Development of a Guideline for Standard Models in the Context of Building Information Modeling

Gamze Hort, Hort@Uni-Wuppertal.deH
Chair of Construction Management & Economics, University of Wuppertal, Germany

Daiki John Feller, Feller@Uni-Wuppertal.de
Chair of Construction Management & Economics, University of Wuppertal, Germany

Anica Meins-Becker, A.Meins-Becker@Uni-Wuppertal.de
Chair of Construction Management & Economics, University of Wuppertal, Germany

Abstract
Modeling guidelines document the jointly agreed model contents and designs as well as the information required by the client and serve as a communication basis for the implementation of a specific project even before modeling. (VDI 2018) They create a uniform understanding of the project structures and contents, provide a prominent module for the contractual specification, and therefore get more prominent due to the ongoing implementation of BIM. The article at hand deals with the conceptual design and the development of a neutral, standardized modeling guideline in cooperation with companies and incorporates their lived best practices processed from a scientific perspective. With the goal of being an aid to different stakeholders for different use cases, the developed guideline addresses various aspects in BIM projects, e.g. the specifications for project and model structure, the definition of project progress-dependent requirements for geometric and non-geometric information etc. in a general manner.

Keywords: Building Information Modeling, BIM Modeling Guideline, BIM Standardization, Employer's Information Requirements

1 Introduction and Motivation
Digitization in the construction industry is accompanied by the availability of all relevant data of a building along its entire life cycle. The BIM method - Building Information Modeling – takes advantage of this idea and centers the described information within the framework of a building data model. The method thus enables the provision of a more efficient basis for collaboration and communication between different stakeholders along the entire value chain and supports a consistent and uniform information management.

Due of the widely publicized method's efficiency gains, more and more complex structures and construction projects are being demanded and created as digital models. For an efficient information management and the effective use of a data models, involved parties need to address different forms of requirements, including the format for information provision and exchange as well as the relevant information's content. The definition of such specific requirements for modeling and of information depth of building information models often does not take place sufficiently despite existing employer's information requirements (EIR). This increasingly leads to misunderstandings and the client's expectations of a model and its usability collide with the contractor's performance obligation.

In the context of BIM projects in the construction and real estate industry, the involvement and provision of basic, company proprietary modeling guidelines as a description for the framework for the creation of building data models in order to make data management based on data models more transparent and to facilitate the handling of the data increasingly seeks attention. Dependent on project individual goals to achieve, modeling guidelines therefore need to be adapted to each specific project before the start of modeling and be communicated, documented and agreed on with all project participants. This ensures the use of a uniform database and facilitates the usability of the data for subsequent processes across the project board. On the part of model creators, the idea of modeling guidelines is not a novelty, since companies often develop own modeling standards and use them internally in order to accumulate the own knowledge. However, the documentation of this knowledge is not observed across the board and the potential of modeling guidelines, as a basis for a common understanding of a model, is not recognized everywhere. A survey within the own network has shown that modeling guidelines are already being created and used by larger companies, but being restricted as in-house modeling aid for their own employees and are in part very software-specific. As a result, the data derived from the building data model may work for internal company processes, such as preparation for tendering etc., but often inflict interface problems in the exchange with external parties such as specialist planners.

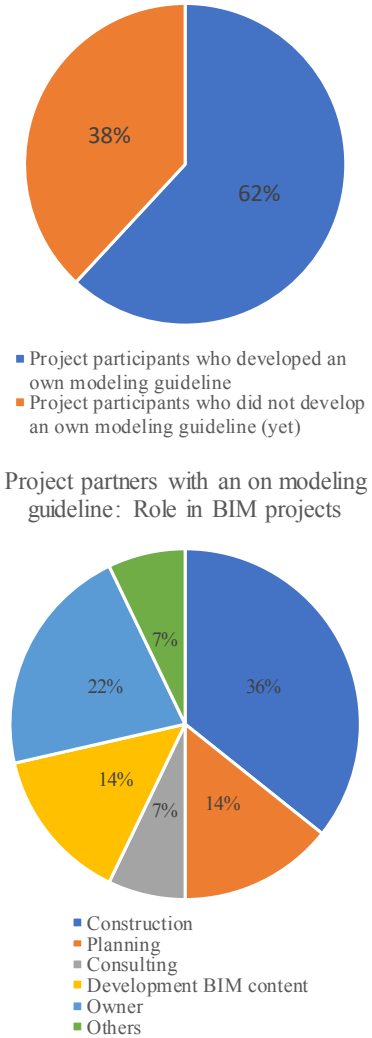

Figure 1: Distribution of partner with own modeling guideline and field of activity

