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Factors Influencing Integrated Project Delivery In Publicly Owned Construction Projects: An Information Modelling Perspective

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Abstract

The objective of this paper is to underline the factors influencing the implementation of integrated project delivery (IPD) in public sector construction projects. These factors are broadly classified under legal, organizational and technological categories. Further the role of information modeling to foster the integration in project delivery is discussed. Focus is placed on the aspects/characteristics of information modeling that can contribute to implementation of integrated project delivery. Traditional project delivery methods have been found by researchers as inefficient and litigious. As a result, the construction industry is in a critical need of alternative delivery methods.IPD has emerged as a solution, although its implementation is not without challenges. Therefore factors influencing its implementation should be identified as a step towards its probable use in the future for public-sector construction projects. Owners, particularly the public ones, are apprehensive due to various factors. The purpose of this paper is to investigate these factors and suggest an information modeling approach to overcome the impediments.

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1. Introduction

Traditional project delivery methodused in public construction sectors has several limitations [1, 2]. Several alternate delivery systems have been introduced from time to time to overcome these limitations. However thereemphasis was on some specific areas of project deliveryandlacked the overall improvement of project delivery. Integrated Project Delivery (IPD) has emerged in recent years as a method with a potential to revolutionize the project delivery. Unlike other alternatives, it focuses on the overall improvement and integrates processes, tools and people in a system.

Despite its potential, implementation of IPD is in its infancy. Very few projects have been reported to be delivered under this system [3]and most of them done under private sector. Its use in public sector construction is limited due to many reasons. These factors can be broadly classified under legal, organizational and technological issues to IPD implementation. The first objective of this paper is to highlight these factors and the focus of the paper will be on the public sector construction. The second objective is to highlight how advanced ICT tools like building information modeling (BIM) can reduce some of these IPD implementation issues.

The rest of the paper is arranged as follows: in the next section, commonly used project delivery system and their strengths and weakness in terms of performance are discussed. The following section introduces IPD, highlights key characteristics of IPD and compares it with the commonly used project delivery systems. Factor influencing implementation of IPD are highlighted next and are categorized under Legal, organizational and technological factors of influence. Next, role of information modeling with specific example of BIM to aid IPD is discussed. At the end, future research direction has been introduced to develop an information model for public sector to implement IPD.

2. Common project delivery systems

Traditional project delivery system, commonly known as design-bid-build (DBB) method is the most used method for public construction projects [4-6]. Under DBB, public owners are required to award architectural and engineering contracts solely based on qualification to provide the design services before construction phase. The lowest cost contractors then build such projects. Due to this disconnect, this system has several shortcomings that result in frequent claims and disputes between the project participantsand cost and time overruns. In addition to this, technical demands of new and complex building systems, which required more coordination between the project stakeholders, have also created a need for alternate delivery methods. Design- Build (DB) and Construction Manager at Risk (CM-at-Risk) and their derivatives have emerged as alternative delivery methods. These methods have been discussed in the subsequent discussion.

One alternate practice for owners is to hire a Construction Manager (CM) to assist the owners in development of accurate construction cost estimates, scheduling, reviewing the designer's plans forconstructability, obtaining and negotiating bids, and coordinating the various aspectsof the work [7]. Due to its nature, the role is usually assigned to contractors. The CM may also perform the construction of the project under guaranteed maximum price under an arrangement where the construction manager'srelationship with the owner shifts from that of an advisor, to that of a vendor. This method is called CM-at-Risk. It does create a team approach in project delivery [8]. However, owners faced difficulties due to downsizing the in-house project management teams, costly disputes between the designers and contractors and varied levels of owner experience. These problems created a need of single source design- build contracting [9].

In the Design- Build (DB) system, a single entity provides both services of design and construction and sign a single contract with owner for the performance of both services. This method facilitates team efforts and allows early participation of contractors to provide their input. Gokhale [7]underlined that contractors can participate in the budgeting, programming, financing, review of the design for constructability and cost of construction.However, DB lacks cross check and several designs and construction related problems in the project tend to remain undisclosed.

From the discussion above, we can say that no single alternative methods works best in all project aspects.It can also be observed in Table 1, which gives a comparison of performance of common project delivery systems used in public sector construction.

