# THE AWARENESS OF INTEGRATED PROJECT DELIVERY AND BUILDING INFORMATION MODELLING - FACILITATING CONSTRUCTION PROJECTS

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ABSTRACT

Construction projects are complex undertakings, which involve many different parties striving towards successful completion. Effective and efficient processes are based on collaboration with an integrated project delivery approach, the project team working together as a cohesive unit towards a common goal. However, the current procurement system adopted creates fragmentation of the design and construction teams, which results in projects being delivered late, constructability issues, final project cost exceeding the approved budget, and variation orders.

A self-administered questionnaire was distributed to various built environment professionals within the Eastern Cape construction industry to determine the current awareness with respect to Integrated Project Delivery (IPD) and Building Information Modelling (BIM).

The findings showed that these systems have many benefits, which can assist in mitigating the aforementioned issues. The respondents indicated that they were aware of IPD and BIM and the related benefits; however, there are barriers preventing the adoption of these systems, such as clients not identifying the advantages, clients being resistant to change, as well as a lack of the requisite-related knowledge and skills.

Conclusions include that collaboration within the construction industry is imperative toward the successful completion of projects and that further information with respect to IPD and BIM is required to raise awareness and promote the adoption of these models.

Recommendations include: all stakeholders need to commit to the ideology behind these concepts and develop an understanding of the concepts and related benefits, and industry associations need to publish information regarding IPD and BIM, as this will increase awareness.

*Keywords: building information modelling, construction, integrated project delivery.*

## 1 INTRODUCTION

The construction industry is characterised by practices and systems, which professionals have become accustomed to. However, these practices and systems have not always produced the best value for clients. All projects are different and have their own unique location, and due to fluctuating time and budget constraints, the final product constitutes an untested model, which has been subject to continuous design variations. The concept of right first time is therefore a challenge to an industry that has not standardised its products. The construction industry is also fragmented, with many inexperienced clients, and delivery courtesy of separate design and construction organisations [1].

"Integrated Project Delivery (IPD) is 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 optimise project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction" [2]. This would be the ideal situation and approach, to commencing with construction projects.

The fragmented industry constitutes the rationale for the study reported on, namely to evaluate the level of awareness of construction professionals with respect to the benefits of


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implementing an IPD approach and tools such as BIM. IPD and BIM could potentially resolve many fundamental issues the industry is currently dealing with.

## 2 LITERATURE REVIEW

The literature review addresses four fundamental issues within the construction industry, namely project delays, constructability, cost overruns, and variations. A review of IPD and BIM was incorporated to enhance the understanding of the concepts, and requirements needed to implement these models, and the related benefits.

### 2.1 Project delays

Construction delays can be divided into critical and non-critical delays. A delay that directly affects the project completion, or in certain cases a milestone date, is considered a critical delay. Delays that do not affect the project duration, or a possible milestone date, are non-critical delays [3]. All delays are reflected as excusable or inexcusable. An excusable delay refers to an unforeseeable event, which is beyond the control of the contractor or subcontractor. Inexcusable delays are events that occur within the contractor's control, or which are foreseeable.

### 2.2 Constructability

There are two common definitions for constructability, namely "the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives" and "the integration of construction knowledge in the project delivery process and balancing the various project and environmental constraints to achieve project goals and building performance at an optimal level" [4].

There are several benefits associated with improved constructability, the main benefits relating to time, cost, quality, and health and safety (H&S) performance. It is noted that along with the associated improvement, the construction process becomes easier and overall project duration can be decreased. It can be expected that the building process will be more efficient and economical, and this will eventually result in cost savings, due to the integration of construction expertise and experience during the early stages of the project.

### 2.3 Cost overruns

Siemiatycki [5] notes that cost overruns can be grouped into three categories: technical challenges; over-optimism, and strategic misrepresentations. Within the construction industry, time has financial implications, which have a huge effect on project completion and overall project costs. There are many factors which contribute to final project costs exceeding the estimated budget, inter alia, projects being delivered late and constructability issues, which problems have a direct effect on project costs.