For various parties involved over the whole value chain of a building project not to deal with such question of which information needs to be included in a model and which to be generated anew, and in order to ease the entry for smaller and medium-sized companies into BIM

application, the development of a standardized modeling guideline has been started. On the one hand, the provision of such document would ensure a clean structuring of data and, on the other side, maps a basic set of information that must be available in the building data model depending on the progress of the project. This way, model creators and model users work based on the same level of knowledge regarding modeling content and depth. This leads to greater transparency overall and promotes communication between all those involved. As part of the research project "Development of a standardized BIM modeling guideline" of the Chair of Construction Management & Economics of the University of Wuppertal, the authors develop a practical approach to solving the problem described in cooperation with the Technical University of Darmstadt and 17 other partners from practice. The goal is to create a generally applicable modeling guideline, which defines and describes the basic working methods and specifications as well as the contents and requirements for the contents in a software-neutral manner. Participants in the project are companies of various sizes that provide design and construction services as the core of their activities, supplemented by software providers with a focus on BIM content as well as consultants. This diversified mix of participating companies allows the identification of a comprehensive cross-section of the current handling of modeling standards and modeling in general in the context of BIM in German-speaking countries. Furthermore, the composition of the practice partners allows for the consideration of a variety of different perspectives from stakeholders within BIM projects. All companies have already gained experience with the BIM method or are actively implementing it.

2 Development of a Standardized Modeling Guideline

For the creation of the first draft of the modeling guideline, the definition scope of a modeling guideline has been developed. Due to the participation of the individual project partners in the research project, the authors were able to draw from a large pool of individual modeling standards, in large parts already documented as company-own modeling guidelines: More than half of the partners (62%, see Figure 1) already use such documents. Partners without documentation of the own modeling standards offered to be interviewed and the contents have been prepared and processed accordingly. This approach enabled a view of the currently lived and implemented best practice within BIM projects and provided a starting and working basis for the modeling guideline in the further project progress. After an initial review of the documents and conducting the interviews, criteria to catalog the contents of the modeling standards have been defined. Respective criteria included the structure of the document as such as well as the content to be included, such as the modeling rules and used classification systems, as well as the depth of detail for geometry and data. The breakdown of the content into the categories mentioned allowed forming an initial idea of what a standardized modeling guideline contains. Furthermore, modeling guidelines were comparable in front of their context (activity area of the respective company), so that a delimitation of relevant contents for an application-unspecific modeling guideline could be identified.

In the first step of the analysis of the individual categories and the assigned contents, modeling-relevant specifics were identified, which can be roughly classified into common knowledge and differences: Aspects mapped as Common knowledge were firstly addressed, discussed, generalized and included in the draft of the modeling guideline. Based on individual discussions with the partners, items from Differences list were discussed, evaluated and prioritized. In case of consensus on the necessity of any item in a generally applicable modeling guideline, these were generalized and included in the draft. By processing the contents compiled in this way and structuring them, a first preliminary draft was produced and distributed to the partners for comment. By evaluating the developed structure and content with the partners, additional necessities have been identified and incorporated into the Modeling Guideline. The draft was iteratively improved and sharpened through discussion, evaluation, processing and integration of the content fed back. Mirroring the draft in various working groups to receive feedback from external user groups and experts enabled further quality assurance. The developed modeling guideline with its contents thus reflects a scientifically prepared cross-

section of the best practice of the partners involved after validation by external technical experts without claiming to be complete.

