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Implementing IPD Principles on Custom Residential Projects: Tools and Best Practices

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Tools and Best Practices

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Master of Science

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ABSTRACT

Implementing IPD Principles on Custom Residential Projects:
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The purpose of this research is to see how Integrated Project Delivery (IPD) principles and practices can be used on high end custom residential construction projects to increase the collaboration and efficiency of the project team. A case study was conducted on a custom home project to observe how and what IPD principles were used. Observations, interviews and a survey were used as part of that case study to gain insights. This research found that IPD principles and practices could be used on residential projects. In addition, the research found that those involved found the experience positive and beneficial to their success on the project.

Keywords: integration, collaboration, IPD, residential, custom, construction, lean

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1 INTRODUCTION

1.1 Background

Integrated Project Delivery has been successfully utilized for several years now on large commercial projects, such as hospitals, office buildings and sports arenas. One of the main goals of IPD is to get the key people talking early and working together earlier in the process to eliminate problems later (Aapaoja, A., & Herrala, M., 2013). Traditionally, when constructing a building the owner hires an architect to draw the plans and design the building (See Figure 1-1). Then once those are sufficiently complete the owner takes those plans and has contractors bid on those plans. The owner typically goes with the contractor whose price is the lowest (Hale, D. R., Shrestha, P. P., Gibson Jr, G. E., & Migliaccio, G. C. 2009). The traditional design, bid, build delivery method usually results in waste and little collaboration because all parties have different objectives (Jia-Yuan Wang, Xiang-Ping Kang, Vivian Wing-Yan Tam, 2008). In contrast Integrated Project Delivery brings key stake holders together sooner delivery in the process (See Figure 1-1) in order to align objectives and goals and find solutions to problems before they happen. This allows problems to be resolved when it is still easy and inexpensive to fix (Nofera, W., Korkmaz, S., Miller, V., & Toole, T. M., 2011). By doing this the construction process is hopefully smoother and the end product that more fully meets the owner's expectations and needs.

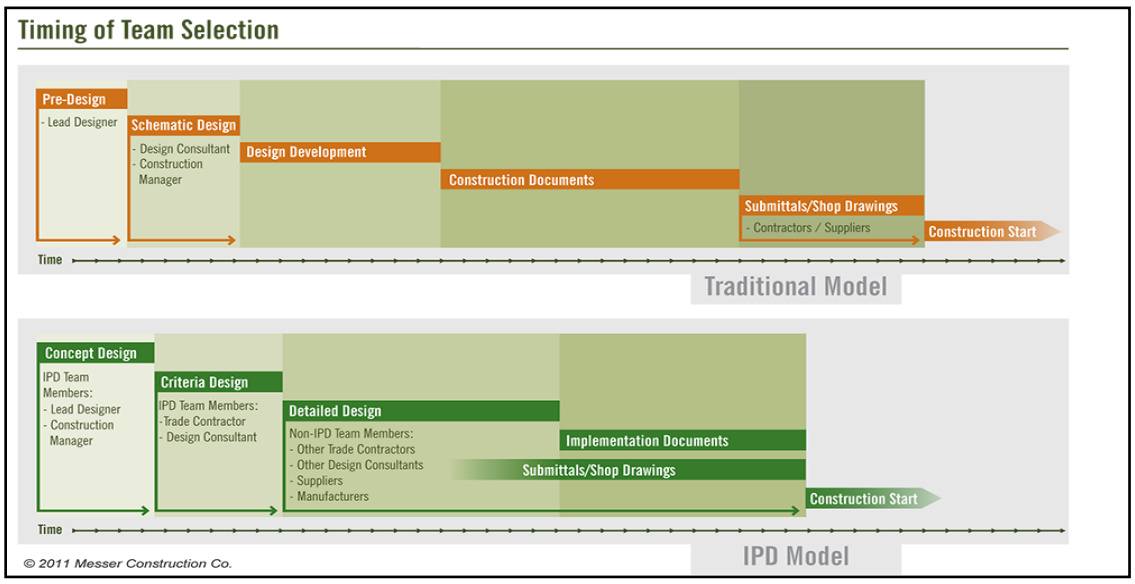

Figure 1-1: Comparison of IPD and Traditional Methods

Although IPD has been used with success in the commercial construction sector the residential sector has seen minimal adoption of this method. While there are significant differences between commercial and residential construction the basic ideas are the same, to construct a building that meets the needs of the owner, is on time and on budget (Hale, D. R., Shrestha, P. P., Gibson Jr, G. E., & Migliaccio, G. C. 2009)

IPD provides a framework to allow that to happen more regularly. The hypothesis for this research is that IPD principles can be successfully used on residential projects and that with the right application of these principles and tools residential projects will see an increase in collaboration and engagement from those involved in the project. As a result, projects will see a decrease in waste, save money, take less time and produce a better product for the owner/buyers.

There are several variations or types of IPD delivery methods being used in the construction industry the two main ones are IPD and IPD-lite. IPD or full IPD incorporates the following key practices, a multi-party contract with shared risk/reward, co-location of the core team for the duration of the project, pull-planning, scrums, lean principles, early involvement of key trades, and BIM. IPD-lite is similar with the main difference being the absence of a multi-party contract. Most commonly BIM and co-location for the duration of the project are also absent from IPD-lite projects. Typically, all the other components of IPD would be found on an IPD-lite project (Building, Design and Construction, 2011).

1.2 Statement of the Problem

Construction as an industry has lagged behind other industries in increasing efficiency (Lee, C. S.,2013). One of the reasons is that the process has remained largely unchanged. Using traditional methods there is a significant amount of waste and rework due to a lack of collaboration early in the process. Commercial construction, especially hospitals, have implemented the IPD delivery method with success for several years now (Ilozor, B. D., & Kelly, D. J. (2012).

Custom residential construction though has not adopted this method. While there are several reasons for this, one is that it can be daunting trying to figure out the best way to use this method and adapt it for residential construction. Residential builders need a framework, tools, and evidence that they can use to begin applying IPD principles successfully and seeing the rewards.

1.3 Purpose of the Research

The purpose of this research is to see how Integrated Project Delivery (IPD) principles and practices can be used on high end custom residential construction projects to increase the collaboration and efficiency of the project team.

1.4 Research Objectives

1. How can IPD principles be used successfully on custom residential construction projects?

2. Identify the best practices/tools used for incorporating IPD principles on a custom residential construction project.

3. Provide a frame work that could be used as a starting place for contractors wanting to implement these principles.

3. Do trades/subcontractors on custom residential projects perceive using IPD principles as beneficial?

1.5 Assumptions

1. Integrated Project Delivery is more efficient than traditional delivery methods.
2. Increased collaboration leads to greater efficiency.
3. Collaboration can be fostered and increased through various means.
4. Owners, architects, and contractors are open to increased collaboration.

1.6 Delimitations

For this case study the research team decided to focus on high end, homes over $500,000, full-custom residential projects. The focus was on the use of IPD principles and how those were implemented. This case study did not include a study of financial or schedule related impacts due to the use of these principles. One current project was selected as the primary case study and one other previously completed project was used for supplemental data. Observations by the author were made via video conference to allow the meetings to be run with the least amount of intrusion possible.

1.7 Limitations

Limitations for this research include the following.

1. Lack of residential projects using IPD principles.
2. Time constraints on the author limiting how long the project could be studied.
3. Distance to the project limited how observations could be made.
4. Limited number of participants.

1.8 Definitions

1. Integrated Project Delivery (IPD) – A project delivery approach that integrates people, systems, business structure and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction (Council, A. C. 2007).

2. IPD Lite – Uses the same principles as full IPD but does not require all parties (owner, architect, contractor) to be on one contract. But still utilizes co-locations, pull planning etc. (Building, Design and Construction, 2011)

3. Lean Construction – Lean construction is a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. (Koskela, Howell, Ballard, Tommelein, 2002)

4. Collaboration – When ideas are freely exchanged among all participants. In an integrated project, ideas are judged by their merit, not on the author's role or status. (AIA, 2007)

5. Big Room – A room where all members of the core team work in the same space for the duration of the project or periodically for a few days periodically throughout the project (Council, A. C., 2007).

