

- Decide Estimating structure
- List rules and assumptions
- Gather Data
- Establish point Estimate. Compare it to an independent cost Estimate
- Develop Sensitivity analysis
- Develop Risk and uncertainty analysis
- Support the documentation of the Estimate
- Present the Estimate to the steering board for approval
- Update the Estimate to reflect actual costs and changes

4. Building Information Modeling (BIM)

In the case of BIM, to elaborate a Cost Estimate, it requires to develop a 3D model and then list the number of materials and equipment to allocate prices to these resources.

The stage of development of the model defines the level of detail. The most implemented stages, according to several Digital Plan of Work, are:

- Strategic Definition
- Preparation and Brief
- Concept Design
- Developed Design
- Technical Design
- Construction
- Handover and close out
- In use
- Demolition



RIBA has listed several deliverables as follows:



	Key Objectives	BIM Objectives / Activities	Model	Level of detail
Strategic definition (stage 0)	- Business case - Strategic brief	- BIM implementation plan across project life cycle phases - Cost of implementation - BIM strategy	N/A	N/A
Preparation and brief (stage 0)	- Project objectives - Project outcomes - Sustainability goals - Project budget - Initial project brief - Feasibility studies - Site information	- Collect data for models - Identification of BIM manager and champions - BIM work plans - Responsibility matrix	Site model (optional)	Low
Concept design (stage 2)	- Concept design - Cost information - Project strategies - Final project brief	3D sketching and form generation - Massing - Spatial programming - Sustainability studies - Project budget - Identify key modelling elements - Existing conditions; e.g. as-built models (if any)	Concept design model(s)	Low
Developed design (stage 3)	- Developed design - Cost information - Project strategies	- Disciplinary models - Federated models - Time and cost dimensions - Sustainability information - Model extraction for design and analysis - Preliminary design coordination - Detailed modelling, integration and analysis	- Federated design model with links to disciplinary models 4D, 5D and 6D models - Design documentation	Medium to high
Technical design (stage 4)	- Technical design and specifications - Design responsibility matrix - Project strategies	- Disciplinary models - Federated models - Time and cost dimensions - Sustainability information - Model extraction for design and analysis - Project procurement documentation - Detailed design coordination	- Federated design model with links to disciplinary models 4D, 5D and 6D models - Specifications	High
Construction (stage 5)	Off-site manufacturing and on-site construction	- Phasing and prototyping - Quantity extraction - Specifications - Fabrication models - Contract administration - Collect as-built information	Federated construction model	High
Handover and close out (stage 6)	Handover of building	- As-built models - Validation and testing - Integration with facilities management systems	Federated asbuilt or record model	High
In use (stage 7)	Undertake in use	- Integration with building management system (BMS) - Integration with monitoring systems	Federated asbuilt or record model	High
Decommission (Stage 8)	Reuse / Recycle / Disposal	Performance Analysis / Simulation of Alternatives	Record Model	High

Figure 12 BIM and Project Life Cycle Matrix¹²

Step 4

RIBA has determined an equivalent between stages of BIM and stages of Nonbuilding projects as the following figure shows. The current theory intends to determine if a different method allows obtaining an accurate, reliable, and precise cost Estimate.

RIBA stage number	RIBA stages	Stage	Stages for non-building projects
0	Strategic definition	1	Initiation
1	Preparation and brief	2	Planning
2	Concept design		
3	Developed design	3	Design and procurement
4	Technical design		
5	Construction	4	Construction and handover
6	Handover and close out	5	Operation and maintenance
7	In Use		
8	Demobilization / Decommissioning	6	Demobilization / Decommissioning

Figure 13 Analogy between stages of BIM and stages of Nonbuilding Project¹³

The phase gate approach is a very well known method for owners that implement TCM, GPC, and GAO processes. Also, figure 10 shows the implementation of BIM. Under the phase gate approach, what are the advantages of BIM compare to others?

Observing the next figure with a traditional stage method for the best alternative for the owner to develop a project and influence in modifications with a low-cost impact.

