CROSS-FUNCTIONAL PROJECT TEAMS IN CONSTRUCTION: A CASE STUDY

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by

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ABSTRACT

For many years traditional project delivery systems have been utilized in the construction industry, but new delivery systems such as Integrated Project Delivery (IPD) are being developed to answer the need for more integrated approaches. Studies have been conducted to assess the impact of project delivery methods on project performance, but few focus on the effect of team composition and organization. However, many factors influence the need for evolving cross-functional project teams (CFPTs) as project needs change and the addition of new participants to the project. This research presents IPD experts’ interviews and a case study of an IPD project delivered at the Pennsylvania State University for a mixed-use laboratory, office and classroom building. The objective is to demonstrate the composition and evolution of the CFPTs organization, from the beginning of the design through early construction. The discussion focuses on the changes in structure and alignment as they relate to project objectives at key stages of the project, shifting engagement of the team members and disciplines within the CFPTs, and the internal and external factors that influence the process. This study finds that the CFPTs should be created at the very early stages of the design in conjunction with a Target Value Design (TVD) approach. The CFPTs and TVD should focus on the main building systems. While the number of CFPTs vary with the project complexity, scope, and scale, overall number should be in the range of four to 10. The personnel for each CFPT should be targeted around four to six people, with some variance based on the objectives and tasks they undertake, and leadership that brings both cross disciplinary knowledge to communicate with other CFPTs as well as strong facilitation skills. Furthermore team performance, thus far, has been assessed primarily by the CFPTs’ capacity to meet commitments. Finally, the CFPT organization combined with the IPD contract structure allows using the team flexibility to leverage the full potential of individuals to best suit the project needs as the project evolves, with little administrative burden as a barrier to getting the best team.
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Chapter 1: INTRODUCTION

Since the 1960s, all non-farm industries experienced significant improvements in productivity while the productivity for the construction industry declined (Teicholz 2013). One of the potential reasons the construction industry experiences this trend is attributed to the top-down focus and hierarchical organization utilized by most companies and during projects (Hall et al. 2014).

Construction projects follow the organizational structure driven by the type of delivery method selected. Konchar and Sanvido (1998) refer to Design-Bid-Build (DBB) as the most commonly utilized delivery method where the owner has separate agreement with the designer and the general contractor sometimes a construction manager. Furthermore with a Construction Management at Risk (CM-at-Risk) method, the owner simply contracts a designer and a contractor responsible for the management and the construction of the facility. Ling et al. (2004) describes Design-Build (DB) as a specific delivery method where the owner hires a single entity responsible for the design and the construction of the project. These three methods have different impacts on project performance wherein a significant difference lies in the contractors changing role in the design integration. With DBB projects, the designer provides a set of design documents used to select a contract that prevent any technical input. However, the contractor in CM-at-Risk projects will have more input because it is responsible for both management and construction for a specific fee, typically with early procurement that allows input and influence on the design. Finally by contracting with an entity regrouping design and construction services, DB allows the builder to be involved and share design responsibility at an early stage (Konchar and Sanvido 1998).

The concept of Integrated Project Delivery (IPD) directly uses the principles from the Toyota Production System (TPS) and Lean Construction that recommend using advanced technologies and organizational methods in order to create value to the owner and improve project outcomes (Seed 2015). Contrary to the other types of project delivery methods, with IPD the owner, the designer and the primary contractors share a single contract, allowing an early involvement of the key participants through a relational, rather than transactional, contract agreement. Leicht et al. (2015) relate the different delivery methods and stipulate that the method itself is not the defining factor determining success. However each delivery strategy is structured with a specific team organization leading to different project performances and outcomes. Based on this principle, Leicht et al. (2015) identified that the delivery methods enabling teams to achieve the highest levels of team integration and group cohesion also increased their chances to meet their, cost, schedule and quality requirements. The need for
highly integrated teams and cohesive group is driven by the necessity for increased project performance. But methods and considerations for organizing the team in integrated delivery systems aiming toward these aspects are not well defined. More integrated projects strongly depend on team organization and more specifically on the management of cross-functional teams (CFT), where people from different entities to work together on a specific scope of the project.

1.1 Problem Statement

For many years traditional project delivery methods have been utilized in the construction industry, but new delivery systems such as IPD are being develop to answer the need for more integrated approach. Studies have been conducted to assess the impact of project delivery methods on project performance but only a few focus on team composition and organization. This research concentrates on project organizations aiming for high collaboration and integration to improve project performance. In IPD projects, the contractual team creates cluster groups or cross-functional teams in order to combine skills to focus on a specific area related to the construction process. However, there is a noticeable gap in the understanding of factors taken into account concerning factors impacting the development and implementation of CFPTs. Therefore the purpose of this qualitative case study is to understand how CFPTs organize and evolve on IPD projects.

1.2 Research Objectives

Research Question: What are the organizational factors influencing the development and implementation of cross-functional project teams for integrated project delivery?

Research Objectives:

1. Identify factors that define and differentiate the needed Cross-Functional Project Teams (CFPTs) for building projects,
2. Identify considerations and factors taken into account for the composition and evolution of CFPTs.
3. Explore the organizational considerations for aligning team roles and responsibilities with CFPTs purposes.
1.3 Research Scope

The scope of this research is to analyze the CFPT organization within a highly integrated construction project, specifically the Agricultural Engineering Building Renewal at the Pennsylvania State University, University Park campus. The study focuses on this specific project because the contractual model encourages integration via specific organizational considerations defined in the multi-party IPD agreement. Also, as there are few IPD projects available because the project delivery method is relatively new to the construction industry. It is appropriate to adopt a case study approach and supplement the case study data with interview data from industry IPD experts.

1.4 Research Approach

The approach taken for this research is to develop interviews with signatory members of the IPD project for the Agricultural Engineering Building Renewal, as well as with selected industry IPD experts. Interviewing participants of the IPD project permits data from different perspective on the same project and to identify similarities and differences considering the CFPTs implementation. Concerning the IPD experts, the objective is to use their past IPD experiences to validate the factors observed in the case study, as well as identify additional influences on the implementation process.
Chapter 2: LITERATURE REVIEW

The following sections summarize previous literature and research. The literature review is broken into four sections to address an overview of integrated project delivery (IPD) and identify the links between delivery method and project performance. Moreover, a background of contractual teams, as viewed from other sectors is developed in order to further introduce the concept of teams and multi-team systems. Then, approaches to cross-functional teams’ (CFTs) composition and organization are highlighted in the construction industry as well as other industries utilizing this method. For both contractual and design team levels, main elements from other research are reviewed to identify gaps and limitations in terms of leadership, decision-making and organization.

2.1 Integrated Project Delivery

Kenig (2011) defines IPD as a multi-party contract divided in two categories. The first category identifies principles integrated into project contractual agreements intended to contribute to an improved working environment for the team:

- Key members tied as equals to support collaboration and team decision-making.
- Shared financial risk and shared reward to align financial incentives with the best interest of the project.
- Liability waivers that motivate members to find solution as a team and reduce adversarial concerns for blaming other members by removing the possibility of litigation.
- Financial transparency that enhances trust by means of an open-book system.

The second category includes behavioral principles are strongly suggested for project, but their application depends on the team’s willingness (Kenig 2011):

- Respect and trust between project participants.
- Cultivating a collaborative environment to encourage members to integrate.
- Open communication where participants understand the need for sharing and innovate.

The contract defines the process used by the team to manage the relationship between members as well as the project goals but other characteristics stay specific to IPD.

2.1.1 Characteristics

Ashcraft (2012) and the American Institute of Architects (AIA 2010) both define IPD as a trust-based delivery method that achieves collaboration, with the stipulation that many aspects are related to the of engagement of the owner. This contract type requires at least the
owner, the architect, and the contractor to share risk, benefits and perform the overall project as a team. Furthermore, Sive and Hays (2009) illustrate the wide-spread issue concerning the ‘traditional’ delivery method; that it assesses risk through litigation in court, to highlight the differences with IPD. IPD enhances team by adjusting risk internally; it is often part of the contract not to pursue other team members in court. This specificity comes from the nature of the IPD contract structure; members of the contract share profits and risks as a team through which the partition of responsibilities and risk is negotiated during the contract development to allocate risk to the party most capable to manage that risk.

The demand for IPD led to the creation of standardized contractual documents for industry organizations, such as American Institute of Architects (AIA) and the Associated General Contractors (AGC). Thus, as industry representative and leader the AGC (2009) published the Consensus Documents 300 and the (AIA 2007) published documents known as C195. The unique contractual element of IPD is the use of poly-party or multi-party contracts as a structure to IPD projects (Ashcraft 2012). The contract will bind the owner, architect, main contractor and other significant trades or consultants into having more integrated roles in the project.

