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The Impact of Delivery Methods on the Profitability of Commercial Construction Projects

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The Impact of Delivery Methods on the Profitability of Commercial Construction Projects

by

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The Impact of Delivery Methods on the Profitability of Commercial Construction Projects

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The University of Texas at Austin, 2011

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According to September 2011 information from the U.S. Census Bureau, the construction industry in the United States is valued at nearly eight hundred billion dollars annually. A 2004 collaborative study by Construction Industry Institute and Lean Construction Institute suggests that as much as fifty seven percent of time, effort, and material investment in construction projects do not add value to the final product. When compared with twenty six percent wastes in the manufacturing industry, it becomes obvious that the construction industry has a problem.

Construction projects that come in over budget and behind schedule have become the rule rather than the exception, leading to contentious business relationships and costly litigation. This study will strive to identify and analyze the primary sources of these problems. Research and industry experience point to a lack of communication and cooperation among the various entities required to complete a construction project as the leading causes of waste in the industry. Further analysis suggests that traditional forms of construction contracts encourage adversarial and non-cooperative behavior between

parties. Additionally, poor communication between various contributors opens the door for additional wasted cost.

Fortunately, the development of tools such as Integrated Project Delivery (IPD) and Building Information Modeling (BIM) present new options to construction professionals that are proving to help address some of the challenges the industry faces today. IPD as a project delivery method creates a culture of collaboration and teamwork, where a culture of risk avoidance and conflict once stood, while BIM provides a platform for better communication among parties. When used together, these tools can reduce or eliminate many of the major sources of waste within the industry. This thesis will provide descriptions, analysis, and case studies that demonstrate the use of these tools and the potential they have to make a positive impact on the construction industry.

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Chapter 1: Introduction

Since 1964 the productivity of non-farm labor in the United States has improved steadily at a rate of approximately 1.77 percent per year (Teicholz). Non-farm labor in this discussion can be generally categorized as product manufacturing. The improvement in non-farm productivity can be attributed to advances in technology and equipment that have developed over the past forty-seven years. During this same time frame the construction industry has seen a decrease in productivity at an average compound rate of -0.59 percent per year (Teicholz). Figure 1 below illustrates the growing gap between the productivity of non-farm labor and construction labor since 1964.

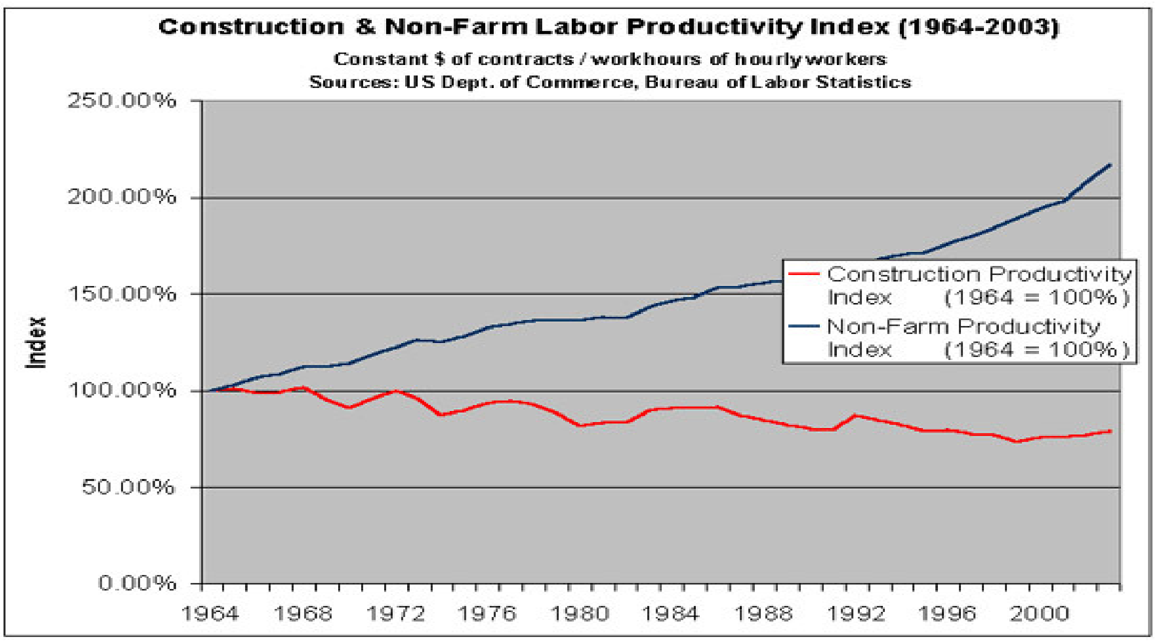

Figure 1: Labor productivity index for US construction industry and all non-farm industries from 1964 through 2003 (Teicholz)

The construction industry has some inherent disadvantages in efficiency when compared to other industries. A majority of the labor is performed outdoors and is therefore subject to delays from the elements. Additionally, each building site is different and represents unique challenges to each building project. While these disadvantages may limit the construction industry's ability to keep pace with the efficiency gains of other industries, it does not explain the magnitude of the gap and certainly does not explain why the productivity of the industry has regressed since 1964.

Along with the regression in productivity, the construction industry has also experienced a higher business failure rate than most other industries over recent years. New construction companies that have been in business for less than one year fail at a rate of approximately thirty-seven percent (McIntyre). These business failures do not just impact the construction industry, they affect society as a whole. The Surety & Fidelity Association of America estimates that sureties have paid over ten billion dollars on contract bond claims since 1992 (McIntyre). Clearly, the struggles of the construction industry are worth taking some time to investigate.

