5D BIM: Creating Cost Certainty and Better Buildings

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Abstract

This paper looks critically at where BIM implementation is on the pathway and sets out the opportunities that arise when 5D (the linking of cost information to a 3D model) is considered to be more than just a quantity take-off exercise. It proposes a methodology, from a practitioner's perspective, for applying 5D BIM to the design and construction of projects with the goal of delivering better buildings with cost certainty. A fundamental of the methodology is to use existing, proven technologies to overcome the problems that exist when the onus is on the BIM author to code model objects in a fashion that estimators can understand. The purpose and intention of this paper is simply to provide context and to start the discussion on what 5D BIM is with a view to developing a mainstream methodology that can be included within a BIM execution plan for a project.

Keywords: 5D BIM, Collaboration, Cost Strategy, Living Cost Planning, Lean Practices.

1. INTRODUCTION

To date, a lot of the focus on Building Information Modeling (BIM) implementation has simply been about design firms learning how parametric 3D modeling software works.

Design firms have been learning about the capabilities of their chosen BIM authoring tool, gauging the benefits to the firm, achieving a level of confidence in an isolated way and exploring collaborative work flows where information is exchanged in two directions.

Working against an even more collaborative approach is a belief that BIM can only add value to large projects and when Integrated Project Delivery (IPD) is the preferred delivery system. Whilst integration is the long term outcome, industry is currently grappling with the issues surrounding collaboration and is now starting to solve the stumbling blocks of liability, ownership and protection of data and intellectual property. The development of BIM guides and execution plans have made it possible to define expectations and clearly specify design deliverables at the various design stages.

While these developments have been extremely encouraging in the area of 3D design very little development has happened in the fields of 4D - linking time and scheduling data; and

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5D - linking cost data to the 3D model. For instance the Veteran's Affairs (VA) BIM guide simply refers to a "4D BIM - phasing plan" and the "discretionary additional use" of "5D - Material take-offs and cost estimating".

For BIM to be truly successful in providing better buildings then all of the D's need to be embraced. This paper will concentrate on 5D and what it can do, so that open discussion can occur and as an industry we can shift to practicing 5D and shaping it as a standard practice for the future.

Change and reform in the construction industry is long overdue, the catalysts for change are here and these will be the accelerators that drive the BIM process to become the industry norm rather than the exception.

2. CATALYST FOR CHANGE

The Global Financial Crisis and world events have made development and construction uncertain. World thinking has changed our behaviours. For the first time in decades people are saving, credit cards are being avoided and there is a growing sense of frugality.

When a consumer decides to spend, it seems that a "saved" dollar is more valuable than a "borrowed" dollar and that a "saved" dollar won't be wasted. Today's consumers are extremely well researched and won't be rushed because there is no compelling reason to buy. There is no fear that prices will rise because competition is rife, in fact delaying the purchase may mean that the product gets cheaper.

So it makes sense to take the time, to be certain that the product is reasonably priced, is of the highest quality and is supported with a strong level of service.

Previously this delay or slowness to purchase was seen as a lack of confidence in the future – something that will pass but now there is a growing realisation that structural change is occurring and that these conditions are here to stay. There is a new paradigm in play.

For the development and construction industry it is particularly difficult to meet this paradigm because past experience tells us that construction is expensive and it is uncertain. Often a customer does not really visualise what is being built until it is built and there is an expectation that there will be delays and cost increases.

Successful building is about creating certainty - in design, buildability and cost. Wisdom, intelligence and technology can create certainty by getting back to basics and making grounded decisions based on facts.

3. BIM PATHWAY

At present projects can confidently be managed using a staged and independent process of inputting data into independent models with the parties collaborating but not integrating to use the software in a beneficial way. For example, architects can set their design, engineers

can create the structural framework and air-conditioning contractors can submit their components all independent of each other using different authoring tools. Software, like Navisworks and Solibri, are then used to bring each model together to deliver a coordinated design.

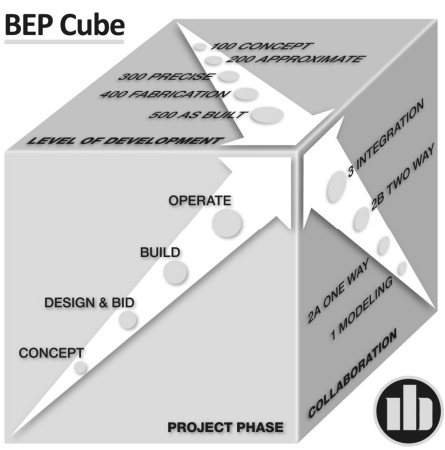
Andrew Gutteridge worked with the Australian Institute of Architects to champion the BIM pathway to provide a logical learning curve for the industry to move from working in isolation to collaboration. The culmination of their work was production of a diagram “Towards Integration” which was later included within the CRC Construction Innovation publication - National Guidelines for Digital Modelling.