2.1.2 IPD“ish”

The adoption of an IPD contract requires a high degree of involvement from the owners, contractors and designers. Some owners are not willing or prepared to use a multi-party contract but still want some degree of integrated development. Franz and Leicht (2012) relate options, such as “IPD-lite” and “IPD-ish,” that are tested among the construction industry as a transition from traditional DBB to IPD. The objective of their study was to compare the outcome of IPD-Lite project against traditionally delivered projects and to identify the outcomes for addendum sections and performance metrics. Hence these options involve a degree of team integration without the legal aspect of a contract referencing common and shared objectives. Similar to the efforts outlined by Franz and Leicht (2012), the AIA introduced “Transitional Documents” modifying original AIA contracts to add greater flexibility to include preconstruction services, BIM, partnering and consolidated team dispute resolution (AIA 2008).

2.1.3 What Drives the Adoption of IPD?

Within their guide to understanding and marketing Integrated Project Delivery, Sive and Hays (2009) describe the need for improving project development by making IPD a culture driven by industry actors. They also highlight that support for IPD comes from architects, engineers and other members of the construction industry that are aiming for win-win situation
with their clients. On the same basis, technology plays a major role in enabling IPD. The rise of building information modeling (BIM) has highlighted interdependencies of design information development that requires early collaboration to provide an efficient and complete model of the project. Rekola et al. (2011) express the need to integrate team members, such as the design team, cost estimator and contractors, at the beginning of a project when using BIM.

Sustainability plays its part on the development of IPD as it becomes inevitable for most of the public projects that require LEED certification (AIA 2010). Several building owners are thinking about sustainability and code authorities are establishing requirements for sustainability rating systems, energy consumption and environmental impacts. The built environment represents the largest contributor in greenhouse gas emission with 76% of annual U.S electrical energy consumption and 48% of U.S annual energy consumption. Molenaar and Gransberg (2009) demonstrate that CM at-Risk and Design-build delivery methods perform better according to the LEED requirements at delivery sustainable and high performance buildings. Their findings show that the level of integration has a strong impact of the level of sustainability. Using a rating based on the percentage of projects that achieved their original goals, with 94% CM at-Risk was the most successful, followed by Design-Build with 82%. IPD projects are not utilized in this research, however the degree of integration during the development of projects is taken into account within the different delivery methods.

The elements highlighted previously are represented in Figure 2-1 by Sive and Hays (2009) as main factors driving the adoption of IPD. Independently or combined they enable a greater degree of collaboration and technology use, to provide better working relationships. The AIA (2007) highlights the differences between traditional project delivery (Design-Bid-Build) and IPD to be mainly in terms of benefits for the owner. On one hand traditional project delivery is defined as fragmented, strongly hierarchical and controlled teams that provide the “minimum-necessary” work to the owner. On the other hand, the IPD concept requires early involvement in the process by each team member to achieve an open and collaborative project. Risks and performance are assessed as a team, to reinforce a common goal that aligns profit to firms with success in achieving value for the owner.
2.1.4 Benefits of IPD

Mossman (2008) provides a compact definition of IPD as a way to “collaboratively align people, systems, business processes & practices to optimize value for the client”, and relates to its characteristics and benefits. He states that the benefits vary depending on the role taken by the team members, but similarities are identifiable due to the nature of IPD contracts. For clients it becomes easier to link improved value and higher quality design with business objectives. IPD enhances the capacity for lower costs regarding construction, operation and energy use. Furthermore, early involvement leads to less rework, better relationships and improvements in decision-making. Indeed, Thomsen (2010) refers to the early involvement of prime members and describes this specification as the means to achieve defect-free buildings. Therefore, the project becomes easier to design with shorter documentation times and better-integrated design benefiting all the members. It also enables greater construction cost certainty and a more constructible project.
2.2 The Impacts of Project Delivery on Team and Project Performance

Project delivery methods present various possibilities for management, directly influencing teams and project performance. Hence, from traditional delivery methods to IPD, the core elements of each method have direct impact on how teams interact, share information, and their level of success delivery projects. This section points out that the relational nature of IPD contracts offers a new opportunity for creating cohesive teams that are challenging to create in other project delivery contexts and that it is a key element to why they have differentiated performance.

2.2.1 Comparison of Project Performance between Integrated and Traditional Delivery Methods

Given that no research shows statistically significant differences between IPD and other delivery systems in terms of performance, El-Asmar et al. (2013) developed a study to fill the gap and evaluate the performance of IPD, design-bid-build, design-build and construction management at risk. The study relates to 35 projects (12 IPD and 23 non-IPD projects) and focuses on data concerning construction managers and general contractors. The research provides quantitative understanding of IPD performance compared to non-IPD and “IPD-ish” projects. The IPD projects present higher performance on six out the nine performance areas studied. The following table uses the figures presented in the research develop by El-Asmar et al. (2013) and gives an overall summary of the findings obtained comparing the performance among the different deliveries methods on nine specific areas by taking the results for IPD projects as reference:
Table 2-1: Evaluating IPD through Nine Performance Areas (El-Asmar et al., 2013)

<table>
<thead>
<tr>
<th>Performance Area</th>
<th>non-IPD</th>
<th>IPD-ish</th>
<th>IPD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Cost</strong></td>
<td>No statistical difference in cost performance (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems Quality</td>
<td>Lower</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Deficiency Issues (Per Million Dollars)</td>
<td>Significantly Higher</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td><strong>2. Quality</strong></td>
<td>Warranty Cost / Latent Defects</td>
<td>Data does not show obvious differences as it is, would need extra statistical analysis (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Punchlist Items (Per Million Dollars)</td>
<td>Significantly Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Construction Speed (Square Foot Per Day)</td>
<td>Relatively Lower</td>
<td>Lower</td>
<td>High</td>
</tr>
<tr>
<td>Delivery Speed (Square Foot Per Day)</td>
<td>Relatively Lower</td>
<td>Lower</td>
<td>High</td>
</tr>
<tr>
<td>Intensity (Average Dollar Value of Construction Work Per Day)</td>
<td>Higher</td>
<td>Lower</td>
<td>Relatively High</td>
</tr>
<tr>
<td>Schedule Growth</td>
<td>Relatively similar but no statistical evaluation (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4. Safety</strong></td>
<td>Overall Percent</td>
<td>Higher</td>
<td>Low</td>
</tr>
<tr>
<td>Design-Related</td>
<td>Relatively Lower</td>
<td>Higher</td>
<td>Low</td>
</tr>
<tr>
<td>Additions and Deletions</td>
<td>Higher</td>
<td>Relatively Lower</td>
<td>High</td>
</tr>
<tr>
<td>Change Order Processing Time</td>
<td>Higher</td>
<td>Relatively Higher</td>
<td>Low</td>
</tr>
<tr>
<td>Request For Information, RFI (Per Million Dollars)</td>
<td>Higher</td>
<td>Relatively Lower</td>
<td>Low</td>
</tr>
<tr>
<td>RFI Processing Time</td>
<td>Higher</td>
<td>Relatively Higher</td>
<td>Low (*)</td>
</tr>
<tr>
<td>Rework (% Of Overall Cost)</td>
<td>Relatively Similar (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resubmittals (Per Million Dollars)</td>
<td>Relatively Higher</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td><strong>6. Communication</strong></td>
<td>Extra Labor</td>
<td>Relatively Higher</td>
<td>Low</td>
</tr>
<tr>
<td>Percent Plan Complete</td>
<td>Relatively Similar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor Factor</td>
<td>Lower</td>
<td>Relatively Lower</td>
<td>High</td>
</tr>
<tr>
<td><strong>7. Labor</strong></td>
<td>Tons of Waste (Per Million Dollars)</td>
<td>Higher</td>
<td>Low</td>
</tr>
<tr>
<td>Waste Recycled</td>
<td>Relatively Lower</td>
<td>Lower</td>
<td>High</td>
</tr>
<tr>
<td><strong>8. Environment</strong></td>
<td>Overhead and Profit</td>
<td>Lower</td>
<td>High</td>
</tr>
<tr>
<td>Return Business</td>
<td>Relatively Similar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The research developed by El-Asmar et al. (2013) statistically compared performance metrics between different types of method delivery. Table 2-1 represents the relative outcomes presented in their research and suggests that IPD has superior performance metrics concerning quality, communication and change performance. However, all the findings do not relate to statistically analyzed data sets. When the metric is followed by an asterisk (*) it means that the analysis relates to interpretations from the authors and that further statistical analysis should be developed to reinforce the comparison.

2.2.2 Influence of Project Delivery on Team Performance

In order to provide an overview of the links between delivery method and team performance, we will utilize the findings exposed in Franz (2014) dissertation. The dissertation relates to results of a statistical analysis of 204 projects to assess the role of project delivery and team integration in the performance of construction projects. One of the main findings related in this research is that project delivery methods are not factors influencing success. Nevertheless projects following delivery strategies enabling the use of integrated practices resulted in greater project success.