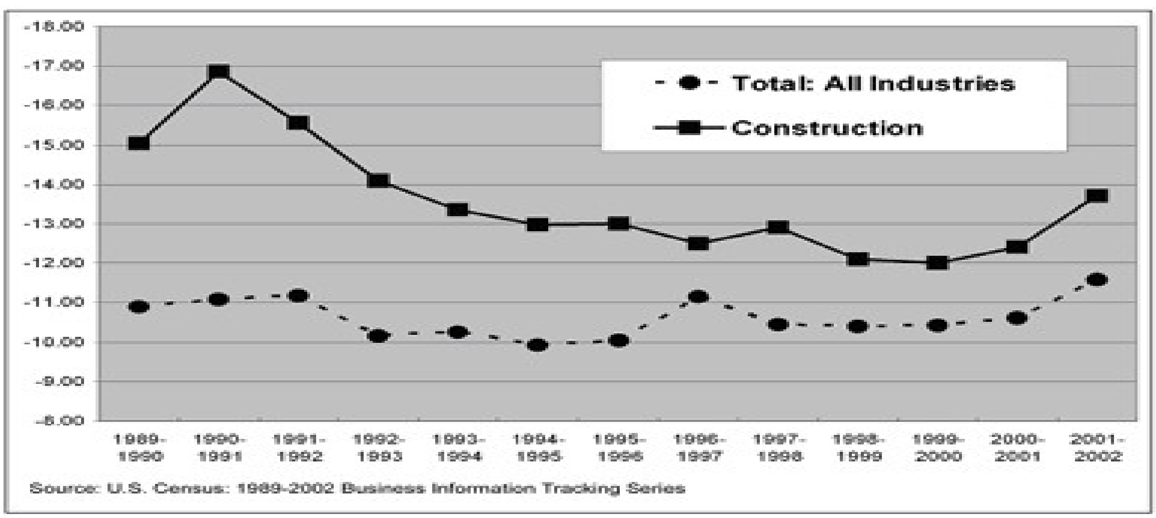

Figure 2: Failure rate of construction businesses and businesses in other industries between 1989 and 2002 (McIntyre)

The construction industry makes up about eight percent of the gross national product of the United States and directly employs six percent of the U.S. workforce. The Business Roundtable described the construction industry as a “seminal” industry due to the fact that the construction price of every factory, office building, hotel, or power plant affects the prices of the goods or services that are produced in the building (Federal Facilities Council). The success or failure of the construction industry can affect the livelihoods and quality of life of everyone.

This study will strive to identify the major sources of waste in the construction industry that have led to these startling statistics. I will begin by giving an overview of current project delivery methods employed by the industry. From there, primary sources of waste within the industry will be identified and discussed. Finally, potential solutions will be explored and discussed. These solutions include the adoption of Integrated Project Delivery (IPD) and the development of Building Information Modeling (BIM). The numbers above suggest that there is considerable opportunity for improvement within the construction industry. With an increasing number of building owners demanding sustainable, high-performance buildings, these new approaches offer opportunities to address both existing industry flaws and challenges created by more complex building systems (Korkmaz et al). However, before the problem can be solved, an understanding of the status quo must be achieved.

Chapter 2: Traditional Project Delivery Methods

This chapter will highlight the project delivery methods that are commonly used in the construction industry. Currently there are three dominant delivery methods: Design-Bid-Build, Construction Manager, and Design-Build. These delivery methods offer different options for structuring the relationship between the three major parties in a construction project: the owner, the designer (usually the architect), and the builder. Chapter 3 will focus on the inherent flaws that these systems have and how they create waste within a construction project, but first an understanding of these systems must be attained.

DESIGN-BID-BUILD

According to a 2010 study by RSMeans Reed Construction Data Market Intelligence, nearly fifty-three percent of construction projects use design-bid-build as the project delivery method (*Design-Build*). Design-Bid-Build has been the predominant delivery method in the modern construction era. It is a system that is based upon leveraging the competitive bid process to keep costs down. The Associated General Contractors of America defines Design-Bid-Build as a project delivery method with two distinct characteristics. First, there are separate contracts for design and construction. Second, the only criterion for selection is lowest total construction cost.

The term "Design-Bid-Build" is reflective of the three distinct phases that encompass projects that are delivered following this method. The design phase is kicked off by the selection of an architect for the project. The architect is contracted to run the design side of the building project. Architects are typically selected based on a combination of fee and reputation. Architectural fees have traditionally been set as a percentage of the total construction costs for a project, but many different methods are used. These fees usually range from nine percent to twelve percent depending on the nature and complexity of the project (Beck). Once hired, the architect will work with the owner to determine the owner's building needs and develop a written program that addresses these needs and provides a basic layout for the design of the structure. The architect then hires the remainder of the design team, which consists of various disciplines of consulting engineering firms. Consultants will negotiate their own fee structure with the architect. These consultant's fees are often characterized as a percentage of the overall construction costs as well. With the design team assembled, work begins on producing schematic drawings, followed by design development drawings, and then finally construction documents.

The release of construction documents signals the owner to begin the process of selecting a general contractor to handle the procurement and installation of the materials as designed and communicated through the construction documents. The construction documents are sent out to general contractors for cost bids. Interested general contractors solicit bids from subcontractors and then compile those in to their bid for the project. The contractor with the lowest acceptable bid is then selected to proceed with building the project.

One of the key characterizations of Design-Bid-Build projects is the owner must enter in to and manage two separate contracts, one for the design of the building and one for the construction of the building as shown in Figure 3 below. The allure of Design-Bid-Build is the thought that the competitive bid process helps keep costs down and is generally fair to all of the parties involved. The building owner is also given considerable control over the project since he must act as the intermediary between the design team and the contractor when conflicts arise. However, with this control, the owner also assumes the majority of the risk involved with the undertaking of a construction project.

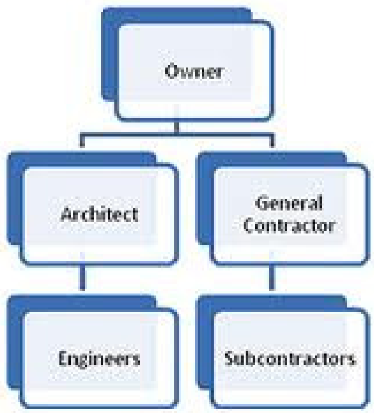

Figure 3: Diagram of Design-Bid-Build contract relationships

CONSTRUCTION MANAGER

Projects that use a Construction Manager delivery method are very similar to Design-Bid-Build, but take advantage of the expertise of general contractors during the design portion of the project. Approximately six percent of owners opted for some form of a Construction Manager delivery method according to the 2010 study from RSMeans Reed Construction Data Market Intelligence (*Design-Build*). This method was the first real attempt at improvement upon the Design-Bid-Build approach during the modern construction era. There are two different types of Construction Manager delivery methods: Construction Manager Agent and Construction Manager at Risk.

A Construction Manager Agent delivery method allows the owner to hire a construction manager up front to represent the owner during the design phase and helps manage the design team. The construction manager agent is usually hired based on reputation and fee similar to the way an architect is selected under the Design-Bid-Build method. The selected construction manager will then assist the owner in selecting the design team and making sure that the design follows the owner's interests and remains within budget. Having a construction manager on board during the design phase allows for greater budget control since the construction manager can use their pricing experience to help notify the design team of changes that will significantly impact the cost of the project. While the design team will still contract directly with the owner, all communication from the owner is run through the construction manager as shown in Figure 4 below.