Table 1.Comparison of performance of common project delivery systems

Parameter	DBB	CM-at-Risk	DB
Cost	Ranks lower than others due to trend of intentional under bidding due to problems in design. This leads to change orders and thus increase in total cost of the project [10].	Guaranteed Maximum price ensures higher cost accuracy.	Perform well on cost front.
Schedule	Stakeholders take the initial decision deadlines less seriously because changes can be made later [5, 10].	Performs well on schedule as capable of procuring long lead item early in the project.	Most efficient due to possibility of parallel phasing [5].
Quality	Quality of projects delivered through this system is usually good due to presence of independent advisors and the expanded design phase.	Most efficient as independent construction professional expertise during design phase help meeting or exceeding quality of project.	Performs well as contractors are on also on board during design but they are not independent which may affect the project quality.
Administrative Burden	Administratively burdened due to the need for developing multiple bid packages, issuing them, receiving proposals, evaluating them, negotiating the contracts and overseeing its implementation.	Administratively burdened due to multiple contracts.	Less administrative burden due to lesser contracts and lines of communication.
Coordination and Teamwork	Fragmented and does not promote teamwork.	Early involvement of construction manager improves coordination.	Promotes coordination and teamwork.

It is evident that no single system performs superlative on all fronts.It is because, the alternate systems were developed with limited focus on achieving targeted goals instead of overall delivery system improvement and thus their approaches are fragmented. Azari-Najafabadi et al [11] regarded this localized focused approach as a reason for owners to fail to achieve desired objectives.

Researchers have advocated the use of more integrated approaches to overcome this fragmentation issue and to achieve outcomes that are more predictable. Such an approach should allow opportunities for the entire project team to effectively communicate and coordinate throughout the project phases [12, 13] Integrated Project delivery discussed in the next section has emerged as a solution to fragmentation.

3. Integrated project delivery

Integrated Project Delivery ("IPD") is based on the Australian "Alliancing" model. It has emerged recently in response to the need of reducing inefficiencies and wastes that are embedded in the current design and construction practices of the construction industry [14].

It is a 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 optimize efficiency through all phases of design, fabrication and construction. IPD principles can be applied to a variety of contractual arrangements and IPD teams will usually include members well beyond the basic triad of owner, architect, and contractor. At a minimum, though, an integrated project includes highly effective collaboration between the owner, the architect, and the general contractor ultimately responsible for construction of the project, from early design through project handover" [15].

IPD demands the use of relational contracts or a single agreement that all the key participants' signs including owners, designer and contractor. Subcontractors and vendors are sometimes also added to the contract if needed. These joint contracts are common in the U.K., Australia, and New Zealand while still in infancy stage of use in U.S. [7].

Different organizations approaches IPD differently also the level of sophistication varies [3] thus there is no accepted standard definition of IPD. There are, however, consistent similarities that have been found within most IPD projects and definitions. At core, an integrated team jointly develops project targets, makes decisions by mutual consensus and shares the risks and rewards for achieving them [RW.ERROR - Unable to find reference:41]. For this paper, we have used the characteristics of IPD as defined by American Institute of Architects (AIA). Cohen [16] has identified early involvement of key participants (EIKP); shared risk and reward (SRR); multi-party contract (MPC); collaborative decision-making and control (CDMC); liability waivers among key participants (LWKP); and jointly developed and validated project goals (JDVG)as the key characteristics of IPD projects. Following Table 2, briefly describes all these characteristics.

Table 2.Key IPD characteristics and descriptions

Characteristics	Description
EIKP	Involving the team including designer, constructor and trade contractors' right from the beginning of the project to help the owners to crystallize the project's goals and objectives from very early on and collaborate throughout the project.
SRR	Participating team members mutually shares the benefit of achieving project targets and simultaneously bears the risk of missing the targeted cost (schedule and quality).
MPC	The parties sign a single integrated agreement that clearly sets defines the role and responsibilities of all team members.
CDMC	The parties need to agree upon a clear and specific set of criteria for decision-making and control of project, which can be established according to the owner's goal for the project.
LWKP	Contracted parties waive any claim amongst themselves except for in the instance of a willful default to reinforce the sense of unity and a collaborative environment.
JDVG	Owner, with the help of the project team clearly defines achievable goals and benchmarks for measuring them. Risk and rewards are associated with achieving the set targets.

