NATSPEC

BiM Paper

NBP 001

November 2013

BIM and LOD

Building Information Modelling and Level of Development

This NATSPEC BIM Paper provides an introduction to the concept of Level of Development (LOD) and its value in the management of the Building Information Modelling (BIM) process.

It includes recommendations about implementing LOD on projects and guidance on developing and interpreting LOD Tables.

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BIM and LOD – Building Information Modelling and Level of Development

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Comments

NATSPEC welcomes comments or suggestions for improvements to its documents and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities. NATSPEC also encourages users to share their experiences of applying its documents on projects with us.

Contact us via email at bim@natspec.com.au.

Formatting conventions used in this document

In addition to the text formatting conventions used for Section headings, Clause titles, etc., other conventions are summarised below:

Text type	Example	Indicates
Normal italicised text	*NATSPEC National BIM Guide*	The name of a specific document or standard.
Grey bold text	**Data Reuse**	A cross reference to a Section, Clause, Table, Diagram, etc. that can be found in this document.
Blue text	www.natspec.com.au	Hyperlink/web link

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1. INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This NATSPEC BIM Paper seeks to address some of the issues currently associated with Level of Development (LOD) in the AEC industry. These include:

- Misconceptions and misunderstandings about LOD.
- The value of LOD as a project management tool.
- A lack of clear guidance about applying LOD on projects.
- The layout and complexity of many LOD Tables overwhelms many practitioners and discourages them from investing the development time necessary to make them a useful management tool, or even making a start.
- The format of many LOD Tables obscures, rather than clarifies, important patterns and relationships, reducing their effectiveness for their intended use.
- Although there are a number of LOD Table templates available, there is currently no industry accepted standard. Practitioners are faced with different LOD Table formats from project to project, making their interpretation more difficult.

Note: **LOD Table** is the concise term used in this Paper for Model Element Table, Model Progression Specification, Model Collaboration Matrix, etc.

1.2 KEY POINTS ABOUT LEVEL OF DEVELOPMENT (LOD)

- LOD is a means of defining the extent to which model elements have been developed, from conception in the mind of the designer through to their construction and operation.
- The concept of LOD recognises that model elements within a model evolve at different rates throughout the design process. It follows that LOD should only be used to describe model elements, not models as a whole.
- The development of information associated with model elements is as important as the development of geometry, and is integral to its LOD.
- The intention of a LOD is to provide clarity and certainty about what is expected of everyone involved in a model's development, so they can plan their work with confidence.
- LOD is a valuable project management tool. When documented in an LOD Table, it can serve the following purposes:
    - As a common reference for stakeholders planning model development.
    - For recording agreements made about model deliverables.
    - For planning and coordinating project resources.
    - For communicating project requirements to team members and organising their workflows.
    - For monitoring progress against the project program.
- LOD is a means to an end. LOD is meaningless without clear definition of the model's purpose or intended uses.
- The resources devoted to developing and maintaining LOD Tables should be proportional to the degree that they assist management of the project.
- When implementing LOD on projects it is recommended that existing standards defining model element geometry and data content are referenced and an existing LOD Table format used to document the LOD values required for each element at nominated project milestones.

2 OVERVIEW OF LEVEL OF DEVELOPMENT (LOD)

2.1 MODEL DEVELOPMENT AND LOD

Level of Development is a conceptual framework that attempts to address the fact that model elements develop at different rates during the design process (See sidebar). LOD describes the relative development of individual model elements in their journey from conception to realisation. Locating an element on this evolutionary scale indicates how much it can be relied on for decision making purposes. LOD is a metric that allows project programmes and deliverables to be more clearly defined. As an industry standard, it aids communication and coordination between project stakeholders.

2.1.1 History of LOD

Vico software first developed a metric, which they referred to as Level of Detail, for describing how definitive model elements were for the purposes of cost estimating.

The American Institute of Architects (AIA) developed the concept further in *AIA Document E202 – 2008 Building Information Modeling Protocol Exhibit*. It includes this definition:

> **"The Level(s) of Development (LOD) describes the level of completeness to which a Model Element is developed."**

It describes the steps through which a model element can logically progress from the lowest level of conceptual approximation to the highest level of representational precision. The document defines five Levels of Development and assigns numerical notations from 100 – 500 to them. Each subsequent level builds on the previous level.

The definition of LOD was amended in *AIA Draft Document G202 – 2012 Building Information Modeling Protocol Form* to the following:

> **"The Level of Development (LOD) describes the minimum dimensional, spatial, quantitative, qualitative, and other data included in a Model Element to support the Authorised Uses associated with such LOD."**

Note the shift from a narrow Model Element-based definition to one linking LOD to Authorised Uses. Refer to **2.3.1 Authorised Uses**.

2.1.2 LOD notations

The AIA LOD notations are comprised of numbers at intervals of 100, allowing the system's users the flexibility to define intermediate LODs. Defining additional 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.

The definitions of each LOD from LOD 100 – LOD 500, given in *AIA Draft Document G202 – 2012,* are summarised in **Table 1**. Note: Short descriptions are from *AIA E202-2008*.

The nature of the collaborative design process

Design projects are characterised by the evolving nature of the designed product. Another aspect of the design process is that different elements of a design will be at different stages of development at any given time. Footings may be designed, documented and even constructed before anyone has thought about what tiles will be used in a bathroom, let alone their colour.

When designing collaboratively it is essential for planning purposes that everyone knows what to expect from each other at different points in the process, including the status of a design's constituent elements. Team members will want the answer to questions such as: "Which elements are still largely notional and likely to change?" and "Which elements are sufficiently resolved that I can confidently rely on them to progress my work?

Differences between BIM and traditional paper-based methods

Paper-based documents usually offer plenty of visual clues about the precision and completeness of a design and its component parts. Sketch designs are often freehand and final working drawings are heavily dimensioned, annotated and cross referenced.

BIM, however, generally provides fewer visual clues about the relative development of model elements. Elements of identical appearance can contain very different amounts of information. One may contain nothing of significance, and another a treasure trove of information including manufacturer, model number, serial number of the installed unit, commissioning and maintenance history, etc. More significantly, geometry and data give no indication of how well developed each element is for its intended purpose, how much the author expects others to rely on them or whether they are likely to change. LOD spells this out.