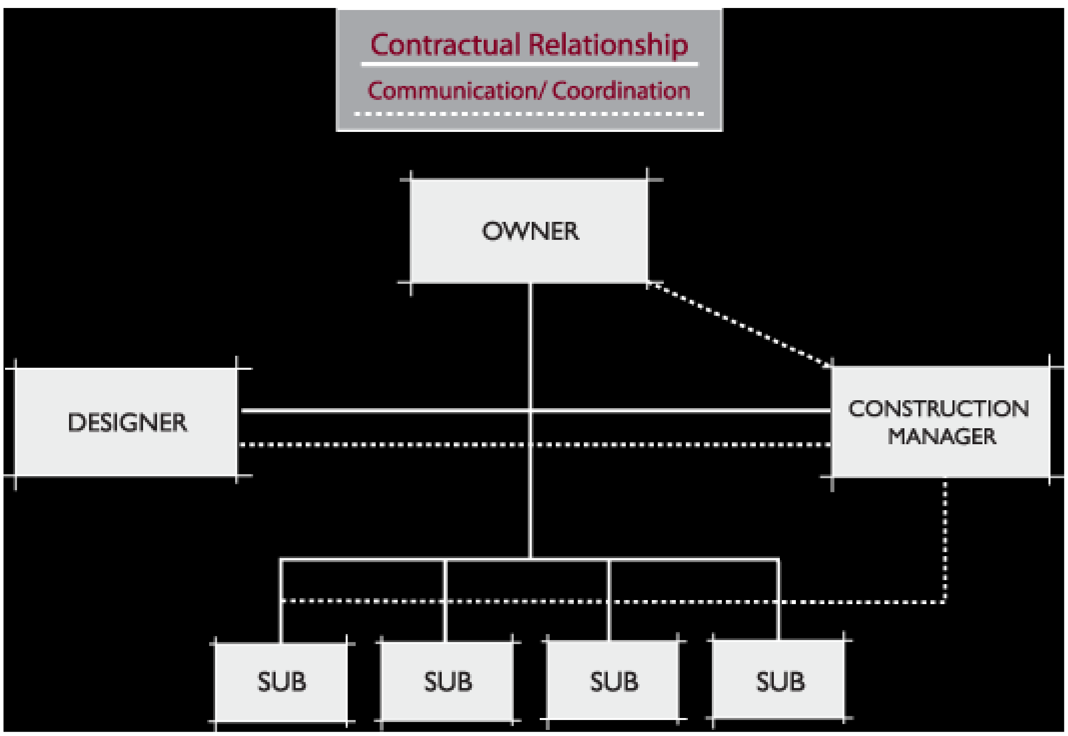

Figure 4: Diagram of Construction Manager Agent contractual relationships (Turner)

The other option is a Construction Manager at Risk delivery method. Similar to the Construction Manager Agent method, Construction Manager at Risk allows the owner to get a construction manager involved early on and help with budget management during the design process. However, instead of acting as a representative of the owner, the construction manager acts as an additional consultant during the design process. Normally construction managers at risk will work for a negotiated fee during the design process. Once the design is complete, or nearing completion, the construction manager will put together a Guaranteed Maximum Price (GMP) for construction costs to build the job. This price establishes a budget for the construction manager to use throughout the construction of the project. The term “at risk” signifies that the construction manager absorbs all risk of cost overruns throughout the construction of the project. Likewise, the construction manager often keeps any cost savings that the construction manager can create after the acceptance of a GMP. The relationship between parties within a Construction Manager at Risk structure is shown in Figure 5 below.

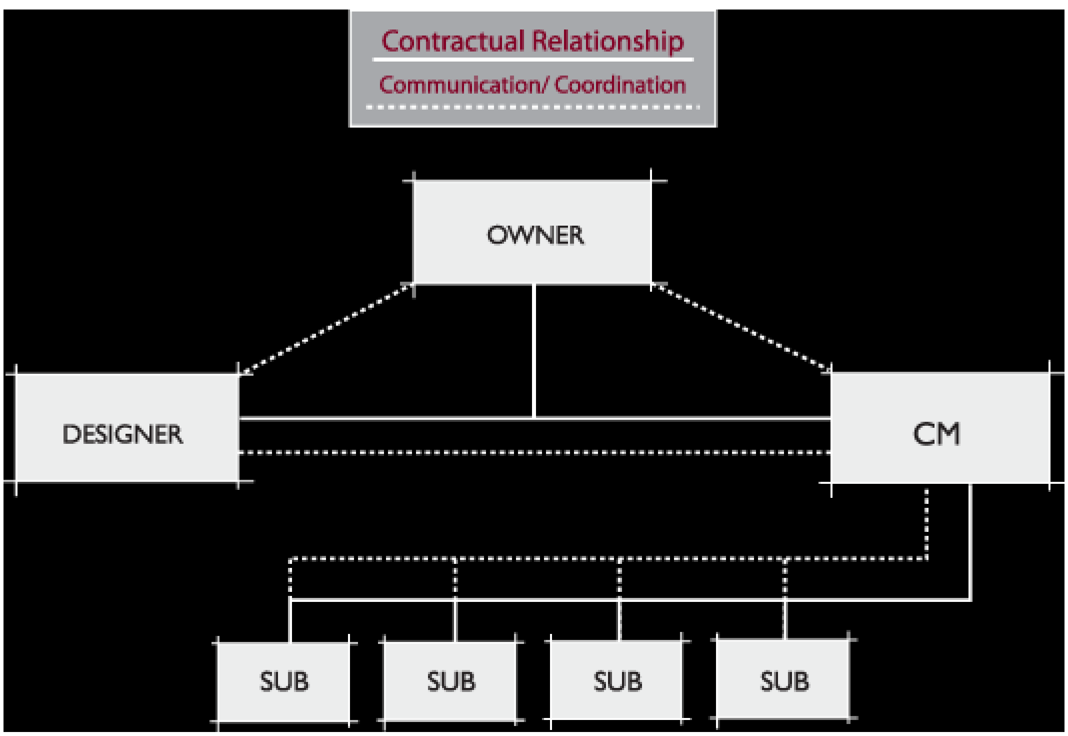

Figure 5: Diagram of Construction Manager at Risk contractual relationship (Turner)

DESIGN-BUILD

Design-Build has been the fastest growing project delivery method in recent years, growing to a nearly forty-one percent market share in 2010, a ten percent increase since 2005. Nearly eighty percent of military construction projects are now Design-Build (*Design-Build*). Figure 6 below demonstrates the growing use of the Design-Build approach. The contracting of a Design-Build project represents a significant departure from Design-Bid-Build and Construction Manager contracts. Design-Build is defined by the owner entering in to a single contract for the design and construction services for the project. Some companies now contain both design professionals and contractors to lend themselves specifically to Design-Build projects. Others approach Design-Builds by entering in to a joint venture with another party to form a design and construction partnership.

