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Comparison of Key Project Performance Indicators of Different Construction Sectors in Terms of Collaboration and Integration

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Abstract

There is strong evidence to suggest that the use of collaboration and integration principles and methods improve overall project performance in the construction industry. Commercial Integrated Project Delivery (IPD) and Civil Infrastructure Alliance Contracting have specific collaboration and integration principles that define each as a unique delivery method. This paper investigates the similarities and differences between IPD and alliancing in terms of their key principles and explains the differences using the inherent differences between the construction sectors that have dominantly used each of the project delivery methods. The study uses 14 key performance indicators that are typically used to measure the performance of construction projects categorized into a) design optimization and b) construction risk management. The study concludes that IPD is more preferable for projects that require design optimization as the major KPI while alliancing might be more suitable for projects that deal with a significant amount of construction risks. The findings of this study can serve as a guide to properly identify collaboration and integration principles that will allow for better and enhanced project performance in a specific construction sector.

Keywords: Integrated project delivery; alliance contracting; integration and collaboration; project performance; project delivery method.

1. Introduction

The traditional approach to deliver projects using design-bid-build transactional contracting methods intentionally separates designers from construction contractors in order to maintain checks and balances [1]. In doing so, it limits opportunities for team collaboration and integration to bring the best value to the project and often creates adversarial environments leading to claims, disputes, and delays. Due to this, owners have turned to alternative delivery methods integrating design and construction with the objective of reallocating risks among project stakeholders and increasing the collaboration among project teams. The recent appearance of relational project delivery arrangements (Integrated Project Delivery (IPD) and Alliance Contracting (Alliancing)) represents a paradigm shift as they entail risk sharing rather than risk transfer, taking project team collaboration and integration to a higher level.

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The commercial construction sector in the U.S., specifically the health care facilities sector, has seen successful implementation of the IPD approach over the past decade. IPD is considered a structured, but flexible project delivery arrangement that promotes and enhances team collaboration and work process integration. IPD is a project delivery approach that integrates people, systems, business structures, and practices into a collaborative process to optimize results and increase value of the project by maximizing efficiency through all phases of design, fabrication, and construction [2]. While IPD is still an evolving concept, it comprises a broad spectrum of project delivery strategies, methods and tools that fundamentally promote team collaboration and work process integration to achieve the best value for the project.

It is also important to note that another highly integrated project delivery method called Alliance Contracting or more commonly Alliancing has been successfully employed internationally to deliver large infrastructure and industrial projects in Europe, Australia and New Zealand. In Australia, Alliancing has become a broadly accepted procurement and delivery method for risky and complex projects. Philosophically and conceptually, Alliancing strives to achieve the same goals as IPD and both operate on a "best for project" basis where everybody wins or loses. Alliancing has performed with similar positive results as commercial IPD in a survey of 71 alliance infrastructure projects, 85% of projects met or came in under budget, and 94% of alliance projects were completed on time or ahead of schedule [3].

Even though both IPD and Alliancing aim at accomplishing the success of a project via enhanced collaboration and integration of project participants and work processes, the focal areas and strategies appear to be different as their application project types are different. IPD in the U.S. has been predominately used in the health care facilities projects and Alliancing in heavy civil projects. This study first compares the main characteristics between IPD and Alliancing and then, evaluates two categories of key project performance indicators (KPI), namely, a) Design optimization and b) risk management that are typically considered for commercial projects and civil infrastructure projects. The study concludes that both IPD and Alliancing share the philosophical common denominator but IPD focuses more on design optimization driven collaboration and integration while Alliancing is more focused on construction risk management driven strategies and methods.

2. Key Characteristics of IPD and Alliancing

IPD characteristics may be categorized as six cardinal pillars using research findings from [4],[5], and [6]. They are a) early involvement of key stakeholders, b) shared risk and reward, c) collaborative decision-making and control, d) jointly developed and validated targets, e) Liability waivers among key participants, and f) multi-party agreements. The characteristics in these six pillars are not mutually exclusive but rather highly interdependent. However, in practice, there is no consistent model accepted by the industry as a whole. "Different definitions and widely varying approaches and sophistication levels mean that the term "IPD" is used to describe significantly different contract arrangements and team processes." [5].