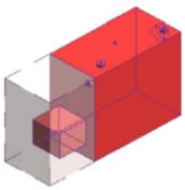
LOD 100 Conceptual	LOD 200 Approximate geometry	LOD 300 Precise geometry	LOD 400 Fabrication	LOD 500 As-built
				
The Model Element **may be** graphically represented in the Model with a **symbol or other generic representation**, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square metre, etc.) can be derived from other Model Elements.	The Model Element **is** graphically represented in 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.	The Model Element **is** graphically represented in the Model as a **specific** system, object, or assembly **accurate** in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.	The Model Element **is** graphically represented in the Model as a **specific** system, object, or assembly that is **accurate** in terms of quantity, size, shape, location, and orientation with **detailing, fabrication, assembly, and installation information**. Non-graphic information may also be attached to the Model Element.	The Model Element **is** a **field verified** representation **accurate** in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Element.

Table 1: LOD summary

Note that the external appearance of the Model Element does not necessarily change at each LOD, as shown above for LOD 300 – LOD 500. However, the non-graphic information attached to it may change.

An example of how intermediate values of LOD can be formulated can be found in *BIMForum Level of Development Specification* (*BIM Forum LOD Spec*). Its authors "identified the need for an LOD that would define model elements sufficiently developed to facilitate coordination between disciplines, e.g. clash detection/avoidance, layout, etc. The requirements for this level are higher than those for 300, but not as high as those for 400." They designated this LOD 350.

2.1.3 Aspects of LOD

The LOD concept encompasses a number of aspects of designed elements:

- Level of graphic detail/precision of modelling.
- Amount, quality and relevance of non-graphic information.
- Type of non-graphic information, e.g. embedded in model elements, linked to model elements, separate from (but cross referenced to) model elements.

While all these aspects contribute to the concept of LOD, they do not define it - LOD is the sum value of them all.

Essentially, when all of these aspects are taken into consideration, LOD represents the extent to which information about an element can be relied on for decision-making purposes at a particular point in time. This is the most crucial notion in the context of collaborative working arrangements.

Alternatives to LOD

Proposals have been put forward for terms that are more descriptive of LOD's intent, e.g. Degrees of Certainty (DOC) (Succar et al.), or delineate aspects of LOD more clearly, e.g. Level of Detail, Grade. While each of these proposals has their merits, LOD has become widely established and, as long as it is well defined and understood, it will serve its purpose.

Some believe that non-model items like 2D objects should not be included in LOD Tables. This implies a strict Model-based interpretation of LOD. However, LOD as a measure of reliability and fitness for purpose can be applied to many forms of information.

Use of Terms

While Level of Detail can be seen as a closely related concept, or a subset of LOD, it is best to be conscious of the difference and not to use the terms interchangeably. Use Level of Detail to describe graphic detail only and LOD as a broader concept associated with the reliability of shared information.

> **"The LOD framework allows the author to clearly state the reliability of given model elements …. and state:**
>
> **You may only rely on it for what I specifically say you can."**
>
> *BIMForum LOD Specification*

Even though LOD is intrinsically linked to the modelling process, it is more a measure of how fit a Model Element is for its intended purpose than the specifics of the element.

2.1.4 Level of Development versus Level of Detail

There often appears to be a correlation between LOD and Level of (graphic) Detail because, as the design of elements become more resolved, they are usually defined more precisely geometrically and graphically. In fact, the increasing graphic detail of an element is often used to illustrate LOD (as in the LOD summary above). Unfortunately, this can confuse the two concepts. That they share the same acronym does not help either.

As noted earlier, making assumptions about LOD based on appearance can lead to problems. **Figure 1** illustrates how Level of Development and Level of Detail do not always coincide.

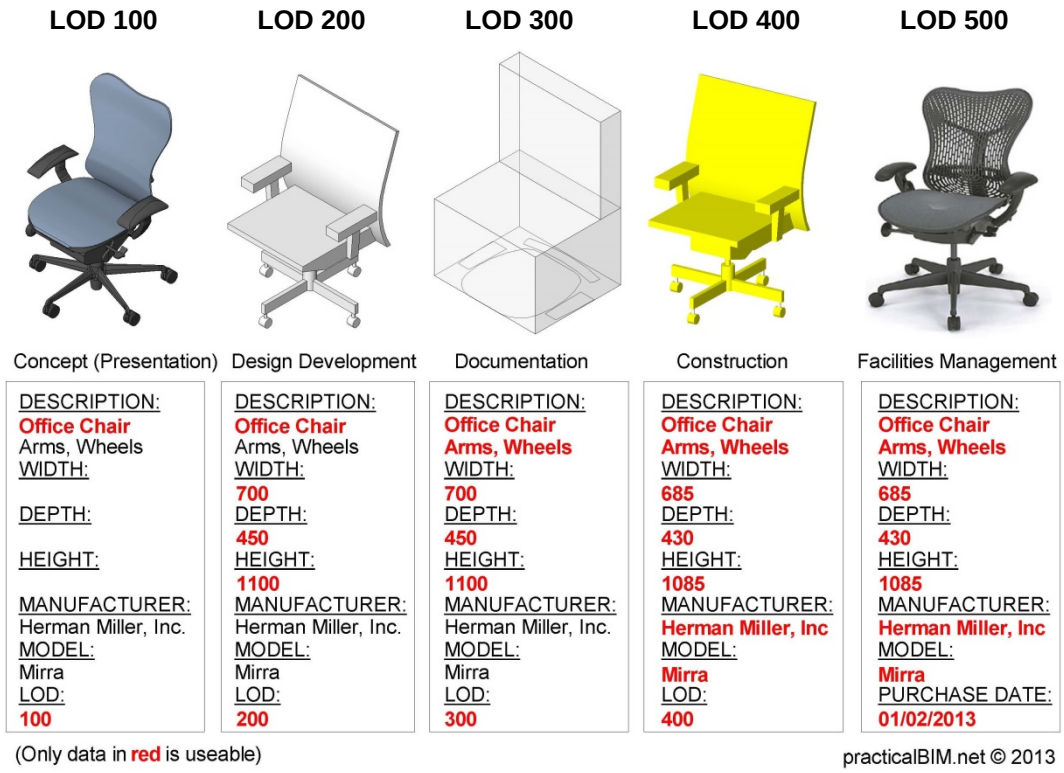


Figure 1: Level of Development versus Level of Detail

The following scenarios also demonstrate how LOD can be used convey developmental expectations associated with the chair in **Figure 1** at different stages of a hypothetical project, and the extent to which this can be independent of graphic Level of Detail.

LOD 100: A photorealistic image of a chair is selected purely for the purposes of a rendering. Even if detailed information is associated with it, it is not assumed to be relevant at this stage.

LOD 200: A generic model of a chair is selected for the purposes of a furniture layout even though a decision about the actual chair has not been made yet. The important thing is the nominal floor space allowance it represents.