¹² Royal Institution of Chartered Surveyors (RICS). (2016, November 4). International BIM Implementation Guide, 1st edition. Page 31. Retrieved January 5, 2019, from <https://www.rics.org/latin-america/upholding-professional-standards/sector-standards/construction/international-bim-implementation-guide/>

¹³ Royal Institution of Chartered Surveyors (RICS). (2016, November 4). International BIM Implementation Guide, 1st edition. Page 32. Retrieved January 5, 2019, from <https://www.rics.org/latin-america/upholding-professional-standards/sector-standards/construction/international-bim-implementation-guide/>

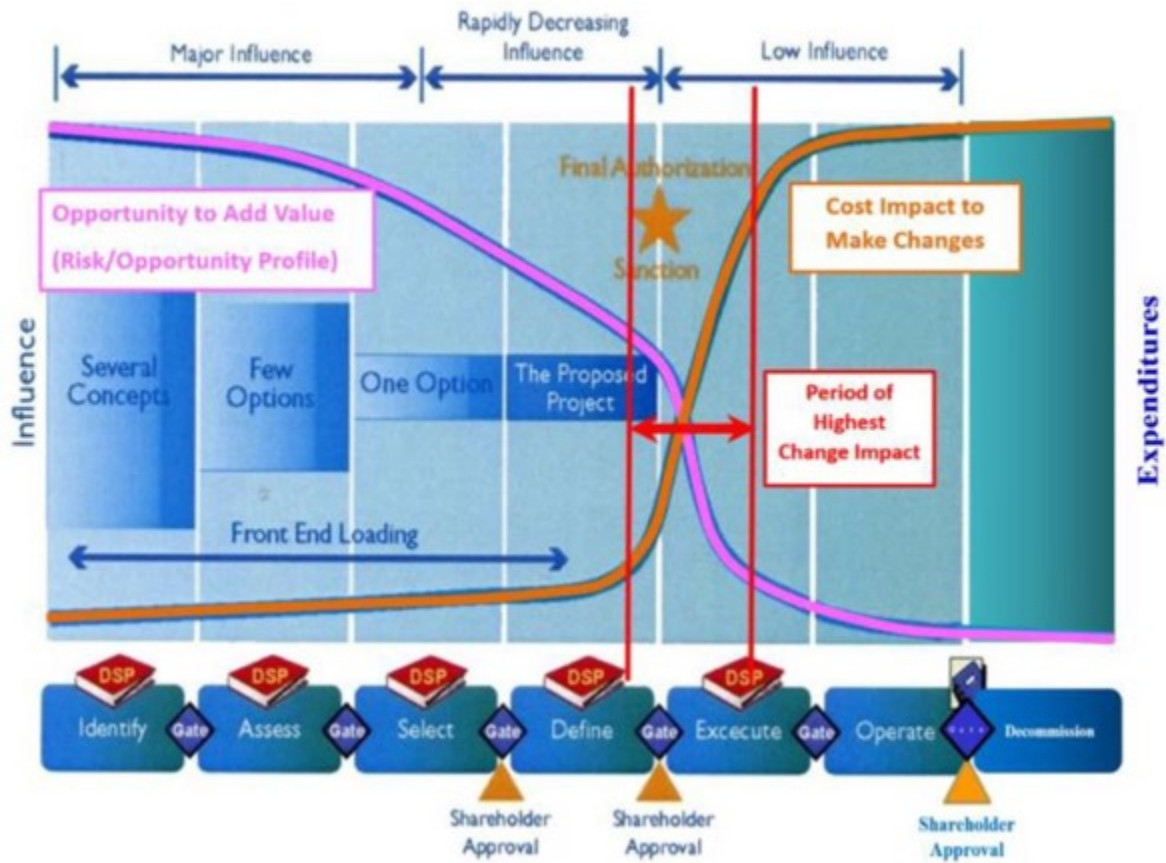


Figure 14 MacLeamy Curve¹⁴

BIM promotes the involvement in early stages of stakeholders based on Integrated Project Delivery (IPD) approach. Collaboration and participation in the early stages of the project is a significant differentiator against TCM, GPC, and GAO that use a traditional approach?

The following figure shows a Front-End Loading stage-gate approach and how an IPD and a typical Project Delivery method influence the changes in design to impact in developing the asset.