### 2.4 Variations

The design and construction components of a building comprise of two separate functions, which are performed by different professionals or organisations working in isolation. This compartmentalisation of construction projects into isolated design and construction roles results in designs without consideration for constructability or production economies, and therefore continue to produce costly mistakes from one project to another. The current organisational structure of the construction industry makes construction projects vulnerable to variation or changes during the construction phase. Variation orders have become so common on construction projects that it is seemingly impossible to complete a project without changes to the design, or the building process in its entirety. Studies have shown that the main changes will be in the scope of work, time, cost, and quality of most if not all construction projects [6].

### 2.5 Project delivery methods

The Banwell Report, published in 1964, expressed views that the existing contractual and professional conventions do not allow for flexibility, which is essential for an industry that is in the process of modernising itself. This report urged the industry to experiment and develop new methods to secure efficiency and economy within construction. The traditional method of commencing with a project starts with appointing a lead designer, usually an architect, engineer, or possibly a combination of both. Other specialists such as quantity surveyors to provide the cost-related information, prepare bills of quantities, compare bids, and provide financial management throughout the project are required.

Construction projects are individually characterised; these projects have their own time and budget constraints to produce the result. In the industry, there are several project delivery methods, which can be utilised; these systems are chosen based on the size, type, and skills required.

Jones [7] noted that over the last decade, there have been many movements in the UK, USA, and European construction industries to offer alternatives to the traditional procurement system of design-bid-build. These new systems focus on trust, partnership, and teamwork to migrate from adversarial contract conditions, therefore providing clients greater value in terms of construction services. Sir Michael Latham's report 'Constructing the team' in 1994 was the major driver towards change, after that other reports have been released including the strategy 'Accelerating Change' which was promoted by the Chartered Institute of Building (CIOB), based on providing greater worth to construction clients on the principle of trust, which continues the movement towards change in the industry.

According to the American Institute of Architects [8], IPD is based on the early contributions of knowledge and experience with the concurrent utilisation of new technologies, which allows all the stakeholders involved to understand their greatest abilities while increasing the value they deliver to the complete project lifecycle. This is a relatively new procurement method, which has become popular within the industry.

Wilson [2] notes the definition of IPD as "A construction project delivery method that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimise efficiency through all phases of design, fabrication and construction".

The whole concept of IPD revolves around collaboration and involvement of team members. Team members need to trust each other and are encouraged to focus on the project outcomes instead of their individual goals and personal gain. The industry is plagued by adverse and antagonistic relationships amongst construction professionals. For the industry to change and progress, the people involved in the delivery process need to adapt to change.

### 2.6 Building information modelling (BIM)

'BIM is a process for combining information and technology to create a digital representation of a project that integrates data from sources and evolves in parallel with the real project across its entire timeline, including design, construction, and in-use operational information' [9].

According to Jernigan [10], BIM methods revolve around virtual models which create the possibility to exchange information throughout the entire construction industry. These virtual models are integrated with information, and when they are shared with other construction professionals and team members, it greatly reduces the chances of errors and increases services. BIM can be used as a tool which aids in the evaluation and prediction of the end result through the different stages of the building process [11].

## 3 RESEARCH

### 3.1 Research method

A self-administered questionnaire was circulated electronically to a sample of architects, construction managers, quantity surveyors, and engineers in the Eastern Cape construction industry. All respondents were registered members of their respective councils. One hundred and fifty questionnaires were sent out and only twenty were returned, resulting in a response rate of 13.3%. The main reason for the low response rate is believed to be due to the lack of understanding and knowledge of the subject matter within the industry.

### 3.2 Research findings

Respondents were required to indicate how frequently projects were delivered late on a scale of 1 (Never) to 5 (Always). A mean score (MS) between 1.00 and 5.00 based on the percentage responses to the range was then computed. The resultant MS of 2.47 is $> 1.80 \leq 2.60$, which indicates the frequency is between rarely to sometimes/sometimes.

With respect to the frequency projects experience constructability problems, the resultant MS of 2.65 is $> 2.60 \leq 3.40$, which indicates the frequency is between rarely to sometimes/ sometimes.