Alliancing used in Australia and New Zealand relies on high levels of integration among alliance members that is thought to also produce enhanced cooperation between the individuals each member assigns to the project. The four most populous Australian states have institutionalized six main characteristics in their policy documents which include a) Early Involvement of Key Participants, b) Risk and Opportunity Sharing, c) Commitment to 'No Disputes', d) No fault-no blame' culture, e) 'Best for Project' unanimous decision-making processes, f) Transparency expressed as open book documentation and reporting, and g) Collective sharing of project risks

2.1 Commercial IPD and Alliancing Principles used on Selected Case Study Projects

Commercial IPD and alliancing share many of the same principles such as early involvement of key parties, transparent financials, shared risk and reward, joint decision making, and a collaborative multi-party agreement" [4]. Australia has institutionalized many of these principles in government policy documents where IPD principles have been used primarily in the private sector in the US.

A content analysis was conducted of selected case study projects performed using commercial IPD in the US and alliancing in Australia or New Zealand to determine the frequency of use of these principles on actual projects. The commercial IPD case studies were building projects, with most of them being hospitals, documented in an AIA and University of Minnesota study published in 2012 [7]. The alliancing case studies were civil infrastructure projects upon which a content analysis was performed to identify the principles documented in the request for proposal (RFP), project alliancing agreement (PAA), or contract templates. The content analysis focused on the commercial IPD collaboration principles and alliancing integration principles used in each respective case study project. Table 1 depicts the percentage of each principle used on 12 commercial IPD projects, and Table 2 illustrates the percentage of each principle used on 10 alliancing projects.

Table 1 Use of IPD principles - Commercial IPD Case Study Projects (AIA 2012).

IPD Principles	Cathedral Hill	Mercy Master Plan	Lawrence & Schiller	Spawglass Austin	Edith Green Wendell	Autodesk	Sutter Health	Cardinal Glennon Childrens Hospital	St. Clare Health	Encircle Health	Walter Cronkite School of Journalism	UCFS Mission Bay	**Total Frequency**
Jointly Developed and Validated Targets	X	X	X	X		X	X			X	X	X	**75%**
Early Involvement of Key Participants	X	X	X	X	X	X	X		X	X	X	X	**92%**
Collaborative Decision-making and control	X	X	X	X	X	X	X	X	X	X	X	X	**100%**
Shared Risk and Reward		X		X	X	X	X			X			**50%**
Multi-party Agreements	X	X	X	X		X	X	X	X	X			**75%**
Liability waivers among key participants	X			X		X							**25%**

Table 2 Use of Alliancing Principles - Civil Infrastructure Alliancing Case Study Projects

Alliance Principles	Robinson Road	Southland Alliance	Jialan Yard Upgrade	Northern Missing Link	Transit NZ	Waikato Roads	Whanganui Road	Australian Government	SCIRT Alliance	NCTIR Alliance	**Total Frequency**
Early Involvement of Key Participants	X	X	X	X	X	X	X		X	X	**90%**
'Best for Project' Unanimous Decision Making	X	X	X	X	X	X	X	X	X	X	**100%**
Transparency expressed as open book documentation	X	X	X	X	X	X	X	X	X	X	**100%**
Gain Share/Pain Share, Commercial Risk and Opportunity Sharing	X		X	X	X	X	X	X	X	X	**90%**
Commitment to 'No Blame' Culture, 'No Disputes'	X	X	X	X	X		X	X	X	X	**90%**
Collective Sharing of (Nearly) all Project Risks	X		X	X	X		X	X	X	X	**80%**

Due to the small number of case study projects for both IPD and Alliancing, it is premature to statistically conclude the differences in focal areas of those key characteristics for each project delivery method. However, one can see that the alliancing projects in Australia and New Zealand use a higher percentage of their defined principles than that of their commercial IPD counterparts in the US. Also, there are some distinctive differences by comparing the two Tables that "Shared risk and reward" and "liabilities waivers among key participants" are not often used in IPD projects while in Alliancing, similar characteristics such as "Gain Share/Pain Share, Commercial Risk and Opportunity Sharing," "Commitment to 'No Blame' Culture," and 'No Disputes' "collective sharing of (nearly) all project risks" are commonly used. This noticeable difference might be caused by the inherent nature of projects that each of the project delivery method is typically applied to. For instance, commercial building (health care facilities) projects may have a major project performance objective which requires design optimization to maximize the space usage for different functions and purposes of spaces. On the other hand, heavy civil infrastructure projects tend to be horizontally linear occupying a considerably large amount of land. Thus, they face a significantly large amount of risks during construction due to environmental concerns, unexpected soil considerations, issues with neighbouring businesses and communities. This hypothesis was evaluated using content analysis of previously published journal articles.

