

## THE PROPENSITY OF BUILDING INFORMATION MODELLING AND INTEGRATED PROJECT DELIVERY IN BUILDING CONSTRUCTION PROJECT

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### ABSTRACT

The Building Information Modelling (BIM) implementation is to create a centralised knowledge sharing resource that contains all the necessary design and operational information about the project. BIM is a collaborative approach and integrated project delivery to design and delivery embraced by various construction teams in the construction projects. In the context of the most suitable project delivery to be used, with regards to the use of BIM, the Integrated Project Delivery (IPD) approach is highlighted as the best method which correlates building procurement of the design-to-construction business process through literature review analysis. IPD is developed as project delivery system that integrates people in effective collaborative approach between the key players in the project. IPD is going to be particularly beneficial for BIM because the contracts relation between the contractor, designers, consultants, constructors, sub-contractors and suppliers were binded and expressly determined at earlier stage. This relationship between these two subjects will helped the project team to achieve the project goals in terms of timely schedule, life cycle costs, quality and sustainability in construction project. Therefore, this study investigates on the propensity of the best methodology of project delivery system which can correlate with procurement adoption for projects adapt BIM concept. This is a descriptive study and the method used is based on review of the literature in relation to BIM and IPD. The analysis revealed that propensity of adopting IPD project delivery and the adoption of BIM are based on these factors: improve the communication, closer collaboration; liability and legal relationships are specifically determined, the best quality outcome; and lastly with reductions in design and construction period, it provides a cost effectiveness and a saving in overall construction period.

*Keywords:* Building Information Modelling, BIM, Integrated Project Delivery, IPD

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## 1. Introduction

Merely a decade, Building Information Modelling (BIM) has been making waves in the construction industry. It has been the buzzword in developed and developing countries (Silva, 2011) across the continent. The activities of engineering, procurement and construction (EPC) are seeking the opportunity to keep the momentum of the BIM growth (PWC 2016) and BIM has been adopted through government or

private industry initiatives globally (Mustaffa et al., 2017).

Eastman et al. (2008), states that utilizing BIM technology has major advantages for construction projects that save time, money, smoother and lead to better plan of construction process. He added BIM could reduce the potential errors and conflict for the benefits all members of the project teams. Further added by Hardin (2009) BIM as the virtual

construction of the structure that contains an intelligent model in a single server which can be shared among the project teams. McAdam (2010) agrees that BIM is a collaborative approach to design and delivery embraced by various construction teams such as employers, engineers, architects, quantity surveyors and contractors in the construction projects. (Weygant, 2011) opined BIM is a technological tool and process that has the capability of improving how buildings are designed and constructed. As highlighted by Rowlinson (2010) BIM application is to create a central database where the construction team can work more collaboratively (Wei Lu et al., 2013) and give input on their expertise knowledge and technique which has all information related to the project's design and working program. He further added as all the design information from multiple disciplines is integrated in a single database, thus design clashes can be determined prior post construction. As a result, project teams are able to save time and cost then perform more effectively, where project can be completed efficiently. In addition, all the parties can benefit from time and cost saving and while receiving a good quality.

### 1.1 Building Information Modelling

BIM has profound impact on all project team if it is adopted effectively and becoming the construction industry standard in the next coming years if it is proactively embraced by the construction industry players. There have been many new terms and definitions relating to BIM have been which have been established and discussed. In conclusion, the term "BIM" can be referred to as the integrated processes (Autodesk, 2012) and modelling technologies with associated set of processes for producing, communicating and analyzing building models (Eastman et al. 2008; Harness, 2008) where it can adopted to the whole of project phases starting from inception up to the managing of the facilities.

(Eastman et al. 2008; Azhar et al. 2012) as a set of policy that integrate the construction work processes with digital technology which develops the fundamentals of management system in construction project throughout the life cycle phases. (Succar, 2009; Tekla, 2013)

As Brad Hardin (2009) put it BIM is not just a software but a process that integrate all the information of construction works to set up a new way of thinking in the essence of not doing the same old things. The concept of BIM is to integrate information and all the data which previously scattered documentation were and then executed all the information into BIM model that consists of structures and architectures design and other related information with regards to construction implementation. A primary goal of BIM is to eliminate re-gathering or reformatting of facility information; which is wasteful (Eastman et al, 2008). Brad Hardin (2009) suggest that BIM is a virtual construction model which contain intelligent technologies that gather all construction work elements information in a single server file which can be shared in order to increase the level of communication and collaboration amongst the project team members.

