Level of Development vs. Level of Detail for BIM

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Report

Advanced Topics in Building Information Modeling

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1. Introduction

1.1 Motivation

When working on projects it was common that a construction gets separated and developed by different departments such as architects, engineers and constructors who would work on their own without always taking into account each other. This often was misleading to bad communication and thus resulting to a slow planning, higher costs, and many errors. To avoid these problems a new process was coming up throughout the years, which had the aim to combine all the teams together and focus on one main project without separating responsibilities. By this idea Building Information Modeling (BIM) was starting to evolve. BIM is a process combining the fields of architecture, engineering and construction in a digital multidimensional model, making various fields, such as planning, designing, constructing and managing, more efficient, flexible and transparent, not only for the persons involved, but also for the clients (Autodesk (2), 2018).

![Figure 1.1 Benefits of BIM (Autodesk, p.5)](image)

Considering the complexity of a building or an infrastructure construction there are some prerequisites necessary, such as defining the tools or the management of data between the parties. Throughout the various work stages of design and construction, there are several drawings with different scales required. Comparable to the scales and phases of the drawings, there is a need of limitation concerning a BIM model as well. For a better control and overall view of the quality and the quantity of the information related to the model as well as a form of
communication between the client and the company, the terms “Level of Development” (LOD) and “Level of Detail” (LoD) are introduced. The Levels are supposed to lead to clarity of a project’s content concerning all the processes (Yoders, J., 2013).

1.2 Scope of the research

The following research benefits for a better understanding and a deeper view of the different levels, starting from the origin of the idea and continuing to a further explanation including some examples. One of the main points of the report is the definition of the Level of Development and its practical use. Furthermore, a closer look will be taken on the terms Level of Development in comparison to the Level of Detail, due to the fact that these are often mixed up or not separated at all, when looking up on the internet. Additionally, is shown how the levels are integrated in a BIM-workflow and what they have in common with the design phases. Finally, an example is presented in which the various levels are represented and explained, so the reader can get an idea of how a process can be developed in practice.

Due to a high variety of definitions and uses in many countries, the information presented in the research refers mainly to the definitions of the American Institute of Architects and BIMForum, who published the first specification. From there on many companies and countries derived their own definitions and ideas, which can differ. (Hörtlagnl, E., 2017)
2. Background

When the first BIM projects started to develop, it was known that the planning was done with a multidimensional model. However, due to the fact, that models have always a scale of 1:1, an important question was coming up. How far does an engineer or any other person in a project has to go with the planning? How much detail should be included? Having in mind, that traditional drawings have certain scales according to the design phase that they have to be delivered, there needed to be developed something similar for digital models. Therefore, a new leveling of detailed information was starting to evolve (Bormann et al., 2015). Information considering the background of the terms was taken from the report of Marzia Bolpagni “The Information Modeling and the Progression of Data-Driven Projects”. The use of the term “Level of Detail” was first introduced and used by VICO Company in 2004 with the aim of facilitating the management of information within a BIM model. They described it as a language between the designers, owners and builders by defining the elements and tasks in a building construction progress. The standardization of this idea was defined into the Model Progression Specification (MPS). According to VICO Company the Level of Detail “serves as a coordination point for information about the building, what is being modeled, and to what level of detail it is being modeled, estimated, and scheduled. It provides the efficient framework for the project stakeholders – a written checklist that matures from a very schematic level of detail to a high level of detail in terms of 3D geometry, cost, and time.” (VicoSoftware, 2015) (Bolpagni, M., p.298).

In 2008 the idea of levels was further developed by the American Institute of Architects (AIA) without referring to “Level of Detail” anymore, but to “Level of Development” by describing it as “level of completeness to which a model element is developed” (AIA, 2008)” (Bolpagni, M., p.299). The document in which the term got defined was intended to help explaining the LOD framework and standardize the use of it with the aim of becoming a communication tool (Bolpagni, M.).

