

## **Does BIM offer a better approach to guarantee a reliable, accurate, and precise Cost Estimate?<sup>1</sup>**

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### **ABSTRACT**

Building Information Modeling (BIM) uses an Integrated Project Delivery (IPD) approach, a collaborative and participative method with stakeholders in early stages of the project; this should be a significant differentiator comparing with TCM, GPC, and GAO which use a traditional Project Delivery approach.

It is necessary at each stage to deliver a document or file with a level of detail according to the development of the model. 5D BIM is one of the deliverables that contains the cost of the resources required to execute the activities and install or produce the project quantities for each component of the model.

Has BIM a better process to define the scope and produce a better cost Estimate than a traditional method for estimating and budgeting?

Can BIM offer a better approach to guarantee a reliable, accurate, and precise cost Estimate?

The current document will:

- 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.

**Keywords:** Cost Estimate, Budgeting, Project Estimates, Building Information Modelling, 5D BIM, Integrated Project Delivery, Front-End Loading.

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## INTRODUCTION

Most of the companies worldwide have adopted the traditional approach for acquiring, created, update, maintain, expand and eventually dispose of organisational assets that consist on the gate approach where the sequential planning that has inputs, activities, deliverables, closing activities, and milestones on early stages that result in the success of the project.

A traditional planning approach defines the activities to do the work and predicts what the time should take, and the cost should be to complete these activities. This Front End Development approach should begin before the engineering design /EPC phase.

The academic community and the private industry have evidenced that the most critical decisions are made by the business decision-makers long before the design and construction stages start. For example, Independent Project Analysis, Inc. (IPA), Construction Industry Institute (CII), Shell, Anglo-American Mining, Saudi Aramco, and Chevron are part of organizations which have evidenced this idea.

The following figure shows different stage-gating processes for the planning approach.

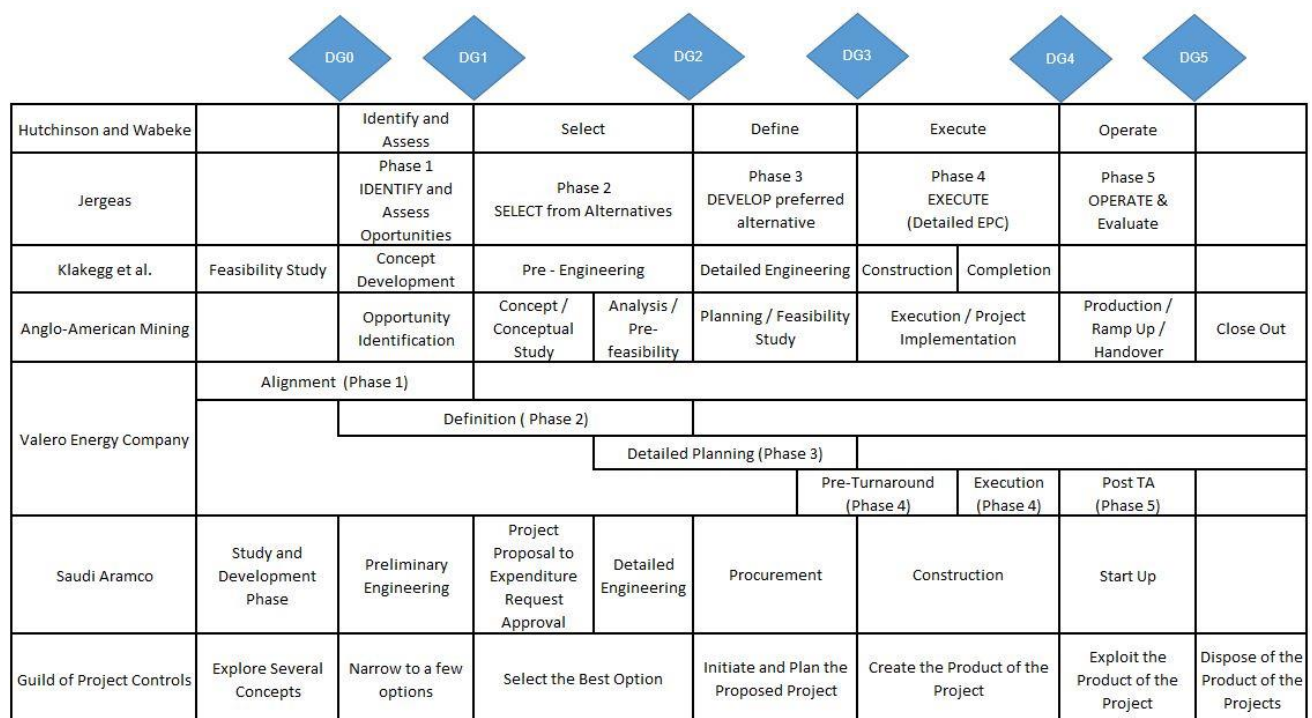


Figure 1 Multi-Stages for Decision Gate Approach<sup>2</sup>

Besides, there are other approaches to assess the effort to plan. The most known processes are Front-End Loading (FEL) and Project Definition Rating Index (PDRI).

<sup>2</sup> By Author

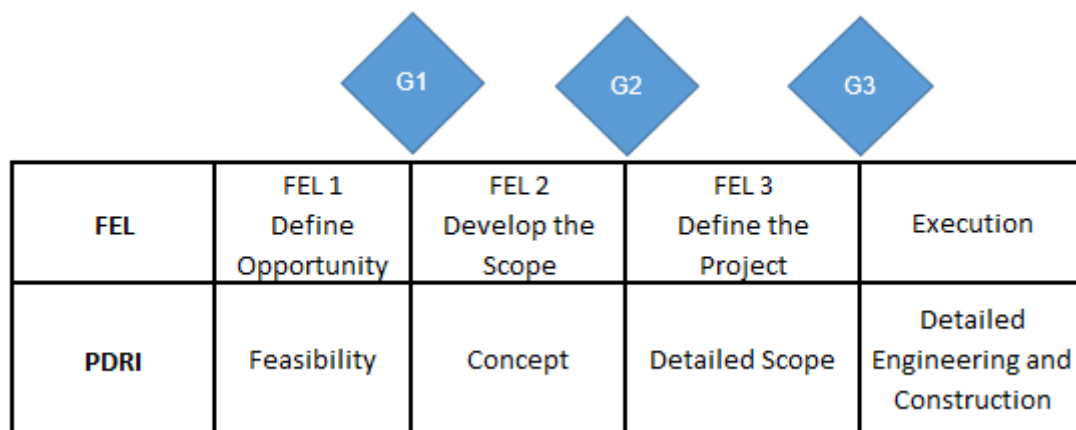


Figure 2 Front End Loading (FEL) and Project Definition Rate Index (PDRI) processes<sup>3</sup>

Despite the implementation of several Front End Development approaches, projects still have cost overruns. Some factors of overruns are wrong Estimates, poor project definition; the initial BOE did not include final costs incurred, unsettle requirements during quotation phase, Project Complexity, Type of Ownership, and other factors.

What are the factors that influence in a Wrong Estimate?

- Poor scope definition.
- Estimates are biased with over-optimism.
- Inaccurate initial Estimates contain overall cost and schedule. It reflects technology development to accomplish the original work scope.
- Ratios and Unit Prices require to be updated
- Estimates changes with the phase of the development of the asset
- Escalation indexes do not reflect actual costs
- Unexperienced Estimator
- Bad calculation of Contingency or
- A contingency is not allowed.

Why do project teams obtain a poor scope definition?