This research re-grouped project delivery strategies into five different classes. Each class is classified directly correlated to the ability to utilize integrated practices and develop project teams into a cohesive unit. For instance, as shows on Figure 2-2, class 1 represents projects with the lowest team integration and team cohesion and Class 5 the highest. The research shows that eighty-four percent of Class V delivery strategy reached completion on time or earlier. However, only sixty-three percent of Class I projects were on time or had early completion, representing the lowest level of team integration and group cohesion. Leicht et al. (2015) specify that even if relationships were found between delivery strategies and project performance, there is no “one-size-fits-all” delivery strategy due to the uniqueness of each project.

Deciding to develop integrated strategies within the delivery of a project can be challenging, however the implementation of integrated practices is more likely to be successful by considering group cohesiveness as well. From the projects analyzed in this research, three factors affecting project delivery methods are highlighted to enable team integration and
cohesion within teams. First, early involvement of the core team including critical contractors and continuous interaction through the design and construction phase is critical factors successful delivery. The second theme is qualification-based selection of team members, rather than price-based. The research shows that the most cohesive teams include processes to evaluate the quality of the team members. The third theme refers to the degree of transparency in cost accounting. The development of trust between team members increases with the use of open book accounting during the delivery process.

This section presented how the use of integrated practices enables team to improve project performance. It seems that by using the “IPD-ish” approach, project teams can utilize principles of IPD without having the contractual requirements. Indeed, in its study, El-Asmar et al. (2013) shows that “IPD-ish” projects presented higher project performance than non-IPD projects but still lower than IPD projects. Moreover within the IPD approach, higher team integration and group cohesion are factors leading to more successful projects. The team is a key element to how project have differentiated performance, therefore it is important to understand how to organize the project team participants to allow for more cohesion and integration.

2.3 Contractual Team

In most industries the role of the contractual team relies on considerations relating to composition, organization, roles, leadership and decision-making. This section starts with an overview of how teams are implemented in other sectors to better compare it with the AEC industry approach. Then, due to the critical impact of team on project success, it is important to identify characteristics and enablers of successful teams to support the adoption of appropriate team strategies for IPD projects.

2.3.1 Overview from Other Sectors

From one industry to another, teams are created, managed and organized differently to support the desired outcomes and objectives. In order to have a broad understanding of the characteristics of teams it is important to consider teams from industries other than construction, such as for sports, military and business activities. Teams are approached differently depending on the objectives and the nature of the work, but similarities arise. Bantel and Jackson (1989) analyzed the relationship between the social composition of top management teams and innovation adoptions in a sample of a 199 banks and found that young educated leaders and diversity of team members increase team performance in general. Furthermore Humphrey et al. (2009) suggest that certain team roles are more important for team performance. They tested this theory in 778 baseball teams to emphasize the need for strong leaders playing a key role in
the development and empowerment of teams. LePine (2003) developed a study gathering 73 three-person team during a three hour computerized decision-making simulation. The main findings highlight the importance of a significant degree of adaptability involving communication and openness between the team members to be more successful. The characteristics related in these studies can be applied to teams for a wide range of activities. To relate with the construction industry, it is essential for teams to communicate, as most projects involve several stakeholders and need to have leaders able to adapt with different sectors and activities involved within the same project.

2.3.2 Composition

Creating the team in an IPD project involves an agreement between team members. Matthews and Howell (2010) describe members of the main contract, or Prime contract, as Primary Team Members. The Prime contract binds all members together to respond to one price and one scope to the client. Robbins et al. (2011) further highlights this characteristic in their analysis of organizational behavior, and adds that larger groups are usually better at developing alternative solutions. However, larger groups can become harder to manage and less effective, thus, a strategy for scaling teams efficiently is to create specific teams focused on areas of failure.

Likewise, Ashcraft (2012) specifies that subcontractors and consultants are not always part of the prime IPD contract and are often integrated via sub-agreements and joining agreements. The contract negotiation should be developed through design workshops and use an expert having significant IPD experience to act as a leader. Even in IPD projects it is still a common practice to have subcontractors and consultants outside of the multi-party agreement. They are procured on a fixed price or time and material basis and are usually outside the risk/reward sharing of the prime agreement. As a mean of comparison Mossman (2008) relates to Design-Build and Design-Bid-Build, stating that the difference with IPD lies in the integration of specialized contractors and consultants as Prime Members. Hence for these specific types of project deliveries the specialized contractors integrate into the team later in the process.

The nature of IPD requires early integration of participants and the formation of the team. According to Townes (2015) the owner can select the team depending on proposals and capacities or teams are sometimes established through self-selection based upon past working relationships. In addition, Sive and Hays (2009) illustrate the need for early team composition by utilizing the MacLeamy Curve to show the potential to reduce costs through early integration because cost to implement changes rise throughout the project lifecycle, as design proceeds.
The capabilities required are enumerated by Ashcraft (2011) when describing how to create, organize and manage IPD teams. Ashcraft (2011) mentions that within IPD, team members have to be from different sectors and require specialized but complementary technical expertise, effective abilities for problem solving, and a high degree of involvement in communication and collaboration.

2.3.3 Leadership and Decision Making

Contrary to the pyramid management structure experienced through traditional project delivery, with IPD the control and leadership are allocated to the core team members depending on their degree of expertise, qualification and understanding of the process to be able to take on risks (Thomsen 2010). In IPD, a management committee organizes the collaboration and sets policies for the execution of the project. The committee gathers representative of each member of the core team including the owner’s representative to increase the degree of transparency.

According to Matthews (2005) the best leadership with IPD is self-governance where a primary member is motivated by the process itself. Thanks to the nature of IPD aiming to share interests, the owner can be confident with this concept and trust the members. Additionally, Elvin and George (2007) develop explanations regarding the process of IPD related to architecture and refer to the concept of “stewardship” aiming for greater communication between experts and users to enhance sustainability.

Finally, Sive and Hays (2009) highlight an upcoming issue related to the role of architects. It is suggested that architects may lose influence due to greater responsibilities given to other members. The early involvement of non-architectural disciplines could lead to shifting focus toward efficiency over aesthetical or programmatic features. The growth of IPD might entail modifications in the situation of architects and motivate them to play a different role concerning leadership. In the meantime, the aim is to improve the capacity of the owner to communicate and manage its facility.

2.3.4 Approaches and Enablers of teams in Design and Preconstruction

One of the key challenges to the deployment of integrated and cohesive teams is defining how the team members will work together. There are many methods and tools that can be used to successfully deliver a project on a lean basis. Thereby these methods relate to organizational and technological means aiming towards a greater degree of collaboration.

Building Information Modeling (BIM) represents the evolution of Computer Assisted Design (CAD) by utilizing new technologies to enable the creation of a simulation of the facility. BIM allows architects, engineers and constructors to communicate using a virtual
environment providing a model of the project as well as cost, schedule and specific information related to each component. The use of BIM could make projects save up to 10% of the cost through clash detection and could reduce up to 7% the construction time for a return on investment of about 634% (Azhar 2011). Moreover BIM brings project participants together and enable greater communication and efficiency instead of following traditional adversary behaviors. Thomsen (2010) emphasizes the need for appropriate management related to the BIM model and the significance for the manager to enhance collaboration by making sure each participants understand its role and responsibilities related to the model. By nature BIM brings the team to collaborate on the same scope and if appropriately managed and implemented it participates significantly to increase integration. However Ashcraft (2008) highlights a lack of BIM contract documents stipulating risk allocation, dispute resolution and insurance. The development of such documents would help the team to reduce efforts in establishing roles, responsibilities and strategies. Since participants work on the same virtual model and share information, there are issues related to ownership and intellectual property. Typically a licensed professional from the design or architectural firm manages the BIM model and the person in charge has to be specified in the contact document.

The Lean Construction Institute (LCI) introduced the Last Planner in the construction industry as a system for production control. This system establishes a way to schedule and plan construction work using a Should-Can-Will-Do approach and focuses on a 6-8 weeks look ahead schedule (Ballard 2000). In order to make the planning more accurate it involves the persons executing the work as well as the manager. Bhatla and Leite (2012) combine lean construction and BIM in the development of a framework where lean construction is utilized to remove waste and BIM to enable collaboration. More specifically they developed an analysis integrating Last Planner System within the development of a BIM model and the research shows that it significantly reduced RFIs and the number of change orders issued leading to a perceived increase of value to the owner.

The guide developed by the UHS on lean delivery explains to what extent pull-planning leads to a more collaborative delivery. Pull-planning is a method of planning where the work is planned from a defined milestone and becomes more detailed by going backwards and closer to the date of execution. Tiwari and Sarathy (2012) from DPR Construction developed a conference paper on pull-planning based on using the method to manage a healthcare project that gathered 15 construction companies and 20 design consultants. To make the communication easier, they implemented “I Get-I Give” cards, filled out by each project participant to create a customer supplier relationship between team members. As a result of using this method, the team reduced potential production of non-value work and increased
communication and trust. However, they specify that despite the benefits rising from pull-planning, the team faced challenges in continuous execution of the approach because the method requires discipline and commitment to be successful.