With respect to the frequency projects exceeded the approved budget amount, the resultant MS of 3.05 is $> 2.60 \leq 3.40$, which indicates the frequency is between rarely to sometimes/ sometimes.

With respect to the frequency variations occur on projects, the resultant MS of 4.05 is $> 3.40 \leq 4.20$, which indicates the frequency is between sometimes to often/often.

Respondents were required to indicate their degree of awareness of IPD on a scale of 1 (Never heard of IPD) to 5 (Actively involved in IPD). The resultant MS of 2.45 is $> 2.60 \leq 3.40$, which indicates the degree of awareness is between have heard of IPD and have heard of IPD and have a fair understanding of IPD/have heard of IPD and have a fair understanding of IPD.

Table 1 indicates the respondent's perceived likelihood of IPD to satisfy certain criteria based on percentage responses on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree), and MSs between 1.00 and 5.00. It is notable that all MSs are > 3.00, which indicates agreement as opposed to disagreement.

Table 1: Respondents' perceived likelihood of IPD to satisfy certain criteria.

| Criterion | Response (%) Unsure | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | MS |
|---|---|---|---|---|---|---|---|
| Advantageous to owners | 20.0 | 0.0 | 0.0 | 0.0 | 50.0 | 30.0 | 4.38 |
| Technology integration (i.e. BIM) | 10.0 | 0.0 | 0.0 | 5.0 | 50.0 | 35.0 | 4.33 |
| Cost predictability | 10.0 | 0.0 | 5.0 | 5.0 | 50.0 | 30.0 | 4.17 |
| Long-term efficiency of building operations | 15.0 | 0.0 | 0.0 | 10.0 | 55.0 | 20.0 | 4.12 |
| High-performance design (Sustainability) | 15.0 | 0.0 | 0.0 | 15.0 | 50.0 | 20.0 | 4.06 |
| Risk management | 10.0 | 0.0 | 0.0 | 25.0 | 40.0 | 25.0 | 4.00 |
| Schedule predictability | 10.0 | 0.0 | 5.0 | 10.0 | 55.0 | 20.0 | 4.00 |
| Construction efficiency (i.e. Lean) | 10.0 | 0.0 | 0.0 | 20.0 | 55.0 | 15.0 | 3.94 |

Further interrogation in terms of MS ranges indicates that the first two presented criteria have MSs > 4.20 ≤ 5.00, which indicates respondents agree to strongly agree/strongly agree that IPD will be advantageous to owners and result in technology integration (i.e. BIM). The other criteria have MSs > 3.40 ≤ 4.20, which indicate the respondents' concurrence is between neutral to agree/agree in terms of IPD satisfying the criteria, namely cost predictability, long-term efficiency of building operations, high-performance design (sustainability), risk management, schedule predictability, and construction efficiency (i.e. lean). These criteria are all complementary in terms of achieving successful projects and client satisfaction, and thus advantageous to owners.

Table 2 indicates the extent to which 14 issues constitute barriers to adopting IPD, in terms of percentage responses on a scale of 1 (Minor) to 5 (Major), and MSs between 1.00 and 5.00. It is notable that 13/14 (93%) MSs are > 3.00, which indicates a major as opposed to a minor extent.

The issues that ranked first to tenth have MSs > 3.40 ≤ 4.20, which indicates that respondents perceive these to constitute barriers to adopting IPD between some to a near major/near major extent. General lack of industry support, building owner does not see the advantages, and lack of necessary skills and knowledge predominate. The issues are interrelated, such as lack of support, which is likely if building owners do not see the advantages and are resistant to change; lack of trust in industry partners; lack of available information about the process, licensing, and liability concerns; general lack of available, appropriate insurance; and procurement method constraints/limitations. These issues are further underscored by lack of necessary skills and knowledge, and lack of the appropriate technology.