Most of the cases, according to Glen Butts from NASA, there is an Omission of scope that becomes real and unrealistic or optimistic assumptions.

According to MacLeamy, the implementation of changes in the first stages of the project regarding the scope of the project has a low-cost impact. The MacLeamy curve shows how the

<sup>3</sup> By Author

effect of changes influences the cost of those implementations, notably, in the early stages of a project.

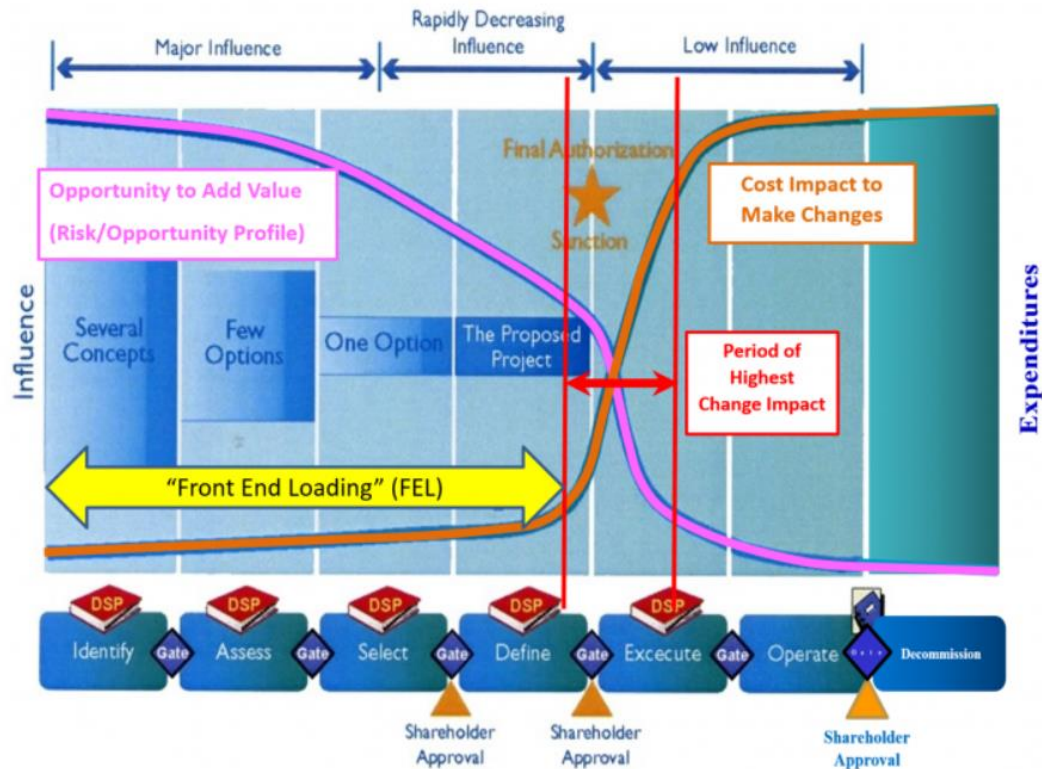


Figure 3 MacLeamy Curve with Front End Loading process<sup>4</sup>

Integrated Project Delivery is a concept from The American Institute of Architects (AIA) which intends to improve the interaction among stakeholders, systems, business structures, and practices into a process that improves collaboration among owners, contractors, and designers. Also, it helps to reduce waste and improve efficiency during all phases of design, fabrication, construction, and decommissioning.

It suggests moving decisions upstream where they are more effective and less costly, as shown in Figure 4. This redefinition of phases has two key aspects: the early involvement with inputs from contractors, installers, fabricators, and suppliers; and also designers; and the ability to model and simulate the project using BIM tools. The result is a design with a high level of completion before the documentation for construction starts.

<sup>4</sup> Guild of Project Controls. (2015, December 10). 10.3 Managing Change the Owner's Perspective Rev 1.01. Page 7 Retrieved September 15, 2018, from <http://www.planningplanet.com/guild/gpccar/managing-change-the-owners-perspective>

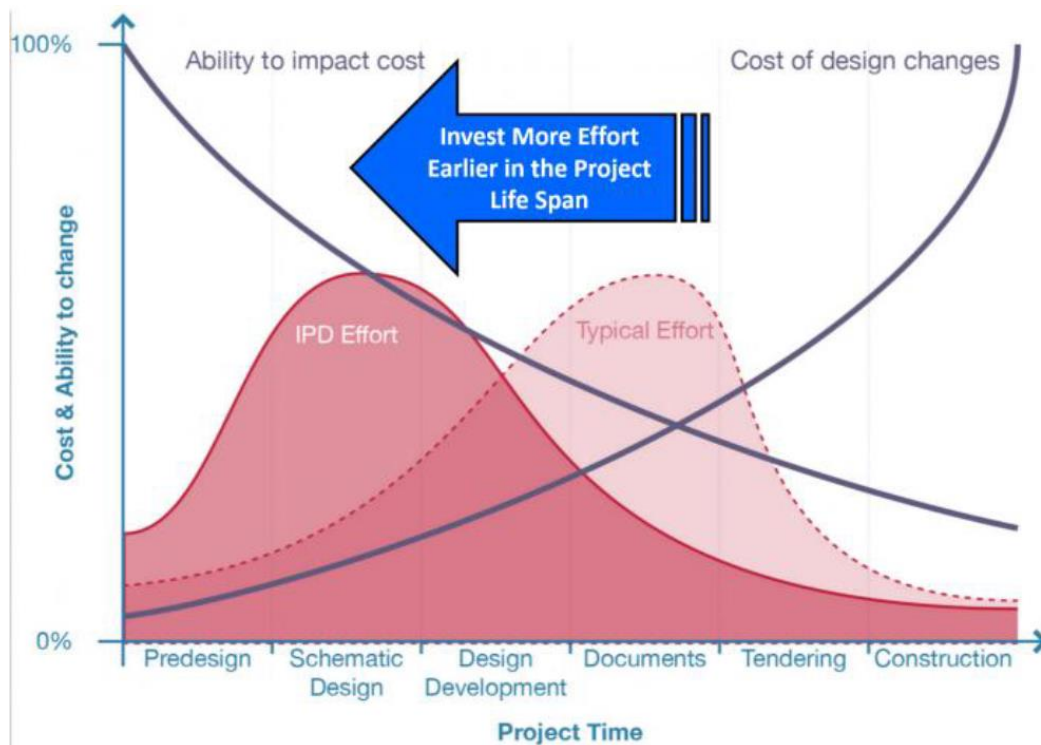


Figure 4 Left Shift of Front End Loading<sup>5</sup>

Building Information Modelling (BIM) has adopted this concept to implement these processes and involve in early stages all the stakeholders under collaborative platforms to improve collaboration, communication, and coordination among all participants.

BIM has had an impact on:

1. Professionals, Projects, Firms, and Industries
2. Involvement of Major Stakeholders in the life cycle of the project
3. The operating system of the project environment. E.g., Technology, Work Practices, Processes, Legal, Commercial.
4. Project Delivery. It affects all the processes.

The benefits of BIM are listed but not limited to:

1. Improvements of overlaps among design, construction, and operations.
2. Enhance analytic power of risk, procurement, and asset management functions.
3. Reduction of waste. A more sustainable environment.