### 2.4 Cross-Functional Teams

In IPD, the contractual team integrates several members to assemble the team to respond to the project requirements. By doing so it necessitates organizing the team and often the choice of cross-functional teams (CFTs) represent a suitable choice allowing re-organizing the team into interdisciplinary groups that each has a specific goal.

#### 2.4.1 Characteristics

More integrated projects strongly depend on team organization, more specifically on the management of cross-functional teams (CFT). CFTs originated from the manufacturing industry in the late 1970s to improve efforts associated with product development and have been used increasingly since then. The difference between a cross-functional project team (CFPT) and a CFT is that in a CFPT participants are brought together to work on a single project for a limited amount of time where according to Krajewsky and Ritsman (2005), a CFT regroups people from one company but different areas or business units, such as finance, marketing, management and other departments, to work together with a common objective. The CFT members are part of the same organization with different expertise and responsibilities.

MacDonough (2000), showed that 97% of the companies selected in its research have used CFT and 33% use them all the time. The study highlights found the use of CFT is not related to the level of revenue performance of companies. Moreover, the data shows that 55% of the companies originally used CFTs to improve outcomes related to speed and concerning process reasons, 24% adopted CFTs to improve cross-functional interaction. Hence the main objective when using CFT is to enhance involvement, interaction and communication among members.

#### 2.4.2 Composition

Henke et al. (1993) relate to specific considerations concerning team structure and composition of CFTs. Structurally, CFTs usually gather between 8 to 10 members and each CFT is responsible for its self-management. When different CFTs are established to work on the same project, they often integrate support groups to assist the main CFTs, and all groups are under the control of the Product Management Team (PMT). Secondly, their paper insists on personnel considerations related to interactions and personalities. The study shows that more
effort is spent in the design of the team, rather than on the training of the team members to get them to work efficiently. Thirdly, within the team itself, cohesion and attractiveness are key elements to performance and efficiency. Concerning attractiveness, when members are devoted to the team they show higher interest to the goals and other members considerations. Moreover, cohesive teams show greater interest in discipline and responsiveness. These characteristics seem to significantly impact communication between members on both horizontal and vertical organizational directions.

On the other hand, with regards to the construction industry, Seed (2015) justifies the need for CFT or “Cluster Groups” because of the complexity of construction projects. Construction requires extended skills, not be manageable by a small group. Hence a CFT should integrate, at minimum, an owner representative, an end user, an architect and/or a designer, a general contractor or construction manager and at least one key trade contractor. Seed (2015) also specifies that each group needs a person focused on budget considerations, such as an estimator. Clusters follow the same principles as CFTs; the team members have complementary skills and bring different perspectives that allows better decision-making via distributed leadership. In most cases the groups are created as part of the Target Value Design (TVD) process and focus on a specific scope such as building system, department type or other element related to the project needs. The ultimate objective of a CFT is to provide an organization that enables communication, innovation, and performance (Love and Roper 2009).

2.4.3 Limitations

Literature extensively assesses project performance related to team characteristics. UHS (2014) and Cheng (2015) emphasize the need for cross-discipline collaboration via the use of CFTs that include necessary members to respond to a specific scope such as estimator and constructor. Leicht et al. (2015) demonstrated in their study that team integration and group cohesiveness are characteristics that any team in construction projects should aim for in order to increase performance. Suprapto et al. (2015) also related team performance and the collaborative aspects leading to success in a study about relational factors in owner-contractor collaboration and the mediating role of team working. However they highlight the need for day-to-day managerial attention to make sure the collaboration aspects are followed efficiently. Other literature approaches the importance of team features impacting project performance, however no specific research relates how the organizational factors enabling cohesion and integration within CFTs and teams supports project success in design and construction. Researchers highlight the need for such characteristics but they do not provide specific ways to achieve them.
Chapter 3: RESEARCH METHODOLOGY

The goal of this research is to develop a framework of the organizational factors influencing the successful development of CFPTs for integrated projects. The Agricultural Engineering renewal project at Penn State University is being delivered through IPD, allowing a case study observation as well as the elaboration of interviews. The research will utilize the data obtained through interviews with members of the IPD project, and augmented through interviews with other industry experts in IPD.

3.1 Case Study Observation

The Penn State Agricultural and Biological Engineering (ABE) building renewal represents the first IPD project delivered at the university. It represents an opportunity to observe the project organization and gather data related to this specific type of delivery method and its characteristics when implemented by a first-time construction owner. The project consists of a renovation of a 16,000 square feet multi-story historical section of the building as well as the demolition and reconstruction of the rest of the,77,00 square foot, building. The project scope will incorporate new graduate education labs, research labs, offices, classrooms, a fermentation facility and an area maintenance shop. The project will be pursuing LEED certification for a total estimated cost of $30 million, with a targeted construction start of summer of 2016 and completion date of winter 2017. Being an IPD project, a Project Management Team (PMT) leads a multi-party group consisting of PSU, EYP Architecture and Engineering, DPR Construction, MMC Mechanical, and Lighthouse Electric.

To develop this case study, the project was followed from the beginning of the design process to the early stages of construction. The project team held general meetings once a month at the university, allowing me to map the evolution of the team’s CFPT organization throughout the project lifecycle. Through working sessions with the general contractor’s project manager, I developed a first draft of the overall CFPT evolution. Furthermore, in order to develop an accurate CFPTs map evolution; I interviewed project leaders from the five signatory members. The interviews focused on capturing and confirming the CFPTs evolution, including all organizational modifications, as well as additions or replacement of members. The case study approach allows the project to reflect the context and narrative of the evolution of the CFPT throughout the design phase and early construction, as well as making sure that all elements accurately reflect reality.
3.2 Interviews

Interviews were conducted with members from different roles, as well as industry experts outside the ABE team, to obtain a broad array of expert opinions. The interviews were semi-structured, first because the questions needed to provide guidance for conversation and secondly because the questions evolved based upon the unique discussion with each interviewee. Specific questions were asked in order to capture the background and experience of the interviewees (i.e. previous IPD experience). Then the questions were open-ended in order to engage them in a discussion related to the project and other experiences from highly integrated project.

Pilot interviews were conducted with a few industry experts and some of the PMT members that have experience in IPD. These interviews permitted data collection from experienced members and also gain feedback on the questionnaire and on which additional members should be interviewed. Then, interviewing Design Assists partners brought another perspective. Finally, during the research period other industry experts were interviewed to increase the data from experienced professionals. Interview experts are defined as an industry member that has experience in more than two IPD projects and has more than 10 years of experience in the industry. The requirement of two or more IPD project allows participants to compare different projects and provide insights across different facilities, project goals and teams. The second requirement of a minimum of 10 years of experience is chosen so that the participant can provide comparison between IPD and less integrated projects. The interviews were sequenced to get the interviewee to think about the IPD process and provide insights concerning their experiences from other IPD projects. The duration was typically between 20 and 30 minutes for typical interviews, but sometimes took longer based on willingness and responses. The interviews were selected to gather all of the major signatory roles from multi-party projects, and continued until no new perspectives or data was gained from additional interviews. However, it proved necessary to interview approximately 5 project participants and 7 industry experts.

3.3 Qualitative Research

The study can be defined as qualitative research as the study suggests that there is a cause-effect relationship amongst organizational factors and team performance. The case study observation combined with the interviews helped identify variables:

- **Independent Variable:** cause, influence or affect outcomes
  - Company’s policies and organization.
  - Owner’s involvement.
- Member’s previous experiences on integrated projects.
- Contract requirements

- **Confounding Variables:** affect dependent variables leading to alternative explanations
  - Incentives to aim toward integration and cohesion.
  - Behavior / Personal motivation.

- **Dependent (Moderating) Variables:** new variables that measure the joint impact of two variables
  - Organization
  - Communication
  - Lean Practices

Furthermore, the qualitative research was completed using an inductive model through which the researcher sought generalizations or theories by asking open-ended questions to participants. The participants answered upon past experiences and their knowledge of the industry. The study utilized the data obtained and provides an analysis to develop discussions. At last, because of the targeted scale of the study, focusing on the Penn State project and industry experts, the research is at a Meso level of research. This type of level for the theory is utilized for research relating to organization and communities, and in our case an integrated construction project.