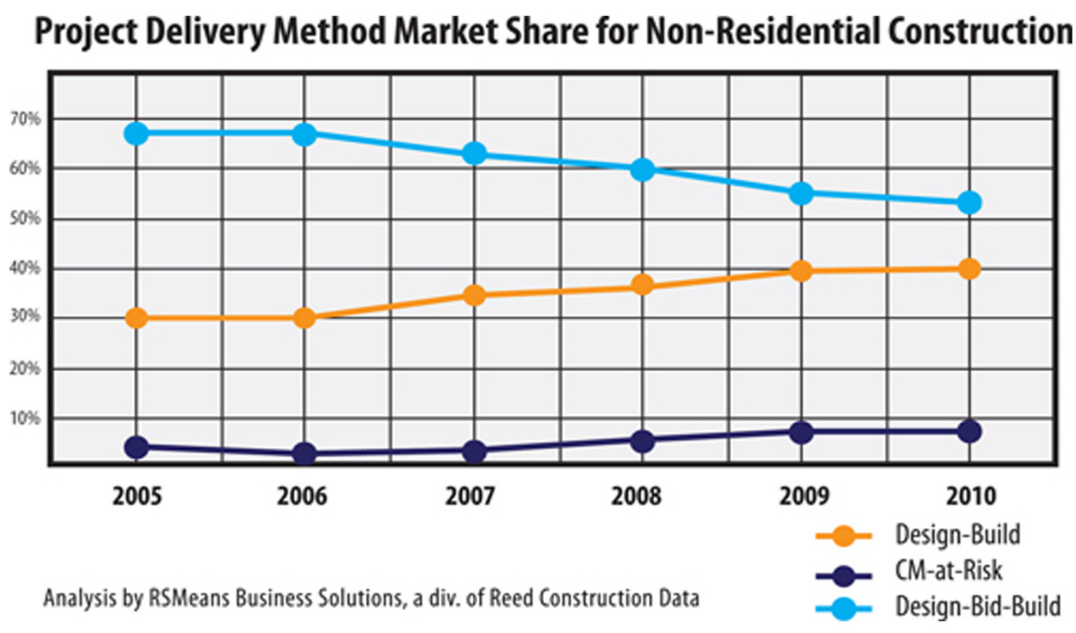

Figure 6: Project delivery method market share for non-residential construction from 2005 to 2010 (*Design-Build*)

To use this approach, owners must develop the program for the building prior to selecting the design-build firm. Owners with considerable construction experience are sometimes able to perform the programming requirements themselves. Others sometimes hire architectural firms or construction managers to assist with programming or provide bridging documents to give design-builders enough information to put together a reasonable bid. Once a program has been developed, requests for proposals are sent out to design-builders. The selection of design-build firms is based on several factors including cost, schedule, experience, and reputation. This allows the owner to select the design-builder, which offers the maximum value to the project rather than being forced to select the low cost bidder.

After a contract is awarded, the design-builder goes to work on completing the design of the building. Like the Construction Manager delivery methods, Design-Build projects have the advantage of involving a construction expert in the design process. Additionally, these projects can be fast-tracked since the construction side does not have to wait for the design to be completely finished before they start working on site. This helps compress the project schedule. This delivery method has been found to complete projects at least thirty-three percent faster than Design-Bid-Build projects and twenty-three percent faster than Construction Manager at Risk projects (Bramble et al). Design-Build projects have also been found to control costs better than Design-Bid-Build or Construction Manager delivery methods. Design-Build projects resulted in unit costs that were over six percent lower than Design-Bid-Build projects and over four percent lower than Construction Manager projects according to a recent study of U.S. building projects (Bramble et al). Figure 7 below shows the timesavings with the project timeline for Design-Build projects versus Design-Bid-Build projects.

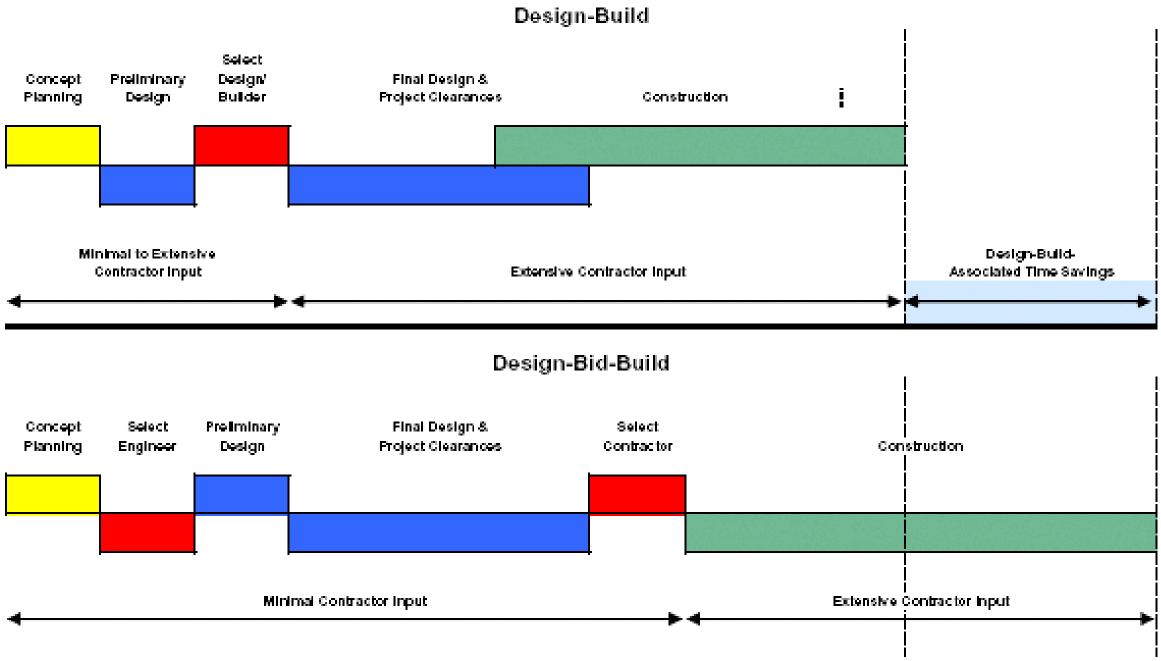

Figure 7: Comparison of timelines of Design-Build projects and Design-Bid-Build projects (Molenaar)

The relationships created by these project delivery methods influence the behavior of each party involved. The following chapter will identify weaknesses in these methods as they are currently employed in the industry and how they contribute to wasted cost within projects.