<sup>5</sup> Guild of Project Controls. (2015, December 10). 10.3 Managing Change the Owner's Perspective Rev 1.01. Page 4 Retrieved September 15, 2018, from <http://www.planningplanet.com/guild/gpccar/managing-change-the-owners-perspective>

4. Enhance collaboration, coordination, and communication
5. Information can be anywhere at any time.
6. Product-oriented. It is more relevant knowledge than skills
7. Facility Management process is more integrated and automated
8. Optimization of Procurement and Contracts activities
9. Standardization of methods and systems to increase profitability
10. Facilitator of new technologies such as digital fabrication, cloud computing, big data, and other tools.
11. Smart cities concept
12. Create new business opportunities

BIM covers different stages of the life cycle of an asset. Companies require to reach a maturity level for implementing BIM, not only to design the 3D model but also for collecting, for coordinating and for communicating all the information to all stakeholders during the life cycle of the asset.

It is necessary at each stage to deliver a document or file with a level of detail according to the development of the model. 5D is one of the deliverables that contains the cost of the resources required to execute the activities and install or produce the project quantities for each component of the model.

Most of the Estimates use the traditional approach for estimating and budgeting.

Has BIM a better process to define the scope and produce a better cost Estimate than a traditional method for estimating and budgeting?

Can BIM offer a better approach to guarantee a reliable, accurate, and precise cost Estimate?

The current document will:

- 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.
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## **METHODOLOGY**

### **Step 1**

Building Information Modeling is a method that not only develops a 3D model. It uses the data elaborated to communicate, collaborate, and interact among different stakeholders during design, construction, operation, and decommissioning stages. Building projects and nonbuilding





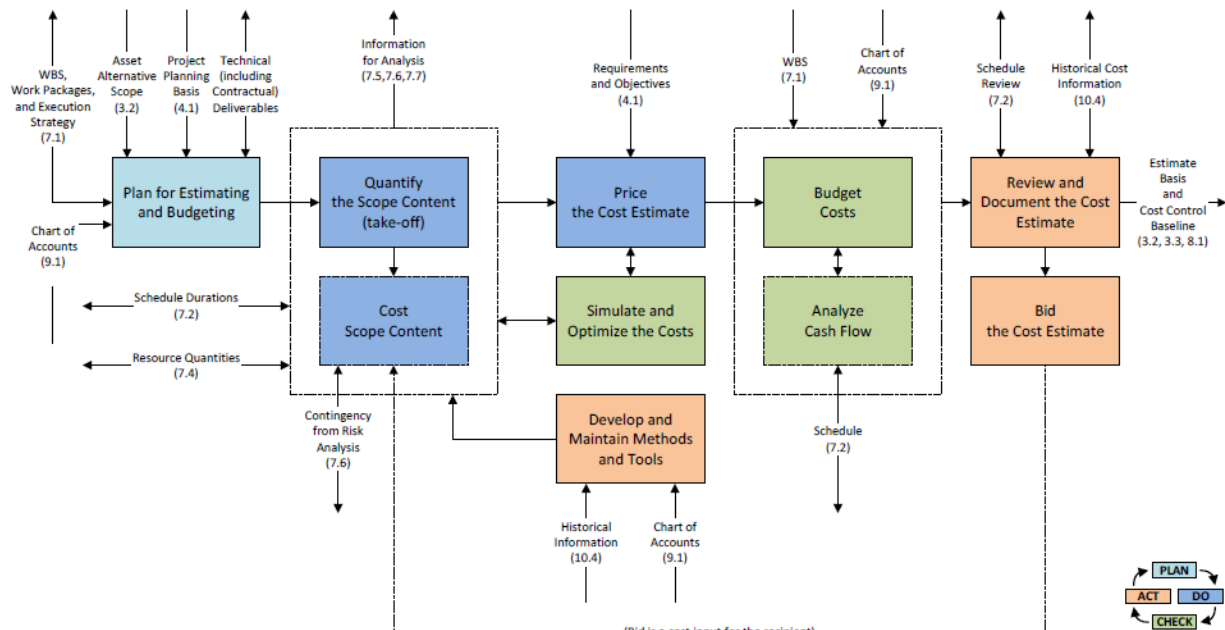


Figure 6 Process Map for Cost Estimating and Budgeting<sup>7</sup>

### 3. Government Accountability Office suggests the following Cost Estimating Process:

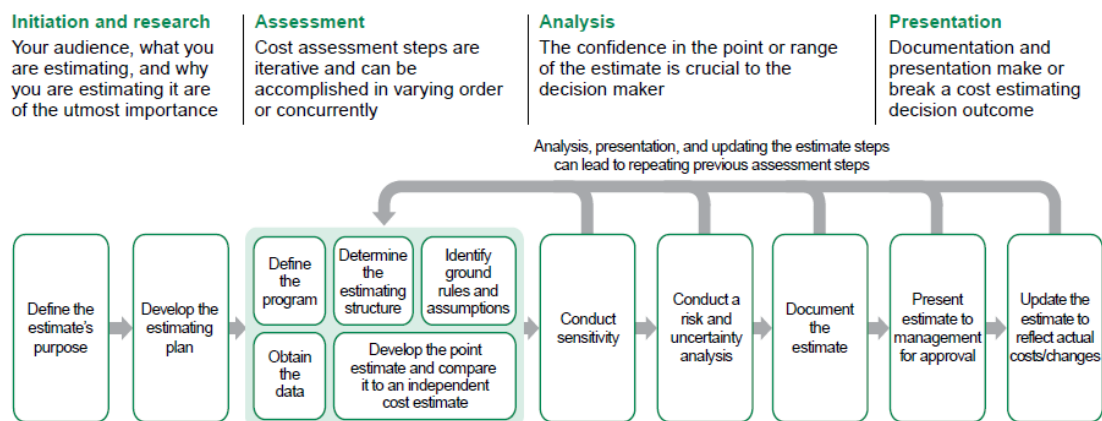


Figure 7 Cost Estimating Process<sup>8</sup>

### 4. Building Information Modelling or BIM is a method that uses technology, improve work practices and processes, for the construction of any building and nonbuilding project. The following figure shows different stages of the life cycle of an asset.

<sup>7</sup> H. Lance Stephenson. (2015). Total cost management framework: An Integrated Approach to Portfolio, Program, and Project Management (2nd ed.). Morgantown, WV: AACE International. Page 176

<sup>8</sup> GAO Cost Estimating and Assessment Guide- Best Practices for Developing and Managing Capital Program Costs. Page 8