### 3.4 Data Analysis

The research data is presented by first describing the case study through the main characteristics related to the Agricultural Engineering project. Information related to team organization and composition, collaboration, communication and integration are presented allowing an overall understanding of the project. Second is the data collected from the interviews and organized to be able to transfer the data collected. The responses are organized per interviewee and summarize the key elements provided during the interviews. By doing so, the researcher was able to identify repetitive elements and trends within the answers. The recurring answers were highlighted and coded depending on their degree of importance related to the question, and, how they link to the general impacts on CFPT organization. At last, the data collected from the interviewed is compared to the case study to assess the significance of the methods used. It also permits further recommendations related to organization and collaboration that could be utilized in integrated construction projects.
3.5 Research Limitations

The research concentrates on the PSU project and industry expert interviews. The findings are limited due to the limitation to one case study observed. This limitation is partially due to the limited number of highly integrated projects being developed in the East coast of U.S. and also it is the first IPD project at Penn State. However, combining the case study and expert interviews still allows conclusions on regarding how CFTP methods and organizations are successful.
Chapter 4: CASE STUDY

This chapter introduces the case study elements observed. The data was collected by direct observation during the design phase of the project of team meetings as well as document reviews and interviews with the senior project manager of each signatory partner. The purpose of using this approach is to understand how the CFPT was originally organized and how it evolved. The case study will then serve as a basis for comparison with information obtained with the expert interviews.

4.1 Background

The IPD contract gathers five signatory partners: owner, designer (architecture and engineering), general contractor, mechanical contractor and electrical contractor. Penn State first selected the general contractor and designer as a team. The team then made the selection of the specialty contractors. Finalizing the original selection process, the IPD team presented a list of five goals that they wish to achieve through this project:

- Enhance student and faculty experience (environment that supports excellence in research and teaching),
- Respect, reinforce and improve PSU-ABE brand and image,
- Building design quality (design and materials should set a high standard for architectural aesthetics and quality),
- Improve building neighbourhood (building should communicate with the neighbouring project and landscape), and,
- Life cycle and sustainability (the project should minimize life costs, and remain relevant for a 50 to 100 years lifecycle).

4.2 Project Team Organization

In order to re-group members from the different, signatory companies to reach the objectives, the participants self-organized by cross-functional project teams. The Project Management Team (PMT), including members of all five signatory members, is responsible for decision-making in instances when the CFPTs cannot come to a common agreement. The members are divided into several scope-specific CFPTs focusing on achieving project goals in conjunction with the Target Value Design process (TVD). The concept of TVD is a management technique that has been utilized in the manufacturing industry to achieve cost predictability during new product development (Zimina et al. 2012). According to Pishdad-Bozorgi et al. (2013) designers need the assistance of builders to determine design alternatives, estimate costs, and provide
value engineering services during the design phase. Therefore, TVD involves both current and continuous processes of designing to set a target value (cost for this case study) and assessing the team performance toward achieving the design targets. This method creates possibilities for the project team to achieve the greatest value for the owner. Furthermore, during design, other members were selected and added to the team as needed to bring expertise by system.

The non-signatory design-assist partners have different contracts payment terms and input on the project decision-making. Some are incentivized through shared savings, while others are under traditional Lump Sum contracts. Figure 4-1 shows an example of the contractual relationship between project participants. The signatory members are linked to the IPD contract and each of them has subcontractors, some of which are incentivized, while others are not.

Figure 4-1: Project team contractual relationships - Example

4.3 Cross-Functional Project Teams Characteristics

The different CFPTs created for this project are presented in Figure 4-2. Divided in two categories; TVD and support CFPT are all designed to answer a specific need. The following figure was developed using documents given by the team as well as interviews with some
project managers. The items highlighted in Figure 4-2 show the main elements for which each CFPT is responsible. According to the project team, they selected these specific categories to become CFPTs because they represent the main systems in the building (e.g. MEP) as well as corresponding to the highest budget expenses. Indeed, as explained previously, IPD encourages the use of the TVD approach, making sense for a project this scale where the main areas of focus are per system and money equivalent.

The CFPTs are all structured with an agenda, meetings and information specifications. The team leader of each TVD CFPT is responsible for the coordination of weekly coordination calls, information exchange and follow up with other CFPTs. Due to the small scale of the project, the project team cannot continuously collocate, and therefore the team meets every month for three days. These monthly meetings are led by an IPD expert working for the general contractor and allows the team to meet face to face, organize pull-planning sessions and make sure each CFPT can collaborate with each other. At last, the main focus of these meetings relates to evaluate the current state of the TVD CFPTs.

This project presents five main system areas representing the five TVD CFPTs. Mechanical, Electrical and Plumbing (MEP) are joined due to the extensive need for coordination between these trades during design and construction. Shell and Envelope are directly related, they each have specific requirements but the team decided to schedule joint meetings because of the correlation between the two systems. Moreover, the Site CFPT was originally separated with its own agenda and meetings, but because the project site is relatively small, making most of the site elements connected to the Envelope and Shell, the project team made the decision to regroup Site with the other two CFPTs. Program Validation is a necessary CFPT to allow the project team to start the design, once completed it merged into Fit Out. Finally, the Support CFPTs are created similarly, however, their objectives are subordinate to the other CFPTs, they assist with coordination, information exchange, logistics, and other elements that are needed across the project team but are not directly supporting the identified project goals.
4.4 Target Value Design Cross-Functional Project Teams Evolution

Figure 4-3 represents the evolution of the CFPTs throughout the design phase of the project. Program Validation, the first CFPT, is required in the contract to be completed in order to enable other CFPTs to begin their design. Once this CFPT task was complete, the project team created a set of CFPTs when the first two members (designer and general contractor) of the team were selected in January 2015. The three original CFPTs were MEP, Shell and Envelope, Site and Fit-out. A leader was chosen by common agreement among CFPT participants to govern each. Then, each CFPT evolved differently, leading to various the need for group and member modifications. Hence, Figure 4-3 shows the three main organizational changes experienced by the project team, represented by the different highlighted areas in blue, red and green.
Figure 4.3: TVD Cross-Functional Project Teams evolution through design phase – Types of changes
Type “1” (red) refers to a change experienced due to the expansion of the CFPTs through the on-boarding of new project participants, in this case the Mechanical and Electrical contractors. The new CFPTs created gather a main MEP CFPT and an Electrical CFPT with members of the Electrical and Mechanical contractor partners. The necessity for a separation between the two CFPTs is that they both need to hold separate meetings focusing on specific system related topics. However, as the systems work closely together, it is important to keep the communication between the teams to assure appropriate flow of information. Eventually, Figure 4-3 highlights the change in leadership, where the “mechanical engineering 1” from the Designer was originally leading the CFPT. The on-boarding of new project participants impacted the organization and the need for a different leader, bringing builder’s input and construction specific expertise.

Type “2” (blue) relates to a change brought on by the project team when they identified a lack of interaction for these CFPTs. Originally, Shell and Envelope were gathered under one CFPT with a need for separate meetings on specific topics. However, Site was a separate emphasis, with its own meetings and agenda. The project team realized that the Site CFPT did not have many meetings during the first few months of the design phase and that, due to the relatively small site area, the three CFPT have many elements that required extensive collaboration. Thus, the project team decided to gather the three CFPTs under one main CFPT led by “designer 1.” In this case, the team described this individual as the most capable of leading such large CFTP, by showing extensive leadership skills and technical expertise. From then on the CFPT held meetings with the three groups in order to collaboratively develop the design and exchange information. In summer 2016, to prepare for construction, the leadership switched to “project manager 1” from the GC because the members believed he was better able to bring field input and coordinate with subcontractors at this stage of the project.

Type “3” (green) is the last type of change experienced during this case study. The Program Validation is a task CFPT that focuses on area reparation and definition in order to allow the rest of the project team to begin design. This CFPT objective took place at the very earliest stage of the design phase and, once completed, dissolved and re-emerged into the Fit-out CFPT. In the new grouping, the principal activities are based on the elements developed during the program validation. It appears that “designer 2” was brought on the project to focus on this specific program validation task; this explains why they left the group after the completion of the task. When Program Validation merged into Fit-out, the “architect 1” from the Designer took over the leadership of the CFPT.
4.5 Support Cross-Functional Project Teams Evolution

Support CFPTs are created to assist the TVD CFPTs. Figure 4-4 represents the evolution of the five Support CFPTs during the design phase of the project. First, the Budget CFPT was terminated by the team when realizing that the objectives of this CFPT could be done by a single person. Figure 4-3 shows that when the Budget CFPT was terminated in July 2015, the Assistant Project Manager 1 (APM1) from the GC took over the responsibility of reporting to the PMT the TVD numbers for each CFPTs. This approach was made possible by the TVD approach that requires each CFPT to be responsible for their specific budget.

In January 2016 the Scheduling CFPT was created when enough participants with field responsibilities joined the project team. This CFPT started in January 2016 to prepare for construction in August 2016. The PM 1 from the GC took the lead of this CFPT as the team realized that the GC had an extended need for coordination with the other trades being the signatory members with the greatest amount of subcontractor.