LOD 300: During documentation a simple placeholder that helps minimise model file sizes is selected. The chair may appear in schedules or be used for costing but is not expected to be used for ordering.

LOD 400: A chair with a specific manufacturer and model number is selected for ordering purposes.

LOD 500: The chair has a manufacturer, model number, supplier, serial number and date of purchase, but its image, e.g. a photograph, may not necessarily be included in the model.

2.1.5 LOD Models

To refer to a model as a LOD 300 model fails to recognise that a model's constituent elements have different LODs at different times, depending on the model's purpose. Labelling a model by LOD devalues the usefulness of the concept. Do not ask for, or offer to deliver, an LOD 300 model. It is more accurate and just as easy to refer to a model by its place in the program, e.g. Concept Design model, Week 12 Milestone model, or its purpose, e.g. Preliminary costing model. While many will understand what is meant when LOD is used as a sort of shorthand descriptor for a model, it is ambiguous and perpetuates confusion for just as many others.

2.2 LOD TABLES – CHOREOGRAPHING MODEL DEVELOPMENT

Integral to the concept of LOD is model development (sometimes called progression) and collaboration. With so many model elements needing to be developed over time by different parties, how can the process be coordinated?

AIA Draft Document G202 – 2012 Building Information Modeling Protocol Form includes a Model Element Table for documenting the collaborative development of models during a project using protocols defined in associated documents *AIA Draft Document E203 – 2012 Building Information Modeling and Digital Data Exhibit* and *AIA Draft Document G201 – 2012 Project Digital Data Protocol Form*. The Model Element Table can be used to document who is to be the Model Element Author (MEA) for each model element at each project phase, and to what LOD it must be developed.

The intention of LOD Tables is to provide clarity and certainty about what is expected of everyone involved, so they can plan their work with confidence. Knowing the LOD of model elements at each stage will determine how much reliance the recipient will place on it, how much effort they will invest in resolving issues associated with it, and how much responsibility they will take for work based on it.

2.2.1 LOD Tables as a project management tool

LOD Tables can assist communication between project stakeholders and improve its management. They are often included in BIM Management Plans for the following purposes:

- As a common reference for stakeholders planning model development.
- For recording agreements made about model deliverables.
- For planning and coordinating project resources.
- For communicating project requirements to team members and organising their workflows.
- For monitoring progress against the project program.

Responsibilities for managing the development and updating of the LOD Table should also be documented in the BIM Management Plan.

LOD Tables represent a detailed aspect of project planning. They are the end product of team decision-making based on strategic project planning, not its starting point.

Figure 2 (overleaf) shows the place of LOD Tables in the project planning and management process.

Understandable errors

The error of applying LOD to the whole model is understandable as models and drawings, typical of each project phase, are often used to illustrate the concept. Hand sketches are used to illustrate the conceptual design phase, drafted sketch plans the preliminary or schematic design phase, and working drawings the construction phase. The apparent uniformity of the drawings masks the fact that many elements are at different levels of development with regard to decision-making.

Just to confuse things further, it is common for the development of graphic and non-graphic information to move in tandem during model development – firmer, more detailed element information is often added as the form of an element becomes more precisely defined. But this is not always the case – to assume so is a mistake.

LOD Table Functions

An LOD Table can be used as a common reference when planning model development and as a means of recording the following:

- Model elements to be included, or not.
- The party responsible for each model element (the Model Element Author) at agreed stages of the project.
- The LOD for each model element at agreed stages of the project.

The individual components of LOD Tables are described in more detail in **Appendix A**.

