engineering, acoustics, and land use planning, are combined within a unified environment. Each specialist object (e.g.,

Figure 3. Automatically generated facade points from LoD2 building data and spatially evaluation of noise immission (©DB InfraGO AG).

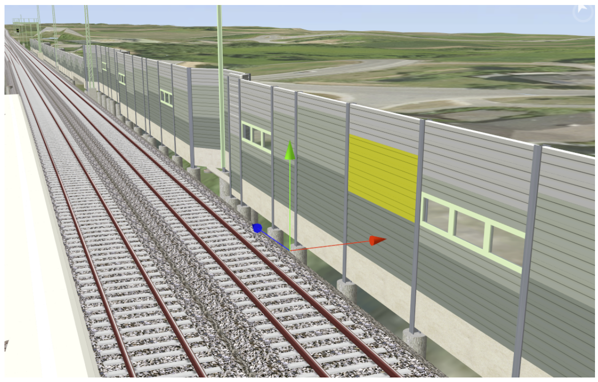

Figure 4. Parametrically defined noise barriers in the BIM model.

a noise barrier or track section) is embedded in its respective domain model and can be referenced from others. This cross-linking eliminates redundant data management and supports automated updates across planning disciplines.

Ultimately, the integration of parametric noise protection planning into the BIM model enables a shift from fragmented post-processing toward an interactive and transparent planning process. The BIM-based simulation results—such as isophone maps, grid-based propagation visualizations, and categorized affected areas—support early scenario analysis, stakeholder engagement, and faster approval processes.

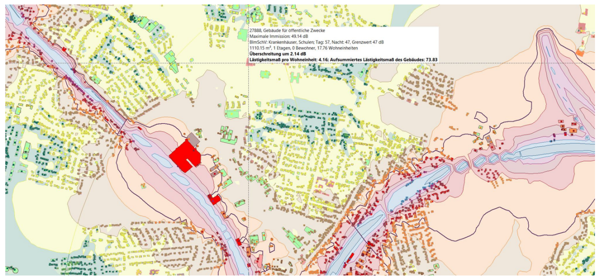

Figure 5. Model based generation of isophones within the BIM model, showing the sound pressure levels in dB(A) at the Kassel curve (©DB InfraGO AG).

4. CONCLUSION AND OUTLOOK

The integration of noise protection planning into a BIM-based workflow presents a significant step forward for infrastructure projects in terms of efficiency, transparency, and collaboration. The EAV-Infra project demonstrates that parametric modeling of infrastructure, combined with geospatial and cadastral data, enables automated and scenario-driven sound propagation analyses within a unified digital environment.

Compared to conventional workflows, where acoustic analysis is decoupled from infrastructure planning, the BIM approach allows changes in track alignment or terrain to directly update relevant components in the noise model. This not only reduces planning effort and time but also improves the accuracy and traceability of results. By visualizing sound immission effects—such as isophone maps or façade-level impact—directly in the BIM model, the method enhances stakeholder understanding and supports transparent decision-making.

The integration of standardized datasets (e.g., ATKIS, ALKIS) and regulatory frameworks (e.g., 16th BImSchV) into the digital planning process enables automated assignment of sensitivity classes and supports consistent evaluation across the project area. The linkage of specialist models, such as track alignment and noise barriers, through parametric references further supports modularity and coordination between disciplines.

As part of EAV-Infra, additional modules for auralization and psychoacoustic evaluation were also explored, allowing a perceptual representation of noise impacts beyond purely physical metrics. These capabilities open up new possibilities for stakeholder engagement by providing immersive audio simulations and perception-oriented analysis.

The flexibility of the KorFin® platform positions it as a scalable solution for international infrastructure projects. By extending its functionality to meet the requirements of international customers, KorFin can support a wide range of planning scenarios and regulatory frameworks.

Future research will focus on further automating the auralization process directly from the BIM model and expanding the representation of psychoacoustic parameters—such as loudness, sharpness, and annoyance—within the digital planning environment. This will not only enrich the communicative power of BIM-based tools but also foster more human-centered noise assessment and planning practices.

5. ACKNOWLEDGMENTS

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