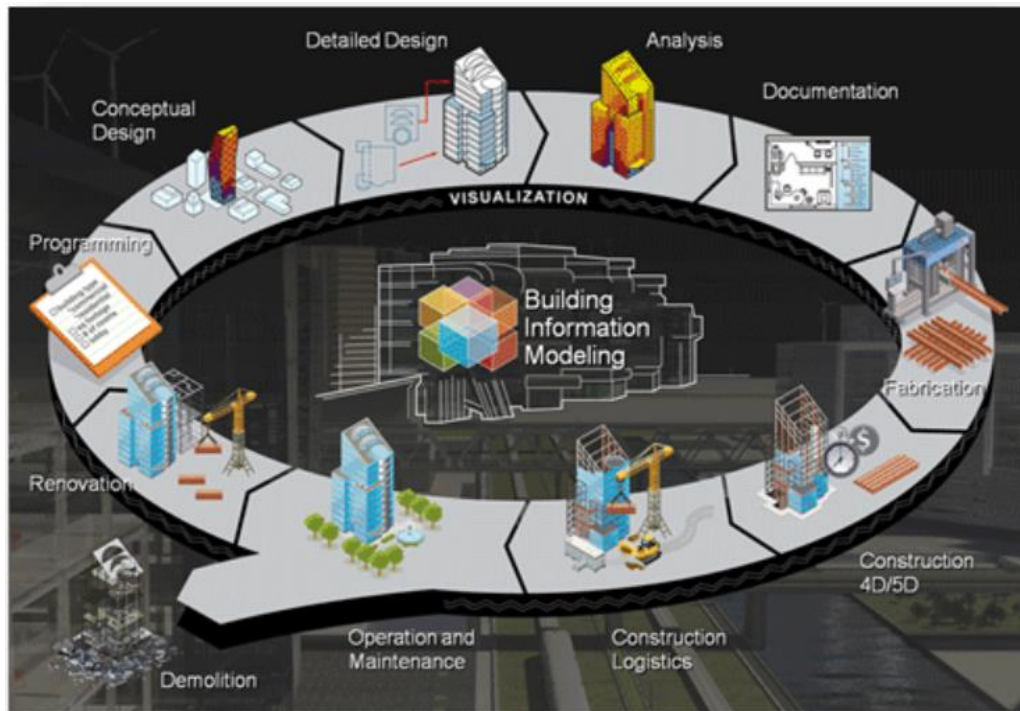


Figure 8 BIM Workflow<sup>9</sup>

All companies require to reach a maturity level for implementing BIM. It not only produces 3D models but also gathers, coordinates, and communicates all the information in a Common Data Environment (CDE) with all stakeholders through the life cycle of the asset. The goal is to reach level two and three of maturity, as observed in the following figure:

<sup>9</sup> The BIM hub. (2015, April 8). #BIM: Bringing a 'sea change to the industry's workflow?. Retrieved April 23, 2019, from <https://thebimhub.com/2015/04/08/bim-bringing-a-sea-change-to-the-industrys-workflo>

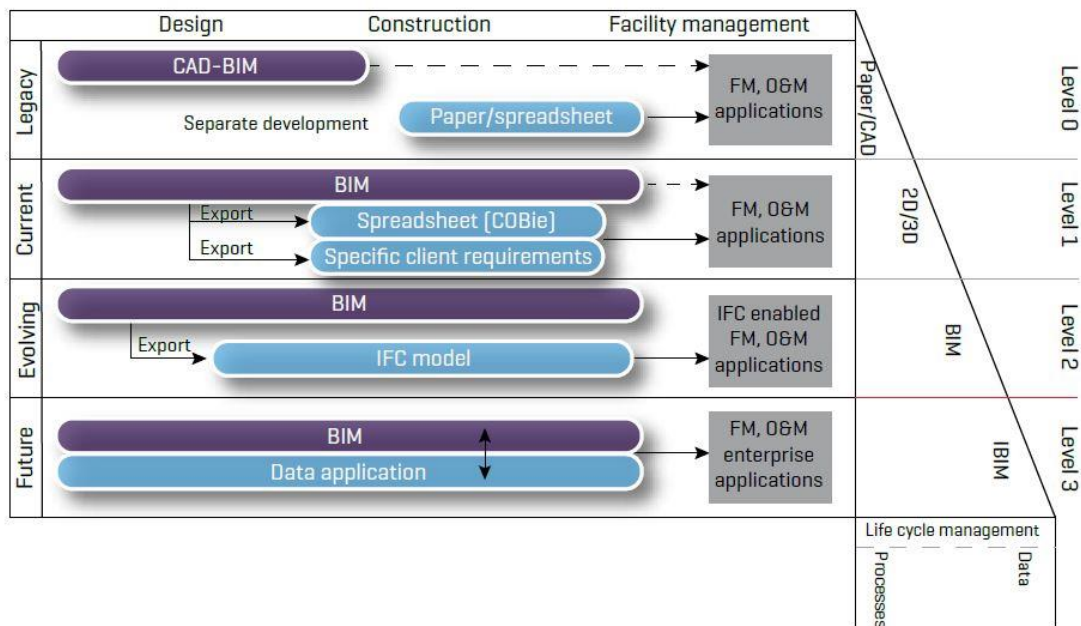


Figure 9 Facility Manager and Maturity Levels from Bew and Richards<sup>10</sup>

Several institutes have elaborated execution plans for BIM to promote best practices. They include the following:

- I. Goals to set expectation levels for all stakeholders
- II. Roles and responsibilities for all project team members
- III. An overall BIM strategy, including procurement and project delivery
- IV. A BIM process and exchange protocols for all team members
- V. Data requirements at different stages of the project
- VI. Elaboration of procedures for collaboration and methods to handle shared models
- VII. Quality control of models; and
- VIII. Technology infrastructure and software required for implementation.

Some execution plans are listed below:

1. Penn State University's BIM execution planning guide version 2.0
2. The US Department of Veterans Affairs - The VA BIM guide
3. The Building and Construction Authority from Singapore - BIM guide: version 2.0

<sup>10</sup> Royal Institution of Chartered Surveyors (RICS). (2016, November 4). International BIM Implementation Guide, 1st edition. Page 62. Retrieved January 5, 2019, from <https://www.rics.org/latin-america/upholding-professional-standards/sector-standards/construction/international-bim-implementation-guide/>

4. CPIx (UK) - BIM execution plan
5. BIM protocol by the CIC (Construction Institute Council)/BIM Pro)

A Digital Plan of Work is attached to those plans such as:

1. Royal Institute of British Architects (RIBA) - Plan of work 2013.
2. BIM task group. Digital Plan of Work (PAS 1192-2).
3. Building Information Modelling from AIA and Digital Data Exhibits.
4. Digital Plan of Work from the UK Government.

Also, these plans help to define the key objectives, BIM activities, type of model, and the level of development (LOD) to obtain the following:

- I. To elaborate a conceptual design or a planning stage of a project
- II. To analyze and to enhance the profitability of the project looking for efficiencies in time, cost and sustainability-related
- III. To manage documentation, procurement and pre-construction planning activities
- IV. To conduct the construction process and commissioning
- V. To support the operation and maintenance phase
- VI. Also to retrofit and demolition

The following figure shows an information delivery cycle from BSI - PAS 1192-2:

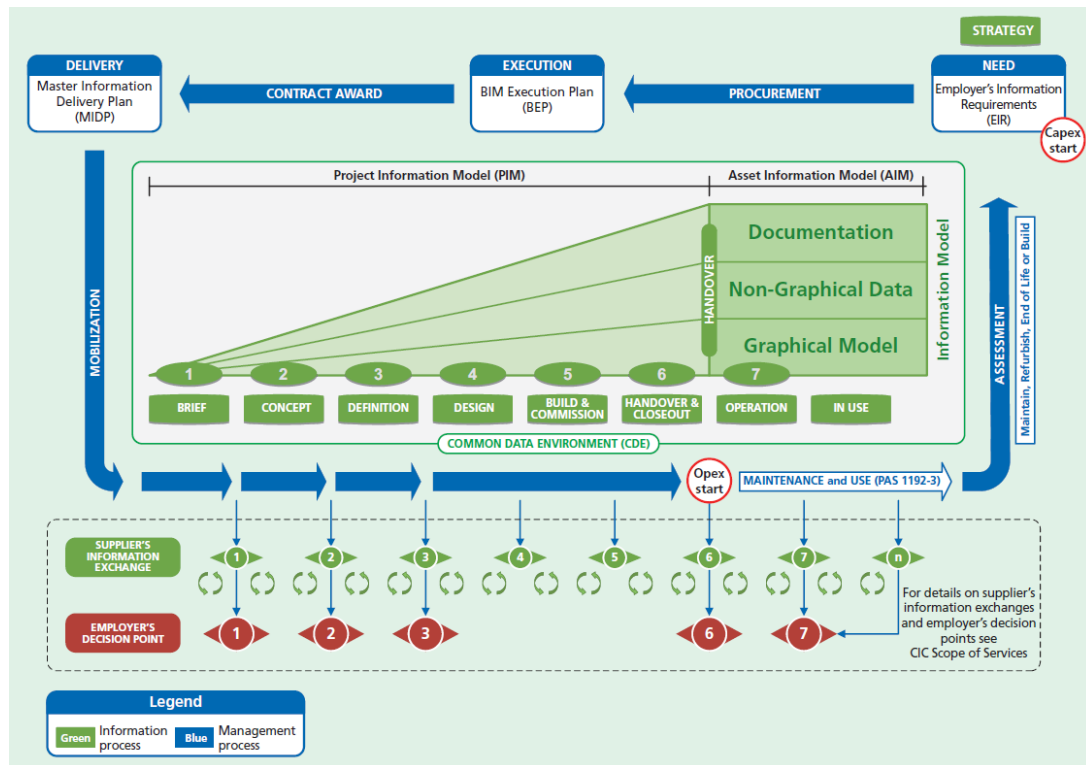


Figure 10 Information delivery cycle<sup>11</sup>

The information is under a Common Data Environment (CDE) through the phases of asset development. There is a simple workflow for a project cost Estimate that summarises all the process:

<sup>11</sup> British Standard Institution. (2013, March 28). Publicly Available Specifications (PAS) 1192-2. Standards | BIM Level 2. Page 8 .Retrieved January 5, 2019, from <https://bim-level2.org/standards>

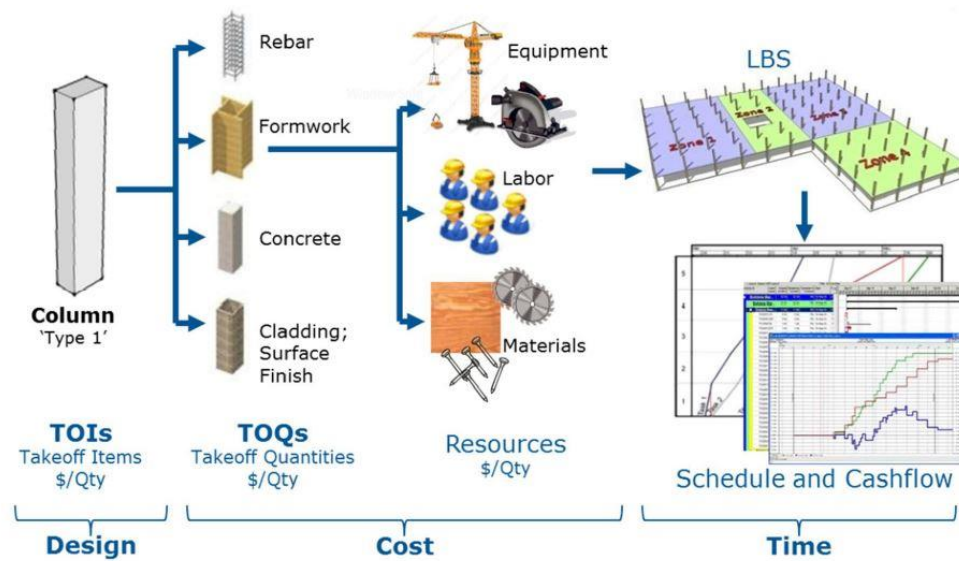


Figure 11 5D Workflow<sup>12</sup>

This simple workflow applies to each phase; what is different is the Level of Development (LOD) of the model required for each stage.

### Step 3

GPC has the following list of processes to elaborate a project Cost Estimate:

1. GPC
  - Cost Estimating and Budgeting Overview
  - Elaborate a Cost Estimating and Budgeting Policies and Procedures Manual
  - Describe the Estimate Purpose and Scope of Work (Owner)
  - Establish a Top-Down Cost Estimate (Owner)
  - Describe the Estimates Purpose and Scope of Work (Contractor)
  - Elaborating Bottom-Up Project Estimate (Contractor) (ABC)
  - Validation of the Trade-Offs
  - Validation of Traceability of Costs (Horizontal and Vertical)
  - Elaboration of a Cost Risk Analysis
  - Baseline and Communication of the Loaded Cost Schedule

<sup>12</sup> Trimble Vico Office. (2011, March 8). The Vico Office 5D BIM Workflow.wmv [Video file]. Retrieved from [https://www.youtube.com/watch?v=gdacRTap5\\_Y](https://www.youtube.com/watch?v=gdacRTap5_Y)

- Capturing Progress and Updating Schedule
- Assessing Progress
- Forecast of Project Performance
  
- 2. AACE International - Total Cost Management
  - Elaboration of Estimating and Budgeting Plan
  - Quantification of the Scope (take-off)
  - Adding Cost to Scope
  - Pricing the Project Estimate
  - Simulation and Optimization of the Estimate
  - Budgeting Project Estimate
  - Analyzing Cash Flow
  - Revision and Documentation of the Estimate
  - Bidding the Final Project Cost Estimate
  - Elaborate Methods and Tools
  
- 3. GAO
  - Describe Estimate Purpose
  - Establish Estimating plan
  - Describe program characteristics
  - 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
<b>Strategic definition (stage 0)</b>	<ul style="list-style-type: none"> <li>• Business case</li> <li>• Strategic brief</li> </ul>	<ul style="list-style-type: none"> <li>• BIM implementation plan across project life cycle phases</li> <li>• Cost of implementation</li> <li>• BIM strategy</li> </ul>	N/A	N/A
<b>Preparation and brief (stage 0)</b>	<ul style="list-style-type: none"> <li>• Project objectives</li> <li>• Project outcomes</li> <li>• Sustainability goals</li> <li>• Project budget</li> <li>• Initial project brief</li> <li>• Feasibility studies</li> <li>• Site information</li> </ul>	<ul style="list-style-type: none"> <li>• Collect data for models</li> <li>• Identification of BIM manager and champions</li> <li>• BIM work plans</li> <li>• Responsibility matrix</li> </ul>	Site model (optional)	Low
<b>Concept design (stage 2)</b>	<ul style="list-style-type: none"> <li>• Concept design</li> <li>• Cost information</li> <li>• Project strategies</li> <li>• Final project brief</li> </ul>	<ul style="list-style-type: none"> <li>• 3D sketching and form generation</li> <li>• Massing</li> <li>• Spatial programming</li> <li>• Sustainability studies</li> <li>• Project budget</li> <li>• Identify key modelling elements</li> <li>• Existing conditions; e.g. as-built models (if any)</li> </ul>	Concept design model(s)	Low
<b>Developed design (stage 3)</b>	<ul style="list-style-type: none"> <li>• Developed design</li> <li>• Cost information</li> <li>• Project strategies</li> </ul>	<ul style="list-style-type: none"> <li>• Disciplinary models</li> <li>• Federated models</li> <li>• Time and cost dimensions</li> <li>• Sustainability information</li> <li>• Model extraction for design and analysis</li> <li>• Preliminary design coordination</li> <li>• Detailed modelling, integration and analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Federated design model with links to disciplinary models</li> <li>• 4D, 5D and 6D models</li> <li>• Design documentation</li> </ul>	Medium to high
<b>Technical design (stage 4)</b>	<ul style="list-style-type: none"> <li>• Technical design and specifications</li> <li>• Design responsibility matrix</li> <li>• Project strategies</li> </ul>	<ul style="list-style-type: none"> <li>• Disciplinary models</li> <li>• Federated models</li> <li>• Time and cost dimensions</li> <li>• Sustainability information</li> <li>• Model extraction for design and analysis</li> <li>• Project procurement documentation</li> <li>• Detailed design coordination</li> </ul>	<ul style="list-style-type: none"> <li>• Federated design model with links to disciplinary models</li> <li>• 4D, 5D and 6D models</li> <li>• Specifications</li> </ul>	High
<b>Construction (stage 5)</b>	<ul style="list-style-type: none"> <li>• Off-site manufacturing and on-site construction</li> </ul>	<ul style="list-style-type: none"> <li>• Phasing and prototyping</li> <li>• Quantity extraction</li> <li>• Specifications</li> <li>• Fabrication models</li> <li>• Contract administration</li> <li>• Collect as-built information</li> </ul>	Federated construction model	High
<b>Handover and close out (stage 6)</b>	<ul style="list-style-type: none"> <li>• Handover of building</li> </ul>	<ul style="list-style-type: none"> <li>• As-built models</li> <li>• Validation and testing</li> <li>• Integration with facilities management systems</li> </ul>	Federated asbuilt or record model	High
<b>In use (stage 7)</b>	<ul style="list-style-type: none"> <li>• Undertake in use</li> </ul>	<ul style="list-style-type: none"> <li>• Integration with building management system (BMS)</li> <li>• Integration with monitoring systems</li> </ul>	Federated asbuilt or record model	High
<b>Decommission (Stage 8)</b>	<ul style="list-style-type: none"> <li>• Reuse / Recycle / Disposal</li> </ul>	<ul style="list-style-type: none"> <li>• Performance Analysis / Simulation of Alternatives</li> </ul>	Record Model	High