The issues ranked 11th to 14th have MSs > 2.60 ≤ 3.40, which indicates that respondents perceive these to constitute barriers to adopting IPD between a near minor to some extent/some extent. Uncertainty about risk management in IPD, and general lack of precedents, are also likely to contribute to general lack of industry support. Similarly, the last two issues, namely projects I work on are too small, and projects are not complex enough.

Table 2: Extent to which issues constitute barriers to adopting IPD.

| Issue | Response (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Un-sure | Minor 1 | 2 | 3 | 4 | Major 5 | MS | Rank |
| General lack of industry support | 10.0 | 5.0 | 0.0 | 5.0 | 55.0 | 25.0 | 4.06 | 1 |
| Building owner does not see the advantages | 15.0 | 5.0 | 0.0 | 25.0 | 25.0 | 30.0 | 3.88 | 2 |
| Lack of necessary skills and knowledge | 5.0 | 5.0 | 5.0 | 20.0 | 35.0 | 30.0 | 3.84 | 3 |
| Owner resistance to change | 5.0 | 5.0 | 5.0 | 16.0 | 42.0 | 26.0 | 3.63 | 4 |
| Lack of available information about the process | 0.0 | 5.0 | 10.0 | 20.0 | 50.0 | 15.0 | 3.60 | 5 |
| Lack of trust in industry partners | 10.0 | 5.0 | 5.0 | 30.0 | 35.0 | 15.0 | 3.56 | 6 |
| Licensing and liability concerns | 15.0 | 5.0 | 5.0 | 30.0 | 30.0 | 15.0 | 3.52 | 7 |
| General lack of available, appropriate insurance | 10.0 | 10.0 | 5.0 | 30.0 | 25.0 | 20.0 | 3.44 | 8 |
| Lack of the appropriate technology | 10.0 | 5.0 | 15.0 | 25.0 | 25.0 | 20.0 | 3.44 | 9 |
| Procurement method constraints/limitations | 5.0 | 0.0 | 21.0 | 16.0 | 37.0 | 21.0 | 3.42 | 10 |
| Uncertainty about risk management in IPD | 15.0 | 10.0 | 15.0 | 20.0 | 25.0 | 15.0 | 3.23 | 11 |
| General lack of precedents | 0.0 | 5.0 | 11.0 | 42.0 | 32.0 | 11.0 | 3.15 | 12 |
| Projects I work on are too small | 0.0 | 25.0 | 15.0 | 15.0 | 15.0 | 30.0 | 3.10 | 13 |
| Projects are not complex enough | 5.0 | 25.0 | 20.0 | 20.0 | 25.0 | 5.0 | 2.63 | 14 |

Respondents were required to indicate their degree of awareness of BIM in terms of a scale of 1 (Never heard of BIM) to 5 (Actively involved with BIM). The resultant MS of 3.21 is > 2.60 ≤ 3.40, which indicates the degree of awareness is between have heard of BIM and have heard of BIM and have a fair understanding of BIM/have heard of BIM and have a fair understanding of BIM.

Table 3 indicates the respondent’s perceived likelihood of BIM to satisfy certain criteria, in terms of percentage responses on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree), and MSs between 1.00 and 5.00. It is notable that all MSs are > 3.00, which indicates agreement as opposed to disagreement, and that BIM is likely to satisfy certain criteria.

The first two criteria have MSs > 4.20 ≤ 5.00, which indicates respondents agree to strongly agree/strongly agree in terms of BIM realising long term efficiency of building operations,

Table 3: Respondents' perceived likelihood of BIM to satisfy certain criteria.

| Criterion | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | |
| Long-term efficiency of building operations | 5.0 | 0.0 | 0.0 | 10.0 | 45.0 | 40.0 | 4.32 |
| Risk management | 5.0 | 0.0 | 0.0 | 10.0 | 50.0 | 35.0 | 4.26 |
| Cost predictability | 10.0 | 0.0 | 5.0 | 5.0 | 50.0 | 30.0 | 4.17 |
| Construction efficiency (i.e. Lean) | 10.0 | 0.0 | 5.0 | 10.0 | 40.0 | 35.0 | 4.17 |
| Coordination and collaboration | 5.0 | 0.0 | 5.0 | 5.0 | 32.0 | 53.0 | 4.16 |
| Schedule predictability | 10.0 | 0.0 | 5.0 | 10.0 | 45.0 | 30.0 | 4.11 |
| Customisation and flexibility | 10.0 | 0.0 | 5.0 | 20.0 | 25.0 | 40.0 | 4.11 |
| High-performance design (Sustainability) | 10.0 | 0.0 | 5.0 | 20.0 | 35.0 | 30.0 | 4.00 |