Chapter 3: Sources of Waste

According to September 2011 information from the U.S. Census Bureau, the construction industry in the United States is valued at nearly eight hundred billion dollars annually. This value is down considerably from highs over 1.2 trillion dollars in the summer of 2006. A 2004 collaborative study by Construction Industry Institute and Lean Construction Institute suggests that as much as fifty seven percent of time, effort, and material investment in construction projects do not add value to the final product (Kenig). When compared with twenty six percent wastes in the manufacturing industry, it becomes obvious that the construction industry has a problem (Kenig). Additionally, almost three-quarters of all construction projects come in over budget and behind schedule (Miller et al). It is difficult to get to over four hundred billion dollars of annual waste without having many contributing factors. A 2006 study of delays in construction projects in the United Arab Emirates identifies "preparation and approval of drawings" (lack of communication) and "inadequate early planning of the project" (lack of coordination) as the two largest causes of delay (Faridi and El-Sayegh). Additionally, a 2004 survey conducted by FMI and the Construction Management Association of America (CMAA) indicated that the majority of building owners feel that incomplete drawings and poor planning are the primary causes of cost overruns (EC&M). This chapter will demonstrate that the contractual relationships created by traditional project delivery methods contribute to both of these forms of waste. It will also examine the cause and effect of poor communication on construction projects.

CONTRACTUAL RELATIONSHIPS

In Chapter 2, three types of construction project delivery methods were introduced: Design-Bid-Build, Construction Manager, and Design-Build. Each of these delivery methods are characterized by the contractual relationships they create between the owner, the design team, and the builder. This section will identify and evaluate the behaviors that these contractual relationships encourage and the possible side effects that can create waste within a project.

Whether the project is Design-Bid-Build, Construction Manager, or Design-Build, it is a common industry practice to enter in to a contract with the design team in which the fee of the designer is based on a percentage of the total construction costs. This practice fails to align the interests of the designer with the interests of the owner. The owner wants a building that meets the program requirements as efficiently as possible. A percentage of construction cost fee structure gives the designer a financial incentive to increase the construction costs. While the vast majority of architects are honest professionals who are, in fact, looking out for their client's best interests, contracts would be better suited to financially reward behavior that reflects the interests of the owner. The same idea can be applied to Construction Manager fees that are based on a percent of total construction costs. While the implication is not that designers and construction managers are taking advantage of owners, it is apparent that these parties are not being financially motivated to reduce costs. Integrated Project Delivery contracts, as further described in Chapter 4, provide terms that align the interests of all parties through shared risk and reward payment.

Similarly, traditional project delivery methods actually discourage collaboration and collective problem solving among contracted parties. In 2004, the Construction Users Roundtable (CURT), the American Institute of Architects (AIA), and the

Associated General Contractors of America (AGC) released a joint publication urging change within the industry. Included within that release was the statement that "the historical reasons for this dysfunctionality are many, including multiplicity of participants with conflicting interests, incompatible cultures among team members and limited access to timely information" (Kenig). For the average ten million dollar construction project, four hundred and twenty separate companies will participate in some form or fashion (Hendrickson). Among those four hundred and twenty, there are typically fifteen to twenty that would be considered "key" participants. In traditional project delivery methods, these participants all have separate contractual agreements. Subcontractors and some designers are often two contracts removed from the owner. Sub-subcontractors and suppliers are even further removed. Each contract represents a hurdle to open communication. When a subcontractor is hired on under a general contractor, the subcontractor will run all project communication through the general contractor. Likewise, an engineer hired by an architect will direct project communication through the architect. This behavior is motivated by avoidance of risk, and prevents open, effective communication and collaboration between key parties. Project participants are focused on their own bottom line which hinders cooperation and can create waste when the best solution for the project as a whole is not achieved (Furst). Chapter 4 will further discuss how Integrated Project Delivery offers a solution by allowing the key participants to be included in the integrated contract, thereby leveling the playing field and encouraging a "best for the project" approach.

When the project delivery method requires competitive bids, additional costs are incurred. To help illustrate the costs of competitive bidding, consider an example commercial construction project with an approximate total construction cost of thirty million dollars. According to Reed Construction Data, the average commercial building project attracts nearly fifteen bids from general contractors. Each of these fifteen general contractors require about five people committed to putting the bid together for four to five weeks (Miller et al). The cost of providing a proposal for the project is estimated to be nearly fifty thousand dollars for each contractor. If a contractor bids fifteen different thirty million dollar projects and wins only one of these, there are fourteen projects worth of proposal cost, or approximately seven hundred thousand dollars that has to be accounted for somehow. These costs of these fourteen failed bids have to be recouped by the contractor in the one project that was won. The contractor's costs for failed bids in this example project come out to a little over two percent of the total construction costs.

Contractual claims represent ninety percent of the claims that occur within the construction industry (Shapiro). According to a study by the Federal Facilities Council (FFC), one in four construction projects results in a lawsuit. The transactional costs for resolving these lawsuits each year cost the industry between four and twelve billion dollars. Root causes of these costly disputes identified by the FFC study included: inequitable allocation of risk between owners, contractors, and subcontractors, inappropriate contracting strategies, the low bid process, lack of alignment of the owner's, general contractor's and subcontractor's objectives, inadequate owner involvement, poorly developed and executed contracts, poor communication, lack of project management procedures, and fast-track scheduling. These issues are exactly what Integrated Project Delivery is set up to combat.

ERRORS IN CONSTRUCTION DOCUMENTS

Building owners have taken note of the struggles that the industry has undergone in recent years. According to a 2010 survey of building owners conducted by the Construction Management Association of America and FMI, thirty three percent of building owners feel that the quality of construction drawings is on the decline. Figure 8 below shows the full range of owner responses regarding drawing quality change since the survey was conducted in 2009. The majority of owners felt that the quality of design documents and construction documents produced by design teams stayed the same or regressed in 2010 (D'Agostino). The same study, in 2004, noted that eighty percent of respondents indicated that design documents had declined to the point that subcontractors were being forced to complete the design through the shop drawing approval process (EC&M). Some estimates show that as much as twenty-five percent of the cost of a project is related to issues stemming from contractor's interpretations of construction documents (Mullins).