Using this diagram as a reference and applying it to the Australian industry, it was found that the mainstream uses 3D modeling in an isolated way (1B) and the cutting edge design teams are acting in a collaborative way (2A one-way and 2B two-way collaboration). Rather than spending time judging whether what is being done now is BIM or not BIM, it is far more important to acknowledge that industry is practicing and improving and that this is just part of the BIM pathway.

Industry design professionals are mostly engaged in the use of parametric modeling in one form or another but sceptics have a lack of trust in the software’s intelligent design to fully integrate the model for each element.

Construction professionals also perceive a lack of protection of the input of information and data, if and when it is changed, by who and how it is tracked. What is important to remember is that even at 2A and B the duties and working practices for two dimensional work remain the same for three dimensional work.

At this point on the pathway it doesn’t matter how you relate to parties throughout design, but rather that you do and that the obligations and design outcomes are clear.



Development of the BIM Execution Plan (BEP) has provided this clarity. The BEP defines the scope of design work, the Level of Development (LOD) and the two-way exchange of information for all parties to the project including the quantity surveyor (QS), cost engineer or estimator and can be clearly depicted on three scales – refer figure 1.

Figure 1: BIM Execution Plan Cube

4. CREATING COST CERTAINTY IN 5D

Developing certainty in cost, design and buildability reduces risk and creates better projects with sustainable profits. We know that 3D modeling and strong design coordination creates certainty in what is being built and that the 5th Dimension, or 5D, is all about cost. While there is considerable discussion and collaboration between different design partners often 5D is reduced to just the simple one liner of “Quantity Take Off” and attention is placed on coding by the designer with an expectation that later the costing process will be made easier.

This approach means that several opportunities are missed:

1. The costs are not known until the model reaches LOD 300 or greater.

2. The design itself is not tested at an early stage for functional efficiency or benchmarked against known elemental costs.

3. There is no integrated cost plan and the design team is not provided with real-time cost feedback as the design progresses.

4. The costing process is still a separate exercise which is not transparent.

An alternative and better approach is for the cost planner to push accurate cost codes into the model information and then to extract all of the information that is needed to complete a thorough cost estimate via a 5D BIM authoring tool. Part of this approach includes making allowances for work that has not yet or will not be modeled.

This approach means that all of the “missed opportunities” will be delivered and the result is a better building because the available money can be targeted at the most important features of the building design in a transparent way that builds trust amongst all project partners.

5. 5D QS AND COST PLANNER

The modern QS is taking the traditional QS role to the next level, utilising models to provide detailed and accurate 5D estimates and living cost plans. This assistance is provided to projects at any phase from concept design through to construction and completion.

The ability to complete a series of estimates for various designs at the early phase of a project is paramount because this is when the dye is set, planning evolves and cost overruns are avoided. If the scope of a project matches the budget at the outset then constant redesign is avoided and the priority features of the project are included.

It is well established that early decisions have the highest level of influence on project outcomes at the least cost. This is because redesign, construction delay and disruption, change order and rework costs are avoided.

The technique is simple, basically an estimate is done, then its elemental costs are benchmarked and the functional performance of the design is analysed and tested against competing projects. The QS then provides feedback to the concept designers, a new scheme is produced and the process is completed again.

Once the project design passes this budget test and proving up phase then the Cost Plan is established for the project and this recipe becomes the basis for managing and monitoring the fluctuating construction costs during design.

A 5D QS can do this extremely quickly, an endless number of times and in a complexity of combinations. For a 2D QS this is not possible because project schedules do not allow enough time for endless manual take-offs and even if there was, then the re-measurement process is too labour intensive to be viable, the combinations that need to be considered are too complex and there are too many variables for a QS to complete the required “what if” style calculations manually.

The traditional process is to complete the design to a particular stage i.e. schematic design, developed design, etc.; then freeze further design until an estimate is completed and permission is granted to proceed to the next design stage.