Major construction project involves several key parties that require collaboration in order to complete the project effectively. The use of BIM technology enables communication to be increased between traditionally segmented process in construction. Rowlinson (2010) states that "*the BIM implementation is to create a centralised shared knowledge resource that contains all the necessary design and operational information about the project*". He further added that "*the demand for BIM is being driven by the potential for cost savings resulting from less design clashes which then led to shorter time and turn results in fewer delays and cost overrun*".

BIM has taken the concept of 3D technology by applying the engineering and architectural designs to develop 3D models that automatically automatically updated in line with the change of the database. With BIM, future conflicts on the design can be avoided as the problems already being anticipated and pre-empted at earliest stage. By adopting the BIM process, construction methods becomes more time saving and economic

In Mc Graw's analysis of BIM in 2009, it is shown that most owners demand the use of BIM for its ability in improving communication, better coordination and managing the information between the owners and the project team throughout the design and construction process. BIM projects facilitate the multidisciplinary information from basic schematic design, to cost

estimating and scheduling up to facilities management. Architects would have the opportunity to visualise and portray the model efficiently. For the designers, BIM generate perspective views and animations between the owner and the local authorities. On the other hand, engineers can calculate the designs and make decision with regard to the project's sustainability, whilst Quantity Surveyor can produce an accurate estimation on the construction cost.

Willem Kymmell (2008) stated that BIM and its processes are related to simulation and the virtual model which can be separated into several major categories which enlighten the owner the purpose of the project, enabling the project teams to design, develop, analyse as well as managing the operation and construction of the project. These categories may require different BIM carryover tasks and tools in each of these phases as briefly described in Table 1

**Table 1** BIM relation in construction phases

No.	Phases	Activities
1.	<b>Pre-Construction Phase</b>	<ul style="list-style-type: none"> <li>• Related to planning and design works;</li> <li>• During the pre-construction phase, the target is more to functional requirements and construction budget;</li> <li>• BIM 3D models will facilitate the designer to communicate and integrate the construction documents and drawings to ensure any clashes and variations to design can be detect and accurately reflected the linked drawings. According to Hardin (2009) the 3D model is able to provide the project team to plan the work schedule to finish in accordance to construction timeline.</li> </ul>
2.	<b>Construction Management Phase</b>	<ul style="list-style-type: none"> <li>• Activities during the construction where the project teams have an access to provide all necessary information;</li> <li>• Hardin (2009) reiterates that this phase deals specifically with the relationship between the contractor and the design team where it focuses on goals and scheduling, constructability and trade coordination;</li> <li>• BIM model acquire at this stage to get more details information concerning the status of the components, fabrication, installation, and payment stages;</li> <li>• BIM will help to visualize and to show exactly what materials have been on site, what components have been installed as a tracking tool for making progress payment and cost control;</li> <li>• When problems arise, BIM be able formulate a solution and assessment by showing the correct visual. The visualisation of 3D model has the ability to represent the site conditions from the issues.</li> </ul>
3.	<b>Post-Construction Phase</b>	<ul style="list-style-type: none"> <li>• This phase evolves the property management;</li> <li>• BIM will be available for operations and maintenance procedures; and it represent the "as built" to reflect the actual condition of the project;</li> <li>• All the equipment building systems <i>i.e</i> mechanical systems or any special plumbing system can be accessed, controlled and maintained through BIM and links to database;</li> <li>• The aid of 3D visual model will helps to troubleshoot the problems arises regarded to the systems more quickly and efficiently.</li> </ul>

The next topic will explain on integrated project delivery which significantly subject matter to be discussed as part of this study because it is known as an ideal type of procurement method and particularly beneficial to support BIM contracting process.