¹⁴ Guild of Project Controls. (2015, December 10). 10.3 Managing Change the Owner's Perspective Rev 1.01. Page 2 Retrieved September 15, 2018, from <http://www.planningplanet.com/guild/gpccar/managing-change-the-owners-perspective>

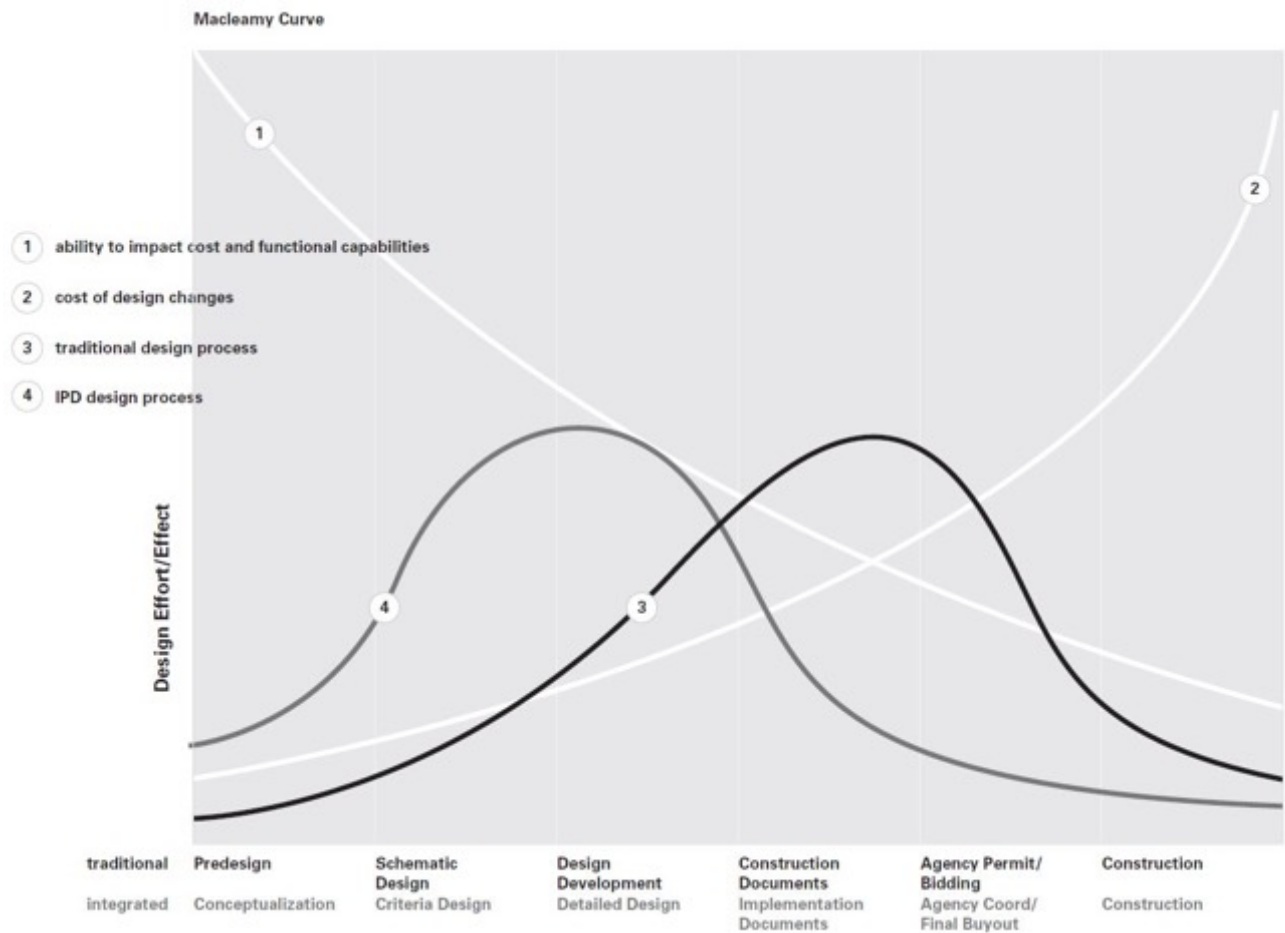


Figure 15 Front-End Loading and Project Delivery Approach.¹⁵

Have the efforts involved to produce a project cost Estimate at any stage, an influence in the cost Estimate prepared under BIM? Have a 5D BIM better accuracy than a cost Estimate made with a traditional process design?

FINDINGS-

Step 5

¹⁵ American Institute of Architects. (2007). Integrated Project Delivery: A Guide. Version 1. Page 21. Retrieved from <http://content.aia.org/sites/default/files/2017-02/Integrated%20Project%20Delivery%20Guide.pdf>

The following figure shows the early involvement of stakeholders. Besides, it shows a comparison between traditional project delivery and the IPD approach for the activities during the execution of each phase.