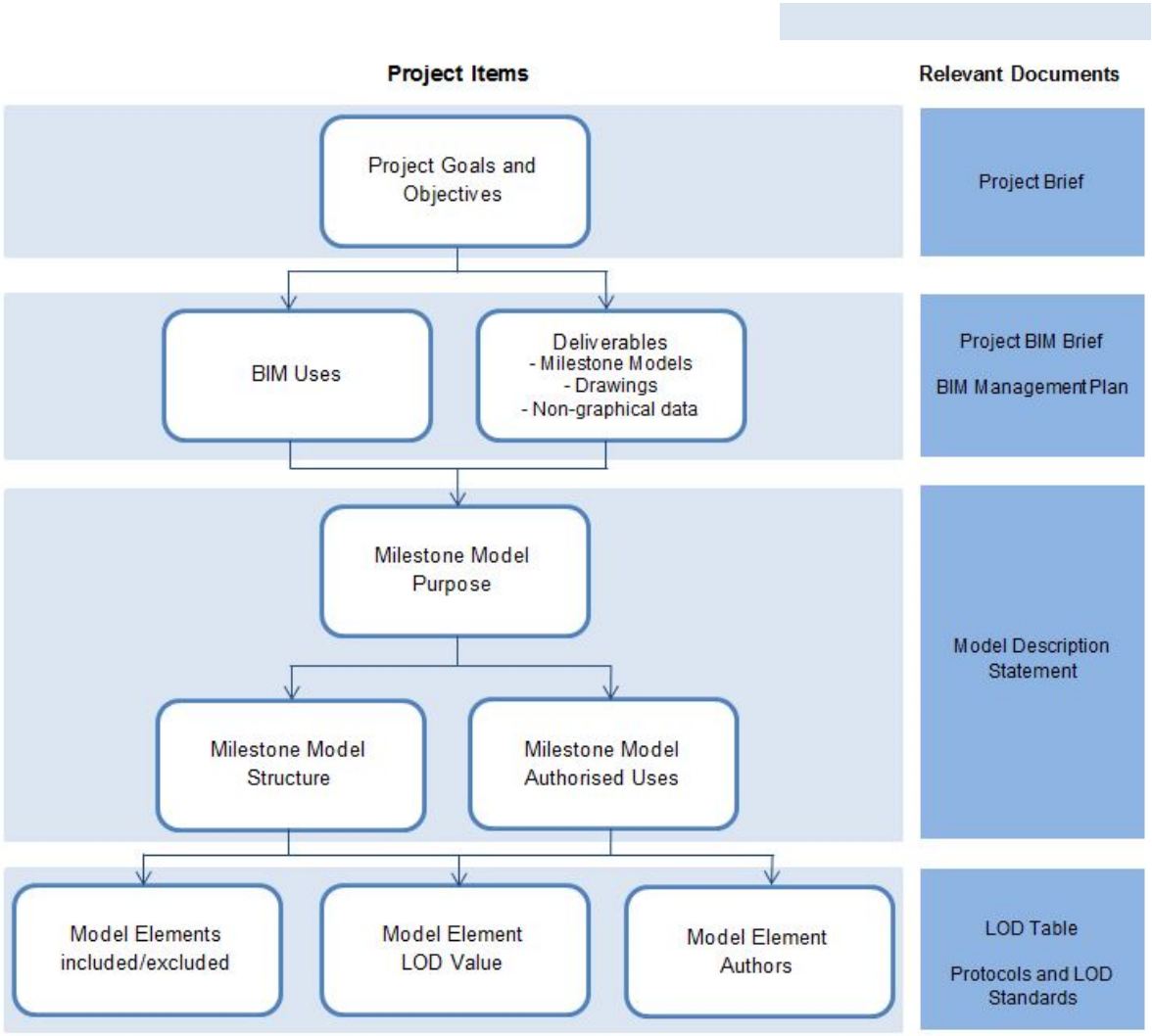


Figure 2: LOD Tables as a project management tool

If LOD Tables are made too complex or attempts are made to define every aspect of model collaboration before this is realistically possible, they can absorb a disproportionate amount of energy. This can be counterproductive – they may end up not being used at all. **Appendix A, 4.4 Strategies for LOD Table development** provides guidance to assist those developing and using LOD Tables.

2.2.2 LOD Table templates

The preparation of an LOD Table can be aided by using an existing template.

Templates available include:

- AIA Draft Document G202 – 2012 Building Information Modeling Protocol Form.

  Incorporates the well-recognised template or 'Model Element Table' on which most templates are based. Download from http://info.aia.org/aia/digitaldocuments.cfm.

- USACE Minimum Modeling Matrix (M3).

  An Excel based template incorporating the United States Army Corp of Engineers minimum modelling requirements for their projects. Its focus on two deliverables, the Design Model and the Record Model, reduces its complexity compared to many other templates. Built-in filters allow model content to be sorted by a number of criteria, simplifying the task of locating required information.

  Download from https://cadbim.usace.army.mil. See 'Document Center' > 'BIM'.

  Note: You have to register or sign in for the documents to display. Click on 'Sign in' in the top right hand corner.

2.3 RELATED CONSIDERATIONS

2.3.1 Authorised Uses

The intended use of a model directly affects how it is modelled and what data is included. Like any product, it is important that potential users of a model have a clear understanding of its intended purpose and any limitations associated with its use. A model incorporating a large proportion of elements with high LODs does not necessarily mean it is well developed for any use one may choose. The LOD values shown in a LOD Table are only relevant to the uses documented and to those relying on them at a given milestone. If a recipient of a model is not aware of its intended use or assumes it can be used in ways never intended, significant problems can arise. To avoid this problem the *AIA Draft Documents E203 – 2012, G201 – 2012* and *G202 – 2012* include the concept of Authorized Uses.

> **"The term "Authorized Uses" refers to the permitted uses of Digital Data authorized in the Digital Data and/or Building Information Modeling protocols established pursuant to the terms of this Exhibit."**
>
> *AIA Draft Document E203-2012*

Authorised Uses highlights the relationship between deliverables, modelling and documentation.

The Authorized Uses defined for each LOD value in *AIA Draft Document G202-2012* are summarized in **Table 2** (Overleaf)

2.3.2 LOD Table summary statement

The Authorised Uses listed in **Table 2** represent a general list of possible uses for BIM and constituent Model Elements. As the specific uses of BIM (and Authorised Uses) on each project will differ and directly affect LOD, it is important to make them as clear as possible to the recipients of an LOD Table.

One way of doing this is to include a brief written statement with each LOD Table that summarises the model's intended purposes and uses at each milestone. This will assist interpretation of the LOD Table and reduce the risk of errors and oversights caused by misinterpretation. It will also highlight any mismatches between model uses and the LODs listed that need to be resolved.

Apart from basic project identification information, the statement should briefly describe the model's purpose for its primary intended recipients and users at each project milestone. The statement can also include comments on Model Elements that do not readily fit within the Notes cells in the LOD Table.

	LOD 100 Conceptual	LOD 200 Approx. geometry	LOD 300 Precise geometry	LOD 400 Fabrication	LOD 500 As-built
Analysis	Analysis based on volume, area and orientation by application of **generalised** performance criteria assigned to **other** Model Elements.	Performance analysis of selected systems by application of **generalized** performance criteria assigned to the **representative** Model Elements.	Performance analysis of selected systems by application of **specific** performance criteria assigned to the **representative** Model Element.	Performance analysis of systems by application of **actual** performance criteria assigned to the Model Element.	Performance measured from installed systems.
Cost Estimating	Development of a cost estimate based on **current** area, volume or similar **conceptual** estimating techniques (e.g., square metres of floor area, hospital bed, etc.).	Development of cost estimates based on **approximate** data provided and **quantitative** estimating techniques (e.g., volume and quantity of elements or type of system selected).	Development of cost estimates suitable for procurement based on the **specific** data provided.	Costs are based on the **actual** cost of the Model Element at buyout.	Operation and maintenance costs measured from installed systems.
Project scheduling	Project phasing and determination of **overall** Project duration.	For showing ordered, time-scaled appearance of **major** elements and systems.	For showing ordered, time-scaled appearance of **detailed** elements and systems.	For showing ordered, time-scaled appearance of **detailed specific** elements and systems **including construction means and methods**.	Maintenance scheduling derived from installed systems.
Coordination	N/A	**General** coordination with other Model Elements in terms of its size, location and clearance to other Model Elements.	**Specific** coordination with other Model Elements in terms of its size, location and clearance to other Model Elements including **general** operation issues.	Coordination with other Model Elements in terms of its size, location and clearance to other Model Elements including **fabrication, installation** and **detailed** operation issues.	N/A
Other authorised uses	Additional Authorised Uses of the Model Element developed to **LOD 100**, if any, including Authorized Uses identified or required by the uses set forth in Section 4.4 of *AIA E203-2012.*	Additional Authorised Uses of the Model Element developed to **LOD 200**, if any, including Authorized Uses identified or required by the uses set forth in Section 4.4 of *AIA E203-2012.*	Additional Authorised Uses of the Model Element developed to **LOD 300**, if any, including Authorized Uses identified or required by the uses set forth in Section 4.4 of *AIA E203-2012.*	Additional Authorised Uses of the Model Element developed to **LOD 400**, if any, including Authorized Uses identified or required by the uses set forth in Section 4.4 of *AIA E203-2012.*	Specific Authorised Uses of the Model Element developed to **LOD 500**, if any, including Authorized Uses identified or required by the uses set forth in Section 4.4 of *AIA E203-2012.*

Table 2: LOD – Authorized Uses

2.3.3 Coordination of model elements

During the development of a building design, not only do the collective LODs of model elements increase but coordination between model elements is progressively refined. The processes are related at a broad level but the degree to which model elements have been coordinated cannot be inferred from their LOD values. Even though decision making about, or modelling of, individual elements can be well resolved, it is possible for the model as a whole to be poorly coordinated.