By working out all the requirements described in the modeling guideline, potential opens up to transfer this content from a document-oriented to a data-oriented system. For this purpose, the authors drafted a database design, which enables the dynamic provision of the described content. By formulating the appropriate queries, this data is to be output in a defined structure, for transfer and processing into continuous workflows. Currently being developed, the database will be made publicly available at the end of the research project. Addressed workflows aim at the simplification of the applicability of the defined requirements according to the modeling guideline: On the one hand, the transfer of the defined requirements for model elements in the authoring software used is addressed; for Autodesk Revit this workflow was accomplished using a specially developed Python parser, for Graphisoft ArchiCAD this is currently being worked on. Based on the requirements, checking rule will enable users to check their models according to the requirements before handing them over.

In addition, the ongoing development of a catalog of requirements for model elements of the technical building equipment adds progress to the usability for application within BIM projects. After completion and validation, the added requirement catalogue is to be implemented within the database.

3 Structure and Content of the Developed Modeling Guideline

The analysis of the available modeling guidelines showed great variation in structure, content and depth of information. On the one hand, some explained BIM-specific terms or described architectural model elements; on the other hand, they were modeling manuals for specific software that do not go beyond geometric modeling. Others listed in detail the information requirements for geometry and content per model element or assigned spheres of responsibility to the model objects.

During the exchange of this interim draft with the partners, it quickly became clear that software and product neutrality must be ensured in the standardized modeling guideline. Therefore, the contents are described in such a way that they can be implemented independently of the software. In addition, there should not only be a pure listing of the model elements or a pure description of the geometric modeling, but both the geometric modeling depth (LoG) and the relevant information depending on the level of detail (LoI) should be addressed. Since the depth of detail in the geometry and the contents is strongly dependent on the respective project goal or the respective BIM use case, it should also be possible to adapt the requirements for the modeling and information depth to specific projects. In order to meet the requirements of a standard at the same time, the division of the developed modeling guideline into a main document with the regulations and modeling recommendations that must be observed as well as additional appendices that must be adapted to the specific project was concluded. In the modeling guideline, the description of BIM-specific technical terms was deliberately omitted in order to keep the document lean. As a supplement, an added glossary provides consultancy on terminal issues if need be.

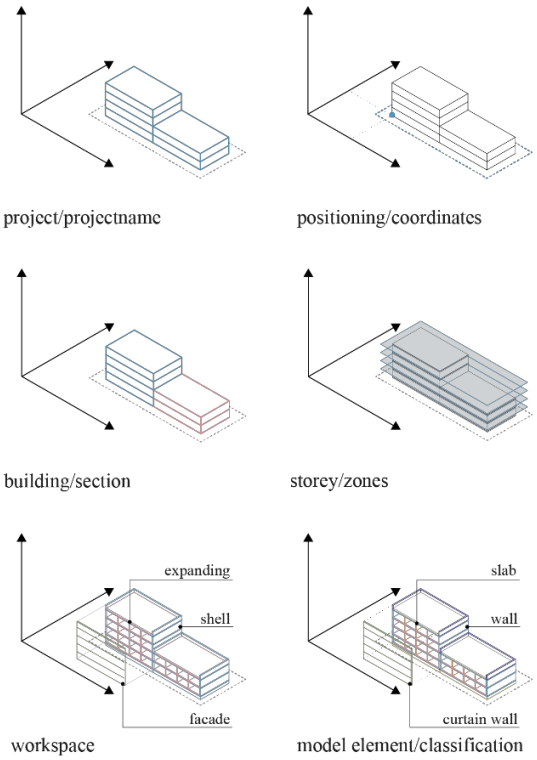

Figure 2: Content of the Modeling Guideline - main document

The main document describes the basics of modeling, which are permanently valid. These include, among other things, the basic principles of model creation, general and coordinating regulations as well as specifications for rooms and building elements. In order to meet the objective of the openBIM approach, all data must be derived from a data model for clean data management in accordance with the principle of the single source of truth.

In addition, several specialist planners are often involved in BIM projects. A common model structure is essential for linking and coordinating the various specialist models. For this reason, the modeling guideline specifies, for example, that information on the project origin, insertion point or floor heights must be defined before modeling begins (see Figure 2). The object planner applies these and all other specialist planners use this model as a reference model.