6. Scrum – A meeting done regularly to establish tasks that need to be completed over the course of a determined time period typically1-3 weeks (Baiden, B. K., Price, A. D., & Dainty, A. R., 2006).

7. Pull-planning – Pull planning is a technique used to develop a plan for coordinating phases of a project. This should not simply be a process of working backwards to plan a project (Cho, S., & Ballard, G., 2011).

2 REVIEW OF LITERATURE

Inefficiency and waste are two problems that plague the construction industry. This review of literature will seek to understand the effects of waste and inefficiency on the construction industry and on the residential sector specifically. The review will also look at what is being done in the commercial sector to improve efficiency and reduce waste. Different delivery methods, which are being used to improve efficiency, will be reviewed for how they are being used and how successfully. A review of the differences between residential and commercial construction is also included.

2.1 State of the Construction Industry

The construction industry suffers from widespread inefficiency. The McKinsey Institute found that the construction industries gross value added per hour worked since 1947 has seen minimal improvement. Other industries such as manufacturing, agriculture and wholesale industries have seen massive improvement (See Figure 2-1). One survey of British architects found that 60% of their projects were late (Changali, Mohamad, Nieuwland, 2015). Often projects are over budget as well. Two examples of this are Apple's new headquarters in California which was completed two years late and over budget; the Berlin airport was also late and extremely over budget. The airport is an extreme example at six times over budget and with 66,500 building errors in need of correction as of August of 2017 (The Economist,

2017). Across the world 90% of infrastructure projects are either over budget or late (Rivard, 2000). Smaller projects also suffer from these problems. While there are many reasons for this, the two main reasons are 1) each project has around a dozen sub-contractors all trying to maximize profit 2) the slow adoption of technology (Rivard, 2000).

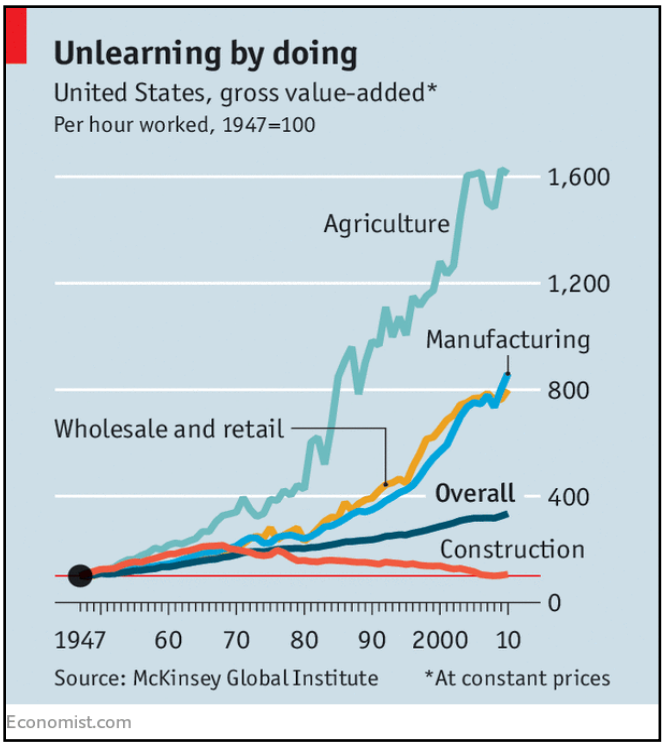

Figure 2-1: Efficiency of Construction

2.1.1 Attitudes Towards IPD in the Construction Industry

In their research Kent and Becerik-Gerber (2010) examine how the construction industry has adopted the use of Integrated Project Delivery (IPD). There has been a huge interest in IPD but the status of its implementation is unknown. Projects have continually shown the benefits of IPD however, the amount of IPD projects has remained small. Kent

and Becerik-Gerber (2010) used a web-based survey that was designed to target a wide range of construction professionals to shed light on the current status of IPD and its future widespread adoption within the construction industry. They conclude that IPD is still in its infancy. Most professionals either do not have direct IPD experience or are not familiar with its concepts, which suggests education is needed throughout the industry. The biggest concerns regarding IPD implementation revolved around risk and reward sharing, liability insurance and open-book accounting. Their findings show that the keys to a successful IPD project are centered on fostering collaboration and good leadership.

The main reason for resistance to adopting IPD typically comes from the owner or upper management and stems from fear of the unknown. Educating owners, and others, by providing literature, presentations, or other means can help overcome these fears (Fischer et al., 2017). Azhar, Kang and Ahmad (2015) found that public sector owners view IPD characteristics as beneficial and agree that IPD can improve project delivery effectiveness. It is concluded that IPD is still new in public sector construction but that it will continue to receive increasing attention in this field. Major barriers are rooted in the way public owners perceive IPD. Their perceptions are influenced by contractual and statutory limits and resulting lack of experience with IPD.

2.1.2 Characteristics of Integrated Project Delivery

Matthews and Howell (2005) researched how implementing a lean delivery method, like IPD, will help maximize value and minimize waste. They believe that normal contractual agreements stifle cooperation and innovation, and rewards individual contractors for both

reserving good ideas, and optimizing their performance at the expense of others. Four major problems with traditional contracts are

1. Good ideas are held back
2. Contracting limits cooperation and innovation
3. Inability to coordinate
4. Pressure for local optimization.

IPD seeks to resolve these issues with a different contract structure. With IPD all Primary Team Members (PTM) are responsible for all provisions of the prime contract with the Client. PTM also share the risk and profit for the total project (El-adaway, 2010) With this structure a single contract binds the IPD team to the client. This contract spells out the commercial terms and defines the scope, schedule and cost of the project. All PTM also sign a Team Member Agreement agreeing to be fully responsible for all terms of the prime contract sharing in the cost and profit. It creates an organization able to apply the principles and practices of Lean Project Delivery System (Aapaoja, A., & Herrala, M. 2013).

The American Institute of Architects (AIA 2007) defines IPD as "a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all project participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication and construction." IPD is a new method by which construction projects are organized and executed, and the following characteristics differentiate IPD from traditional delivery methods.

1. A multi-party contract
2. Early involvement of key participants
3. Collaborative decision making and control
4. Shared risks and rewards
5. Liability waivers among key participants
6. Jointly developed project goals (Sive 2009).

All the above characteristics are typically incorporated in projects that are considered full IPD. Many IPD projects in the U.S. however, do not employ all of these characteristics; instead, they sample some of the IPD characteristics to achieve higher efficiency. There are fundamental differences between traditional delivery methods and IPD; the main differences are in terms of contracts, project team relationships, and compensation structures.

Project alliancing is another method that seeks to increase collaboration, communication, and increase efficiency by aligning the objectives of all involved. This method utilizes many of the same core concepts as IPD but with a few subtle differences. The main difference between IPD and project alliancing is the inclusion of lean tools and management approaches but also BIM in the IPD (Lahdenpera, 2012; Lichtig, 2006). As to team selection, in project alliancing there is a standardized process for selecting the best team (including the key stakeholders) while in IPD projects the team members are typically selected separately (Lahdenpera, 2012; Lichtig, 2006). This process includes interviews and workshops with each potential member to determine the best team to meet the needs of the project (Walker, D., & Hampson, K., 2003). Also, the integrative and collaborative formal contract, which is compulsory in alliances but not on all IPD projects, is identified as a

difference. In alliance projects there are separate contracts for the development and implementation phase (Ross, 2003). Contracts are typically used in full IPD projects as well, but it considers the whole lifecycle of the project (Lichtig, 2006). Furthermore, the IPD contract allows involving numerous subcontractors on the same contract conditions (Lahdenpera, 2012), even in the different phases of the project.

2.1.3 IPD Use in Commercial Construction

IPD is becoming increasingly popular and more organizations are expressing interest in its benefits to the architecture/engineering/construction (AEC) industry (Asmar, Hanna, Loh, 2013). The industry as a whole however is still learning about IPD and its potential. Kent and Becerik-Gerber (2010) distributed a survey that was designed to target a wide range of professionals in the construction industry and to determine the level of awareness, experience, and interest of the respondents regarding IPD. Overall, 55.3% were inexperienced, saying they had not been involved with an IPD project.