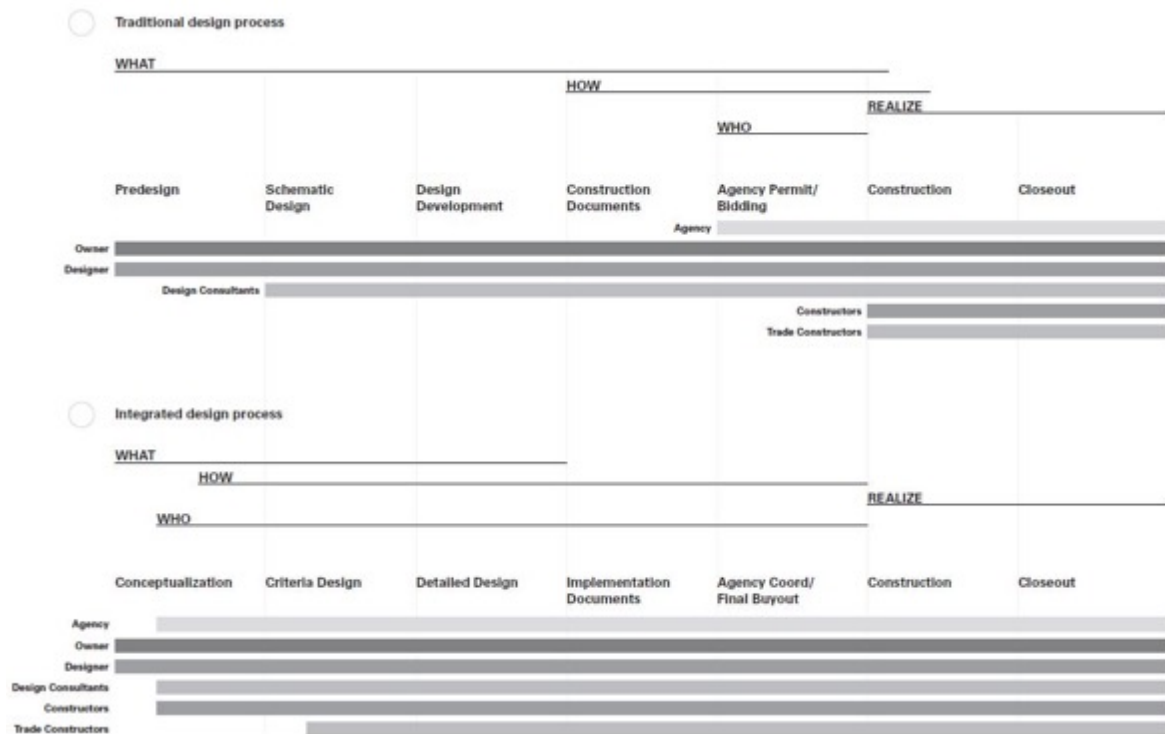


Figure 16 Integrated Design Process and Traditional Design Process¹⁶

The reader can observe that the integrated design process, according to the figure above, planning construction activities and accountability of responsibilities begin since the conceptualization phase. Besides, constructors participate in this phase. This early participation, the definition of how to construct and who do it, might have an impact on the factors that might affect a project cost Estimate.

For this reason, it is essential to assume the following:

- There is a Gate at each stage, for example, the end of Schematic Design (traditional design process) or Criteria Design (IPD process), where the design is approved to continue to the next phase.
- A cost Estimate is an outcome at the end of each stage. For example, at Schematic Design (traditional design process) corresponds a Level 2 of Estimate Class according to GPC or Estimate Class 4 according to AACE International. See figure of equivalent Classes of Estimate below.

¹⁶ American Institute of Architects. (2007). Integrated Project Delivery: A Guide. Version 1. Page 22. Retrieved from <http://content.aia.org/sites/default/files/2017-02/Integrated%20Project%20Delivery%20Guide.pdf>