The Technology CFPT brings support for information exchange and model coordination. Also led by the PM1 from the GC, it remained consistent throughout the project and was later joined by the BIM experts of the Electrical Contractor (EC), Mechanical Contractor (MC) and General Contractor (GC) to bring more expertise for technology related matters.

To start the Sustainability CFPT, only three participants were gathered at the beginning to prepare theoretical elements required to obtain LEED and was completed in September 2016 with additional participants with capabilities to help preparing for LEED. This CFPT was led by Designer 1 of the Designer after a common decision from the team due to his expertise and leadership skills. The LEED preparation was complete by May 2016 and the CFPT was put on hold until the beginning of construction as it reached its primary goal. Similarly to the Program Validation CFPT, this CFPT had a specific goal and was no longer needed once this goal was achieved.

The last support CFPT is the Academic Enhancement. This CFPT is specific to this project and owner. Having their first IPD project on campus, Penn State desired to highlight the importance of learning with this project and asked the project team to be involved as much as reasonably possible with classes and students. Moreover, it permitted students to utilize the project as an example for projects and research.
Figure 4-4: Support Cross-Functional Project Teams evolution through design phase
4.6 Characteristics of a Successful Cross-Functional Project Team

The creation, composition and evolution of the CFPTs is described in the previous chapter. It is, however, important to highlight the characteristics that make a successful CFPT. After a meeting with members of the project team, they specified that the Electrical CFPT was the most successful. The Electrical CFPT was the most consistent at meeting commitments throughout the entire design phase. Three main reasons were highlighted: first, at the beginning of the project the CFPTs were asked to fill a “task matrix” to identify roles and responsibilities from the team members to meet their objectives. It appears that by taking the time as a team to complete the task planning it allowed them to be more effective in meeting commitments. Secondly, the Electrical CFPT has a very clearly-defined scope, especially when compared to the other CFPTs and was composed of fewer participants. According to the project team these elements enabled them to be more involved and dynamic making the design process more efficient. Finally, the leader of this CFPT has strong facilitation skills and managed to keep members involved and motivated to meet their milestones.

4.7 Conclusion: Case Study

The project team for the Agricultural Building Renewal organized in CFPTs in order to focus on specific areas and systems of the building. The teams were divided in two categories; the TVD CFPTs and the Support CFPTs. Each CFPT has a specific set of objectives and the nature of the Support CFPTs is to assist the TVD CFPTs to achieve their goal.

The project team specified that each team needs a leader with skills that enable them to manage the interactions and understand how the elements of its CFPT relate to the other ones. The team leaders are responsible for managing their personnel, reaching the objectives set by the project teams, and reporting to the PMT. Then, within each CFPT, members are selected depending on their capabilities to help the group reach its goals. For example in the MEP CFPT, the PM of both EC and MC are represented as well as representatives of the other three signatory partners.

The CFPTs were originally created to answer a specific goal, however it appears that they evolved following the different project phases. Some participants were added to the teams as the project progressed, such as design assist partners. At other times members were removed, added or switched from a team to another if the project team seemed that it was a necessary change to help them. One project participant referred to this process as an organic evolution, where the project team needs to continuously improve. Indeed, the case study highlights three main types of main change concerning the CFPTs; expanding, joining, and, dissolution / emergence. Expansion refers to the addition of project participants requiring the modification
of a specific CFPT. Joining concerns the need for modification when the project team realizes that improvements could be found by combining CFPTs. At last, the dissolution and emergence concerns a CFPT that has a specific short term goal. Once this goal is complete the CFPT is rearranged to focus on another system. Following the same principles, the Support CFPTs evolved throughout the project highlighting the concept of an organic developments that takes into account the project performance and the team capability to learn and improve to adapt the CFPT organization accordingly.

CFPTs are likely to be more successful if they have a well-defined scope and take time to define roles and responsibilities of participants. A more specific scope suggest that a smaller group can be selected which makes it easier to manage and keep members involved in the design.
Chapter 5:  EXPERT INTERVIEWS

The case study set a basis for the expert interviews by highlighting the organizational evolution of the CFPTs during the project and the main modification concerning participants and teams. Therefore the interviews are structured around determining what is different between this case study and other projects to highlight best practices and validate the elements observed in the case study.

5.1 Experts Selection

For these interviews, experts are described as AEC industry members with a minimum of 10 years of experience in the industry and 2 or more IPD projects. In order to obtain a broad picture of best practices and recommendations concerning CFPT and IPD projects, the selected experts have different background and specialization.

Table 5-1: IPD Experts Profiles

<table>
<thead>
<tr>
<th>Experts</th>
<th>Company Type</th>
<th>Role on Projects</th>
<th>Industry Experience</th>
<th>Number of IPD Projects</th>
<th>Dollar Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical Contractor</td>
<td>Project Manager</td>
<td>30</td>
<td>7</td>
<td>$5B</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical Contractor</td>
<td>Project Executive</td>
<td>10</td>
<td>4</td>
<td>$20M</td>
</tr>
<tr>
<td>3</td>
<td>General Contractor</td>
<td>Facilitator / Project Executive</td>
<td>15</td>
<td>7</td>
<td>$70M</td>
</tr>
<tr>
<td>4</td>
<td>General Contractor</td>
<td>Project Executive / Project Manager</td>
<td>20</td>
<td>5</td>
<td>$1.5B</td>
</tr>
<tr>
<td>5</td>
<td>Owner</td>
<td>Project Manager</td>
<td>20</td>
<td>20</td>
<td>$300M</td>
</tr>
<tr>
<td>6</td>
<td>Owner</td>
<td>Project Manager</td>
<td>30</td>
<td>20</td>
<td>$700M</td>
</tr>
<tr>
<td>7</td>
<td>Designer</td>
<td>Architect</td>
<td>15</td>
<td>15</td>
<td>$40M</td>
</tr>
</tbody>
</table>

5.2 Interview Questions

The design of the questions for the interviews was developed to start a conversation with the experts. Table 5-2 present the questionnaire developed, as well as the main categories. First, in order to obtain data about the participants’ identification and past experience, questions were asked. This information is presented in Table 5-1 to show data categorizing the experts. Then, to start the conversation about IPD and the teams, part 3 starts with questions concerning
general team organization and gets into more details about team creation, composition, evolution and main changes observed. Finally to conclude the interview, the experts were asked to reflect on the CFTP approach by thinking about how this approach could be utilized on other projects. The objective of asking these questions is to be able to compare the answers with the findings from the case study. These experts had experiences on diverse projects type and scale allowing for a wider vision of CFTP organization in IPD projects.

Table 5-2: Interview Questions

<table>
<thead>
<tr>
<th>Categories</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expert Information</strong></td>
<td></td>
</tr>
<tr>
<td>1 Name:</td>
<td></td>
</tr>
<tr>
<td>2 Company Name / Type:</td>
<td></td>
</tr>
<tr>
<td>3 Position:</td>
<td></td>
</tr>
<tr>
<td>4 Experience in the Industry:</td>
<td></td>
</tr>
<tr>
<td><strong>IPD Background</strong></td>
<td></td>
</tr>
<tr>
<td>5 How many IPD projects? ($ equivalent)</td>
<td></td>
</tr>
<tr>
<td>6 What type of projects?</td>
<td></td>
</tr>
<tr>
<td>7 What was your role in these projects?</td>
<td></td>
</tr>
<tr>
<td>8 What changes were consistent across projects, were there any that had unique circumstances?</td>
<td></td>
</tr>
<tr>
<td><strong>CFPT Overview</strong></td>
<td></td>
</tr>
<tr>
<td>9 How where the teams organized?</td>
<td></td>
</tr>
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<td>10 How should teams identify the needed CFPTs within a project?</td>
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<td>11 How should / can team identify when the structure should change?</td>
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<td>12 What type of changes usually occur related to CFPT organization?</td>
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<td>13 What competencies are needed by CFPT leaders?</td>
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<td>14 How did the CFPT structure impacted the projects? What did it enable, what was challenging?</td>
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<td>15 What aspects of CFPTs are translatable to other project delivery, and which are challenging to apply elsewhere?</td>
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5.3 Results

The results of the expert interviews is presented to show elements that help answering the research questions. The interviews were structured to guide a discussion around IPD and CFPTs in order to understand how the different experts approached the aspects highlighted in the objectives. The following section presents the data obtained and highlights the main outcomes of the interviews.

5.3.1 Needed Cross-functional Project Teams

The interviews questions allowed experts to specify elements related to general team organization, the team approach to design and how to identify which CFPTs are needed. They also seemed to be thinking that the frequency of meetings and interactions was an important factor.

Team Organization

All experts stated that teams utilize a CFPT organization in IPD projects. Two experts with experience on higher scale projects insisted on the need for a PMT and SMT as a solution to the general management of the other CFPTs. However, one expert with experience on smaller scale projects specified that sometimes project team utilize focused groups or temporary CFPTs that focus on an issue that need to be taken care of.