Projects that are implementing the IPD process are seeing positive results. One study found that using IPD achieves statistically significant improved performance (Asmar, Hanna, Loh, 2013). Ilozor and Kelly (2011) found that the use of Building Information Modeling (BIM) in conjunction with the IPD delivery method was overwhelmingly positive. They concluded that the use of BIM was an enabling tool for IPD. They also found that most commercial projects utilize BIM even if they do not use IPD.

Because commercial construction can be very complex, for example hospitals, good communication is essential to having a successful project. The Innovative features of IPD like, Pull Scheduling/Planning, co-locations, scrums, and Daily huddles, coupled with the use

of BIM, all help create better communication and collaboration (Korkmaz, Miller, Toole, 2011). Even if a full IPD process with shared risk/reward and IPD contracts is not used, projects that used basic principles and practices saw positive results including increased efficiency and collaboration (Lee, 2013).

2.1.4 Elements of Creating More Collaborative Teams

Innovative features of IPD are implemented using a number of tools and approaches. Some IPD devices come from Lean Project Delivery (LPD), a "production management-based" approach to project delivery developed by the Lean Construction Institute (LCI). The following outlines important components and tools for IPD collaboration, including lean methodologies such as process planning, target design value, pull scheduling, and set based design (Sive 2009; Kim and Dossick 2011; Kent and Gerber 2010; Smith et al. 2011; Singleton and Hamzeh 2011)

1. Integrated Form of Agreement: Unlike contracting in traditional project deliveries, all the parties (including owner, designers, constructor, and trade partners) join into a single agreement requiring them to share risks and rewards. This cooperation encourages everyone on the team to think of the project first, since their commercial interests are clearly bound up with the overall success of the project.

2. Process Planning: IPD emphasizes process planning even at the early project stages. Robust planning is conducted to define how the design and construction processes will be performed. Workflow is mapped out with the involvement of all relevant participants, instead of directed only by the owner.

3. Charrettes: Design processes are conducted as group work. Options are created, analyzed, and decided in group working sessions. Unlike traditional-method delivery, meetings in an IPD project are not assigned only for making decision, but also function as working sessions for all project participants.

4. Building Information Modeling (BIM): BIM is used not only for the technical design process. It also facilitates coordination among all project participants, as well as improves visualization and fosters interdisciplinary collaboration that leads to team integration.

5. Target Design Value (TDV): In IPD, design is conducted to fulfill owner's need and expectation under an allowable budget. To achieve this, verification of owner's needs is conducted robustly. Unlike in the traditional design-bid-build delivery method, where the designer finished the design first and defined the cost to actually build it, design is conducted to achieve the maximum value the owner can receive within the allowable budget.

6. Pull Scheduling: IPD expects each participant to produce only the level of design documentation of a particular component needed by the next member of the team. Schedules start with milestones and long-lead items. Detail is developed by all those responsible for identifying specific needs and exploring the most efficient sequence. The team can decide when to invest more or less effort to produce the information needed.

7. Set-Based Design: Set-based design is the parallel development of multiple design solutions for a given element, until it is absolutely necessary for one solution to be chosen. The benefit is ensuring the best decision, not the most expedient. Balancing the additional effort of set-based design are the efficiencies gained from pull scheduling and other methodologies. (Council,2007)

2.1.5 Effects of Using IPD and IPD Principles on Projects

Christopher Lee in his paper, Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects, found three major conclusions. The first conclusion is that the general culture of NAVFAC and USMC contains potential for implementation of IPD, indicated by the majority of positive responses for wanting NAVFAC to implement IPD. The second conclusion is that short term immediate changes can be made to implement some IPD principles without having to resort to major structural changes. The third conclusion is that full implementation of IPD will be extremely difficult, but not entirely impossible within the federal government. However, full implementation will require major legislative changes at the congressional level along with structural changes within current NAVFAC policy.

Kulkarni et al. (2012)compared collaborative and IPD-like methods, like Construction Management at Risk (CMR), to traditional methods and found that collaborative project delivery systems do save money for public owners. These savings do not have to come directly from reduction in costs of change orders. There might be several other reasons behind observed savings in collaborative delivery systems, which needs to be dealt into in detail by future researchers. In addition, it is also observed from the data that the level of uncertainty is extremely high in case of traditional DBB or CSP projects, while CMR or IPD give the owner more control over his/her budget. CII data shows a wide spread of percent changes on their DBB or CSP projects. Thus, as a result of this study, CMR can be assumed with confidence to be more desirable for more complex and risk prone projects.

3 METHODOLOGY

3.1 The Method

The purpose of this research is to see how Integrated Project Delivery (IPD) principles and practices can be used on high end custom residential construction projects to increase the collaboration and efficiency of the project team.

Case study research is often used in studies seeking to answer the questions of "how" and "why" since these usually deal with tracing processes (Yin, 2018). Case studies focus on the uniqueness of case coming to know the particulars of that case and then taking what is learned and generalizing it for application in other situations (Stake, 1995). This style of research is also a good choice when the topic has limited research resources from which to draw from (Fox-Wolfgramm, 1997), as is the case with this research. For the reasons discussed above a case study was the chosen as the appropriate choice for this research.

The research was done by conducting a cases study on a full custom home being built in Idaho. The research was done in collaboration with the general contractor which has been implementing IPD principles on their projects for a few years now. As part of the case study several data collection methods were used including observations of key meetings, a survey, and interviews with project management. This research used both quantitative and qualitative data collected through the surveys and interviews with key personnel. Qualitative data was

collected through open-ended questions, allowing the respondents to answer freely. Quantitative data was collected through multiple-choice questions. Utilizing a survey for this research provided valuable data in response to the objectives of this research the questions that have been compiled.

In order to understand how IPD principles are perceived by the trades the survey was administered to participants on a project using these principles, specifically following co-location meetings. Observations were also made by the researcher by attending co-location meetings to understand how these principles were being implemented. Interviews were also conducted to understand what tools and practices are for implementing these principles.

Interviews were done with the key project personnel to better understand how they are using IPD principles and practices, and what tools they are implementing. A complete list of key personnel will be given with the details of the case study (Section 4.1). These interviews were also used to understand the timeline and big picture of using IPD principles on custom residential projects. Finally, this allowed us to understand how those overseeing the whole project perceive the benefits of using this method as well as the problems associated with using IPD principles. The author also observed several different meetings throughout the early stages of a custom residential project to see firsthand how this process was used and to see how those involved responded.

3.2 Survey Questions

The survey questions were developed with the purpose of obtaining data about the use of IPD principles on custom residential construction projects. The author, along with industry professionals created the survey questionnaire (See Appendix 1). The survey questions were

designed to help the research team better understand the attitudes and perceptions of the participants regarding the implementation of IPD principles and practices on residential project.

The first three questions had been used on previous surveys administered by the general contractor on previous projects with success. No changes were made to those three questions. The final two questions were created with input from the contractor and faculty members specifically for this research. The survey was submitted to the IRB for review as part of the research approval process and was designated as exempt. After a final review of the survey with the contractor, it was administered to the participants during the course of the case study project.

In an effort to protect the validity of the survey several steps were taken. First, survey results were anonymous in order to collect results that were honest and accurate. Second, the questions were worded in way that would not lead the participant to answer a certain way. Questions asked for their opinion or to rate some aspect of their experience. While custom home projects differ in scope, size, and materials, the same basic procedures (inspections required, trades needed, scheduling practices, etc.) are generally similar on each project.

3.2.1 Selection of the Case Study and Population

The project for this case study was selected because it was the project that best fit the criteria. The project was a detached, fully custom single-family home. The estimated cost and scope also fit within the desired criteria of at least $600,000. This project was also in the development stages allowing observations to be made of the critical first co-location

meetings. Being able to observe these the beginning of the project was critical because during the early stages is when most IPD principles and practices are used/applied.

The population for this study consists of the project managers, foreman and superintendents of the sub-contractors working on custom residential projects for Magleby Construction. The survey was sent out at the end of the initial co-location meeting for the project and again at the half-way point co-location for the project. Following the co-location the attendees were sent a link to the survey, and asked to fill it out before leaving. The researchers decided sending the survey immediately following the co-location would provide an improved response rate from the population. This would also allow the administrator of the survey the opportunity to make sure the respondent understood the topic and any confusion could be clarified.