In 2013 the Level of Development Specification was published by a group, called BIMForum, in the US, in which all terms got explained and shown (Yoders, J., 2013) and the acronyms “Level of Development” and “Level of Detail” got finally separated. By the time the terms became more and more important and got developed and integrated into the BIM workflow. Today there are new kinds of levels established by several groups and countries, which are included in their relevant documents. Besides the Level of Detail and Development, there are also the terms Level of model detail, Level of information detail, Information Level, Level of model Definition, Element geometry etc. having similar interpretations (Bolpagni, M. (2), 2016).
3. Level of Development

3.1 The necessity of LOD

A BIM model contains several elements, to which graphical information can be attached, such as length, height, width, surface, volume and non-graphical information, such as material, manufacturer, costs etc. Furthermore, additional information about the project is necessary e.g. the persons involved, deadlines, deliverable parts at certain points. Considering all these facts, the idea of developing levels not only helps a user to plan and organize himself, but it is also very efficient, because “others than the author can extract information from the Model” (BIMForum, p.9). With the help of LOD finally everyone has the opportunity to know how far elements are developed, if the information is reliable or when the next elements are available to continue working on it. All in all, the term “Level of Development” can be seen as an art of communication between the teams and clients, which leads to a higher transparency of a project. However, a detailed description of the LODs has to be clarified in contracts and BIM execution plans (BIMForum, 2017). Furthermore, the concept of LOD can be also used for various parts of a BIM project like quantity take-off, 3D coordination, 3D control and other ones as mentioned in figure 3.1.

![Figure 3.1 Highest value project activities (Autodesk, p.5)](image-url)
Another important fact is, that a certain level cannot be assigned to a model. The Level of Development has to be referred to a specific element or a group of elements (BIMForum, 2017). Finally, due to the high amount of information, associated to an element, the Level of Development can furthermore be divided in “Level of Information” (LOI) and “Level of Geometry” (LOG), which are summed up in the formula below and additionally explained in the following paragraphs (Mini,F, 2016).

\[
\text{LOD} = \text{LOI} + \text{LOG}
\]

Level of Development = Level of Information + Level of Geometry

### 3.2 Level of Information

The Level of Information contains only non-graphical information concerning an element or a building system. There are no specific definitions referring to a limitation of information, but it is fact, that the higher the LOD gets, the more non-graphical information should be included. A way of listing, delivering or exchanging information can be done with special tables, which are shown in the next chapters. However, the exact depth and details should be agreed within the contract and execution plan (Mini, F., 2016).

### 3.3 Level of Geometry

Level of Geometry is referring mainly to the graphical information in a BIM model, which can be related more to the scaling in drawings and thus directly to the design phases.

### 3.4 Defining the levels

As mentioned before the levels are comparable to the scale in drawings. It is of particular importance to understand, that due to the uniqueness of each project, e.g. complexity, diverse requests, a Level of Development cannot have the same amount and type of information for each construction. That is the reason, why there cannot be a detailed and expanded description of a level and leaves the progression to the teams. The American Institute of Architects (AIA) shows rather a “minimum dimensional, spatial, quantitative, qualitative and other data” (AIA, p.11) rather than the completeness or a specification of it (AIA, 2013).

The following paragraphs explain the various Levels of Development by dividing the information in graphical and non-graphical, starting from LOD 100 to 500. The definitions are taken from the Level of Development Specification Guide (BIMForum, 2017) and an example of a floor plan with various LODs are shown below. For special systems BIMForum also offers examples in the Level of Development Specification Part I 2017.
LOD 100  “The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.” (BIMForum, p.9)

LOD 200  “The model element is graphically represented within the model as a generic system, object or assembly with approximate quantities, size, shape, location and orientation. Non-graphic information may also be attached to the Model Element.” (BIMForum, p.10)

LOD 300  “The model element is graphically represented within the model as a specific system, object or assembly in terms of quantity, size, shape, location and orientation. Non-graphic information may also be attached to the Model Element.” (BIMForum, p.10)

LOD 350  “The model element is graphically represented within the model as a specific system, object or assembly and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.” (BIMForum, p.10)

LOD 400  “The model element is graphically represented within the model as a specific system with detailing, fabrication, assembly and installation information. Non-graphic information may also be attached to the Model Element.” (BIMForum, p.10)

LOD 500  “The model element a field verified representation in terms of size, shape, location, quantity and orientation. Non-graphic information may also be attached to the Model Element.” (BIMForum, p.10)

Figure 3.2: Example of a floor plan with different LODs (Bedrick, J., p.17)
4. Level of Development vs. Level of Detail

The acronym LOD was often defined in the past as “Level of Development” or “Level of Detail”, regarding that the words development and detail were taken for the same use. Throughout the years the definition of LOD got misunderstood and was not enough to express the content of a BIM model, so the two acronyms got separated. By now the AIA has given a clear explanation and examples for both definitions (Lammar Services, 2014).