By definition, any measure of coordination can only be applied to groups of elements, not individual elements, e.g. a defined space, zone, level or whole model. Metrics for describing the extent of coordination or clash detection are emerging. For example, the Indiana University BIM Guidelines & Standards for Architects, Engineers and Contractors 2012 assigns different levels of priority to resolving clashes between defined groups of model elements. A strategy for coordination – the degree considered appropriate for each phase of model development – needs to be formulated early in the project.

Coordination and LOD

Proper coordination of building elements is obviously a crucial part of the design and construction process. One of the significant benefits of 3D modelling is the ability to identify collisions or clashes between building elements during the design process so they can be resolved prior to construction. Avoiding having to resolve these problems on site can result in significant time and cost savings.

There is no point commencing detailed clash detection in the early stages of a design because so many elements are loosely defined and in a state of flux – a lot of effort would be wasted. On the other hand, it is important that potentially significant coordination problems are identified as early as possible so they can be rectified. Major clashes in a well-advanced design are always more problematic and time-consuming to resolve.

If LOD and coordination are parallel considerations of model development, how do you relate the two, and how do you specify the appropriate degree of coordination required at different stages? A metric for coordination similar to that for LOD, and a way of relating them, would be useful.

3 IMPLEMENTING LOD ON PROJECTS

3.1 RECOMMENDATIONS FOR IMPLEMENTING LOD

The key recommendation of this Paper is to use existing standards for LOD. Unless the client has specific overriding requirements, give preference to international standards where possible, followed by national standards. In the absence of suitable options, the project team could adopt a standard already developed by one of its members. Trying to develop a new standard from scratch during a project should be avoided.

Specific recommendations:

1. Define the geometry of each model element for each nominated LOD by reference to a standard. See **3.1.2 The BIMForum LOD specification**.
2. Define the data content of each model element for each nominated LOD by reference to a standard, e.g. *NATSPEC BIM Object Element Matrix (BOEM)*. Refer to **Appendix A** for guidance on using it.
3. Use a standard LOD table to document the LOD of individual model elements at agreed times, preferably spread sheet-based, e.g. USACE M3.
4. Use a standard for the protocols to be observed by team members when collaboratively managing model development on the project, e.g. *AIA Draft Documents E203 – 2012, G201 – 2012* and *G202 – 2012.*
5. Document agreed standards and any variations to them in the Project BIM Brief or BIM Management Plan.

3.1.1 Defining Model Element Geometry and Data

The BOEM and the *BIMForum LOD Specification* are complementary references. **See Figure 3**.

- The *BIMForum LOD Specification* defines the appropriate geometry for a given LOD.
- The *NATSPEC BOEM* defines the parameters (for data content) for a given LOD.

Both are organised by the Uniformat™ classification system, making them easy to cross reference.

Notes on the BIMForum LOD Specification

LOD definitions in the *Specification* are based on model element geometry, with three common uses in mind:

- Quantity take-off.
- 3D coordination.
- 3D control and planning.

Despite LOD definitions being geometry-based, they give a sufficiently clear picture of expectations about model elements for many planning and management purposes.

Definitions for LOD 500 are not included. If required, define the method and accuracy of field verification required and non-graphic information to be delivered. Depending on project requirements, this could take the form of a statement of

3.1.2 The BIMForum LOD Specification

The *BIMForum Level of Development (LOD) Specification* is a reference that defines and illustrates characteristics of many Model Elements at different LODs. Clear definitions allow model authors to define what their models can be relied on for, and downstream users to clearly understand the usability and the limitations of models they are receiving.

The intent of the *Specification* is to help explain the LOD framework and standardize its use so that it becomes more useful as a communication tool.

general requirements or an element-by-element specification.

The *Specification* does not prescribe what LODs are to be reached at what point in a project. This must be decided by the users of the document, as appropriate to their project.

3.1.3 The NATSPEC BIM Object/Element Matrix

The NATSPEC BIM Object/Element Matrix is a series of Microsoft Excel (.xls) worksheets that define a large number of objects and elements by Uniformat™/OmniClass™ classification and groups their properties by BIM uses and LOD. See **Appendix A** for more details.