3.2.2 Review of Questions Asked to Participants

The first question asked the participant to rate their experience on a scale from 1 to 5. Five being the best one being the worst. This was intended to get a broad feel for how the they felt about co-location and the process in general. The second and third questions then asked for specific feed back about what they felt had gone well and what could be improved. These were intended to see if there were common issues that could be resolved in the future and what, according to the participants, was beneficial to them. The last two questions were developed to see how the participants, who are mostly sub-contractors, felt about being involved earlier in the development of a project than on traditional projects and if they felt that this helped them be more efficient once they began work.

These questions were designed to help answer two of the main questions of this study (1) Identify the best practices/tools used for incorporating IPD principles on a custom residential construction projects and (2) Do trades/subcontractors on custom residential projects perceive using IPD principles as beneficial to them? By asking these questions the intent is to identify more specifically what practices and tools the trades perceive as most beneficial and do they feel that they are benefited from using these IPD processes and principles.

3.3 Administering the Survey

The survey was distributed by email to the participants following their participation in a co-location meeting on a project. Surveying took place twice while the projects final design was being completed and before construction started. The surveys were administered about two weeks apart. Due to the length of the project this study was concluded before the project was or a third survey would have been given at project completion. Following this procedure allowed all the responses to be tracked and recorded in one area. Tracking the responses in this way also allowed for a more efficient process to review the results and allow to study and examine the responses.

3.3.1 Reviewing and Studying the Results

Once the responses had been obtained they were then reviewed and entry/grammar differences were modified so that the results could be sorted and grouped together correctly. For those responses that could, charts or graphs were created so they could visually be

understood more clearly as well as patterns identified. Through studying and sorting of the results, the connection to the research objectives were able to be more clearly identified.

3.3.2 Tools Development

In an effort to help educate participants tools were developed to explain key concepts and practices that would be used during the project. These tools were also developed to aid other general contractors or owners who are considering implementing IPD principles on their projects. These tools give a definitions of terms, outline goals or outcomes, who participants should be, and any other information that relevant to a specific meeting, practice or principle.

These tools were developed based on past experiences, drawing on the lessons learned from previous projects, in addition to drawing on research. The author met with two members of the general contractor to review notes from previous projects and discuss what would be most important to include on these tools for future reference. Notes from conferences, books, and papers on the topic of IPD were reviewed and key points were also incorporated. Each tool was reviewed for content and revised to be as concise as possible while maintaining the necessary information. Graphics were also added to show the setup of rooms, materials and equipment used, or to help portray the main idea or principle.

The tools developed during this research were Pull-Planning, Scrum, and Minimal Viable Product (See Appendix 3). Other tools had been created prior to this research by the general contractor and several other tools were under development when this research concluded. The ultimate goal for these tools is to have a resource that can be used as outlines for the various meetings and practices. In addition, they are to give those interested a framework to follow, with suggestions of best practices to use to help achieve success in using IPD principles.

4 FINDINGS

4.1 Case Study

For this research the author collaborated with a contractor that builds high end custom homes in the Utah, Idaho, Wyoming and Colorado areas. These custom projects range from $600,000 into the millions. There work has won numerous awards throughout the years and they are recognized as one of the top custom builders.

For this case study the project chosen was a custom home being constructed in Southern Idaho. The value for this home is estimated between $700,000 to $800,000 with an estimated square footage of approximately 3,200 total square feet. Construction duration is expected to be approximately seven months. The number of trades on the project is estimated to be between 20-30 by project completion. The general contractor project management team consisted of a project manager and a superintendent with supporting help from the office staff.

4.1.1 Process Overview

To better understand the whole process that would be used for the case study the author interviewed the president of the division, who would be helping oversee the project, and the vice president of a collaborating company. These two have been refining the process described for several years now and given several presentations on this process at

conferences. While the process used by the general contractor and outlined is not a prescriptive process or one size fits all, each project has different circumstances that may require adjustment, this section outlines a basic framework that can be followed. This process seeks to implement IPD and Lean Principles, while it does not follow everything used in a full IPD process the idea is to take the key principles and adapt them to a specific project.

The process is initiated when the owner, or in this case a home buyer, wants to build a custom home. Initial discussions take place between and preliminary plans are created with the general contractor showing basic floor layout, size, look, etc. the key sub-contractors needed for that project, likely structural, HVAC, plumbing, and electrical, are asked to consult on the design.

At this point a Purposes, Behaviors and Objectives meeting would be held to review and educate those participating about this process. A project kick-off meeting may also be applicable. Then, co-locations would begin to discuss the various elements of the project and refine the design, plans, and estimate. Once the construction plans are complete bids would then be awarded. Throughout the project co-location meetings can be used for team building, to overcome a specific issue, review work done, make adjustments, and continue to plan/coordinate upcoming work (See Figure 4-1). Below, the figure shows a comparison of a traditional method and the method used on the case study project. This figure shows where the overlap between the two is and where each delivery method is unique. As Figure 4-1 show there are more steps between the preliminary plans and the final set of drawings being completed. There are also more people involved in the process of creating the final design using IPD principles. While this makes the design process may take longer, a more complete design is created as a result.