	Guild of Project Controls	AACE Current	ANZI Z94.0 (PMI)	AACE (Pre-1972)	Association of Cost Engineers (AcostE) UK	Norwegian Project Management Association	American Society of Professional Estimators (ASPE)
	Level 1	Class 5	Order of Magnitude ('-30% to + 50%)	Order of Magnitude	Order of Magnitude Estimate Class IV ('-30% to + 30%)	Concession Estimate Exploration Estimate Feasibility Estimate	Level 1
	Level 2	Class 4	Budget Estimate ('-15% to +30%)	Study Estimate	Study Estimate Class III ('-20% to + 20%)	Authorizaton Estimate	Level 2
	Level 3	Class 3		Preliminary Estimate	Budget Estimate Class II ('-10% to + 10%)	Master Control Estimate	Level 3
	Level 4	Class 2	Definitive Estimate ('-5% to +15%)	Definitive Estimate	Definitive Estimate Class I ('-5% to + 5%)	Current Control Estimate	Level 4
	Level 5	Class 1		Detailed Estimate			Level 5 Level 6

Figure 17 Levels of Cost Estimates¹⁷

- The detail reached for each cost Estimate is based on the recommendations from AACE, GPC, GAO, and BIM. In all cases, there is a link among the level of detail of scope definition, the WBS and Schedule. The following table shows the level of detail recommended by AACE, GPC, and GAO.

	GPC	GAO	AACE
Scope Definition	1%-15%	1%-15%	1%-15%
WBS	Reporting Elements	Reporting Elements	Project Areas
Schedule	Reporting Elements	Reporting Elements	High Level to identify project areas

Figure 18 Level of Detail of Deliverables¹⁸

The Criteria Design stage from AIA is the equivalent to Developed Design for RIBA, and it has the following process:

¹⁷ Guild of Project Controls. (2015, October 03). 08.01 Introduction to Managing Cost Estimating Budgeting Rev 1.03. Retrieved September 15, 2018, from <http://www.planningplanet.com/guild/gpccar/introduction-to-managing-cost-estimating-budgeting>

¹⁸ By Author

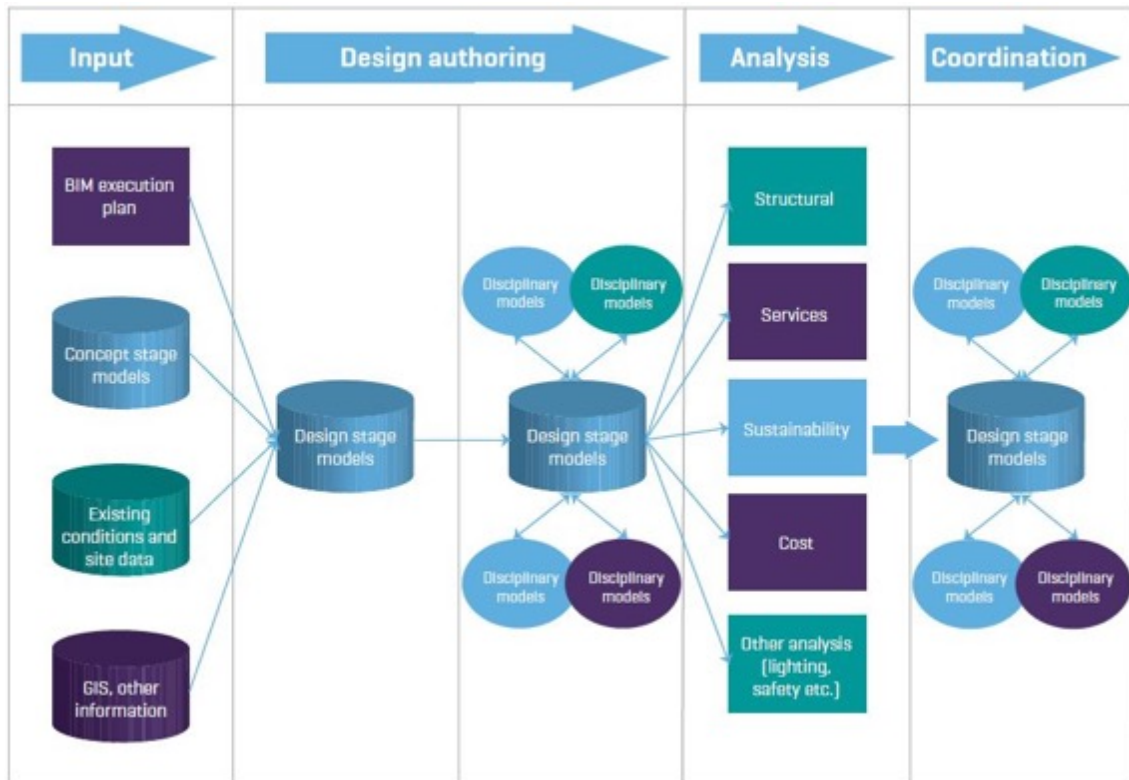


Figure 19 Developed design-stage workflow using BIM¹⁹

The workflow above shows as a deliverable for analysis, a Cost Estimate. Areas, volumes, and quantities exist, and it can be an input to elaborate a project cost Estimate.