and risk management. The remaining criteria have MSs $> 3.40 \leq 4.20$, which indicates that respondents' concurrence is between neutral to agree/agree - cost predictability, construction efficiency (i.e. lean), coordination and collaboration, schedule predictability, customisation and flexibility, and high-performance design (sustainability). These criteria are all complementary in terms of achieving successful projects and client satisfaction.

Table 4 indicates respondents' agreement with 'summary statements' in terms of percentage responses on a scale of 1 (Strongly disagree) to 5 (Strongly agree), and MSs between

Table 4: Respondents' agreement with 'summary' statements.

| Statement | Response (%) | | | | | | MS |
|---|---|---|---|---|---|---|---|
| | Unsure | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | |
| The use of alternative construction procurement systems will assist in delivering projects on time | 10.0 | 0.0 | 20.0 | 10.0 | 40.0 | 20.0 | 3.67 |
| Integrating the design and construction teams will reduce constructability issues | 0.0 | 0.0 | 0.0 | 0.0 | 35.0 | 65.0 | 4.65 |
| IPD and BIM will assist projects staying within budget | 20.0 | 0.0 | 15.0 | 10.0 | 20.0 | 35.0 | 3.94 |
| Integrating the design and construction teams will assist in fewer variation orders occurring | 0.0 | 0.0 | 5.0 | 10.0 | 40.0 | 45.0 | 4.25 |

1.00 and 5.00. It is notable that all MSs are > 3.00, which indicates agreement as opposed to disagreement. The MSs of two statements are > 4.20 ≤ 5.00, which indicates that respondents agree to strongly agree/strongly agree that integrating the design and construction teams will reduce both constructability issues, and the occurrence of variation orders. The other two statements have MSs > 3.40 ≤ 4.20, which indicate that respondents' concurrence is between neutral to agree/agree - the use of alternative construction procurement systems will assist in delivering projects on time, and IPD and BIM will assist projects staying within budget.

## 4 CONCLUSIONS

Construction professionals experience fundamental issues that are the focus of this study. Respondents noted that their projects are delivered late, the final project costs exceed the approved budgeted amount, they encounter constructability-related issues, and variations are incurred on projects.

There is a degree of awareness of IPD; however, few respondents are familiar with the concept and have a good understanding thereof. Certain barriers to the implementation thereof predominate, namely lack of industry support, building owners not seeing the advantages thereof, and lack of related skills and knowledge.

The respondents are aware of BIM and the potential benefits of implementing BIM in the workplace. A lack of related understanding, knowledge, skills, and experience is preventing the adoption and migration to this technological advancement in construction planning and administration.

## 5 RECOMMENDATIONS

The first step towards implementing IPD and BIM within the construction industry is to raise awareness, as all stakeholders need to identify with the ideology behind these concepts, a prerequisite being a fair understanding of the concepts and the related benefits. Industry associations need to publish more information with respect to IPD and BIM, which is likely to increase awareness and the likelihood of more organisations adopting these systems in their organisations and for projects.

Organisations may benefit from slowly adopting a more integrated approach, and this can be done by implementing an alternative procurement system such as design-build on projects, which in turn will facilitate and promote the integration of both design and construction teams without having to adopt IPD completely. BIM has been in existence for some time; however, the South African construction industry is trailing other countries in terms of implimenting BIM. BIM is being progressively implemented internationally because of the many benefits that accrue to all the major stakeholders, especially clients. Large organisations certainly need to adopt this technological development the soonest, as doing so will result in competitive advantage. Many global organisations are relishing the rewards of implementing BIM on their projects.

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