### 1.2 Integrated Project Delivery (IPD)

IPD is a new approach to agreements and processes for design and construction. The American Institute of Architects (AIA, 2007) defines IPD as, "...a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively

*harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction*" (AIA IPD Guidelines, 2007). According to Thomsen et al. (2009), the essential concept of IPD is interdisciplinary assemblance and collaboration which anticipate a legal relationship of design and construction professionals in order to ease barriers to communication, which in turn removes many of the troublesome legal hindrances. Benedict and David (2011) highlighted that the agreement precisely require the professionals team to share risk and reward, contribute equally, and employ

alternative processes and technologies, all in support of the achievement of the same goal which are reduced cost, time, loss and waste. According to Glick and Guggemos (2009) a full IPD project has five major structural elements involved:

- 1) Early participation of key project team;
- 2) Shared risk and reward based on project result;
- 3) Jointly control the project;

- 4) Mitigate legal responsibility and risks; and
- 5) Jointly develop and certify project goals.

Hall et al. (2014) in his study also highlighted major attributes of IPD. In Integrated Project Delivery: Guide published by AIA in 2017, the document listed out the principle attributes of IPD. Therefore, the attributes of IPD as shown in Table 2.

**Table 2** The attributes of integrated project delivery

Item	Attributes of IPD	
1.	<b>The Early Participation of Main Team.</b>	<ul style="list-style-type: none"> <li>• The participation of main team at early stage enhance better and innovative ideas which then decentralised to ensure that only selected ideas will be used while unfeasible ideas can be omitted at earlier stage;</li> <li>• Team involvement from all parties give immediate feedback on constructability;</li> <li>• Team produce accurate pricing and put the ownership of cost risks commitment;</li> <li>• Team have an agreement in place in giving consent empowers the integrated partner to have a cost-effective and working plan commitment.</li> </ul>
2.	<b>Collaboration</b>	<ul style="list-style-type: none"> <li>• Encourages informal collaboration from key participants with iterative and immediate face-to-face communication;</li> <li>• Members of each interdisciplinary team are put together in open space office concept;</li> <li>• Informal information exchange with a member of interdisciplinary team can bring out probable hurdles and the combination shall create a formation of good ideas</li> </ul>
3.	<b>Generate and Support of Team Ideas</b>	<ul style="list-style-type: none"> <li>• Promoting a culture of “team idea generation and support” which led to innovation with the presence of strong project leaderships and stewardship and creative thinking;</li> <li>• The each leaders of the team should ensure that their team is working with a motivated environment of teamwork spirit to stay in line with overall project vision.;</li> <li>• IPD team members need to be people who has these characteristics:                             <ol style="list-style-type: none"> <li>a) the collaborative mindset;</li> <li>b) the readiness to make changes;</li> <li>c) have good personalities, creativity and adaptability and innovative thinking.</li> </ol> </li> </ul>
4.	<b>Sharing</b>	<ul style="list-style-type: none"> <li>• IPD contractual relationship is based on risk and rewards sharing, key participants sharing the pain and the gain of the project performance;</li> <li>• Sharing of risks and rewards for projects implementation creates competitiveness in each team, wherein each interdisciplinary is responsible for innovative thinking to generate savings on the overall project plan so that it does not interfere with the progress of others' work.</li> </ul>
5.	<b>Financial Transparency</b>	<ul style="list-style-type: none"> <li>• IPD is based on transparency among the contracting parties especially in decision making in terms of planning and project cost savings;</li> <li>• Cost assessment involving all contracting parties benefit in reducing the risk of cost uncertainty.</li> </ul>
6.	<b>Joint Decision-Making</b>	<ul style="list-style-type: none"> <li>• Collaborative mindset in order to make any important decisions;</li> <li>• The collaboration of all parties with its own background of expertise creates innovation in project implementation especially in terms of progress and project coordination.</li> </ul>
7.	<b>Trust &amp; Accountability</b>	<ul style="list-style-type: none"> <li>• Trust enhances collaboration between parties and building the accountability;</li> <li>• With the concept of trust, all information exchange process between contracting parties is easier to implement;</li> <li>• The concept of trust among disciplinary can prevent repetitive and redundant works.</li> </ul>

In conjunction with the attributes of BIM as information gathering fields which can be integrated and shared among the project team and supported by IPD procurement method makes it suitable for use in BIM enable project.

