APPENDIX C
LEVELS OF DEVELOPMENT DEFINITION

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CONSTRUCTION SECTOR ACCORD

BIM
BETTER BUILDING PROCESS.
BUILDING BETTER PERFORMANCE.

New Zealand Institute of Building

TABLE OF CONTENTS

Appendices are published separately and can be downloaded from **www.biminnz.co.nz/nz-bim-handbook**

Appendix A – Modelling and documentation best practice

Appendix B – Model coordination

Appendix C – Levels of development definitions

Appendix D – BIM uses definitions

Appendix E – Procurement Model Considerations

Appendix F – Exchange Information Requirements - template

Appendix G - Level of Development Specification

Appendix H - BIM evaluation and response - template

Appendix J – BIM execution plan – template

Appendix K - Model description document - template

1— LEVEL OF DEVELOPMENT

Level of Development (LOD) is a scale used to show the reliability of content that is expected to be included in specific model elements at different times during model development. The main purpose of LOD, when incorporated in Model Element Authoring (MEA) schedules and BIM Execution Plans, is to clarify what each member of a design/construction team is required to author in their models, at each stage, and to what extent others can rely on them.

Critically, as the LOD progresses, other information associated with those elements can also progress, not just the geometry.

LOD is a means of defining the extent to which a model element has been developed, from conception in the mind of the designer to its construction and operation. It represents the extent to which information about an element can be relied on for decision-making purposes, at a particular point in time.

Project models at any stage of delivery will invariably contain elements at various levels of development.

2— LEVEL OF DEVELOPMENT VERSUS LEVEL OF DETAIL

LOD is sometimes misinterpreted as level of detail rather than level of development. However, there are important differences. Level of detail is essentially how much geometric detail is included in the model element. Level of development is the degree to which the element's geometry and attached information have been thought through – the degree to which project team members can rely on the information when using the model. In essence, level of detail can be considered as an input to the element, while level of development is reliable output.

3— LOD NOTATIONS

LOD notations generally comprise numbers at intervals to give users of the system the flexibility to define intermediate LODs. LOD 350 is identified as a higher level of detailed coordination between disciplines – higher than LOD 300 but not as high as LOD 400. Defining additional intermediate LODs can be crucial in some circumstances, particularly for contractual reasons – e.g. the handover of models from the design team to the construction team. However, any such intermediate LODs must be well defined within the relevant BIM Execution Plan.

4— ASPECTS OF LOD

The concept of level of development was originally conceived as the sum of different aspects that defined the information and geometry of each element, including:

- **Graphical model.** 3D geometry is only one type of information. Geometrical shape and composition may help project stakeholders learn how building elements occupy spaces. As the project develops, its shape accuracy, location, and extent in 3D space becomes more important, especially for spatial coordination. But as mentioned throughout this handbook, BIM is not just the model. These graphical models contain different types of information to explain geometric elements individually, as a system, and as a project, as a whole. How far a model should be developed will depend on the project objectives and should be defined in an MEA schedule

- **Documentation.** This set of information can illustrate how graphical models are composed, set out, constructed, and perform, and how they should be used. Although most model authoring software includes 2D documentation capabilities, separate documentation, such as asset information, specifications, calculations, and warranties, is compulsory. How these separate documents tie back to the graphical model and LOD requirement can be resolved in different ways

- **Non-graphical information.** Asset information such as hyperlinks, formulae, and alphanumeric text can be embedded within geometrical elements or linked to/from external data sources. This information can follow the model as it is transferred between project stakeholders. A precisely defined object-based data structure and classification ensures information gets populated, transferred, and delivered in a smooth manner, and should be defined within the project BIM Execution Plan.

In the New Zealand context, however, LOD typically only defines the extent of model geometry development, with requirements for documentation and non-graphical information such as asset data often defined separately within the model element authoring schedule.

5— LOD DEFINITIONS

When specifying LODs, it is important to reference the latest BIM Forum LOD specification. The main body of the BIM Forum specification provides more detail for each LOD on an element-by-element basis. This edition of the BIM Handbook has removed LOD 500 or 'field verification' from the LOD definitions on the basis that geometric development to a particular LOD and field verification are not mutually exclusive – that is, the LOD defines the required geometric detail, whereas field verification confirms that the Model Element is a true reflection of the constructed element, and as such cannot be defined on the same spectrum. This change is described in further detail in Section 7.

LOD OVERVIEW AND POSSIBLE USAGE

LOD represents the extent to which information about an element can be relied on for decision-making purposes at a particular point in time.

LOD 100	LOD 200	LOD 300	LOD 350	LOD 400
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 can be derived from other Model Elements.	The Model Element is graphically represented within the model with approximate quantity, size, shape, location, and orientation.	The Model Element is graphically represented within the Model as a **design specified system**, object, or assembly in terms of quantity, size, shape, location, and orientation.	The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, orientation, **and interfaces with other building systems.**	The Model Element is graphically represented within the Model with detail sufficient for fabrication, assembly, and installation.

6— DISCONTINUOUS PROGRESSION

As each project requirement is unique, LOD progression for each element can also be unique. Not all elements need to start at LOD 100 (massing) and progress to higher LODs. Some elements can start at LOD 200 and increase to LOD 300 and then LOD 400 to represent fabrication detail, while others (such as manufacturer-specific model elements) can start at LOD 400. While LOD cannot regress, it does not have to be continuous, which is why a full model cannot be assigned an overarching LOD number.