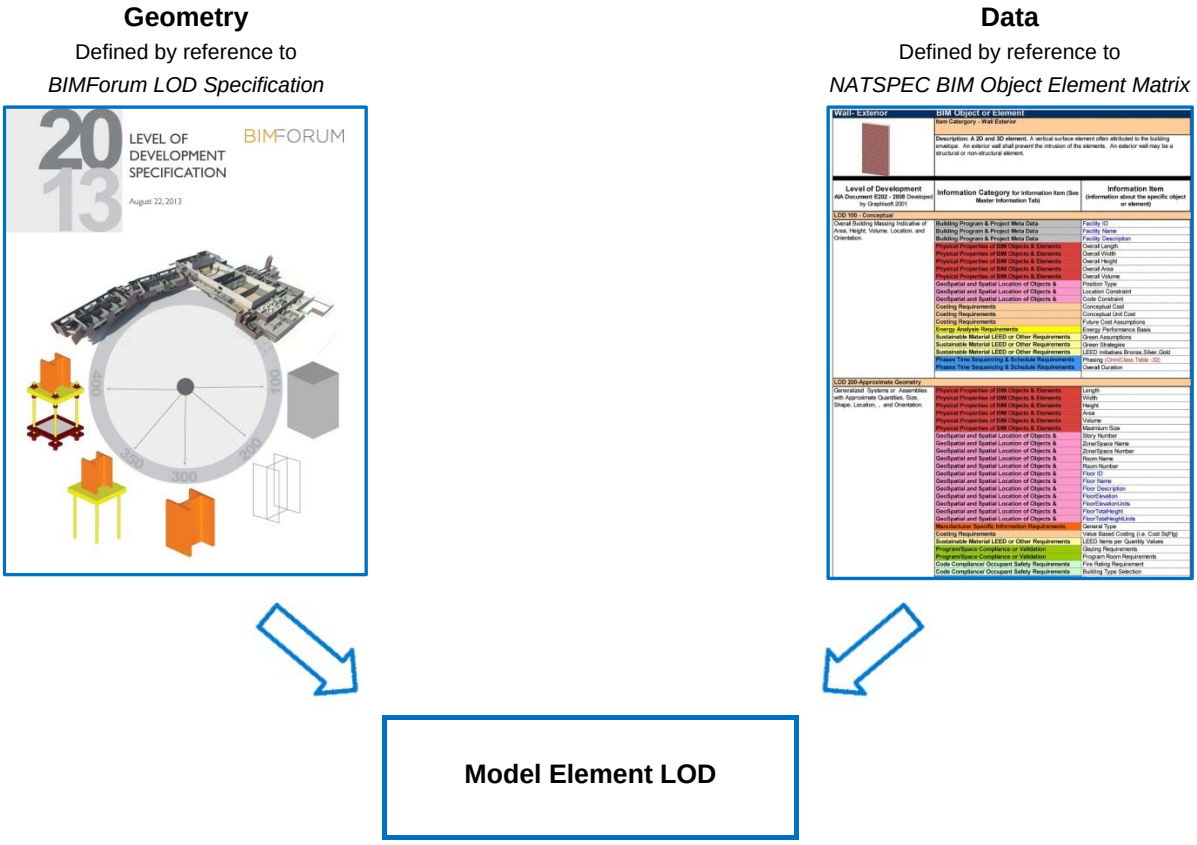


Figure 3: Defining LOD by reference to standards

4 APPENDIX A

4.1 COMPONENTS OF LOD TABLES

Model Element by CSI UniFormat™ classification									Notes
				4					
				LOD	MEA	LOD	MEA	LOD	MEA	
A SUBSTRUCTURE										
A10	Foundations	A1010	Standard foundations							
		A1020	Special foundations							
		A1030	Slab on grade							
A20	Basement construction	A2010	Basement excavation							
		A2020	Basement walls							
B SHELL										
B10	Superstructure	B1010	Floor construction							
		B1020	Roof construction							

1 2 3 5

1. **Model Element list**: A list of model elements, usually ordered by an established element classification system, e.g. UniFormat™. The amount of detail required for a project can be adjusted by selecting the desired level of a classification system or pre-selecting a set of elements. Items not required to be modelled can be indicated by an abbreviation such as 'NM' (non-modelled) or 'NR' (not required).
2. **LOD value cells**: Cells for entering LOD values for each Model Element are cross-referenced to nominated project milestones. Sometimes this arrangement is reversed, with project milestones listed in columns for each LOD value.
3. **Model Element Authors (MEA) cells:** Cells for indicating the MEA responsible for developing each model element to the required LOD. Some tables, like the *AIA G202-2012* shown here, show the MEA for every model element at each LOD. On the basis that many model elements have the same MEA for most phases of a project, some tables consolidate this information in a single column. In this instance, if a model element is shared between more than one MEA, all are listed in the one cell. Where responsibility shifts from one MEA to another, the row for the element is duplicated and the MEA responsible for each LOD value entered against that value.
4. **Project milestones headings**: Cells for entering nominated project milestones. Cross-references the LOD for each Model Element to each nominated project milestone. Sometimes this arrangement is reversed, with LOD values shown in the heading cells and project milestones entered in the cells below.
5. **Notes**: Cells for explanatory comments or qualifying remarks.

Optional components

The example above shows the essential components of LOD Tables included in *AIA Draft Document G202-2012*. The following items can improve the table's functionality when it is implemented as a spread sheet:

- **Model element inclusion/exclusion indicator**: Instead entering 'NM' or 'NR' against Model Elements not included in the model, some LOD Tables include a separate column of cells for showing this, usually by means of a checkbox or Yes/No option. This assists the filtering and sorting of model content for various purposes.
- **Information format indicator**: Some LOD Tables make provision for indicating the format in which information is provided at a given LOD (referred to as 'Grade' in USACE M3). For example, 3D geometry only, 3D + data. Opinions differ on whether it is appropriate to include items in the LOD Table that are not geometrically modelled. Some argue that this is useful because it comprehensively shows what is expected for the project in one place. Others believe only 3D model elements should be included and that items such as textual information should be documented elsewhere. If the latter approach is adopted, the information should be coordinated and clearly cross-referenced by, for example, using the same classification system.
- **Additional classification systems:** Classification systems other than that used to order model elements can be added to allow model content to be searched by different criteria or to point to other information, e.g. product data or specification worksections associated with a Model Element. This assists cross-referencing.
- **Definitions of LOD**: LOD definitions are generally best incorporated by reference to a standard but they can be included directly in the LOD Table for quick reference.
- **Colour coding**: Colour coding can be used to signify the status of a number of items. It makes it easier to identify related or like items such as discipline or role.

4.2 THE NATSPEC BIM OBJECT ELEMENT MATRIX

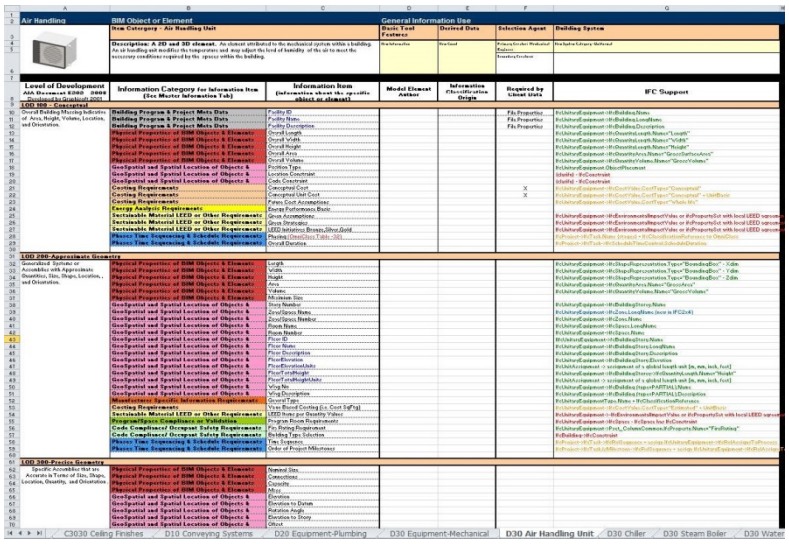


Figure 4: A typical page of the BIM Object Element Matrix

The *NATSPEC National BIM Guide* outlines a number of ways the *BIM Object Element Matrix* (BOEM) can be used on projects. Refer to clause 1.4 of the *NATSPEC National BIM Guide* **How to use the NATSPEC National BIM Guide**.