In the descriptions of the geometric modeling, it was possible to provide less detailed information within the framework of the standardized modeling guideline than in the available modeling manuals of some partners, since these are strongly dependent on the software used. Consequently, general formulations resulted, such as that intersections are to be carried out cleanly, no overlaps may take place or alike. Furthermore, in addition to the coordinating regulations, the modeling guideline also deals with organizational aspects of the project, which must be defined and documented on a project-specific basis prior to modeling. These may already be part of the BIM execution plan (BEP) or the employer's information requirements (EIR), but are also listed in the modeling guideline since they influence the model structure and the information stored in the model, such as the project information and project structure (see Figure 2). Furthermore, the main document describes selected modeling methods and procedures. Since modeling methods can vary depending on the software or application and therefore makes it difficult to standardize the procedure, these methods are only presented as ideal-typical suggestions.

Appendix 1, in addition to the project organizational aspects listed in the main document, provides an orientation aid for documenting the described contents, if not already defined and documented in the BEP. Appendix 2 contains exemplary abbreviation systems for the use of designations for files and model elements for the purpose of illustration and guidance, since this represents a criterion for the internal or also external evaluability of the data of model elements.

Appendix 3 describes the relevant requirements for model elements depending on the geometric and informational depth of modeling. All relevant properties deposited as attributes to the model elements are listed individually for each model element. The differentiation of the LoG and LoI per model element helps the project participants to define the LoG and LoI per model element depending on the project objective or the BIM use cases without the need to develop the corresponding contents on one's own. Information requirements that go beyond the basic set described, e.g. in dependency of BIM use cases, must also be supplemented. An assignment option delivers orientation for the discussion and documentation of respective responsibilities for the supply and the entry of this information before the start of the project.

Annex 3 of the modeling guideline is suitable as a specification sheet and contractual fixation of services within the individual models due to the detailed requirement descriptions considering the responsibilities. Furthermore, the annex can provide information about the data contents of the delivered models to parties who must have access to them after completion of the planning and realization of the construction project. An essential factor, the description of requirements per model element comprises into two parts: The first part describes the model element with assignment to IFC class and other classification systems (DIN276, OmniClass, UniClass), provides an illustration for the assignment of the model element in the model, and a description of the geometric modeling for the different levels of detail. The second part contains a listing of the attributes of the model element, also with assignment of the level of detail as well as the spheres of responsibility.

4 Interim Summary

Although the table of contents and the graphics in the requirements catalog of the model elements of the architecture provide an overview of the model elements listed, documenting the requirements for the model in the specified depth is not expedient in the long term, especially considering the use of the document after modeling for tracking the data included in the model. In addition, the implemented data changes or new is generated during the life cycle of a structure. Replacing the analog method with a digital one provides relief in many ways, only to name two with easier accessibility and usability. Within the scope of the research project, therefore, the development of a database on the contents of the modeling guideline is pursued. In contrast to a Word or Excel list, the use of a database has the advantage that one can structure and use the created data for different purposes, for example for the transfer into a modeling software or checking the model versus the described data. Thus, in addition to the main document of the modeling guideline with fixed regulations, a user-friendly solution can be provided for the project-specific requirements for the respective model elements and contents.

Furthermore the validation of the modeling guideline along a project that is in realization or already realized projects would catalyze the development of the modeling guideline in many ways: First, practical application of the guideline would reveal potential discrepancies between the theoretical approach along the documentation and the practical implementation when modeling. Building on this feedback, an analysis and discussion of the discrepancies would be stimulated, which in the positive case would be fed back into the modeling guideline, improving quality on structural, content, and application levels. On the other, perhaps the more important or weighty part, such practical application and testing of the modeling guideline would signal a leap of faith for other project participants involved in planning to apply or refer to the modeling guideline: In the project business, solutions are naturally sought that preferably work without major adaptations. Times for the adaptation of solutions to one's own processes and systems are reduced in order to manage a constant business process. The application and validation as well as documentation of the modeling guideline based on real projects would show in advance that the modeling guideline is not a purely academic construct, but rather a productive result, which creates benefits when applied.