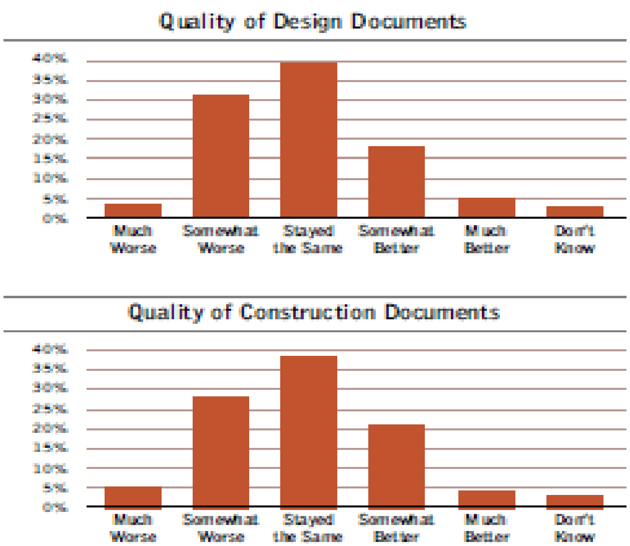

Figure 8: Owner responses to survey question of change in quality of design documents and construction documents between 2009 and 2010 (D'Agostino)

A common complaint among general contractors is a lack of construction knowledge demonstrated by today's architects. Spurred by the recession in the early 1970's, architects began to move further and further away from the role of "master builder" that they represented for ages. The master builder both designed the building and oversaw the construction of it, filling the role now most closely resembled by design-build firms. In recent times, architects have become a specialized service provider (Miller et al). The way most architecture firms are structured, the most experienced architects provide the schematic design, and then serve more of a project manager role for the remainder of the project, allowing their understudies to finish the detail drawings. As a result, many detail drawings are created by young architects or designers who have very little experience with actual installation of the materials they are drawing. In fairness, the designers are also working under time constraints that often do not allow for time to fully evaluate every detail in a set of drawings. However, inefficient details can lead to significant amounts of wasted time by builders. The following chapters will demonstrate how early collaboration with builders and use of three-dimensional modeling technology can help designers find the most efficient details for a given condition.

Besides difficult details, another contributing factor to the perception that design document quality is on the decline is the use of "boilerplate" specifications. Boilerplate specifications refer to specifications used by architects and engineers that are used on every project and not adjusted to cater to the needs of the project they are intended for. In my experience preparing bids based on plans and specifications from various architects and engineers, I have found that many architects and engineers use template specifications and do not take adequate care in reviewing and understanding what their specifications truly require. For instance, occasionally in the steel building industry architects will specify a premium grade paint finish on a roof that will not be visible. In cases such as this, the owner will often end up paying extra for a feature that adds no real value to the building. The specifying designer is not intentionally wasting the owner's money, he or she simply does not understand the cost implication of various metal panel paint finishes to the same degree that a metal building subcontractor does. Given the number of building products available in the industry today architects cannot and should not be expected to be experts on all products. This problem can be addressed by early collaboration with key subcontractors, a practice that will be further discussed in Chapter 4.

Within the current system, inefficient details and boilerplate specifications are sometimes caught when a project goes out for bid. Projects that come in over budget are often "value engineered" to remove some unnecessary cost. Many times my company is asked to provide value engineering ideas that can remove some cost from the project without compromising the design intent for projects that come in over the owner's budget when bid. Value engineering is a useful procedure in traditional project delivery methods to help weed out inefficient uses of material. However, by the time a subcontractor has a chance to offer value engineering ideas a significant amount of time has already been spent drawing and pricing the wrong detail or specification. Additionally, in order for a change to be made, a formal request for information (RFI) must be generated, followed by an official addendum from the designer. This process takes time and therefore creates wasted cost. In an Integrated Project Delivery environment this process would occur at the beginning of the design phase to maximize efficiency and allow the subcontractors to make recommendations that may otherwise be too late by the time they get a chance to value engineer in a traditional project.

Inconsistencies found in construction documents cause another set of problems for the project team. Given the amount of information that must be communicated through the drawings and specifications it is not surprising that inconsistencies and errors are often found. However, these avoidable mistakes create additional waste within projects in the form of rework for the designers and RFI's for builders. In my previous experience as a consulting engineer, I experienced the difficulties that designers face in eliminating errors within drawings. For example, the size of a steel beam may be designated on a plan sheet, an elevation drawing, and several section drawings within the same set of plans. During the design of the structure, each time this beam is re-sized, the size designation must be changed at each occurrence where it is shown in the plans. Given the multiple iterations required to finish a set of construction drawings, this can become very time consuming and confusing. To limit the exposure to this type of mistake, some designers will show sizes on plan sheets and then give only very generic information on subsequent reference drawings. This practice does eliminate a great deal of rework for designers and the RFI's that come as a result of having conflicting information on the drawings, but is inconvenient for a builder trying to understand a particular building condition. Chapter 5 will introduce a solution for this issue through the use of Building Information Modeling.

An often overlooked source of waste can be found in the shear amount of paperwork it takes to complete a construction project. For most architects and engineers, each set of progress drawings issued during the course of a job requires a full set of drawings to be plotted. A typical construction project will have about five to ten complete progress sets. Material suppliers prepare shop drawings to demonstrate the materials that they intend to provide on the project. Several copies, usually four to six, of each vendor's shop drawings are printed and distributed to the general contractor and the applicable members of the design team. The design team and general contractor then review the drawings for accuracy. If the drawings meet the design team and contractor's requirements, an approved set of drawings is sent back to the supplier for them to begin fabrication. If the drawings are rejected or need to be resubmitted, the process starts again. For an average ten million dollar construction project fifty-six thousand sheets of paper are required (Hendrickson). Arol Wolford, founder of Construction Market Data, states that ten percent of the cost of a project is comprised of processing, printing, and transporting documents (Miller et al). Chapter 5 will discuss how Building Information Modeling software allows for electronic submittal review and even makes paperless projects possible.

The sources of waste described in this chapter have been identified as the two biggest contributors to inefficiency in the industry (EC&M; Faridi and El-Sayegh). The following chapters will introduce Integrated Project Delivery and Building Information Modeling as important tools that have proven effective in addressing these concerns and improving the overall outcomes of construction projects.

Chapter 4: Integrated Project Delivery

As defined by the American Institute of Architects (AIA), Integrated Project Delivery is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction. This chapter will give an overview of what Integrated Project Delivery is, discuss the ways in which it addresses the sources of waste described in Chapter 3, and provide case study information that supports its use as a way to produce better construction projects.

DESCRIPTION

At its most basic, Integrated Project Delivery is set up to reward parties for making decisions that are in the best interest of the project as a whole. Key contributors of knowledge are brought in as early as possible and encouraged to work with the design team to minimize the waste that is built in to the project during the design phase. Integrated Project Delivery is intent on breaking down the silos of information that are found in other project delivery methods by rewarding open communication and dialogue between all parties. For these reasons, Integrated Project Delivery contracts are radically different than other construction contracts.

The AIA recognizes three main types of Integrated Project Delivery contracts: Project Alliances, Single Purpose Entities, and Relational Contracts. In Project Alliance contracts, the owner guarantees payment of all direct costs, but overhead and profits are dependent upon the eventual success of the project. In this arrangement all major decisions are made by a consensus of the contracted parties. The contracted parties must include the owner, primary builder, and primary designer at a very minimum. For more effective implementation all key designers and subcontractors should be included in this single project contract. Another feature of Project Alliance contracts is that all parties waive the rights to any claims between them except for willful default (Cook et al).