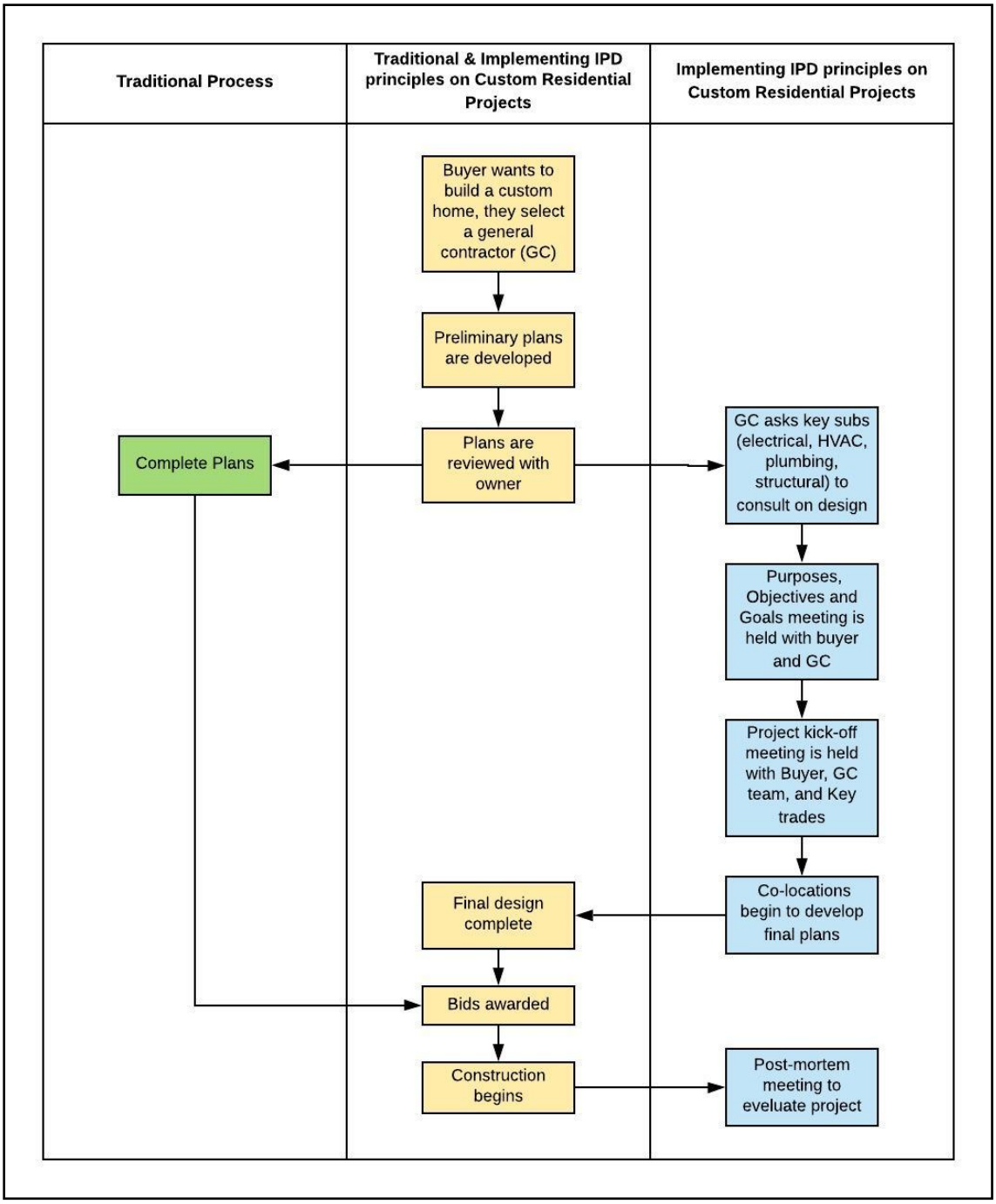

Figure 4-1: Process Overview

4.1.2 Setting Project Purposes, Objectives and Goals

To begin the project a meeting was held with the owner and the general contractors project management team to establish the purpose, objectives and goals for the project. The discussion focused on what the owner, in this case a home buyer, was looking to get out of their new home. This meeting took place in a conference room at the general contractors office, participants sat around a table with a large screen at one end that was used to present topics and review items. Topics centered around what needed to be accomplished for them to feel the project had been a success, for example staying in a budget, creating a space that they could relax and unwind, and features that would like to have. From this discussion an overall purpose was established to help guide decisions for the rest of the project. Then, a few specific objectives and goals were agreed upon by the group that would be the measure of success. Based on conversations with the project management team the author found that the purpose, objectives and goals vary widely based on the owner/buyer and their circumstance. Establishing these items was deemed critical by the project management team in meeting the owner/buyers expectations and as a result having a successful project.

4.1.3 Project Kick-Off

The project kick-off meeting took place following the purposes and objectives meeting and brought together the owner/buyer, the general contractor project management team, and the core trades for this project. For this meeting the buyer/owners both sat in the front row of seating along with the project manager (PM), estimator, and superintendent for the project. Participants from the various trades sat in the remaining seating, no seating assignments were made. The PM lead the meeting inviting the owners to help present on key items throughout

the meeting. During this meeting the purpose, objectives, and goals that were created previously were shared with and discussed with the whole team. This allowed the owner to communicate their vision and what they are hoping to accomplish. Success for the project was defined and the main objectives were discussed. This helped align the goals of all involved and defined success to ensure that everyone was working toward the same purpose.

4.1.4 Co-Location Meetings

Co-locations were used to get the major team players on the project in the same room in order to discuss and resolve problems. On this project the author observed several co-location meetings over the course of several weeks as the project was getting started. Because this project was still in the beginning stages meetings typically only involved one to three trades/sub-contractors, the owner, and the general contractor project management team.

Agendas for each meeting were sent out several days in advance to all participants for them to review and have adequate time to prepare any materials necessary. This also allowed the agenda to be revised before the meeting if someone had an item that needed to be added. Agenda items were kept to a minimum to keep these meetings under two hours in length, of the meetings observed all stayed within two hours. The agenda was created by the general contractor's project management team and the project manager was responsible for running the meeting.

Meetings began with brief introductions of those in attendance. These introductions included their name, company, and their scope of work. After introductions the purpose of the meeting and agenda were quickly reviewed by the project manager. This helped focus the group and refresh everyone of the objectives, purpose and outcomes of the co-location

meeting. The agenda items were then addressed in sequence with the project manager driving the meeting. As items were discussed assignments were made and noted, as were resolutions and plans made.

For this case study the home buyer (owner) attended each meeting as did the general contractor project management team. For this case study project that team consisted of the project manager and the superintendent. The other attendees consisted of one to two representatives from the trades/sub-contractors participating in that meeting. For example, one of the co-locations was to discuss and review the mechanical, electrical, and plumbing (MEP) for the project. Each MEP sub-contractor had a foreman or superintendent, someone who would oversee the day-to-day work and typically a project manager in attendance.

4.1.5 Co-Location Set Up

Co-locations are critical to successfully coordinating and collaborating. These meetings are where issues are resolved, and ideas are shared. The set up of the room used for these is very important. The room should be set up in way that allows for flexibility and re-arranging to allow smaller groups to break off and work. For example it is recommended to use tables with wheels to make moving them quick and easy.

Co-location meetings were held in the same room, in this case at the general contractors' offices, every time. The room was big enough to fit up to around 30 people. The co-location room was set up specifically for hosting co-location meetings so that it was available when needed. Tables, chairs, and white boards were provided for use by the participants. Other materials were also available including sticky notes, markers, notepads and pens/markers. All the tables, chairs and whiteboards had wheels so they could be moved and

rearranged quickly as needed (See Figure 4-2). A web camera was at the front of the room so those attending via computer could see the other attendees, a projector with was also available for use. For reviewing plans or other documents a camera was attached to a table to give an overhead view. This allowed those on the video call to see the plans as well so they could see what was being done and give input.

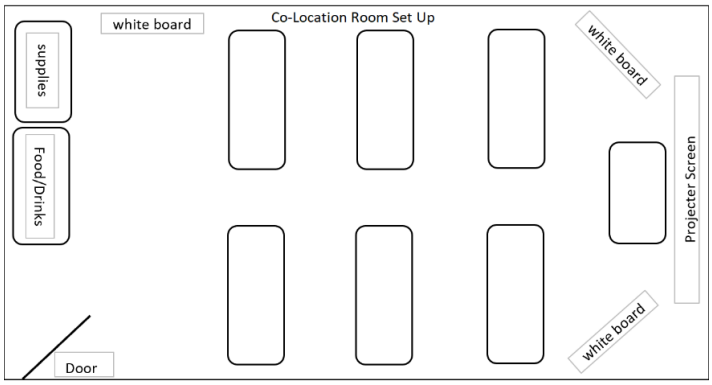

Figure 4-2: Big Room Set Up for Co-Locations

4.1.6 Survey

As part of the case study a survey was administered to the those that participated in the co-location meetings. Representatives from the structural steel, framing, electrical, plumbing, HVAC, footings and foundation, roofing, interior trim, and window and door trades all participated. Those participating were foreman, superintendents, and project managers, each trade had one to two representatives present. Members of the general contractor's project management team did not take the survey. The first survey was given at the first meeting and another was given later to track if the perceptions of the trades had changed as the project progressed.

The survey questions were designed to help answer two of the main questions of this study (1) Identify the best practices/tools used for incorporating IPD principles on a custom residential construction projects and (2) Do trades/subcontractors on custom residential projects perceive using IPD principles as beneficial to them? By asking these questions the intent is to identify more specifically what practices and tools the trades perceive as most beneficial and do they feel that they are benefited from using these IPD processes and principles.

4.1.7 Overall Perceptions

The first question asked the respondent to rate their experience. They had five options to choose from (1) horrible (2) it's been okay (3) neutral (4) this has been good so far (5) I'm really excited this has been great! Overall, out of 21 responses 65% responded 4, this has been good so far, with the remaining 35% responding 5, I'm really excited this has been great! (Figure 4-3)

Figure 4-3: Question 1 Results

4.1.8 Feedback

The survey asked respondents to give specific feedback about what they felt was positive about the experience as well as what, going forward, could be improved. While the comments varied the positive feedback comments could be summarized under three different categories (1) accountability (2) communication (3) finding solutions.

The common theme throughout the comments under accountability were centered around everyone sharing in the accountability and being responsible for solutions (Table 4-1). This accountability then was perceived to lead to greater efficiency and cooperation on the project. The feedback related to communication would also seem to support that with the comments focusing on getting things out in the open, getting input from trades on the best way to move forward with construction, and allowing the design team to collaborate with the construction team.

The largest portion of feedback concerned finding solutions. From the feedback it appears that the trades feel this process aids them, and the team as a whole, find solutions to problems early streamlining the construction process. From the feedback it also shows that the trades appreciate the opportunity to give feedback and find solutions to those problems as the project progresses (Table 4-1).

Similarly, the improvement suggestions could be summarized under (1) time management (2) plans (3) post meeting follow up. The tables on the following page provides a summary of the comments and the distribution of comments between the three general categories.