By employing these key characteristics in an IPD project, most of the shortfalls of the commonly use project delivery methods can be addressed. If IPD is compared to other discussed delivery methods on the same parameters discussed in the previous section it can be seen that IPD has a potential to perform better for obvious reasons. Cost and schedule are carefully estimated and agreed upon by whole project team with all the necessary input. EIKP also ensures quality project. Single contract drastically reduces the administrative burden. Coordination and teamwork are not just a culture but necessity of IPD projects. Thus, in a nutshell, IPD is a business shift that integrates the project participants and aligns all interest towards one successful project. It requires leadership from owners and full buy-in from all the key participants. In hand with the structure of IPD discussed above, it also requires a mind shift from the traditional way of work. Its foundations are laid on trust and willingness to collaborate. Use of catalyst like Building information modelling (BIM) and lean design and construction concepts also facilitates IPD.

Despite the advantages of IPD, its implementation is not easy. Especially, in the public sector, there are several factors influencing its use. Following section will categorize these factors under broad classifications and highlight some of the influencing factors of IPD in public sector.

4. Factors influencing IPD

As the name suggest, IPD works on the concept of integration.Mitropoulos and Tatum [13]defined the different level of integration is achieved through Contractual, Organizational, and Technological mechanisms. Utilizing the similar classification, for this paper, factors influencing IPD implementation in public sector are categorized under legal, organizational and technological factors of influence.

4.1. Legal issues

In the public sector, federal, state and local laws governing procurement, procurement inhibit integration of project stakeholders. For most countries, DBB is still the most used project delivery systems [4]. These systems, as compared to the other common delivery systems, are most restricted in terms of achieving IPD characteristics. Following discussion will highlight some of the conflicting legal issues that preclude use of IPD.

4.1.1 Different criteria for services procurement

The main conflicting idea that precludes use of IPD under present laws is the presence of two different criteria for procuring design and construction services.

Architects and engineers (A/Es) services for public projects are procured through negotiated contracts based on the competence and qualification for the desired services at fair and reasonable price. Price quotations are not part of selection criteria under quality-based selection.While on the other hand, Procurement laws of construction services mandates the selection of contractors on public contracts through open completion and based on lowest responsible bid. For such procurement, design documents needs to be 100% complete before the selection of contractor. Therefore, it does not allow involvement of key participants at the design stage, which is one of the key characteristics of IPD projects. Simultaneously it inhibits the other key characteristics of IPD like multiparty contracts, shared risks and rewards, CDMC and possibility of JDVG.

4.1.2 Risk allocation mechanism

Risk allocation mechanism defined in the tradition delivery methods obstructs the sharing of risks and rewards. Owner's warranty safeguards contractors against any design fault as long as it is constructed according to plans and specifications. Designers and contractors try to transfer the blame of the problem on the other party in case of any delays, cost overruns or any other issue arising on the construction site. Such warranties also obstruct the possibility of LWKP.

4.2. Organizational issues

As discussed above, utilizing all six key characteristics of IPD and thus implementing pure IPD, while desirable may not be possible for most public entities. On the other hand, IPD is getting popular in the private sector across many developed countries. Following discussion will focus on organizational issues that any project will likely face even if the legal constraints are removed and owners are free to use IPD.

4.2.1 Project management

- *Size of projects*

Some critics believe that IPD should be reserved for larger, complex projects because IPD requires a significant initial cost investment and additional design efforts as well as increased owner involvement but a variety of smaller projects have been delivered and are currently being delivered using IPD [17]. Therefore, this conflicts the general perception of IPD application to large only.

- *Type of projects*

IPD is more beneficial in repetitive facilities rather than the unique one-time projects. As it allows project team to re-use and even improve upon the design developed for one facility. Additionally lessons on previous projects become a source of knowledge for subsequent projects, influencing the up-front cost and investment time for these projects. In this case, parties would already have standard form agreements, effective business models, and design, leadership, and project teams already in place [18].

4.2.2 Organization culture

More than the size and type of projects, what matters is the willingness and knowledge of owner organization to take the lead. In other words, IPD is more suitable for active owners as it challenges the cultural paradigms, and demands more collaboration among project participants.Utilizing IPD requires radical changes in workplace organization, atmosphere and relationships. It is because; the current organizational practices and structures constitutes around the typical phased construction delivery method. The relationship and work processes needs to be change to accommodate the new more collaborative business practices. Owners need to identify this paradigm shift and take actions to transform accordingly.