4.1 Level of Detail

The definition of Level of Detail according to Trimble Company is “The way a model looks” (Reis, J., 2017), referring to the amount of input and “how much detail is included in the model element” (BIMForum, p.9), e.g. “specific shapes and measurable location of steel pipes in a model” (Reis, J., 2017). An exact description of the levels is questionable, because a certain publication has not been released from BIMForum. However, a document has been published from the Architectural, Engineering and Construction industry (AEC) in the UK having four main grades/levels of detail and an example, which are shown below.

\[G0\] Symbolic (not representative of the physical object) This might be used for electrical symbols or an object which is modelled the same regardless of scale

\[G1\] Low resolution conceptual placeholder […]

\[G2\] Medium resolution detailed component for design/construction […]

\[G3\] High resolution, fully detailed object. Typically only used for visualisation ” (AEC, p.36)

![Figure 4.1: Applying Grades of Detail on a chair (AEC, p.26)](image-url)
4.2 Level of Development

According to Trimble Company the Level of Development is defined as “The depth of thinking applied to the model” (Reis, J., 2017) referring to the output and the “the degree to which the element’s geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model.” (BIMForum, p.9). For example, when the question arises, “whether the pipes in a model have been engineered and the permanence of their placement” (Reis, J., 2017). Nowadays the standards are referring usually to the Level of Development. Since there is a relation between the two terms, the Level of Development can be seen as an effect of the detail. The higher the details are, the higher the development can be expected to be and vice versa (Reis, J., 2017).
5. LOD in the BIM-Workflow

Knowing that each element has its own Level of Development and that only a minimal required amount of information is standardized, it is important to get clear how the several levels are developed and how each LOD of the elements is recorded and employed during the BIM workflow. The documents are also used for quantity take-off, 3D coordination, 3D control, planning and mirror a part of the contract and BIM execution plan. Apart from the graphical and non-graphical information about the elements and building systems it is considerable taking into account additional information such as the persons involved, the deliverable parts, the deadlines, the form of the deliverable product and the relevant recipient of it.

An example of a document is given by the BIMForum and defined as a “Model Element Table”. The Table is divided in four main parts containing building systems, attribute tables, standard milestones and project specific milestones, which are partly explained in the following section. They are defined and taken from the Level of Development Specification Guide (BIMForum, 2017).

**Building Systems**

The table contains the listed building elements, shown in the rows, and relevant Attribute Tables for each system, which refer to the according tab with the relevant attribute information.
**Milestones/Deliverables**

The columns describe the LODs for different milestones concerning the project, which consist of three additional sub columns, such as Level of Development, Model Element Author (MEA) and Notes. The given Table in Figure 5.2 depicts standard milestones for the completion of the traditional design phases, other deliverables, BIM-Use information exchanges etc. The users are free to change or add additional milestones if needed and further sort them like in figure 5.2.

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Deliverables</th>
<th>Attributes</th>
<th>LOD Profile</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Level 2</td>
<td>Level 3</td>
<td>Level 4</td>
<td>Level 5</td>
</tr>
</tbody>
</table>

*Figure 5.2: Example of a Model Element Table (BIMForum, p.14)*

**Attribute Tables**

The Attribute Table consists of an Attribute Description, a LOD Profile and the Milestones. All in all, relevant Attributes are listed to the associated building systems, the correlation of LOD requirements and the existing ones are shown and finally attributes are marked to specific milestones and deliverables.

*Figure 5.3: Example of an Attribute Table (BIMForum, p.15)*
MEPF Attribute Tables

The MEPF attribute tables contain information about the mechanical, electrical, plumbing and fire part of a project and have a different format than the other ones, because several components can be used to make up a specific element. The systems are separated into system component elements, such as D40 Fire Protection or D20 Plumbing, and system distribution elements e.g. ducts, pipes. The tables are also separated into two sections, depending on attributes of elements, if they common or specific.

![MEPF Attribute Table Example](image)

*Figure 5.4: Example of a MEPF Attribute Table (BIMForum, p.16)*
6. Design phases

According to the *Level of Development Specification* the Levels of Development have no direct relation with the design phases, due to the different levels referring to the several elements. Nevertheless, the levels of the architect’s model can be used for an estimation and orientation to classify into the already known design phases (Leistungsphasen). In the following picture a rough correspondence is showed (Bodden et al., 2017).

![Figure 6.1: Relation between LOD and design phase (Eschenbruch, K., p.10)](image-url)
7. Example

To demonstrate several LODs, the following building was designed with the software *Revit 2019*. The example consists of various elements like floor, ceiling, walls, doors, windows and furniture.

![Example in Revit 2019](image)

*Figure 7.1: Example in Revit 2019*

The purpose of the example is to show that a uniform LOD cannot be applied to a whole BIM model and to see how the various levels can evolve throughout a simple building. The example is only a simplification of a possible small project, which is used to represent a part of the BIM process. For a better overview screenshots of the 3D-Model, the section through the construction and the elevation are taken.