Table 4-1: Positive Feedback

Accountability	Making everyone accountable to each other, at least to pay attention
	Getting everyone on board with joint-accountability
	Having the ability to voice issues experienced during last construction phase, and having the opportunity to talk with related trade partners and management upfront in hopes of finding solutions to those issues so going forward, everyone can perform their tasks with greater efficiency.
Communication	Getting things out in the open
	The direct input from the different people involved in the project
	General Contractor crew being susceptive to Trade Partners input
	Understanding client needs and desires better to produce a final project people are excited about being part of.
	It helps to meet with the architect and engineer face to face. This helps get clear answers to questions about the plans
Finding Solutions	Great having input up front with the designers and other sub contractors. I think it will help solve some of the problems we encountered on the last phase
	I like seeing people bring solutions to this phase and even though last phase didn't go as smooth as it could have, its great to see how vested people are in the project. Its going to be great.
	Everyone working together to reach the same goal
	Feedback from door installer on door issues and solutions to implement
	Trying to find the most efficient way to get the project built.
	Talking through the problems that occurred in phase 1
Other	Positive team
	Open mindedness and new ideas for future phase
	Being part of the team
	We may have a great set of drawings
	Good flow to the project, scheduling has been good.
	Better work environment

Time management was the biggest area of concern with comments centered around the amount of time meetings took. Most feedback, from the trades, in this category had some relation to wanting it to be less time consuming and balancing the level of detail required. Another area of concern was that trades that were only needed for small portions of the meeting stayed for the entire meeting (Table 4-2).

Plans and drawings were another area that came up several times in the comments. This feedback focused on making sure that the plans were up-to-date for the meeting allowing them a clear idea of what was needed from them. Another concern was making sure the changes made were communicated to those that those changes affected. Which ties in with the feedback on follow up. The main feedback under follow up was centered on communicating

what was discussed during the meeting and any changes made were effectively and quickly communicated to those involved (Table 4-2).

Table 4-2: Improvement Suggestions

Time Management	To move through things a little quicker and when we come to a stumbling block that really up to the engineer or the archetype let them have a good time to come up with solutions and then we can regroup and look at the solutions
	It's hard to block out an entire day for meetings, but if it must be than it must be.
	Trying not to get in to so much detail with a large group
	Some disciplines can fall under multiple groups, but I would say that moving forward, try to have those trade partners with less imperative, time consuming concerns participate earlier in the round tables so they don't have to sit through the entire session where they need not be involved with the remainder of the discussion.
Plans/Drawings	Create a clear set of plans
	Up-to-date set of plans will be great
	Possibly getting the site work package finished earlier so I can get you better budgets
	Notify trades if they are affected by any changes to plans in addition to updating sheets on plan grid.
	Better plans
Follow Up	No complaints here. Just want to make sure we implement everything we talked about and not make this week a waste. Build on it and keep the momentum.
	Follow up with meeting notes and scrum/white board images.
	keeping the communication going throughout the project
Other	Keep communicating and I think a lot of the bugs will be worked out before we start excavation. Maybe send out a summary of what was talked about
	More snacks for the people that are there all day :)

4.1.9 Early Involvement & Effect on Efficiency

The final portion of the survey asked two yes/no questions to the trades asking if they found being involved early was beneficial and if they felt that over all this process aided them in working more efficiently. These were intended to get a broad feel for how the trades perceived this process affected them.

From the results 100% of those that responded answered yes, they found being involved early to be beneficial to them (Table 4-3). In addition, 100% of those who

responded also indicated they felt this process created an environment where they were able to be more efficient (Table 4-3).

Table 4-3: Perception of Early Involvement and Efficiency

Question	Yes	No	Response Rate
Was early involvement helpful?	10	0	45%
Did this process help with efficiency?	10	0	45%

Due to the timing of the survey that included the last two survey questions the response rate was low. The last two questions were added later and due to timing, they had to be sent out via email instead of at the conclusion of a co-location meeting. As a result, fewer results were received. In addition due to circumstances there was a shorter amount of time available to collect responses from the second survey which also contributed to the lower response rate.

The process for this case study mainly used two key IPD principles (1) the of the early involvement of trades and (2) seeking to align the goals of all project parties. These principles were implemented through the use of various tools including co-locations in big room settings, scrums, setting project purposes, objectives and goals, collaborative scheduling, and seeking and implementing feedback after the co-location meetings. The main IPD practices found on full IPD projects that were not used include, multi-party contracts, shared risk/reward, and co-location of major team members for the duration of the project. This project would also not meet the definition of IPD-Lite.

4.1.10 Observations

From the observations of the meetings there were several key take-aways. Frist, getting the owner to buy into the process. During the project purpose and objectives meeting a considerable amount of time was spent explaining the process, the benefits, and why this process helps achieve better results (See Appendix 2). Second, stimulating discussion about expectations and what will define success for the project. This provides a clear direction that can be presented during the kick-off meeting with the trades. Third, having the owner present at the kick-off meeting to interact with the trades/team and help present their vision and expectations (See Appendix 2). Finally, during co-locations engaging the trades, getting their input, and diving into the details. The facilitator needs to engage the trades and create an environment that encourages open dialogue (See Appendix 2).

4.1.11 Interviews

Interviews were conducted by the author with two of the individuals who created this process for the general contractor. A key highlight from those interviews was regarding the timeline of the meetings. In the interview it is emphasized that co-locations take place primarily before construction begins, during the design phase. Another key take away was that the timeline, tools, and practices used are flexible and should be used as needed to fit a specific project's needs (See Appendix 2). Also during these interviews and other conversations they mentioned that the owners of case study project highly recommended this process to others.

4.1.12 Cost Impacts

Exact numbers were not available for use in this research but there were several impacts to cost worth noting. First, during the early stages as noted earlier key trades consulted on the project's design. These trades are in some cases paid for their time. Because of this, initial costs are typically higher than on projects using a traditional method, per conversation with the project team. However, the savings from using IPD principles has been shown on previous projects completed by the same general contractor off-sets that cost. Additionally, per conversations with the general contractor, because of the nature of custom houses the majority of savings are found in increased efficiency during construction due to less change orders and re-work. In addition to some from value engineering or design changes made on the recommendation of trades during design. The general contractor and owner also felt that this process allowed more value to be added to the project because of the input provided through collaboration between the owner and trades.

5 CONCLUSIONS

5.1 Summary of Findings

The purpose of this research was to see how Integrated Project Delivery (IPD) principles and practices could be implemented on custom residential construction projects, what are the best principles/practices and do trades feel these principles are beneficial and increase their efficiency? The results of the case study indicate that using IPD principles on high end custom residential projects can be done successfully with the proper application of principles and practices. In addition, the survey results indicate that the sub-contractors/trades feel that this process is beneficial to them.

From reviewing the feedback from trades on the survey trades/sub-contractors generally like using IPD principles because it gives them more input into the design. This allows them to make suggestions that can help them be more efficient and provide a better finished product to the owner. Having them involved early also helps limit costly change orders throughout the project because those issues that lead to change orders are likely to be caught earlier. Identifying issues early is key because the team has more control and options available to solve them then they would later in the project. Costs associated with the changes can also be more easily controlled the earlier they are identified.

IPD principles can be implemented on high end custom residential project through a variety of practices and tools. These practices/tools include co-locations, setting purposes and objectives, pull planning, scrums, minimal viable product, and early involvement of the trades. Because each project is different in scope and circumstance there is not a one size fits all solution to using IPD ideas on residential projects. The research would suggest that the best way to proceed would be to evaluate the needs of the project and decide what practices and tools to use. Below is a summary of IPD principles used on the case study project compared with what would be expected on a full IPD commercial project or IPD-lite project (Table 5-1).

Table 5-1: Comparison of IPD, IPD-Lite and Case

	Multi-party contract	BIM	Co-locations	Pull-planning	Scrum	Shared office space	Purposes meeting	Kick-off	"Lean" practices
IPD	x	x	x	x	x	x	x	x	x
IPD-lite		x	x	x	x		x	x	x
Case Study			x		x		x	x	x

From this case study the following were identified by the author as the key practices and tools that should, in most cases be used. First, having a purpose, objectives and goals meeting with the owner to establish a vision for the project. Establishing these will provide a guide for the project management team as well as the sub-contractors throughout the project as they make decisions. This also allows expectations to be set for what needs to be accomplished for the project to be a success.