According to Udom (2012), by incorporating BIM in construction project, there will be a transition from a traditional practice of an entire project. BIM is expecting to integrate the barriers between the designer teams and the contractor as normally practice in a traditional procurement. The process of designing, constructing and operating facilities in BIM-enable project involved not only the main players in construction disciplines such as architects, engineers, quantity surveyors and contractors but also profession in other areas. Eastman (2008) states that by implementing BIM, any variations of the design to construction phases in construction project will be collaborated at earlier stage during the design phase between the design disciplines and contractor. Therefore, due to the relationships and variation process in each phase of design and construction BIM can cause significant changes in relation to procurement method which determine the contractual agreement between the contracting parties.

### **1.3 BIM Best Procurement**

The procurement method has its own set of contracts which describe the rights, obligations and liability of the parties in construction project. It generally is a transfer of risks from one party to another. The procurement system assists government agencies and private company to manage procurement processes for construction effectively and efficiently. It helps government and private agencies to ensure a project's success outcomes by managing the activities to reduce time and cost overruns. In earlier year Maizon et al. (2006) indicates the factors that determine the selection of procurement criteria are dependent on the project's objectives, particularly which involve time, cost, contractual relationship and workability factors. It is further agreed by Eytoupe et al. (2012) which added that the choice of procurement method is significant to ensure that customer objectives are achievable in relation to time, cost and quality factors.

Discussing in the context of the most suitable project delivery to be used, with regards to the use of BIM, the Integrated Project Delivery (IPD) approach is highlighted as the best methodology which correlate building procurement of the design-to-construction business process through literature review analysis. IPD is developed as project delivery system that integrates people in effective collaborative approach between the key players in the project. BIM is going to be particularly beneficial for IPD, because the involvement of the contractor, designers, consultants, constructors, sub-contractors and suppliers at earlier stage should managed the project teams to achieve the project goals in terms of timely schedule, life cycle costs, quality and sustainability.

According to Porwal and Hewage (2013) there are no specifically procurement methods is best for BIM integration. Wei Lu et.al, (2013) states that the essence of BIM implementation is collaborative working process in construction work that involves integrating of various disciplines at the early stage. Foulke (2012) opined the involvement of the contractor at earlier stage should be necessary for the owner receiving the design proposal as BIM model; so the design model can be visualised, modified and corrected in order to fit all the requirements.

Based on that, in Eastman's opinion (2008) with regard to the use of BIM, the Design and Build (D&B) approach is the best building procurement of the design-to-construction business process. This is further agreed by Foulke (2012) who said that BIM is going to be particularly beneficial for D&B procurement and Turner (1995) added that the D&B approach is popular as the liability for both the design and the build is stated within the contract. Nevertheless, in the opinion of Porwal and Hewage (2013) even though many reviews decided D&B method of procurement is significantly delivered with BIM adoption; the ideal type of procurement for BIM enable is IPD. Porwal and Hewage (2013) and Mason (2017) added that IPD could effectively facilitate and compliment BIM working process. Thomsen et al. (2009) on the other hand stated IPD improves leadership, transparency, coordination and communication and close involvement from principal, main contractor, consultants, subcontractors and manufacturers into the

design decision-making process bring knowledge exchange of cost and construction technology.

## 2. Research Methodology

This is basically a descriptive study and the methodology used is essentially based on document analysis. The documents are extensively review through reading books, journals, conference proceeding papers, online articles from the related field webpage and as well as the academic discussion.

## 3. Results and Discussion

A comprehensive literature review showed the propensity of BIM and IPD in building construction project is the best procurement method as to compliment BIM enable projects. In the view of Eastman et al. (2008), IPD with the application of BIM could improve the traditional fragmented construction process. Compared to other integrated procurement approaches such, as D&B, Constructing Management; the IPD project delivery is more suitable to BIM implementation projects. According to Gallo and Wilson (2017) and Mason (2017), under IPD model the Owners becomes part of the project teams where they essentially share in the financial risks and rewards associated with financial budgeting and work programming for the particular projects. All financial information are fully vetted and made transparent between the project teams. The owner get to fully participate in project discussions in order to share their expertise in technical , knowledge resulting in the best benefits disseminated to all project teams where each discipline is able to achieve the project goals in terms of timely working progress schedule, life cycle costs, quality and sustainability (AIA, 2007).