Today there are modern techniques for the 5D QS to use within the traditional frameworks to set cost strategies and a 5D Cost Plan (or Living Cost Plan). These techniques can be blended within the traditional design and construction phases as follows:

6. CONCEPT DESIGN

At the feasibility and concept design phase, a cost strategy is set that considers all aspects of the project, the client’s brief, the designer’s vision and the site constraints. The strategy is developed after first completing a concept estimate and then testing its elemental costs by benchmarking and the design efficiency by analysing its functional performance.

6.1 Initial Concept Estimate – LOD 100

The initial concept estimate is a fast and effective way to determine the cost of a project and allow decisions to be made quickly and with certainty.

Working with the overall massing model (AIA LOD 100) in Sketchup, Revit or an IFC format, the 5D QS prepares a concept estimate that is presented in an elemental format and sets out each elemental unit rate and quantity. It is understood that not everything is modeled and the 5D QS uses experience to ensure that the total project is included within the estimate. This is done by supplementing the model information with 2D on screen measurement where necessary.

This concept estimate becomes the basis for recompiling the estimate to consider alternative designs during the proving phase of the concept design.

6.2 Elemental Cost Benchmarking

The 5D QS uses cost intelligence from past experience and actual project cost data to critique, review and compare the elemental costs contained in the initial concept estimate to other similar or competing projects. This exercise identifies inefficiencies and highlights opportunities that will benefit the project bottom line. Cost benchmarking is done on an elemental basis because this provides the most consistent results; examples of building elements include substructure, columns, upper floors, staircases, roof, external walls, etc and are fairly consistent around the globe. Some of the different elemental formats include UniFormat II (USA), UniClass (UK) or ACMM (AUS).

By way of example a concept estimate containing a rate of $354.90 per m2 for columns and upper floors would exceed the actual average costs of $279.09 per m2. If the design is made more efficient a cost saving of 3.6% against the estimated total building rate of $2,078.57 per m2 is achieved.

6.3 Analysis of Functional Performance

In a similar fashion the functional performance and efficiency of a building is analysed against actual project performance data to further identify inefficiencies and highlight opportunities to create further savings.

In Table 1, the example concept design for a planned apartment building contains 36 apartments with an average area of 168.9 m2. This exceeds the completed project average of 101.9 m2. It is also apparent that much of the inefficiency is occurring within the common spaces and car park areas which are not income producing. Correction of these inefficiencies would improve the building cost performance by 20% without effecting the saleable area and income.

Table 1: Functional Performance Analysis

	Planned Project Concept Design	Actual Completed Projects (Average)
Residential Area / Unit	98.5m2	65.3m2
Common Area / Unit	30.9m2	11.6m2
Carpark Area / Unit	39.5m2	25.0m2
Building Area / Unit	**168.9m2**	**101.9m2**
Residential Area / Unit	98.5m2	65.3m2
Balcony Area / Unit	33.5m2	12.9m2
Saleable Area / Unit	**132.0m2**	**78.2m2**

7. DETAILED DESIGN

At detailed design, the goal of the 5D QS is to produce a schematic design estimate with dynamic links to the model information that will form the foundation for the living cost plan that is used for developed design and bidding. The living cost plan becomes the basis for providing updated estimates every time the model information is changed that can be used for forecast final cost, budget variances, value management, finance, funding and final investment decisions or in negotiations with a contractor.

7.1 Schematic Design – LOD 200

Working with the schematic design model (AIA LOD 200) in Revit or IFC format, the 5D QS prepares a sketch design cost plan that is presented in an elemental format stating the generic construction materials, finishes and services specifications.

The 5D QS maps the model and adds an elemental pricing code to the model information. It is helpful if the author has included UniFormat II (USA), UniClass (UK) or ACMM (AUS) codes in the model information but often it is much quicker and more accurate if the 5D QS adds the preferred codes for the task.

Dynamic links are then created between the generic architectural and structural model elements, the 5D QS elemental rate library and the selected project template that is contained within the 5D BIM authoring tool such as CostX.

It is understood that not everything is modeled and the 5D QS ensures that all of the work is estimated by supplementing with 2D on screen measurement where necessary. Trust and transparency is supported by providing a fully functioning and executable CostX reader version of the sketch design cost plan that is easily interrogated because of the dynamic links between the models, elemental areas and rate library. This executable file becomes the basis for the living cost plan which can be recompiled to consider alternative designs, different construction methods, materials and generic engineering systems during development of the schematic design and any time the model information is revised.