Using the example of suspended ceilings, during preliminary design the design team may be aware that a suspended ceiling is required, without further detail on its make-up and material and the performance it has to deliver. Therefore, during this phase LOD 200 would suffice (LOD 200 – generic assemblies indicative of overall scope and approximate thickness/system depth of suspended ceiling), skipping LOD 100. Even at LOD 200, services engineers would be informed on whether, or not, there is a ceiling and its height.

As the design progresses to developed design, further information can be assigned to suspended ceilings. Spatial expressions and requirements, such as fire and acoustic performances, would start to inform the selection of those suspended ceilings.

An LOD 300 (overall assembly modelled to design specified system thickness, including framing) would be the goal to capture model development, for geometrical and non-graphical information. During this design phase, geometry should be updated to capture a more realistic extent and build-up of each ceiling selection – and systems to achieve design requirements.

Non-graphical information, such as name/system identification and performance requirements, will also be associated with those elements. Meaningful 3D coordination sessions can start when model development of the suspended ceiling is matched with services runs. At this point the design team is better informed on the void space, makeup, and material of the suspended ceilings, along with services run to create a safe and healthy building.

Design resolutions, such as creating bulkheads and developing reflected ceiling plans documentation, can start with these sets of information. Engineering analysis can also start, thanks to better information in this phase, in areas such as energy analysis, lighting analysis, and air flow. Export the whole model or part of the model to simulation software. A healthy iterative process between project team members results in a refined design, ready for progress to detailed design.

Depending on project requirements, detailed design model progression can remain at LOD 300, or progress to LOD 350. If left at LOD 300, the design team can complete ceiling details and documentation in 2D. Complex or congested areas of projects may demand LOD 350, in which case structural interfaces above and adjacent to walls should also be modelled where required for coordination. Include relevant information to connection elements.

Connection elements may include structural backing members, including bracing lateral framing kickers. Expansion joints or control joints are modelled to indicate specific width. The higher demand for modelling and information data can be used for 3D coordination in tight ceiling spaces and complex junctions. Produce a schedule of these elements.

In the construction phase, the main contractor may need to appoint a suspended ceiling subcontractor to fabricate these items from their model to achieve LOD 400. Include all assembly components, such as tees, hangers, support structure, braces, and tiles. Comparing design and construction suspended ceiling models will show modifications from the design to suit the actual construction, if any. Striving for LOD 400 can supplement and support shop drawing reviews; however, it should only be requested of subcontractors or manufacturers who already have this capability, noting that the benefit of modelling to LOD 400 lies in the ability to utilise the model directly for fabrication (including with automated machinery such as CNC).

Please note that just because one building element goes to a higher LOD, it does not mean other elements should achieve the same LOD. LOD should be nominated based on milestones or project goals. Assigning a specific LOD requirement to a type of element should not stop the team further developing those elements should further information become available or be confirmed.

Refer to the BIM Forum LOD Specification for examples of graphical representation of the different LODs.

7— FIELD VERIFICATION

While previous iterations of the handbook and the referenced BIMForum LOD Specification utilise LOD 500 to define elements that have been 'field-verified' (where the model element and real-world object are confirmed as the same, i.e. the model element is 'as-built'), this version uses verification suffixes to define where elements have been verified, and the methods used to do so.

To achieve field verification, LOD progression does not need to pass through higher LOD levels than already developed during design or construction if there is not a project requirement to do so. For example, a structural column at LOD 300 may provide sufficient geometric detail for all future uses of the model element. In such instances, applying a LOD 500 designation would lose the previous element LOD specification, while providing no insight into the verification method used. To this end verification methods are defined as follows.

No Field Verification (NFV) – Not all model elements require field verification, and in these cases it is assumed that what has been built is a true reflection of the Model Element (and vice versa). This should only be used for element types where any potential inaccuracy in the model element is unlikely to be detrimental to the future use of the model or impact on record documentation requirements.

Quality Assurance Verified (QAV) – Typical construction quality assurance methods are used as verification that constructed elements are aligned with the design drawings (and thus the models of which those drawings are products). They might include site inspection records/checklists, quality control forms, and producer statements. This method is used for elements that do not require high levels of as-built accuracy or are highly likely to be constructed in accordance with contract documents and deviation is unlikely – for example, internal doors or curtainwall/glazing elements.

Visual As Built (VAB) ¬– Visual verification is used to validate that what has been constructed is in line with what has been modelled. As with QAV, this method does not necessarily provide millimetre-accurate verification, but it can be used to confirm that the as-built state aligns with the design intent, for example by visually checking that the correct number of light fixtures has been installed in a particular room, or that an isolation valve is located within reach of an access panel.

Measured As Built (MAB) ¬– Where high levels of accuracy are required in record models, for example if future works are to be undertaken within the same site or space, a measurement-based verification method should be utilised. It could include simple site measurements, traditional survey techniques, high-definition laser scanning, or any combination thereof. Any elements specified as requiring measured as-built should also specify the required measurement technique or a required level of accuracy (for example +/- 3mm).

It should be noted that where higher levels of field verification are specified, these methods may be more costly.

An in-depth discussion with the client and their asset management and operational teams is critical to ascertain which geometrical elements, information fields, and verification processes are required for the project. Ideally, this will be captured in the Asset Information Requirements (AIR) at the outset of the project. A retrofit approach late in the project may trigger rework and additional costs, and delay the handover deliverable.

Note that a requirement to field verify elements geometrically does not necessarily also require element information (i.e. asset data to be collected) or vice versa – all are dependent on client requirements.

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The New Zealand BIM handbook.

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