Design Approach

All experts agreed on the need for utilizing a TVD approach. They highlighted that the nature of IPD projects requires each CFPT to have specific cost focus for their specific scope. Each CFPT is responsible for its own cost analysis and then reports to the PMT that gather the current project cost estimate to compare it with the original estimate.

How to identify the needed CFPTs

To create the CFPTs, it appears that 5 experts explained that it needs to be a balance between the project scope and the main building systems such as the structural and mechanical elements. Furthermore, the last 2 experts specified that it should be a balance between the project scope and the restraining elements that will require the most design considerations and a higher spending. Each project has a specific scope impacting the scale and type of building systems that are considered in a project, therefore the CFPTs should be developed in consideration to better fit each project.

Cross-Functional Project Teams Interactions

The discussion led the experts to talk about the importance of project team meetings and team interactions. 5 experts specified that ‘big’ room meetings, that gather the entire project
team, should be schedule a minimum of twice a month. However all experts insisted that team should have big room as often as possible, depending on the project scale and budget, in order to engage is face to face interaction. Additionally, concerning communication within each CFPT, all experts agreed that they should schedule cluster conference calls at least once a week in order to make sure every team participant gets a chance to communicate with all the members of its CFPT. Ideally all experts would like to be able to collocate in every project, meaning that all project participant would share a common space, but it strongly depends on the location and scale of the project.

5.3.2 Cross-Functional Project Team Composition and Evolution

The composition and evolution of CFPTs in IPD project varies from a project to another. The experts providing approximate numbers for the composition of the CFPTs and their experiences on how they evolve and how to identify the need for changing a CFPT.

Cross-Functional Project Teams Composition

According to Figure 5-1, the experts gave a range from 4 to 10 person per CFPT. It appears that the 3 experts with the most experience highlighted the fact that it always varies from a project to another and the project size and scope would impact the number of participants involved, and thus the number of CFPTs required. Furthermore, Figure 5-2 shows that the experts find that a CFPT should be composed of around 6 people. Again, experts with experience on larger project gave a larger number of people per CFPT than those with experience on smaller projects. An expert highlighted that a project with larger scale would likely have more complex systems to design requiring the input of more participants. Having around 6 people in a CFPT allow for the team to be manageable by one leader as well as allowing all members to participate equally. Finally, 3 experts specified that each CFPT should include an estimator that reports the current work estimate of the cluster to the PMT.
Cross-Functional Project Teams Evolution

Concerning the evolution of the CFPTs, experts from the mechanical contract and general contractor companies stated that all key participant to the project should be onboard at the beginning of the design in order to create the CFPTs. They added that it is required in order to avoid having to onboard new members later that requires time. On the other hand, the rest of the experts representing architects and owner stated that the CFPTs should be created as early as possible, meaning when most members are onboard. This difference is interesting, because it shows that, from the point of view of architects and owners it might not be as important to have all participants onboard from the very beginning. Indeed owners and architects familiar with traditional design-bid-build delivery are used to being part from the very beginning, with contractors added later. Finally, all experts insisted on the fact that the only time a CFPT should dissolved is when all goals are reached and objectives completed.

Additionally, most experts agreed that a CFPT might need to change either its organization or some members when it is not meeting its commitments. The experts representing the owners added that if a CFPT has a low team cohesion, showing a lack of collaboration and involvement, it is a sign that changes need to be made. They stated that such phenomenon is often linked with difficulties to meet commitments. On the other hand the expert with the most IPD experience insisted that there should be no major structural changes concerning CFPTs, they should be designed one way at the outset and remain until they reach their goals, with the only modifications due to shifting members to better suit the CFPT needs.

5.3.3 Cross-functional Project Teams Leadership

Roles and responsibilities were approached by the experts concerning the leadership of each CFPT. The experts all gave 2 to 3 main characteristics that made a good leader in their past experiences. Table 5-3 shows that 5 expert favor the need for a leader with technical expertise on general aspects of the project and not only the scope of its CFPT. They stated that having cross-expertise allows the team leader to better understand how the action from its CFPT would impact the entire project. Two experts that worked in a facilitation role in their IPD projects highlighted the need for facilitations skills first, meaning that the leader would be able to organize meetings, engage members and report to the PMT. It seems that all experts recommend a combination of cross-expertise and facilitations skills. Additionally, some experts highlighted the importance of a good understanding of cost. Due to the TVD approach, the CFPT goals are directly linked to the cost of the project and having a good understanding would enable leaders to better guide their team. Finally, one of the expert with experiences on smaller
project stated that matching the personality of the leader with the personality of the CFPT members allows for better cohesion and eventually enables collaboration.

Table 5-3: Expert Interviews Data – CFPTs Leadership

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<tr>
<th>Experts</th>
<th>Characteristic of a CFPT Leader</th>
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<td><strong>First</strong></td>
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<td>1</td>
<td>Cross-expertise</td>
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<td>6</td>
<td>Cross-expertise</td>
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<tr>
<td>7</td>
<td>Cross-expertise</td>
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</tbody>
</table>

5.3.4 Successful Cross-Functional Project Teams

During the interviews, experts all approached the elements making a successful CFPT. As stated in the previous sections, changes are required when CFPTs are not meeting commitments, meaning that a successful CFPT, with its abilities to meets commitments, either schedule milestones or TVD elements. For 5 experts, the success of a CFPT is directly linked to the ability of the leader to efficiently organize the team to drive collaboration and involvement. They also specified that CFPTs appear more successful if they are capable of collaborating with other CFPTs on a regular basis to obtain and deliver necessary information. Moreover, for 2 of the experts, a successful CFPT is a team able to reflect on its performance and analyze how to perform better via the concept of continuous improvement.

5.4 Conclusion: Expert Interviews

The outcome of the expert interviews shows that most experts have experienced similar organization on IPD project with some differences of point of views depending on their role. There is a need for using CFPT to organize participants into specific scope focused groups around a TVD approach. The CFPT organization allows to breakdown the project team in smaller groups that focus on specific elements related to the project scope and main building systems. Each CFPT is responsible for its own work estimate and reports to the PMT. The experts also highlighted the importance of face-to-face interactions; every two weeks for big room meetings and every week or more for cluster calls. These face-to-face interactions allow
participants to directly communicate and exchange regarding their work. Furthermore, the number of CFPTs varies depending on the project scope, larger projects will have larger scopes that need the creation of more CFPTs. On the same basis, the number of people per CFPT varies with the scope of the CFPT ranging from 4 to 10 people. It is however important to consider that the smaller the CFPT is the easier it would be for a leader so successfully manage it. Indeed, the experts indicated that a good leader should have a balance of cross-expertise and facilitations skills to both manage its team and understand the impact on the other elements of the project. Finally, a successful CFPT is identified by the experts by its capacity to meet commitments and would represent CFPTs with strong leaders that efficiently collaborate with other CFPTs in the project and take time to analyze their performance to improve continuously.
Chapter 6: DISCUSSION

Thanks to the background and project experiences that the experts described, the interviews highlights observations concerning emerging practices for designing CFPTs for IPD projects. The purpose of this section is to present the common elements that emerged from the interviews and the case study on the structure, composition and evolution of CFPTs, on the organizational considerations for aligning team roles and responsibilities CFPTs purposes. While the ties between IPD contracts and the emerging practices for Target Value Design are popular topics (Seed 2015), the design of the team to support the TVD needs has been less well defined. The ABE project team organized participants into seven scope specific CFPTs, gathering individuals from design, construction, consulting, and specialty trades as appropriate to the CFPTs’ objectives. Each CFPT collaborated with the rest of the project team in pursuit of the objectives set at the beginning of the project to align the scope and target costs. The results from the interviews regarding the structure of CFPTs align with the approach taken, or lessons learned, in the case study. The case study team evolved their CFPTs as they learned from their experiences, engaged new team members, or identified shortcomings in the current organization to support the TVD objectives. This section presents these concepts that emerged from these changes.

CFPTs are created to focus on a specific scope starting during the design phase. The experts stated that the number and purpose of the CFPTs should be a balance between the project scope, size, complexity, and project specific constraints, with the required facility systems. The ABE project team organized the CFPTs primarily around the building systems, such as the Shell and MEP CFPTs, with the Envelope CFPT needed for the historical renovation unique to this project. Furthermore, the team created Support CFPTs, such as Technology and Academic Enhancement, to provide assistance to the TVD CFPTs. This was not cited by any of the experts and does not seem to be a common practice in all IPD projects. Where current literature relates to the need for CFPTs to be created around building systems, this research found that the number of CFPTs depends on the project scope and scale. Project teams will likely create from four to 10 CFPTs, with each having four to eight participants. Four to eight team members was noted by the experts as a manageable size that balances the needed technical expertise of diverse team members with a small enough team to effectively complete tasks. The ABE project was divided in two phases, with the demolition and reconstruction on one part of the building and the rehabilitation of the historical front end of the building. Being a relatively complex project for its scale, the team created seven TVD CFPTs. Additionally, as shown in the case study with the Electrical CFPT, it is recommended to try to create CFPTs with fewer participants working on a more specific scope to enable success.
Face-to-face interactions provide a highly efficient way to communicate among project participants and across CFPTs. It is important to have these interactions as often as possible and, if the project allows it, to collocate. Per the expert interviews, big room meetings should be held two to four times a month and CFPTs should be working together once a week, or more. The ABE project team only had big room meetings once per month because of budget restraints and travel due to the locations of team members. The consensus from the project team interviews was that they would have benefited from meeting in person more often or collocating.