4.2.3 Work processes

An organization that is accustomed of their trial and tested work process expects to show resistance to the changes posed by IPD. The resistance can be aggravated by the by lack of awareness about new processes, inept communication of the effectiveness of the new processes and by trepidation of risk and liability involved in new processes. Zipf [19]emphasized on the importance workshops and training to organizational members about how their daily operations will change with the emplacement of new processes.

4.3. Technological Issues

Most obvious technological issue that can influence the implementation of IPD on any project is related to the legal ownership, liability and interoperability concerns. These challenges are posed by the integrated use of technology to achieve collaboration on IPD projects. Organizations looking forward to IPD should look towards the following issues.

4.3.1 IT infrastructure

An IPD project greatly relies on effective communication and collaboration and requires adequate IT infrastructure support. Cheng et al. [20]discussed the IT infrastructure requirements of an organization to support efficient interorganizational information exchange and emphasized that an efficient IT infrastructure is capable of receiving, storing, retrieving, and coding information to maintain the internal and external informational management needs for both real and virtual environments. Although IT infrastructure is not mandatory to implementation of IPD, experts strongly believe in benefits it can bring to the projects [21, 22].

4.3.2 Information management protocols

Since IPD projects mostly relies on sharing digital information between the projects participants it is essential to decide information management protocols. According to a report [23], these protocols should include information about the ownership, format of representation, access, responsibility and accountability with respect to project information. It also emphasized on the importance of protocols related to culture of open information sharing especially due to distribution of incomplete information during the project that is necessary to communicate with the team. Establishment of these protocols at the beginning of the project is essential to decide over legal ownership, liability concerns.

4.3.3 Interoperability

Different organizations utilize different IT systems based on their needs and availability. When these organizations form a project team, interoperability issues arise due to inconsistency of data format and structures [24]. Resolving these issues to facilitate uninterrupted information transfer is essential.

Implementation of pure IPDis likely to face many challenges due to severalfactors discussed above. Some of these issues require concrete measures like changes in thelaws governing project delivery and complete makeover of current project delivery processes and practices. This may not be a sudden transition and may need some time and endorsement from the construction sector that will come with experience, technology and process improvements. As a starting point, “IPD-ish” projects (having some ofthe key characteristics of IPD) are still possibleunder current practice of work to reduce the level of fragmentation. Information modelling can play an important role in making IPD-ish projects possible. Following discussion will shed more light on this. BIM has been taken as an example to demonstrate the role of information modelling in achieving IPD characteristics on a project.

5. Role of information modeling in bridging the IPD implementation gap

In order for a project team to implement IPD efficiently, certain technologies and collaboration and automation capabilities are required. Owen et.al [25]enlisted the essential capabilities as: modelling of design intent, multi-disciplinary performance analysis, building geometry data, merged with construction site data, and delivery of as-constructed facility model; 4D visualization; virtual prototyping; transparent interoperable and reliable data transfer with third party applications; automated propagation of changes and integrity checking, and computer aided manufacturing and assembly.This requires open system architectures, sharing, and coordination of data between the project team members. To support such integrated effort, it requires efficient information models that are capable of providing the necessary support to team and to ensure coordination between the integrated work processes project lifecycle. BIM technology has provided a foundation for a better and proficient collaboration the project participants and has been tested and proved to be an effective tool for managing construction projects [21]. It can also act as catalyst for implementing IPD as it supports several key IPD characteristics. Following discussion will highlight how BIM is useful and what characteristics of IPD it helps to achieve if used effectively.

5.1. Use of BIM

Although IPD and BIM are independent concepts, synergies exist between the two concepts. AIA document on IPD states that "Although it is possible to achieve IPD without BIM, it is the opinion and recommendation of this study that BIM is essential to efficiently achieve the collaboration required for IPD." [22] In the following discussion, we will talk about how BIM can support IPD.Table 3shows proposed relation between attributes of BIM and IPD characteristics.