What is the accuracy range of the Estimate as each stage, according to BIM? The author has not found an accuracy range for each cost Estimate at each stage developed by any institution.

The following chart shows a simulation of the accuracy range comparing against GPC and AACE.

To elaborate the chart for determining the range of precision for BIM we started assuming the following parameters based on GPC's ranges of accuracy:

- BIM Simulation 1- Phase 4 = +5% to -5%. Phase 3 = +15% to -5% Phase 2 = +30% to -10%, Phase 1 = +60% to -15%
- BIM Simulation 2- Phase 3 = +5% to -5%. Phase 2 = +15% to -5% Phase 1 = +30% to -10%,

¹⁹ Royal Institution of Chartered Surveyors (RICS). (2016, November 4). International BIM Implementation Guide, 1st edition. Page 37. Retrieved January 5, 2019, from <https://www.rics.org/latin-america/upholding-professional-standards/sector-standards/construction/international-bim-implementation-guide/>

For GPC and AACE we have used the following accuracy ranges:

GPC²⁰

Phase 5	100%	-20%
Phase 4	60%	-15%
Phase 3	30%	-10%
Phase 2	15%	-5%
Phase 1	5%	-5%

AACE²¹

Class 5	50%	-20%
Class 4	30%	-10%
Class 3	20%	-5%
Class 2	15%	-5%
Class 1	10%	-3%



²⁰ Guild of Project Controls. (2015, October 03). 08.01 Introduction to Managing Cost Estimating Budgeting Rev 1.03. Retrieved September 15, 2018, from <http://www.planningplanet.com/guild/gpccar/introduction-to-managing-cost-estimating-budgeting>

²¹ 56R-08.73 Recommended Practice. Rev. December 05, 2012. Cost Estimate Classification System – As applied for the Building and General Construction Industries. Page 3. AACE International, Morgantown, WV.

Figure 20 Precision of Classes of Cost Estimates²²

What would be the accuracy of cost Estimates elaborated with BIM?

If a 5D BIM has better accuracy range than a traditional Cost Estimate, it is necessary to collect information made with BIM, then add them in Figure 19 and determine if they meet accuracy ranges according to BIM simulations.

If the 5D BIM outcome locates among the ranges of BIM Simulation 1 or BIM Simulation 2 of Figure 19, it supports the theory that BIM methodology produces a better Estimate than a traditional estimating process.

Step 6

Theoretically, the involvement in the early stages of constructors in developing the alternatives should help to define a better scope. A better scope definition would lead to establishing a better WBS and then it influences the development of a detailed model where it produces a list of quantities, and then add cost. By consequence, a Cost Estimate would have a medium and high level of detail required during each BIM stage, which should be higher than a traditional Cost Estimate.

AIA defines that a Criteria Design stage should produce a finalized outcome, such as:

Scope

Form, adjacencies and spatial relationships

Selection and initial design of major building systems (structure, skin, HVAC and other disciplines)

Cost Estimate (at proper precision)

Schedule (at appropriate precision)

With the level of detail reached, BIM might offer a better process to produce a better Cost Estimate.

CONCLUSIONS-

An IPD approach might help to develop a higher level of detail of the model. Then it leads to a better scope definition and by consequence, better detail when elaborating the list of take-off items of the future asset.

5D BIM outcomes collected and added to Figure 19 would have supported the following:

²² By Author



- Determine if the participation in the early stages of the design process might help to define the scope and then produce a better cost Estimate.
- That IPD approach is better than a traditional approach.
- To determine that 5D BIM is a reliable, accurate, and precise outcome.

As information was not collected to demonstrate the goals of the current research, it is recommended to gather information to assess real data from building and nonbuilding projects.

FOLLOW ON RESEARCH-

In case the reader wants to share information and see if a 5D BIM produced for any project, can validate the theory proposed in the current document, send an email to piero.anticon@gmail.com with the following information:

- Sector or Industry:
- Project Type:
- Stage of Design:
- Level of Development of the Model:
- Cost Estimate:



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