3. Comparison of KPIs in Commercial Building and Infrastructure Projects

A total of 14 project key performance indicators (KPI's) were identified through literature review of the articles that studied KPIs used in construction projects. The 14 KPI's shaping definition of success on construction projects have been observed to be cost and schedule savings, cost and schedule certainty, quality, safety, energy/water efficiency, operational functionality, material optimization, adaptability, minimize claims, minimize environmental impacts, and minimize public disruption. These 14 KPI's were divided into two main categories; project performance objectives closely related to design optimization and project performance objectives closely related to construction risk management.

The aerospace industry and NASA have been using collaborative design optimization strategies for multiple decades and often times refer to this process as multidisciplinary design optimization, or MDO [8],[9],[10]. The goal of this collaborative optimization exercise is to maximize or minimize specific design objectives. In the architecture, engineering, and construction (AEC) industry, MDO has been stated to be used "to improve product quality and reduce time to market" [11]. Some cited benefits of MDO are "22 percent *cost savings* on average…20 percent *less time*" [12], "maximize *energy efficiency*" [13], and "reducing *total project construction cost* by 7 percent" [11], "in a multidisciplinary design environment, use of the collaborative architecture provides additional *operational* advantages" [14], and "collaborative design is an emerging promising field…*optimizing the use of materials and energy* can be effectively achieved using these new technologies" [15]. The following KPI's have been identified as project performance objectives achieved through good design optimization; i)Cost savings, ii) Schedule savings, iii) Energy/water efficiency, iv) Operational Functionality, v) Adaptability, and vi) Material Optimization (Reduced waste)

Risk is defined by the US Project Management Institute (PMI) as, "an uncertain event or condition, if it occurs, has a positive or negative effect on a project objective" [16]. Project uncertainty is the probably that the objective will not reach its planned target value [17]. Construction projects face much uncertainty due to many factors, thus increasing the risk of not achieving the target value, or project performance goals and objectives. "Risk is inherently present in all construction projects…quite often, construction projects fail to achieve their *time, quality, and budget goals*" [18]. Other studies have identified similar uncertainty to achieving project performance objectives, with risks observed causing defective physical works (difficulty in *quality* control), *schedule delays*, and *cost overruns* [19] and [20] identified five main impacts to project success caused by risk; *cost overrun, time delay, quality, safety, and environmental* risks. Legal claims and disputes have also been identified by scholars as a risk present with construction projects, "construction industry professionals have increasingly sought legal assistance to help identify, allocate, control, minimize risk in the design and construction process…in spite of these efforts at controlling risk, the industry has witnessed an alarming rise in *claims and disputes*." [21] "The construction industry has long been considered to have high injury and fatality rates" Cheng et al.[22] goes on to state, "*safety* management information and committees are significantly related to *project performance*." Social impacts of construction projects, such as public disruption, have also hampered overall achievement of project goals. Documented in a study performed by [23] of the Olympic Games development work performed in Sydney, Australia, "Personal *disruptions* impacted more heavily than any benefits. One respondent expressed displeasure with the Olympics in terms of personal *disruptions* to daily activities as follows, 'It's been bloody chaos, mate. It's all bad. Nothing but [a] *disruption* to my life.'" The following KPI's have been identified as project performance objectives achieved through good construction risk management; i) Cost Certainty (meet budget), ii) Schedule Certainty (meet schedule), iii) Safety, iv) Quality, v) Minimize Claims, vi) Minimize Environmental Impacts, vii) Minimize Public Disruption.

Client satisfaction has been observed in literature to be both related to good design optimization and good construction risk management and therefore categorized as both. There are a total of six KPIs categorized as design optimization, seven KPI's categorized as construction risk management, and one categorized as both. The frequency index (0-100) of these total 14 KPI's categorized as design optimization and/or construction risk management represents the frequency of literature articles observed identifying each of these specific KPI's grouped as commercial buildings, civil infrastructure, and general construction projects and is summarized in Table 3.