Figure 12 BIM and Project Life Cycle Matrix<sup>13</sup>

## 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

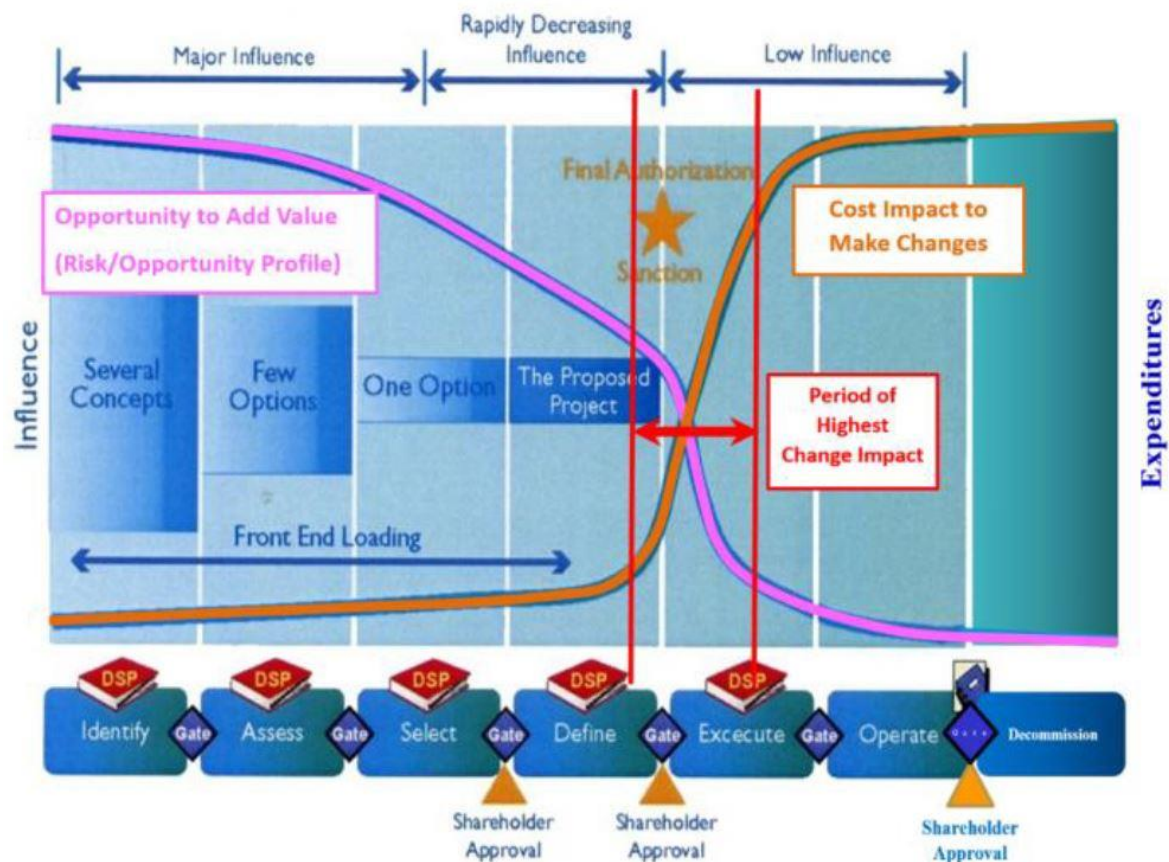
Figure 13 Analogy between stages of BIM and stages of Nonbuilding Project<sup>14</sup>

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.

<sup>13</sup> 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/>

<sup>14</sup> 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 Curve<sup>15</sup>

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.