Table 3.BIM support to achieve IPD characteristics

Attribute	IPD Characteristics Supported
Consistency and accuracy of data	CDMC, JDVG
Design visualization	CDMC, JDVG
Ease of quantity takeoff	SRR,JDVG
Multi-user collaboration	EIKP,JDVG,MPC
Energy efficiency and sustainability	CDMC,SRR,JDVG
Reporting	CDMC, JDVG,SRR

In some cases, the relation between BIM attribute and IPD characteristic is direct and simple to understand while other relationships may not be so straightforward. Consistency and accuracy of data in BIM has a direct impact on the decision-making and better-calculated goals can be set for the project with the integrated and accurate data and collaborative team efforts. BIM has made visualization of the design possible prior to the actual fabrication; this attribute empowers the IPD team with the better design and control of the project. With BIM, quantity takeoffs are much easy and more accurate this can lead to better estimations of cost of project which in turn can strengthen grounds better risk and reward arrangement on the project. It can also be used to establish cost related goals for the project and validate them. BIM interface allows Multi-user collaboration, this interface along with having direct impacts on IPD project in form of ability to support EIKP and helping them to establish project related goals can also be helpful in promoting MPCs. With the sustainable construction gaining more and more attention, BIMs ability to help project team in finding out more energy efficient options can come handy for the team to plan and execute sustainable buildings. Reporting possible through BIM can also support IPD at several stages of the project and thus not only helpful in team decision making and controls but also supports the IPD characteristics of JDVG and SRR to some extent.

5.2. Role of BIM to remove/ease implementation barriers

BIM has a potential to facilitate the sophisticated level of collaboration required by IPD. For example, integrated team can identify potential problems early in the design phase utilizing the 3D visualization capabilities of BIM. Following discussion will highlight some of the possible benefits of using BIM in implementing IPD or IPD-ish projects.

5.2.1 BIM and legal issues of IPD implementation

Using BIM on the project does not have a direct impact on the legal issues discussed in the previous section. These issues require changes to be made in laws and regulations to allow selection of services and risk allocation procedures to allow IPD.

Although with BIM, industry can realize the importance of IPD and can support IPD use to achieve maximum benefits from advanced technologies like BIM. According to Lancaster and Tobin [26] IPD is a form of contract that is required to truly allow BIM based process to occur efficiently by allowing project participants to collaborate early on the project.

5.2.2 BIM and organizational issues of IPD implementation

Organizationally BIM can help in alleviating IPD implantation related issues. Adopting BIM is an organization-wide change. Entire organization goes through changes to become familiar with the software and the processes it requires.Thus, organizations that already developed to adopt BIM will find the organizational changes and changes in the workflows due to IPD relatively easier to cope than those who do not have any BIM background.

Similarly, project management related hindrances mention in the section 4.2.1 could also be eased out using BIM. An organization already equipped with BIM can use it on all projects regardless of the size of project and budget. In fact, in this situation it is a wise decision to get the benefit from the technology already in hand regardless of its lengths and volumes. Like IPD, similar doubts were raised for BIM applicability to smaller projects. With the passage of time and successful application of BIM to small projects BIM experts are now convinced that it can be used for all sizes of projects.

5.2.3 BIM and technological issues of IPD implementation

Role of BIM in helping IPD implementation technologically is rather straightforward. BIM can act as a technological catalyst for driving change. In the technological issues,discussed earlier first is related to appropriate IT infrastructure for IPD. Organizations that have already invested in BIM-oriented infrastructure will need not to invest additional resources. Thus, it is an advantage for such organizations and brings them a step closer to implement IPD by saving them on additional cost of IT infrastructure.

Interoperability is critical for the success of IPD project, as within a project there are many information exchanges between the various members across the building project throughout the whole life cycle. Industry has taken many steps towards somehow providing smooth flow of information. buildingSMART has introduced Industry Foundation Classes (IFC) to counter interoperability.Xue et al. [27]explained IFC as "a common product model that has interoperability between similar and dissimilar IT systems for construction engineering management". BIM data can be shared using an open format of IFC between different software.

Interoperability can also be tackled using BIM Cloud. It allows data from several diverse applications through a central repository platformto explicitly interoperate and exchange information [28].

6. Conclusion

This paper first presented a comparison of common delivery methods used in the public sector for delivering construction projects. Concept of IPD and its key characteristics are then discussed. Next, it attempted to address the underlying issues that influence the adoption and implementation of IPD in public sector. It was observed that while some of the issues require substantial changes like changing procuring laws related to public construction, others could be achieved through utilizing tools that are already in use. Researchers discussed few areas where the highlighted issues can actually be improved through the use BIM technology.

In this paper, several links have been established between IPD and BIM. One of the possible research directions could be the testing of the proposed benefits of BIM in achieving IPD characteristics and easing the implementation barriers of IPD using BIM. It can be achieved by putting the theory to test either by implementing it on some projects. However, this will be long and risky process. Another way of validating the theory could be from collecting review from field experts who are currently involved with BIM and IPD.

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