Single Purpose Entities are sometimes created to produce a project. In this case, project contributors actually join together to form a temporary corporation or other form that will produce the project. Parties are paid for their contributions to the new entity and also have some pay based on the overall success of the project. This method can get rather messy due to the issues of taxation, insurance, and management in general (Cook et al).

The third option for integrated contracting is a Relational Contract. Relational Contracts are essentially limited versions of Project Alliances. In a Relational Contract, parties may limit their liability to one another instead of waiving all claims. Compensation will still be tied to the overall project's success, but parties may not be on the hook for project overruns if they occur. Most decisions are made by collaboration among the project team parties, but usually the owner will retain the right to make the final decision. Relational Contracts help to bridge the gap between traditionalists and the fully integrated Project Alliances (Cook et al).

DISCUSSION

The contractual relationships described above help facilitate the spirit of this project delivery method. The AIA lists nine key principles of Integrated Project Delivery (Cook et al):

1. Mutual Respect and Trust

2. Mutual Benefit and Reward
3. Collaborative Innovation and Decision Making
4. Early Involvement of Key Participants
5. Early Goal Definition
6. Intensified Planning
7. Open Communication
8. Appropriate Technology
9. Organization and Leadership

In a truly integrated project, the interests of each party are truly aligned with the interests of the owner. When projects come in under budget or ahead of schedule, the participants make more money. Instead of each party being incentivized by contract to protect only their own self-interests, they are now motivated to collaborate and find the best solution for the project. It has been my experience that this type of teamwork and "what is best for the project" attitude is extremely rare in traditional project delivery methods.

Early involvement of key participants is one of the major principles of the Integrated Project Delivery approach. Due to the increased level of specialization in today's construction industry, the knowledge required to complete a project is spread over many individuals from designers to subcontractors. Traditional project delivery methods, however, have left the entire project planning process in the hands of just the architects and engineers. In reality, no one understands a trade as well as the tradesman or subcontractor that will be providing or installing this material. Integrated Project Delivery recognizes this expertise and provides an opportunity for the experts in each major trade on a job to influence the design and make the construction of the building more efficient. This effect is depicted in Figure 9 below. This infusion of knowledge in the early stages of the design process can help eliminate much of the costs associated with difficult-to-install details. Essentially, the general contractor and key subcontractors are given the opportunity to provide value engineering ideas for the project to save costs on the front end, thus eliminating an instance of duplicated effort in designing and drawing the detail twice.

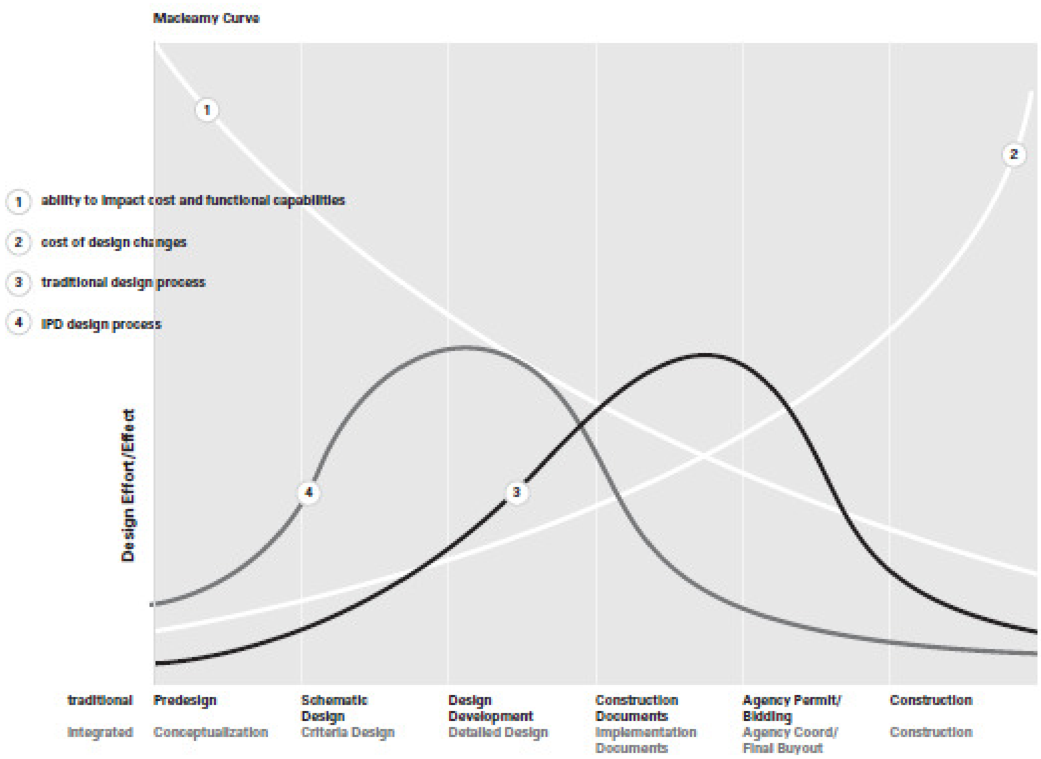

Figure 9: Graphical representation of the value of early collaboration in the design phase (Cook et al)

Integrated Project Delivery, when implemented to its fullest extent also eliminates the need for much of the bid process since the contractor and major subcontractors are already on board from the start of the project. If using a Project Alliance contract, contractors under the contract are guaranteed to receive reimbursement for their hard costs with compensation for overhead and profit being dependent on the overall success of the project. This means that the contractor does not have to waste time and valuable overhead in putting together bids for projects they will eventually lose. The contractor instead will help the project team keep a running tab of costs as changes are made to the design so that the team can closely monitor the budget during the design phase. It is also able to eliminate the wasted time needed for communicating through the chain of contracts that are set up by traditional project delivery methods. With Integrated Project Delivery, all of the team members are on a level playing field, so a subcontractor can go directly to the designer who drew the detail to discuss the problems associated with what was detailed.

This collaboration between designers and builders is further facilitated in instances where co-location of the project team is possible. Most in the construction industry have grown accustomed to working with project teams that are spread all over the country or all over the globe. Organizing a central office for the project team is helpful to promote an Integrated Project Delivery process. The Beck Group has taken the Integrated Project Delivery approach a step further. This company has brought development, architecture, and construction under the same roof as an "Integrated Enterprise". This is Integrated Project Delivery in its purest form (Beck Group Website).