Second, the early involvement of key trades to help with the design process to help identify and resolve problems and create a more complete set of plans before construction begins. This process accomplished through co-locations is key to having success. This not only allows for input from the experts but can help build a team culture. Creating a culture that cultivates collaboration and trust, something that cannot be contracted, is what this entire process hinges on. Early involvement of the trades then serves two purposes, input into the design creating better plans with less issues and creating the right culture. Both elements lead to greater efficiency. While co-locations primarily happen prior to construction they should be used as needed throughout the project.

Third, as part of co-locations or periodically throughout the duration of the project the team should have wellness checks. These are a time to discuss what is going well, what is not, and make adjustments and plans as needed. The purpose of this is to make sure processes that are working are continued, processes that are not are stopped or adjusted, and a chance to allow new ideas to be expressed and implemented. At the completion of a project it is recommended to have a post mortem to evaluate the project as a whole noting lessons learned and what worked well for application on future projects.

While the above are the three main practices that the research found to be the most crucial to success there are many others that could be used as well. Some of these include, team building activities, scrum sprints, pull planning and building information modeling (BIM). Brief trainings on IPD principles and practices may be applicable to help educate owners and trades. Each high end custom residential project is unique with different

challenges and owners with different priorities. Project teams should use the practices and tools they feel will best help achieve success for a particular project.

5.2 Next Steps

This research focused on how IPD principles are being applied on high end custom residential projects, what are the best practices and tools for doing so, and how do trades perceive the use of this process? Future research should focus on if using IPD principles and practices is significantly better that traditional methods on high end custom residential projects. Other future research could also investigate the application of IPD principles and practices on smaller and production residential jobs. Potentially developing a plan that could aid builders that do not work in the high end custom home sector. Next steps could include a study of if using these principles has a significant effect on keeping schedules on time and projects on budget. Another step could be to compare the engagement of trades between projects that use IPD principles an those that do not to see if there is significantly higher engagement on projects utilizing IPD principles.

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APPENDICES

APPENDIX A SURVEY

Post Co-Location Survey

Rate your experience from 1-5 *

Click on the dropdown menu for ratings

1. 1 - Horrible
2. 2 - It's been OK
3. 3 - Neutral
4. 4 - This has been good so far
5. 5- I'm really excited, this has been great so far!

What has been positive about the experience so far? *

Long answer text

Moving forward, what can we do to make this experience better? *

Long answer text

Overall do you find being involved in the design phase of a project beneficial?

- ○ Yes
- ○ No

Do you feel that being involved early has increased your efficiency on the project?

- ○ Yes
- ○ No

APPENDIX B SELECTED INTERVIEW & OBSERVATION NOTES

O'Grady Project Purpose and Objectives Meeting

Who Attended

- PM
- Owner
- Estimator

Brief Explanation of Integration

- Why we do things differently is related to the curve
    - Easy to impact things now rather than later
    - Less expensive earlier
    - Later changes will cost more

- Want to align design intent with objectives and goals early on

How do we Align the Project?

- Project purpose
- Key objectives
- These will influence behaviors

Co-Location

- Gets all the stake holders involved to make things efficient

- Eliminate waste
- Minimal viable product
    - Get people comfortable delivering at 20%
    - Want 80% of the features
    - Iterate
    - Gets more value in a time period

Inverse Relationship Between Engagement and Cost

- High engagement = lower cost
- Low engagement = higher cost
- This is often over looked, and we exclude people disengaging them

Teams

- Think of a high functioning team
- Think of someone that you want on your team, what were their attributes?
    - Have people list these and put on the wall
    - What are the similarities?
        - Willing to change
        - Systems thinker - understands how everything goes together
        - Creative
        - Know a little about everything
        - Communicate well and early, open

- Go through the attributes listed look for similarities, summarize all of them into a few phrases that embody all these attributes. Encourage discussion.

Project Purpose

- Try to define what success looks like, this helps get to the purpose
- What is the vision for the project
- What does success look like form each of the different roles invloved

- Merge all these ideas into the purpose
    - Make sure everyone understands what the purposes are and buys in
    - Make sure to separate purpose from objectives

Objectives

- What needs to be done to accomplish purpose
- Example; on time, on budget, set/manage expectations, limit surprises, good communication, accurate budget,

- Trades need to be educated and taught the process because it is very different than traditional methods.

Trade Kick-Off Meeting 11/15/18

Attendees

- Owner
- PM team
- Key trades (structural, electrical, plumbing, HVAC)

Project Overview

- Location
- Site layout
- Show design renderings
- Plans

IPD Process Review

- Reverse engineer a project
- Concepts
    - Normally we modify actions to get results
    - Its more about managing experiences because those shape behavior
    - Build a team first
    - Integrate plans, estimate and schedule

    - Break down traditional silos
    - It's a team people need to speak up, have fun, be creative

Project Purpose (Manifesto of the Project)

- Created in meeting with owner - free from distractions, compliment the land
- Purpose is surrounded by objectives - Stand the test of time, timeless not trendy, clear communication, eliminate surprises, direct, time, cost
- Outline behaviors - willingness to change, creative, be engaged, empathy,
    - Refine objectives so they are measurable

Co-Location

- A meeting in which all stakeholders in a project attempt to resolve conflicts and map solutions
- Makes project more efficient

Minimal Viable Product

- Normally wait until it's 100% before showing work
    - Lose opportunity to build value
- Deliver at 20% and the iterate
    - This give you more value in the same amount of time
- Target value design is another part of this

Project Implementation Group

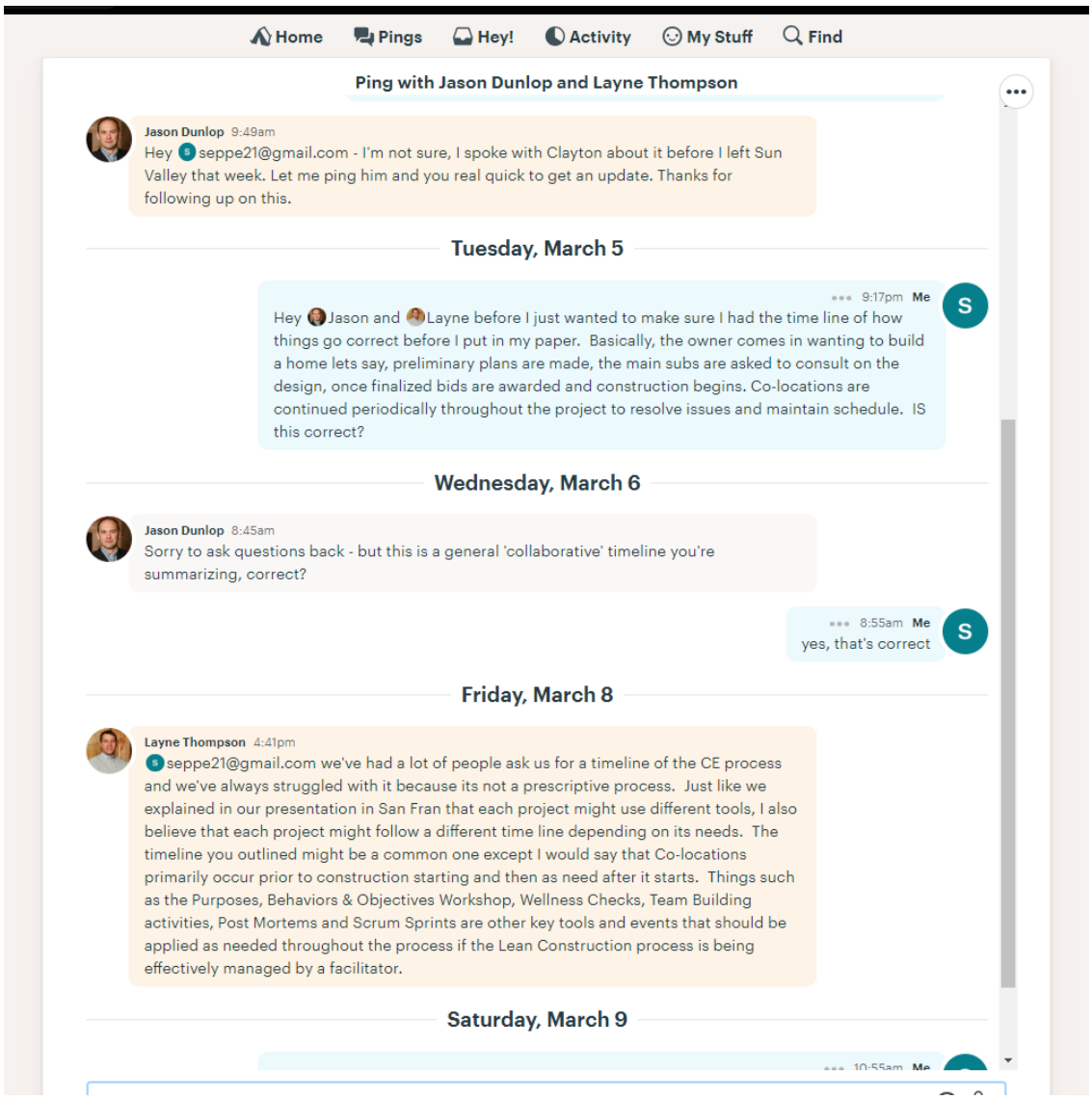
- Smaller groups related to more specific parts of the project
    - MEP, Structural, etc.
    - Meet with each group on a rotating basis
- These meetings need to be useful
    - People need to come prepared
    - Keep them as short as possible
    - Requires people to be proactive