7.2 Developed Design – LOD 300

Working with the developed design model (AIA LOD 300) in Revit or IFC format, the 5D QS prepares developed design cost plans that are presented on a sub-elemental and trade basis, stating the specific construction materials, finishes and services specifications. The final estimate states each sub-elemental unit rate and quantity.

At this stage an extra level of costing detail is added to the model information. This can be done via an instance parameter and then the model is re-mapped where necessary to create further dynamic links between the specific model assemblies (including architectural, structural, civil and MEP), the detailed rate library and the selected project template that is contained within the 5D BIM authoring tool. Again the model information is supplemented with 2D on screen measurement and the executable file continues to be the living cost plan

This detailed information can factor into the different stages of the design and construction process and helps to consider in detail the labour, materials, equipment, and subcontractor costs for each building element.

7.3 Coding

In circulation today there are a number of different coding systems but there is not a published industry code that is suitable for becoming a price code which will automatically link a rate to a specific system or assembly. UniFormat II is one example and while it is close to achieving this goal it has insufficient levels to specifically identify the material and fixing condition. For these reasons the 5D QS uses its own specific code for the material and fixing conditions which is pushed into a model as an instance parameter.

8. QUANTITY TAKE-OFF AND BIDDING

For design, bid, build procurement the rate library is removed from the executable file so that what remains is a bill of quantities that is easily interrogated by contractors and subcontractors because the dynamic links allow each quantity to be viewed in the model. The file is also recompiled in a trade format so that the quantities reflect the scope for each subcontract. Often the building information comprises individual models and the 5D QS uses tools like Navisworks and Solibri to coordinate visually. MEP forms approximately 30% of the total project cost so special care is needed during this phase to ensure that quantities for mechanical, electrical, hydraulic, fire and transportation services are actively coordinated with the building trades.

9. CONSTRUCTION

9.1 Contractors Priced Bill of Quantities – LOD 300

Working with the construction model (AIA LOD 300) in Revit or IFC format, at the commencement of construction, the 5D QS attaches the contractor's offered rates and prices to the executable file. The contractors priced bill of quantities is presented on a trade and zone basis and states the description for each item (including the specific construction materials, finishes and services specifications), the quantity and the offered rate. In some instances re-mapping of the model is necessary to create further dynamic links between the model zones and specific assemblies.

9.2 Change Orders, Variations and Payments

The dynamic links mean that variations and change orders can be calculated reliably, easily and quickly every time a change occurs in the model information. Progress payments are also calculated from the executable file by isolating the completed zones by trade and recompiling the quantities to produce a progress payment calculation that is transparent and easily interrogated. During construction the model will evolve from LOD 300 to LOD 400 as changes occur on site and shop drawings are developed. The 5D QS continually coordinates

the construction model with the contractors priced bill of quantities and provides cost updates, budget performance and variances through each stage of construction.

9.3 Cost Integrated Construction Model – LOD 400

As construction progresses the model information is changed to produce the revised documents that are necessary for the construction process – this information is stored in the Model software. The 5D QS also changes the cost information to reflect the actual contract sum and any cost adjustments and payments that occur during construction – this information is stored in the 5D BIM authoring tool.

9.4 As-Built Cost Data & Facilities Management – LOD 500

Once validation and synchronization is completed between the as-built (AIA LOD 400 or 500) Model and the FM system, The 5D QS pushes the project as-built cost data into the Model instance parameters. The as-built cost data packet usually comprises several different pieces of information including the replacement cost at the base date, manufacturers expected life for replacement, effective life for depreciation and estimated running cost for operating budgets. Care is taken to omit construction costs that will not be incurred again such as demolition of pre-existing buildings.

This as-built cost information is then ready to be integrated into the Facility Maintenance System and FM database for use throughout the life cycle of the project.

10. CONCLUSION

The 5D QS has developed specialist technology skills which compliment traditional cost planning techniques that set strategies from preliminary designs when plans evolve and cost overruns are prevented. 5D BIM provides the ability generate savings and efficiencies and to drive costs for buildings, infrastructure, heavy engineering or land development in the direction that is wanted. When negotiating with contractors and subcontractors the ability to visualise quantities creates trust and is relied upon.

5D BIM is here and finally there is traction to make 5D an integral part of the QS tool kit and every project to create cost certainty. It is one thing to use the technology but on its own it will not generate the certainty that customer's desire.

This requires the wisdom and intelligence of a 5D QS and cost planner. So while it's the way of the future and a must for all projects going forward, it is critical to work with people who know what they are doing and know how to leverage it to get the best results for the building from initial concept through to procurement and on-going management of post construction.

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