Its primary value is as a reference that provides guidance on the properties or parameters that can be included in model elements for different purposes at each LOD, and their naming. If the parameters required for the project are agreed by team members and named consistently from the start, data exchange will be much smoother. The parameters necessary to support various BIM uses are grouped and colour coded to assist selection. For example, if the project team has decided that they will be using a model for energy analysis (colour coded bright yellow), they can refer to the BOEM for suggested parameters for a number of model elements at each LOD. These are then entered into their BIM authoring tools.

Where available, the BOEM provides parameter names for ArchiCAD, Bentley and Revit. It also includes the appropriate IFC and COBie parameters.

4.2.1 Using the NATSPEC BIM Object Element Matrix

The following example illustrates the points made in **Tips for Using Standards** (See sidebar) about tailoring documents to project needs:

- Save a copy of the BOEM in the project file.
- After the uses of BIM have been decided for the project, delete all the (colour coded) uses that do not apply.
- Delete all items not applicable to the software platforms being used (listed in the right hand columns).
- If IFC is not being implemented, delete the list under IFC support header.

The general approach should be to delete all extraneous material so that it is easier to find required information and reduce the risk of irrelevant items being referenced by mistake.

The process noted above only represents the initial edit. Once this is complete the team can assess if any of the remaining items are unnecessary and delete them. As no one system can anticipate every requirement, the team should also decide if any items need to be added.

Tips for using standards

Many BIM standards, e.g. classification systems, COBie and documents such as the NATSPEC BIM Object Element Matrix (BOEM) are comprehensive and extensive by nature. Unfortunately, their scale and detail can create a daunting initial impression. It is helpful to bear in mind that they are reference frameworks to be used only to the extent required for your specific requirements – the whole system is not usually required by everyone for every task.

To be effective they need to be tailored to the task at hand – do not hesitate to extract only what is needed – often this is only a fraction of the whole system. In practice this means significant pruning is required.

Alternative references

If the *NATSPEC BIM Object Element Matrix* is considered too detailed for the requirements of the project, alternative references include:

- *New York City Department of Design & Construction BIM Guidelines* lists properties to be included in a number of objects at each LOD up to LOD 400. See **Object Requirements** in Part 4, Pages 36 – 54.
- *Hong Kong BIM Specification Revision 3.0 – 2011* lists attributes to be included in model elements plus Category IDs for sorting model content. See **3.1 Model Data & Level of Detail** Pages 11 - 17.

4.3 PRINCIPLES OF PLANNING MODEL DEVELOPMENT

Use the following principles for ordering model element development for the creation and interpretation of LOD Tables:

- Broader, overarching aspects of a design need to be resolved before attention is shifted to more detailed aspects. The overall size, layout and form of the building needs to be well defined before the design of the structure and construction system can be progressed. The layout of fixtures, fittings and equipment in internal spaces must be defined before services can be planned in detail, etc.
- Identify and rank building elements with regard to the impact changes to them have on other elements, particularly those that are the responsibility of other disciplines or Model Element Authors (MEA). For example, changing the location of a power outlet and associated cabling is less problematic than rerouting a main air supply riser. Therefore, a higher LOD would be assigned to the air supply riser at an earlier project phase than power outlets.
- Differentiate elements that have more constraints affecting their placement from those with less. For example, waste pipes have to be arranged so that uninterrupted falls are maintained to risers – smaller gas and water supply pipes can be routed with much greater freedom. So, in a design development context it generally makes more sense to focus on resolving the wastepipe layout before the supply pipe layout. Likewise, large penetrations in the structure need to be located and sized accurately before small ones.
- Further to the above, cast-in, embedded or recessed model elements connected to services need to be assigned a higher LOD at an earlier project phase than surface mounted or loose items not connected to services.
- Highlight elements that are shared between Model Element Authors or where responsibilities shift from one party to another. Team protocols for these items may need to be defined in more detail.
- Identify systems and elements that are contractor-designed (Design and Construct). The LOD of these elements at given project milestones will be determined by contractual expectations, e.g. D & C of mechanical services based on schematic design, D & C based on performance criteria only (no schematic design).

  The development of information associated with a model is as important as the development of geometry and needs to be planned with care and discipline to maximise the benefits of BIM. Assess the information needed to provide the deliverables specified for each project milestone and create a plan for adding and managing this information at the model element level.

4.4 STRATEGIES FOR LOD TABLE DEVELOPMENT

Documenting project requirements in the LOD Table represents a large investment of effort for the team. The following strategies for this process are offered as general guidance:

- Tailor the LOD Table to the needs of the project. A simple project or one where the project team have worked together many times before will not require the LOD Table to be as detailed as one for a complex project involving teams that have not worked together before, and are less certain of what to expect from each other.
- Align the development of the LOD Table with the project programme. Attempts to prescribe model development to the n^{th} degree at the very start of a project could prove futile and a waste of effort, particularly before all team members have been engaged. At any given time, LOD Tables should reflect reasonable goals set by experienced practitioners. They need to be routinely reviewed and updated as required to meet project requirements.
- Following on from the last point, LOD Table development is best done progressively. Like the design itself, it is better to start by developing LOD Tables at a broad level, where everyone can agree, and gradually refine them, as required. Rather than getting bogged down in detail from the outset, it is more productive to agree reasonable milestones in the model's development and then clarify what each party must do to achieve them.
- Only invest as much energy developing an LOD Table as is necessary to allow project stakeholders to plan and budget for the work with confidence. Consciously avoid tinkering with it when the benefits cannot be clearly identified.

4.4.1 LOD Table development work method

The task of developing an LOD Table can be made less onerous if it is broken down into a number of steps:

- Assign Model Element Authors (MEA) to each element: This process can be made more manageable by using documents such as the **Model Element Responsibilities Schedule** template found in the NATSPEC BIM Management Plan Template. By excluding considerations of LOD at this point, it allows team members to focus on authorship and responsibility for model elements over the duration of the project. The appropriate MEA will be obvious for many elements – the focus should be on identifying the elements that need to be shared, or where responsibilities need to be transferred from one MEA to another. For a simple project, or where the team has worked together on similar projects before, a Model Element Responsibilities Schedule may be all that is required. If this is not the case, the agreed responsibilities of MEAs will need to be transposed to the LOD Table.
- Decide to what extent MEAs are permitted to act on model elements assigned to them. For practical reasons (available space) formal rules and limitations are probably better documented in a separate document to the LOD Table, e.g. BIM Protocols or the **Modelling Permissions Schedule** template found in the NATSPEC BIM Management Plan Template.
- Decide what model elements should be included or excluded from models at each phase of the project.
- Analyse the deliverables required at each phase of the project and the information requirements of team members necessary to complete their tasks. As for other aspects of project programming and scheduling, working backwards from the requirements of the later phases can assist the process of defining the LOD of model elements.
- Review the BIM uses agreed for the project – they inform the data content of model elements at each LOD.
- Decide the order of precedence/priority for developing elements: Apply the principles set out in **4.3 Principles of planning model development** for this.
- Assign LOD values to model elements.
- Decide what degree of coordination and/or clash detection is relevant at each project milestone. This may relate to the model as a whole, selected levels or zones. If documented elsewhere, cross reference the document to the LOD Table.
- If not already specified, decide the format of information required at each project milestone: The term modelling can de-emphasise the significance of other forms of information still commonly used in projects, including those making extensive use of BIM. In the conceptual design phase, many items will not be modelled, let alone have information attached to them. For example, options for structural systems may be documented in a report. During detailed design phases and on completion of the building, important information can be contained in documents not linked to the model. The format of information required by MEAs at each stage will be based on what they require to fulfil their responsibilities for the next stage of work.

4.5 REFERENCES

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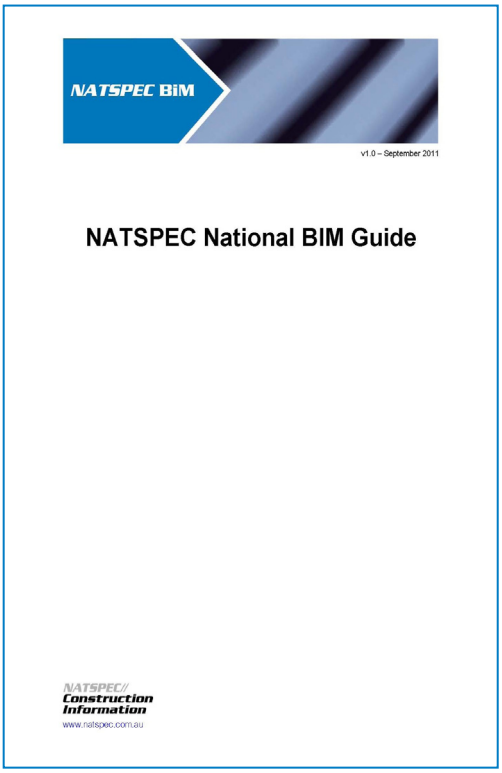
NATSPEC and Building Information Modelling (BIM)

NATSPEC believes that digital information, including 3-D Modelling and Building Information Modelling, will provide improved methods of design, construction and communication for the industry. Further, NATSPEC supports open global systems. This will result in improved efficiency and quality.

NATSPEC's primary focus is on the "i" (information) in BIM and how it is linked to digital models. NATSPEC's areas of interest include how specification information can be best integrated with BIM and the development of BIM guidelines and standards beneficial to the construction industry.

NATSPEC BIM documents

NATSPEC has created a number of documents and tools to assist the implementation of BIM in the Australian construction industry.


NATSPEC BIM

v1.0 – September 2011

NATSPEC National BIM Guide

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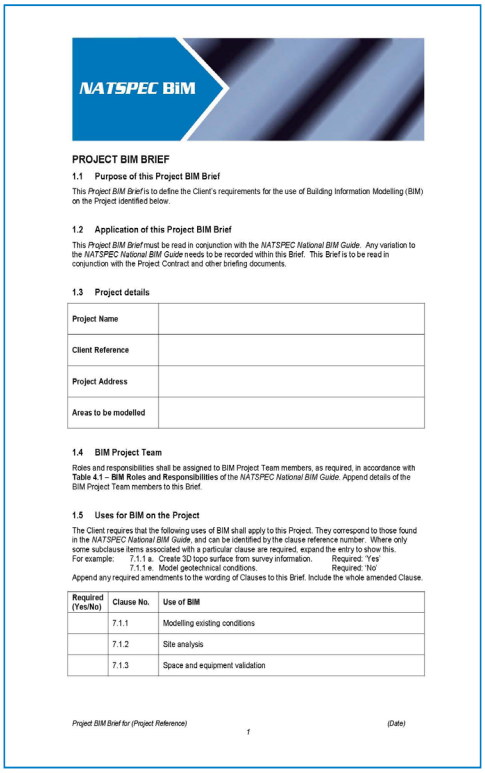
NATSPEC BIM

PROJECT BIM BRIEF

1.1 Purpose of this Project BIM Brief

This *Project BIM Brief* is to define the Client's requirements for the use of Building Information Modelling (BIM) on the Project identified below.

1.2 Application of this Project BIM Brief

This *Project BIM Brief* must be read in conjunction with the *NATSPEC National BIM Guide*. Any variation to the *NATSPEC National BIM Guide* needs to be recorded within this Brief. This Brief is to be read in conjunction with the Project Contract and other briefing documents.

1.3 Project details

Project Name	
Client Reference	
Project Address	
Areas to be modelled	

1.4 BIM Project Team

Roles and responsibilities shall be assigned to BIM Project Team members, as required, in accordance with **Table 4.1 – BIM Roles and Responsibilities** of the *NATSPEC National BIM Guide*. Append details of the BIM Project Team members to this Brief.

1.5 Uses for BIM on the Project

The Client requires that the following uses of BIM shall apply to this Project. They correspond to those found in the *NATSPEC National BIM Guide*, and can be identified by the clause reference number. Where only some subclause items associated with a particular clause are required, expand the entry to show this.
For example: 7.1.1 a. Create 3D topo surface from survey information. Required: 'Yes'
7.1.1 e. Model geotechnical conditions. Required: 'No'
Append any required amendments to the wording of Clauses to this Brief. Include the whole amended Clause.

Required (Yes/No)	Clause No.	Use of BIM
	7.1.1	Modelling existing conditions
	7.1.2	Site analysis
	7.1.3	Space and equipment validation

Project BIM Brief for (Project Reference) (Date)

1

The NATSPEC National BIM Guide is a key reference document that defines roles and responsibilities, collaboration procedures, approved software, modelling requirements, digital deliverables and documentation standards for projects using BIM. It documents a range of possible uses for BIM.

The NATSPEC Project BIM Brief template should be used to document the specific requirements of a project such as uses of BIM and modelling standards by reference to the National BIM Guide.

NATSPEC BIM Portal

All documents and tools can be freely downloaded from www.natspec.com.au. Click on the BIM logo for access to the NATSPEC BIM Portal.