As BIM is a combination of process and technology that integrates information among the contracting parties in achieving their goals of a cost reduction while obtaining a good quality in building constructed (Bell, 2004; Mason, 2017) acknowledge that IPD is to

improve the coordination and the close involvement from key interdisciplinary project teams into the design decision-making process (Thomsen et al., 2009). In parallel with that attributes, the propensity of IPD is the best procurement method shall be considered as to complement BIM enable projects. The propensity of adopting IPD with BIM as shown in Table 3.

## 4. Conclusion

IPD project delivery must be crafted to match the specific project and the level of involvement of the project teams. The larger the projects, there will many interdisciplinary and cross-functional teams that must be given leeway to execute their tasks. Unlike the traditional project delivery, the IPD agreement developed through a process of negotiation of multiple discipline with a high degree of transparency which the parties are be able to openly discuss their goals and give a full trust the shared information and financial modelling system provided by the other project team. All work in IPD is executed in the commitment of the project teams. In relation to BIM working process, IPD agreement is believed as to strongly support on how the project being organised, managed and controlled; it significantly affects project outcome.

From this literature analysis, it is established that there is a significant correlation between IPD and BIM in building construction project delivery. The next direction for this research should focus on an in-depth study on all available tools such as intelligent contract and its usage scope in relation to BIM and IPD.

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**Table 3** The propensity of adopting Integrated Project Delivery (IPD) and the adoption of Building Information Modelling (BIM)

Item	Impact on Construction Contracting	BIM Implementation	Integrated Project Delivery Procurement
1.	<b>The Methodology</b>	BIM's method of implementation could meet the needs of the project owner to integrate all project team (architect, engineer, and contractor) involved in the process of sharing and integrate their expertise in the project into a model.	The IPD agreements approach fulfill the needs of the project owner to integrate all stakeholders (owner, architect, engineer, and contractor) involved in the desire and the expected outcome in the project.
2.	<b>The Goal</b>	The main objective of BIM is to avoid issues of redundancy and error that arise in the traditional procurement which indirectly help to reduce costs and time savings in project.	IPD is one of the alternative methods of procurement projects that replace the traditional procurement method which creates the integration and collaboration of all project parties in order to mitigate cost and material wastes, increase productivity as well as saving time based on a win-win situation.
3.	<b>Improve Communication</b>	Improve the communication between all parties (designer, architect, engineer and contractor) in the project by sharing the expertise and integrate the information into a model.	The involvement of (owner, designer, architect, engineer and contractor) will encourage direct interaction and two ways of communication between contractor and the designer of the project.
4.	<b>Closer Collaboration</b>	Improve the interaction between all parties (owner, designer, architect, engineer and contractor) in the projects by collaboration environment approach as early as at design stage.	The position and responsibility in a contractual agreement binds all parties (owner, designer, architect, engineer and contractor) to collaborate and close monitoring the progress of the project.
5.	<b>The Liability and Legal Relationships</b>	The level of involvement and the intellectual in property rights and liability of each parties towards the project will specifically be determined.	The agreement is structured based on multiparty contract which bind the contract relationship between owner, designer, project consultants and main contractor to promote and reinforce the concept of trust among the contracting parties.
6.	<b>Cost Effective and Cost Certainty</b>	3D, 4D and 5D-model-based can be used for construction activities such as accurate cost estimating and construct ability.	Cost overrun can be reduced because the involvement of multidisciplinary parties can increase by the sharing of experience and expertise in providing a designs, it can be more cost effective and can provide more cost certainty.
7.	<b>A Saving in Overall Time</b>	The incorporation of 3D to 5D models would enhance construction planning and project delivery system.	Speed of delivery since all parties (owner, designer, architect, engineer and contractor) have full responsibility and control towards the design and construction process.

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