<sup>15</sup> 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>

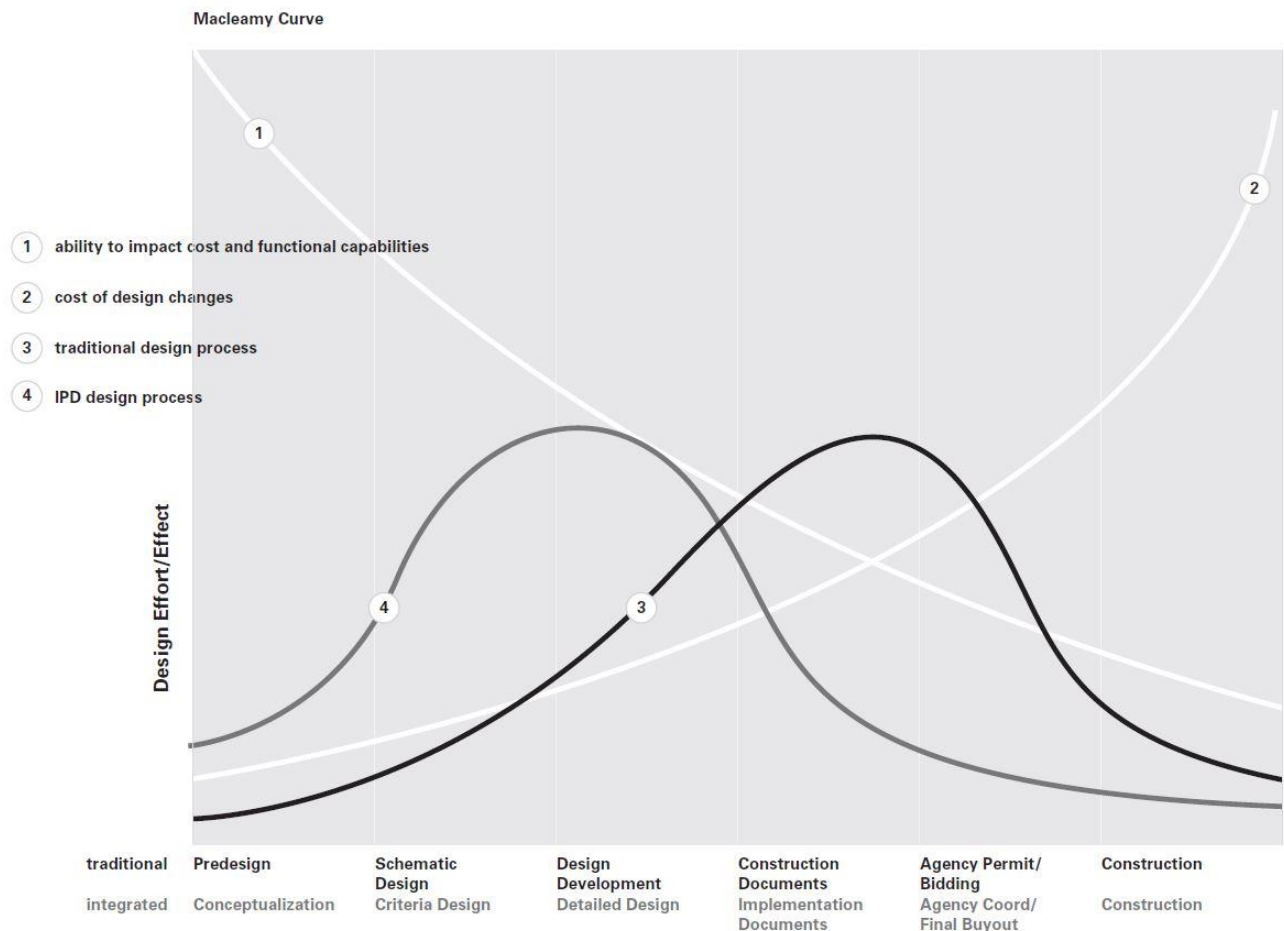


Figure 15 Front-End Loading and Project Delivery Approach.<sup>16</sup>

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

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.

<sup>16</sup> 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>



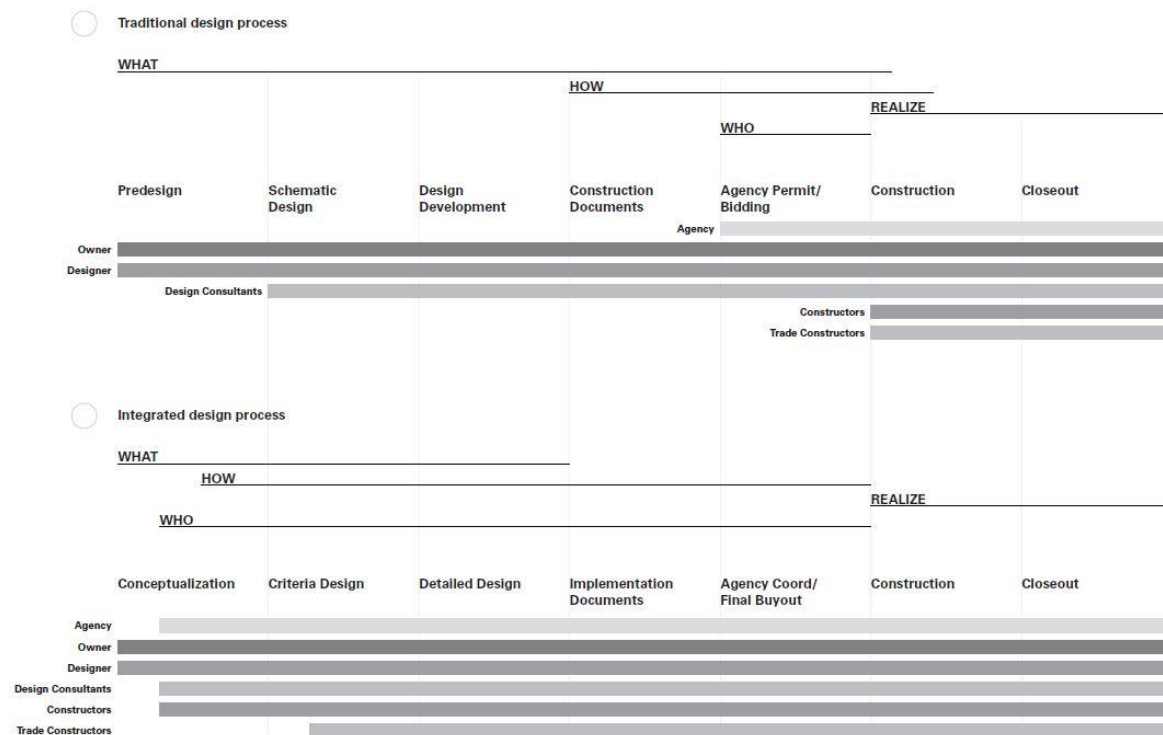


Figure 16 Integrated Design Process and Traditional Design Process<sup>17</sup>

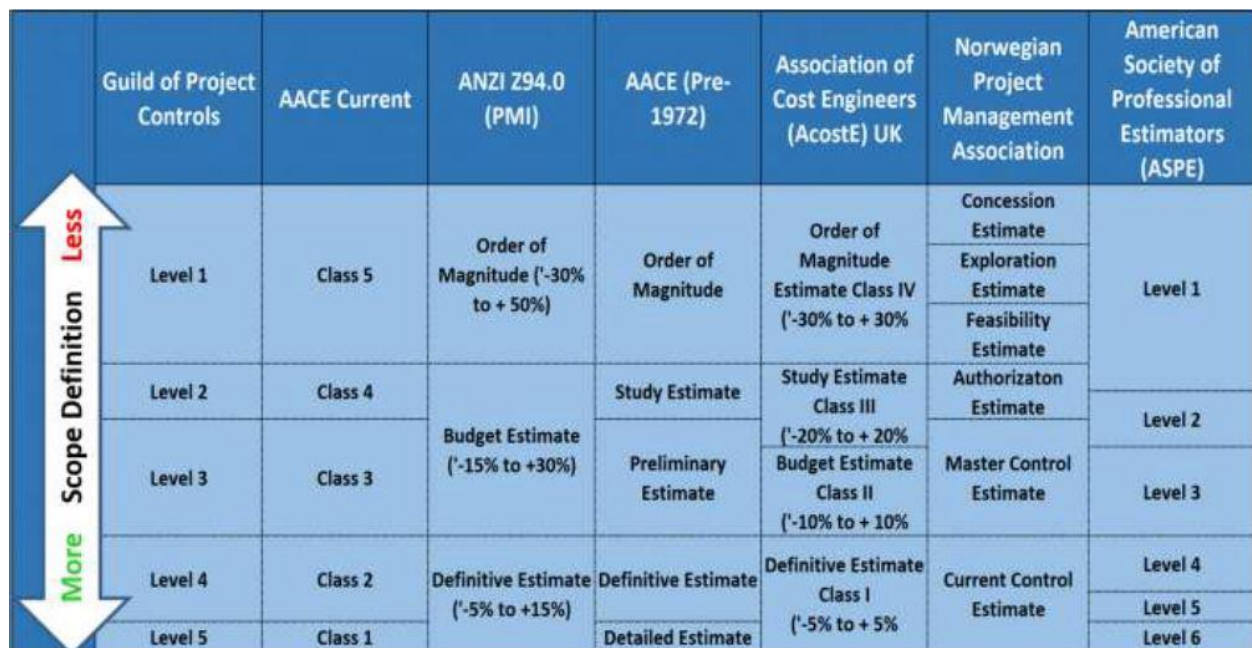
The reader can observe that the integrated design process, according to the figure above, planning construction activities and accountability of responsibilities begin since the conceptualization phase. Besides, constructors participate in this phase. This early participation, the definition of how to 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.