7.1 LOD in practice

**Phase 1**

![Example in Revit 2019 in phase 1](image)

*Figure 7.2: Example in Revit 2019 in phase 1*
In the first phase of the project the building consists of walls, ceilings, foundations and floors, which are not associated with details like material or exact measurements and can be also seen in the section on the right through missing hatchings. Therefore, the LOD 200 can be given, because the building is represented as a simple generic system. In comparison to the mentioned elements, the doors and walls (see elevation) are only drawn with a representative symbol, showing only the rough position without any additional graphical or non-graphical information. That is the reason that the doors and windows are associated with LOD 100.

**Phase 2**

![Figure 7.3: Example in Revit 2019 in phase2](image)

In the second part of the process it is clearly visible, that the foundations, walls, ceilings, floors have been developed, e.g. having added insulation, and associated with certain materials and measurements, which leads to the conclusion, that the elements are on LOD 300. The windows and doors, which were represented in the phase before as a symbol, are now in a further stage having more detailed graphical information about the element itself and also in connection with the construction as a whole. The LOD associated with these elements is at this point on LOD 200. One can notice, that in the 3D-Model several space areas are marked with lines. These are symbolic representations for future furniture, which is at this point of the planning at LOD 100.

**Phase 3**

Throughout several stages in a process, elements and systems are added, removed and edited. However, the question arises: Does it have an impact on other elements by changing graphical information? Depending on the LOD an element is associated to, a change may have an impact. This can happen for example when having a system with LOD 350. This level is
often misunderstood or not used, because an optical difference is not visible. Nevertheless, the level is important to connect neighboured elements with each other. In this example the LOD 350 is shown through the linking of the walls and the reinforced concrete plate between the first and second floor. In the following picture the location, where the two elements meet are presented with and without a connection.

![Diagram showing LOD 300 and LOD 350 details](image)

*Figure 7.4: Detail in LOD 300 (left) and LOD 350 (right) in Revit 2019*

On closer examination one can see that there is a difference among the two details. The left one is in LOD 300 and the right one in LOD 350, where it is visible that a relation between the plate and the walls was taken into account.
Phase 4

In the last stage of the process all the elements of the construction were further developed. The walls, floors and the ceiling are now on LOD 400 having detailed graphical information and additional non-graphical information. An example can be seen in figure 7.6, where one can notice that the content is referring to non-graphical information of walls like costs, manufacturer etc. Furthermore, the doors and windows together with the furniture are at this point on LOD 300, having a specific location, size and orientation.

![Figure 7.5: Example in Revit 2019 in phase 4](image)

In the last stage of the process all the elements of the construction were further developed. The walls, floors and the ceiling are now on LOD 400 having detailed graphical information and additional non-graphical information. An example can be seen in figure 7.6, where one can notice that the content is referring to non-graphical information of walls like costs, manufacturer etc. Furthermore, the doors and windows together with the furniture are at this point on LOD 300, having a specific location, size and orientation.

![Figure 7.6: Example of a table containing non-graphical information in Revit 2019](image)
7.2 Conclusion of Example

By comparing several elements in the example with the given definitions of LODs on page 8, one can see that there is no exact accordance. However, as mentioned before, the universally applicable definitions e.g. like in the *Level of Development Specification Guide*, have to be used as a general indication describing the minimal amount information. Specific information and details should be agreed within the BIM contract. A representation of LOD 500 was in this case excluded, due to the fact, that the construction would remain as it is. Nevertheless, because the last level of the process is used for field verified representation it is common, that the BIM model gets simplified by removing some information and thus resulting to a more clear and easy-to-use picture. (Huber et al., 2011).

8. Conclusion

The Level of Development is a powerful communication tool, that helps organizing and applying information more deliberately in a BIM model and exchange information with several participants of a project. Throughout this idea the coordination, quality and efficiency rise and aim to greater results. For a more uniform work, there are predefined levels, like the definitions mentioned in the *Level of Development Specification Guide of BIMForum*. However, these represent only a minimal amount of information, whereas all details have to be mentioned and listed in a BIM contract and execution plan.

The concept of Level of Development is a part of every section related to BIM, making the process more clear and transparent and is an idea that can be applied to various projects, works and departments giving the user or client the freedom to limit and develop information to their desired needs and dimensions. Finally, one has to be cautious when searching or getting to know with BIM and its terms, considering that BIM is a new method, which is constantly growing, developing and changing and thus can result to misleading information of various definitions which can change by the time.
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</tbody>
</table>
II. Literature


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