Co-Location Structural 11/15/18

- Review plans
- Discuss location of posts, beams, etc
- Give assignments and set up dates for next meeting and follow up dates

Co-Location MEP 12/20/18

- Set up
    - Plans on the table, camera showing the plans for those watching via video
    - In a room with a table that everyone can sit around
- Attendees
    - Owner
    - Electrician
    - PM
    - Owner
    - Plumber
    - Mechanical (HVAC)
- Heated flooring in bathrooms
    - Discuss locations and sqft
    - Discuss locations of controls
- Discuss locations of TV's other media items
- Lighting fixtures, lighting types for different lights
    - Dimmers
    - 6'' LED can lights
        - Different styles and brands, pros/cons of each
    - Get into the details
- Talked about where to run conduit and wires
- Discuss assignments and have specific people assigned to each item and a time to report back



APPENDIX C TOOLS

COLLABORATION
ENGINEERING

2.1 Scrum

KEY PERSONNEL

- Product Owner - Has the vision of what the product will be.
- Scrum Master - Coaches the team through the process. Eliminates obstacles
- Team - Key individuals who will be doing the work.

CREATE A PRODUCT BACKLOG

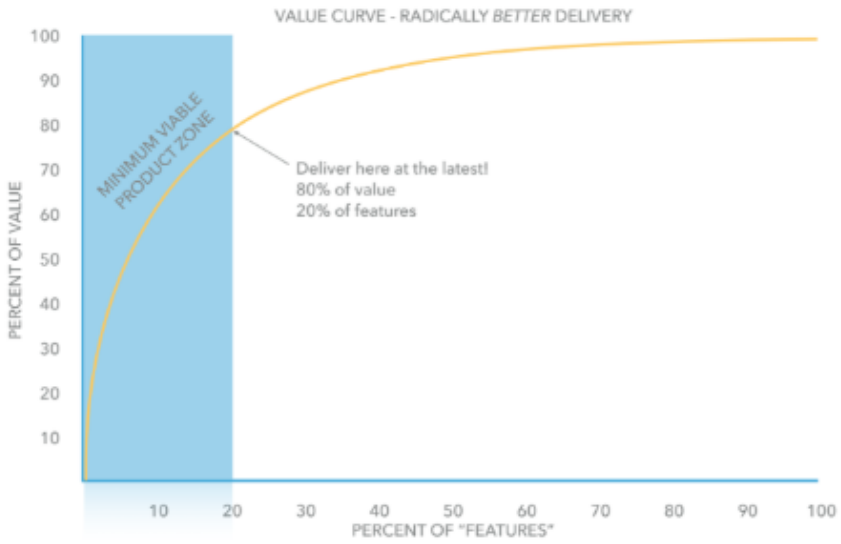
- List of "everything that could be done by the team ever, in order of priority"
  - Product Owner must prioritize items
  - Team members estimate effort needed to complete items
  - Define what "done" is

SPRINT PLANNING

- Product Owner, Scrum Master and Team determine length of "sprint"
  - No longer than a month. 1 to 3 weeks recommended
  - Determine what can be accomplished in that time
    - Do not alter list once established and agreed upon
- Track progress
  - "Scrum board" and sticky notes (whiteboard divided into 3 columns: 1. To do 2. In progress 3. Done) move sticky notes.
    - Makes progress visible
- Daily Sprint Meeting
  - 15 min max.
  - What was done yesterday?
  - What will be done today?
  - What obstacles are people facing?

COLLABORATION
ENGINEERING

2.2 Minimal Viable Product



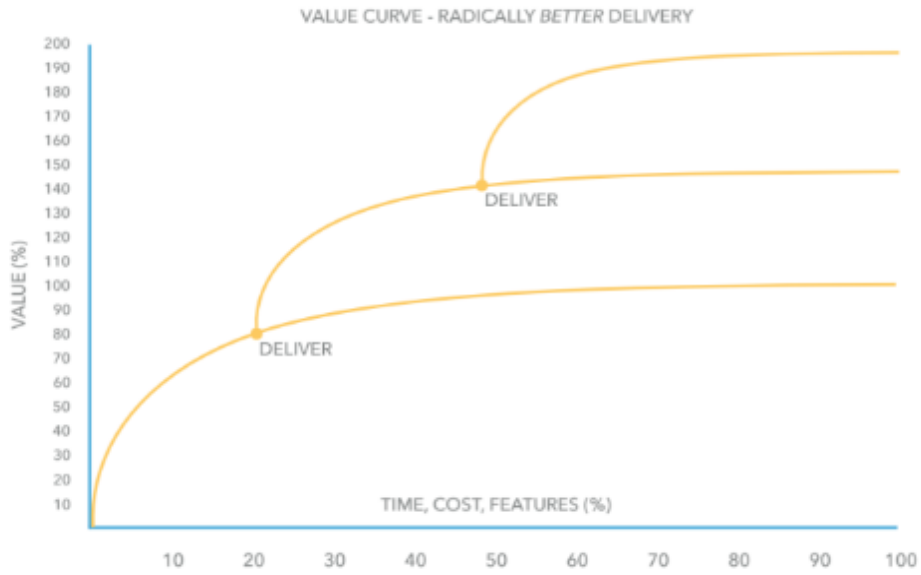
"Whenever you're making something, you want to put it in the hands of those who are actually going to use it as fast as possible"

PURPOSE

- Get more value in a shorter amount of time
- Create more collaboration
- Add narrative about 80% value 20% of features

PROCESS

- The goal is feedback
  - Don't go for perfection right off
- Focus on value
  - Don't try to deliver on a whole list of things
  - Focus on what people actually need/want
- Requires trust
  - "Train yourself to let go of everything you fear to lose" - Yoda



- "Rinse and repeat" it's an iterative process
  - Develop 20%, deliver, repeat. Incremental-release process

OUTCOMES

- In the time taken you to create half of the features of your initial project, you've now achieved 200% of the value, in half the time.

COLLABORATION
ENGINEERING

4.1 PULL PLANNING

SUMMARY

Pull planning is a technique used to develop a plan for coordinating phases of a project. This should not simply be a process of working backwards to plan a project. To succeed it is necessary to have the right people involved in the planning process.

8 STEP PROCESS

1. Select Completion Date
    a. Identify the date that the project or phase needs to be completed by
2. Determine Milestones
    a. What are the major milestones?
    b. Map these out on the board to use as a framework
3. Develop Activities List
    a. Each stakeholder/trade needs to list what tasks they have to complete between each milestone
4. Develop Time Frame
    a. How long will each step/task take?
    b. Apply durations WITHOUT contingencies/float
5. Re-examine Schedule
    a. Can any tasks/activities be shortened?
    b. Do any need more time?
6. Determine Start Date
    a. Based on the info, what is the latest you can start?