<sup>17</sup> 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 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 Estimates<sup>18</sup>

- 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 Deliverables<sup>19</sup>

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

<sup>18</sup> 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>

<sup>19</sup> By Author

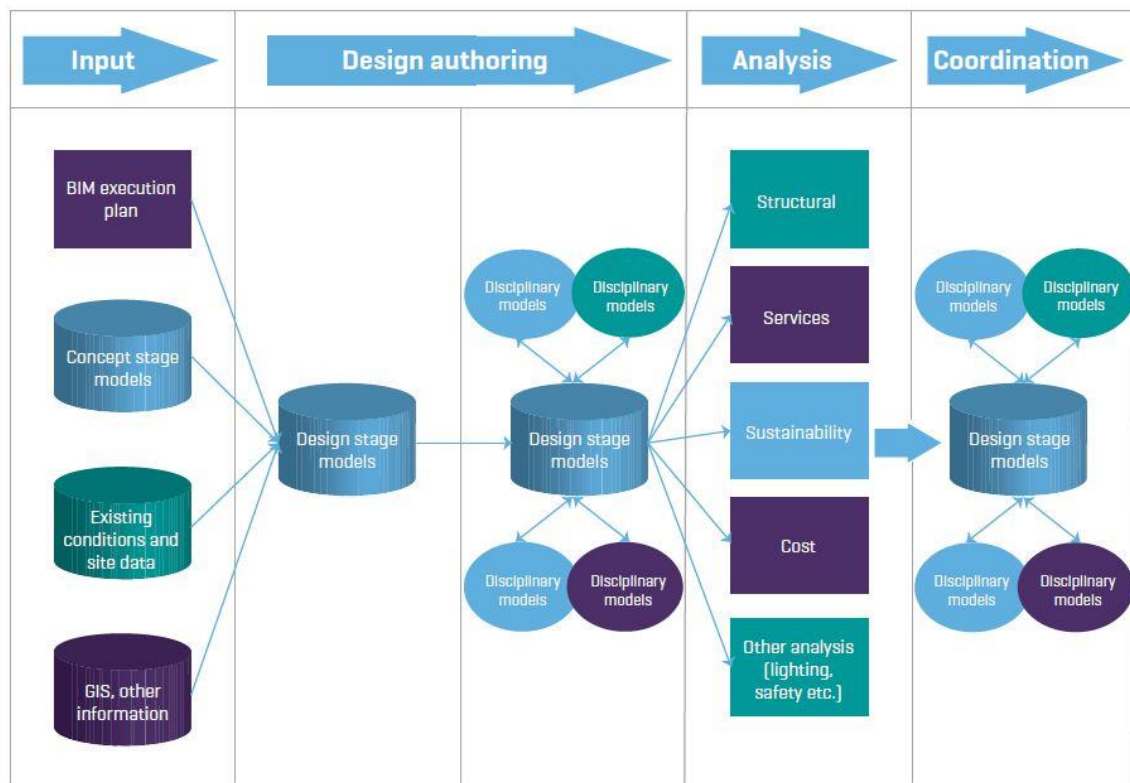


Figure 19 Developed design-stage workflow using BIM<sup>20</sup>

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%,

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

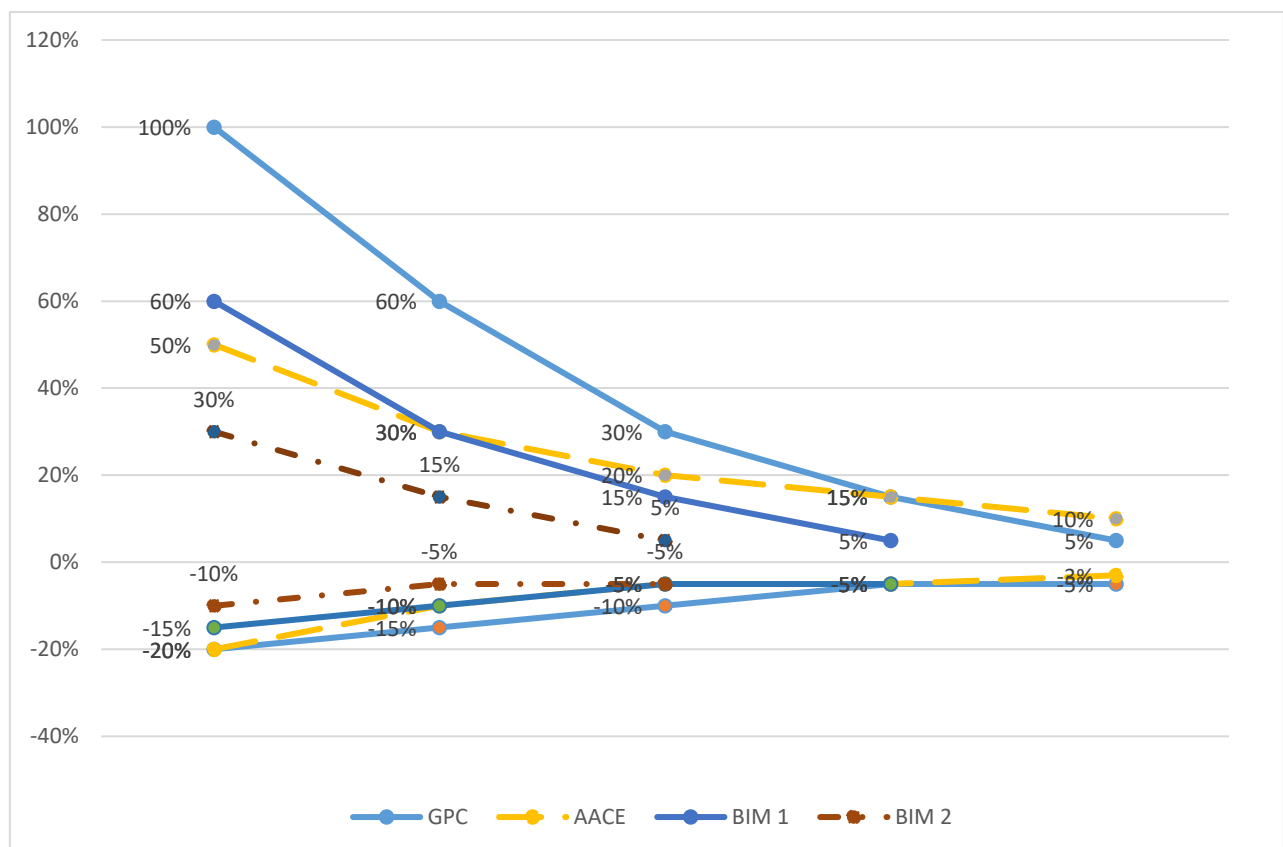
<sup>20</sup> Royal Institution of Chartered Surveyors (RICS). (2016, November 4). International BIM Implementation Guide, 1st edition. Page 37. Retrieved January 5, 2019, from <https://www.rics.org/latin-america/upholding-professional-standards/sector-standards/construction/international-bim-implementation-guide/>

**GPC<sup>21</sup>**

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

**AACE<sup>22</sup>**

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



*Figure 20 Precision of Classes of Cost Estimates<sup>23</sup>*

<sup>21</sup> 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>

<sup>22</sup> 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.

<sup>23</sup> By Author

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:

- 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.anticono@gmail.com](mailto:piero.anticono@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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