Table 3 Literature review of design optimization and construction risk management KPIs

Industry Sector	Design Optimization KPI's							Construction Risk Management KPI's								
	Cost Savings	Schedule Savings	Energy/Water Efficiency	Operational Functionality	Adaptability/Reliability	Material Optimization	Average of All Design Optimization KPI's	Cost Certainty	Schedule Certainty	Safety	Quality	Minimize Claims	Minimize Environmental Impacts	Minimize Public Disruption	Average of all Construction Risk KPI's	Client Satisfaction
Commerical Building																
1 – Franz [1]	X	X	X	X				X	X		X					X
2 – WBDG [24]	X		X	X	X					X						
3–El Asmar [25]	X	X		X		X		X	X	X	X	X				X
4 – Roberts [26]	X	X		X				X	X	X	X		X			X
5 – Ballard [27]	X		X	X		X		X								
6 – Beach [28]	X	X		X		X		X		X		X				
7 – Chan [29]	X	X		X		X		X	X	X	X		X			X
8 – Wong [30]	X	X						X	X	X	X					
9 – Chan [31]	X	X		X		X				X						
10–Sanvido [32]	X			X	X	X		X	X	X	X	X				X
Frequency$_{Building}$	**100**	**70**	**30**	**90**	**20**	**60**	**62**	**80**	**60**	**80**	**60**	**30**	**20**	**0**	**47**	**50**
Infrastructure																
11 – Amiril [18]	X		X	X	X	X		X	X	X	X	X	X	X		X
12 – Molenaar [33]				X				X	X	X	X			X		X
13 – Zhou [34]	X			X		X					X		X	X		
14 – Shen [35]	X		X	X		X		X		X	X	X	X	X		
15 – Toor [36]						X		X	X	X	X	X				X
16 – Tamburro [3]				X				X	X	X	X	X	X	X		
17 – Rankin [37]								X	X	X	X		X			
18 – Ugwu [38]	X	X				X		X	X	X	X		X	X		
19 – Grajek [39]	X							X	X			X				
20–Gransberg [40]	X							X	X			X				
Frequency$_{Infrastructure}$	**60**	**10**	**20**	**50**	**10**	**50**	**33**	**90**	**80**	**70**	**80**	**60**	**60**	**60**	**71**	**30**

Using the average frequency of all sectors including general construction as the baseline frequency index, the results of the frequency analysis summarized in Table 3 indicate commercial building projects are higher in importance of KPI's more closely associated with design optimization, having an average frequency index rating of 62 for all design optimization KPI's as compared to an average frequency index rating of 43 for all sectors' design optimization KPI's. Cost savings and operational functionality were the two highest ranked KPI's for commercial building projects. While civil infrastructure projects are higher in importance of KPI's more closely associated with construction risk management, having an average frequency index rating of 71 for all construction risk management KPI's as compared to an average frequency index rating of 54 for all sectors' construction risk management KPI's. Cost and schedule certainty, and quality were the three highest ranked KPI's for civil infrastructure projects. The results indicate project performance is more closely linked to design optimization for commercial projects, while civil infrastructure project performance relies more heavily on construction risk management.

4. Conclusion

This study found that there is a discernible difference between commercial projects and civil infrastructure projects regarding the relative importance of key performance indicators. Commercial project KPIs are more focused on design optimization whereas civil infrastructure project KPIs promote construction risk management. Thus, it can be inferred that commercial projects are inherently "design-centric" where critical project success factors revolve around the design solution. On the other hand, civil infrastructure projects are much larger in scale and typically impact a greater population making achieving cost and schedule certainty through "construction-centric" risk management key for project success. Both IPD and Alliancing philosophically aim at the same goal of project success through enhanced collaboration and integration. However, due to the different focal points in terms of KPIs, IPD and Alliancing tend to focus more on different collaboration and integration principles and methods. These findings are not based on statistical validation results which could be weakness and open up for future research. However, the results provide highly valuable insights. For example, another major sector in the construction industry is the industrial sector. The industrial sector may have characteristics for both commercial building and civil infrastructure projects. Industrial projects may require design optimization and construction risk minimization. Thus, if an collaboration and integration driven project delivery method is applied for an industrial project, all IPD and Alliancing principles may have to be used in a balanced manner. This is a strong hypothesis which may require future research that the research team has already started to investigate.

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