Project teams have to create the CFPTs at the outset. To enable all participants to be involved at the beginning and clearly align expectations to avoid disruptive addition of participants, this requires engaging all of the project participants – notably the contractors and specialty trades that are not often engaged from the earliest stages of projects. The interviews suggest that designers, owners and contractors have a slightly different viewpoint concerning the specific timing of engaging participants. The contractors and specialty trades all highlighted the importance of engaging them from the project outset, while designers and owners were less specific about when each participant should be involved – generally stating, “as early as possible.” It demonstrated that on project designers and owners are the first involved, whereas it is a significant change for contractors to be involved on day one, however the contractors feel the burden when not engaged that early. The ABE project team added the design-assist trades after the design had begun and found that it required additional time for the onboarding process, re-organization of the CFPTs that disrupted the process, and some evolutions of the team dynamics. The re-training and re-organization of the CFPTs that accompanied it could have been avoided by involving more participants at the project outset.

The extent to which the CFPTs should be modified is limited by the experts for two main reasons. First, each CFPT should only be dissolved when all its goals and objectives are reached. Generally the TVD outcomes are not realized until the completion of the project. Secondly, the team can evolve, to change either its organization or some members, when not meeting its commitments. The experts generally noted this as a failure from the outset to identify some expertise, or a need to address a lack of team chemistry when a CFPT was not collaborating effectively. The case study showed three types of modification throughout the design, likely due to the limited levels of IPD and TVD experience amongst the project team members. When new team members joined, e.g. the addition of the design-assist partners, the team reviewed their organization in order to best utilize these new member firms. While this was disruptive, it was necessary to maximize the value of these new team members and was likely a result of the lack of experience in this delivery method and CFPT design. Finally, the
CFPT focused on the Program Validation stopped when the objective was reached. While these may relate to the evolving learning and experience of the project team members with IPD and the use of CFPTs in the Target Value Design process, the changes demonstrate that the team organization is flexible and enables the structure to leverage continuous improvement as needed to support the project team’s pursuit of the objectives. Project teams have to continuously track their performance in order to leverage the full potential of the IPD contract throughout the process, and, if necessary, reallocate members to respond to low performance or failed commitments.

The role of the CFPT leader is a critical element, and noted as a challenging role to fulfill, to promote team performance both within and across the CFPTs. The interviews indicated that a team leader should have a balance between cross-disciplinary expertise and facilitation skills. The technical expertise allows the leader to better understand the impact of its CFPT on the rest of the project teams, and, the facilitation skills would enable members to engage the CFPT members to meet the target value design objectives collaboratively. Indeed, the case study shows that the leader selected were a mix of technical experts and facilitators, with the leadership changes mostly indicating a need for greater facilitation skills. It was also noted that it was challenging to find members with both strong facilitation skills and cross-disciplinary expertise. However, it is recommended for project teams to strongly consider the facilitation skills rather than only focusing on technical expertise when selecting CFPT leaders.

The research also identified the importance of the IPD contracts, demonstrating how a specific role can be fulfilled by different people from different firms in order to best suit the project team needs. Members from different participants can be added to a specific CFPT without having to revisit the contract values of the companies involved. Indeed, project teams have to consider the CFPT organization, combined with the IPD contract, to leverage the full potential of team members to fulfill the CFPT objectives. As seen in the case study, participants were removed if they do not add value to the process in their original placement. For example, in the Technology CFPT, the BIM expert from the Owner was replaced by the BIM expert from the GC because the team deemed it necessary to have the same person leading the BIM process throughout the entire project. The relational contracting mechanism underlying the IPD contract allows the CFPT structure to be flexible and allows the team to continuously evolve the CFPTs in parallel with the changing design processes needs to utilize team member skills when and how they are needed without adding unnecessary costs. These characteristics enhance the cross-functional organization of the team and allow for greater opportunity for collaboration and innovation.
Chapter 7: CONCLUSION

The elements arising from this research are beneficial to project team and team members that are unfamiliar with the concepts of IPD and CFPTs. Until now, literature presented CFTs as a practice used in IPD projects without providing much in the way of recommendations on their structure, organization, evolution, and only little literature presented on CFTs composition. This research presented considerations about initial outcomes that dictate the organization of CFPTs. Using CFPTs establishes specific groups of design and construction experts to work on a scope in conjunction with a target value design objective to support the overall project needs. This section defines how the answers to the research questions benefit the industry and advance the understanding of CFPT design in the design and construction industry.

This research documented a case study showing the evolution of seven cross functional project teams over the design and early construction phases of a construction project. The concepts driving their initial composition were driven by two demands – the technical expertise needed to support both the design and target value processes, as well as the leadership to facilitate collaborative interaction within and across CPPTs. Three types of team changes were noted throughout those processes: 1) Expansion, 2) Joining, 3) Dissolution and Emergence. While the team observed most changes to be disruptive, they supported the expert interview findings regarding the principles for the ideal composition of the CFPTs.

In addition to capturing the evolution of these CFTs, the concept of cross functional project teams was defined to differentiate the unique inter-organizational nature, and unique challenges of applying CFTs in the design and construction industry. Specifically, the nature of IPD contracts and the use of a Target Value Design process were found to be key enablers and drivers for enabling these concepts to be applied across organizational boundaries. In addition, it reinforces recent research by Franz et al (2017) identifying the project delivery strategy role in supporting the development of integrated and cohesive project teams. This research extends that to define how CFPTs can be used as project management approach to enabling the development of these teams at the project level.

In addition to advancing the general understanding of CFPTs and their application within the design and construction sector, this research captured practical industry guidelines to help new project teams create and manage their project’s CFPTs. This research found that during the design phase, the should CFPTs are created around the main building systems and restraining elements with, generally, four to 10 CFPTs composed of four to eight design and construction team members. The CFPTs should be structured to support the project goals and objectives in conjunction with a TVD process. Additionally, this research found that project
teams should organize and prepare accordingly to onboard all CFPT required participants at the outset of the project to minimize future disruptions when adding members. The CFPTs can focus on their design and will be dissolved once all objectives are met, typically when the project is complete. This research also demonstrated the importance of the contractual elements of IPD to enable the use of CFPTs for flexible capacity to transition members from a CFPT to another when needed to best support project needs. Finally, the CFPT leaders play a key role in the successful development of the project and that project teams should consider the benefits of facilitations skills in addition to the technical expertise.

The case study developed in this research present a visual organization and evolution of the CFPTs that is beneficial for project teams. It allows participants to clearly visualize the different CFPTs created, the participants and evolution throughout the design. Understanding the CFPT approach is a challenge and visual elements can help the different participant to link theory with practice. Also, the organizational diagram representing the project participants and subcontractors involved can provide clarifications to the project team concerning project organizations with IPD.

To expand this research, three main areas could be studied in more depth. First, a study could focus on the link between IPD project performance and the organization of the CFPTs to determinate which and how CFPTs are created, the number of CFPTs and the number participants per CFPTs. This research should capture several projects, likely 15 to 30 depending on availability, representing enough data to obtain a framework regarding how to align CFPTs with IPD project scopes and objectives. It would also serve to reinforce this framework by demonstrating the extent to which it has been a successful approach for other projects. Such research could also help highlighting standard CFPTs that are common and necessary to most IPD projects. Second, the importance of CFPT leaders was highlighted in this research, therefore, future research could focus on identifying how project teams should organize to select participants that have both cross-expertize and facilitation skills. Should it be included in the partner selection process as a key criteria or are there other ways to find participants with these traits? Third, the understanding of the TVD process seems to be a strong enabler to the successful development of CFPTs during design. This process is still quite new to the building design and construction industry. What means and methods can best be best utilized to teach project teams and make sure there is a strong understanding of the process, progress, and relationships among all CFPTs?
REFERENCES


Franz, B., Leicht, R., Molenaar K., Messner J. (2017) "Impact of Team Integration and Group Cohesion on Project Delivery Performance". *Journal of Construciton Engineering and Management,* 143
Hall, D., Algiers, A., Lehtinen, T., Levitt, R. E., Li, C., and Padachuri, P. "The Role of Integrated Project Delivery in Adoption of Integral Innovations." Proc., EPOC.