5 Summary

As described above, the developed modeling guideline represents a first approach for the creation of uniformly structured building data models with uniform minimum requirements in the context

of the BIM method. Based on the compiled, evaluated and qualified experiences and standards of the project participants, it provides a cross-section of the lived actual standard from different perspectives of stakeholders in BIM projects. This gives a broad target group access to practically proven resources that can be used for different application scenarios in projects and companies, e.g. as a comparison or for alignment with their own existing modeling standards, as an orientation aid in the event of ambiguities, and as a basis for creating their own, project-specific modeling guideline. The modeling guideline comes with a product-neutral formulation, which gives it flexibility but limits its direct 1:1 application. Detached from the focus on modeling as a use case, a modeling guideline can be used in the communication of services in BIM projects: By clearly defining the requirements on the part of the client for a model to be created, the contractor obtains transparent insight into the concrete scope of the order. This enables the contractor to estimate the associated effort more accurately. Such an approach anticipates an iterative approximation of the actual state provided by the contractor to the envisioned target state of the client and thus avoids conflicts between the two parties. The benchmark for the model and the project, which is fixed by an agreed modeling guideline, offers both sides security by reducing to eliminating a possible issue of dispute.

By transferring the defined contents of the modeling guideline into a database, different problems are addressed and solved. Shifting the focus from a document-centric to a data-centric perspective makes it possible to make the modeling guideline and its contents, as well as the BIM methodology as a whole, more accessible and easier to use for possible applicants. An individual selection and adaptation of the respective requirements in addition to the standard of the modeling guideline, e.g. depending on a project, is furthermore made possible. Moreover, the machine-readable data output supports the development of further workflows as described above. A transfer of the requirements from the modeling guideline into an authoring software as well as the associated preparation of exports from the authoring software enable the creation of a consistent building data model without having to develop or necessarily have an additional, deep technical understanding of IFC and IFC-related topics. By issuing MVDs according to the defined or adapted requirements of the modeling guideline, the step of content model checking, e.g. before a transaction to other project parties, is further streamlined and made more efficient without having to adapt the quality, structure and content of the model for checking. The provision of rule sets for the Solibri Model Checker also enables structural checking of a model. The assurance of model quality and content is further supported externally via these rule sets beyond the existing routines of the authoring software. The resulting shift of these efforts from the user to the technical and rule-based routine supports the user in his essential activity as a model author.

6 Concluding Remarks

The description of a standardized approach for building data models in the context of the BIM method has both advantages and disadvantages: One positive aspect is, for instance, the uniform structure of building data models, so that different technical and/or partial models can be merged without conflict. Among other things, this streamlines the work process for creating an overall building model and supports the modeling process by eliminating unnecessary communication processes for adjustments and alignments of the model structures. In addition, modelers learn about requirements from the client before starting work, which might have occurred at a later point in time and would require manual post-processing. This also prevents the model from being overloaded with irrelevant model information and reduces unnecessary additional work. Because of the creation of standardized models and standardized levels of detail (geometric and non-geometric), downstream target systems, e.g. for asset portfolio management or facility management (CAFM), can benefit from standardized structural specifications and implement standardized processes more easily.

On the other hand, a standardized modeling guideline - as developed in the present project - lacks a direct, specific reference to the corresponding authoring software due to its general validity, which means that a transfer of the described requirements can only be implemented directly to a limited extent. For a case-specific application of the modeling guideline this is to be

adapted therefore to the own system landscape. Furthermore, the freedom of the modeler and his ability to contribute his own technical expertise to the creation of the model and to discuss possible problems at an early stage may be inhibited. However, the latter is put into perspective to some extent by the fact that the agreement of a modeling guideline on the part of the customer does not relieve him of the responsibility for the performance of his owed service, so that he wants to deliver a good result in his own interest.

Relatively speaking, the agreement of a generally applicable standardized modeling guideline is not necessarily expedient: A building data model must always be considered and created on a project- and application-specific basis; accordingly, the requirements for the model elements vary from case to case. In order to be able to use a model productively after modeling, many dependencies from the downstream processes in the modeling process are omitted here. By agreeing on BIM use cases, corresponding information and, if necessary, detailing requirements can be identified and specified for this purpose; however, as a result of a lack of standards for BIM use cases, this approach cannot be implemented or transferred in a standardized manner at the current time. (Eilers et al 2021) Ideally, these requirements should also be defined and agreed upon in advance, but cannot be addressed because of the nature of the modeling guideline described. Accordingly, the modeling guideline is to be regarded more as a basic framework than as a ready-for-contract document, which must be adapted to the requirements described above and enriched by them for this purpose.

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