While Integrated Project Delivery has been promoted by several major organizations within the construction industry, including the American Institute of Architects (AIA) and The Associated General Contractors of America (AGC), adoption of the process has been relatively slow. Major reasons for the reluctance of the industry to embrace Integrated Project Delivery are concerns about the risks of close partnerships required and a lack of legal and insurance infrastructure at this time (Kent and Becerik-Gerber). While insurers are working on solutions for Integrated Project Delivery, the costs are high due to the high customization required for project specific policies (Collins and Rogers).

Recent changes to energy codes and the promotion of Leadership in Energy and Environmental Design (LEED) requirements by the U.S. government have led to a potential market for Integrated Project Delivery to truly get a foothold in the industry. A recent study of "green" building projects suggests that three key components have a significant impact on the project success: earlier involvement of commissioning agents in projects, timing of contractor involvement in the project delivery process, and owner type. This study suggests that "the added requirements of such projects are commonly understood to require integrated project delivery, early involvement of key project parties, owner commitment to sustainability and use of simulation tools" (Korkmaz et al).

CASE STUDY RESULTS

The early returns from projects delivered using the Integrated Project Delivery framework have been positive. The following case studies are a selection of several available from completed AIA research. More projects using this delivery method are being examined and are currently in the process of being constructed.

In 2008 Autodesk, a construction software company, teamed with KlingStubbins and Tocci Building Companies to build an interior finish-out in a fifty-five thousand square foot office building in Waltham, Massachusetts. Some of the challenges facing this project included a program requirement to reach Leadership in Energy and Environmental Design (LEED) Platinum rating for Commercial Interiors and a tight delivery schedule that included just eight and one-half months to complete design and construction. Autodesk selected the team based largely on their willingness to participate in the Integrated Project Delivery contract structure. Three major subcontractors were also included in the sharing of risk and reward for the project. Within the integrated contract was a provision for an Incentive Compensation Layer (ICL). The ICL included the architects' and builders' expected profits for the project. These profits were contingent upon reaching specific project goals. However, along with putting their profit at risk, the team also had the opportunity to receive additional compensation of up to twenty percent if the project goals were exceeded. Along with the shared risk and reward represented in the ICL, the participants also waived all claims against each other besides fraud, willful misconduct, and gross negligence. All parties also waived their rights to subrogation against team members. The contract also identified what would be considered a success for the project team. Criteria for success included schedule, budget, sustainability, quality of craftsmanship, functionality, and design quality. Within the overall project budget, the team was free to move money or resources to areas of need as they saw fit. As proof that an Integrated Project Delivery contract structure can change behavior, John Tocci, head of Tocci Construction, suggested that the team move additional resources to the quality of materials and detailing to ensure that the team met its design quality requirements. Given that the design quality is the responsibility of the architect, this likely never would have happened in a traditional project delivery method. It would truly be a shocking development in a Design-Bid-Build project for a contractor to offer up part of his budget to an architect to ensure that the owner felt satisfied with the architect's performance. The team also demonstrated great flexibility within the Integrated Project Delivery arrangement. At one point during the design phase of the project, the owner decided to add a three-story atrium that cut through the middle of the building. Incredibly, the architect and builder were able to model and price three different alternatives for this feature within one week. In my experience under traditional circumstances, contractors are often hesitant to price changes until the design team has completed drawings for fear of liability should the unknown details of the drawings add unexpected costs. KlingStubbins, the architecture firm, found that close collaboration with the builder eliminated the need to re-detail the same condition multiple time along with answering various RFI's. Additionally, some submittals and shop drawings were eliminated altogether. At the end of the project, the team had brought the project in below the contract target price. The architects and builders also realized higher profits than originally projected while producing a building that exceeded owner requirements (Cohen).

The most commonly cited success story of Integrated Project Delivery is the Sutter Health Fairfield Medical Office Building in Fairfield, California. Sutter Health was seeking to build a three-story, seventy thousand square foot medical office building as the first piece of a six and half billion dollar capital program. Sutter Health was interested in the ideas of Integrated Project Delivery and wanted to give it a test-run on this small part of a large capital investment program. Sutter Health selected HGA out of the request for qualifications (RFQ) respondents based on previous work with the firm. Sutter then put HGA together with The Boldt Company to make sure that the three parties would be a cultural fit. The three parties then entered in to a three-way contract to provide design and construction of the project. The contract required that the team select the key design-build subcontractors early on in the design phase of the project. The subtrades, however, were not included within the integrated contract. This project did include provisions for shared risk and allowed the team to collaboratively manage contingency funds, but it did not implement a financial incentive plan. Sutter has since adopted the practice of pooling project savings to be distributed to members of the team for meeting project goals. The contract also called for all parties to maintain open books with regards to project costs. As with Autodesk, the participants in this case waived their rights to sue each other. Provisions for mediation and limits to liability were established by the contract agreement. Again, the architects enjoyed less responsibility for detail work as much of that was handled by the various subcontractors. Over half of the project submittals were processed without paper documentation, saving both printing costs and shipping costs. The project only had owner-initiated change orders, avoiding any change orders that could have arisen from conflicts in the design drawings. This project also relied heavily on Building Information Modeling (BIM) and lean construction practices to eliminate project waste. The impact of BIM and lean construction on construction projects will be further discussed in later chapters. The project came in approximately one hundred thousand dollars below the previously agreed upon guaranteed maximum price despite the addition of over eight hundred thousand dollars of value-added scope additions from the owner. Additionally, participants reported appreciation of the mutual respect and partnership that was characteristic of this process (Cohen).

The Walter Cronkite School of Journalism at Arizona State University was completed in 2008 in Phoenix, Arizona. The site on which the building now stands was not its original planned location. A previous scheme at another site had fallen through, leaving the university only twenty four months left in its bond to develop a new program at new site. Arizona State contracted with Ehrlich Architects, HDR Architecture, and Sundt Construction to form the major members of the integrated team on this two hundred and thirty thousand square foot building. In this case, city procurement regulations required that the contract be issued as a two-way owner/design-builder contract. However, the team decided from the outset that in order to complete the project in the twenty four month window remaining in the bond, an alternative to the Design-Bid-Build method would have to be used. The team agreed up front that they would not allow the terms of their traditional procurement contract to dictate behavior. They agreed to follow the principles of Integrated Project Delivery regardless of what their contractual obligations were. After Ehrlich, HDR, and Sundt were on board, the team then immediately turned to selection of subcontractors. Subcontractors were selected based on qualifications, and allowed to negotiate a fixed fee, but with the requirement that they disclose all cost accounting for the project with the rest of the team. Subcontractors were brought on board before design began to allow for early collaboration. All subcontractors were also required to use BIM for their part of the project. The budget and schedule of the project were set by bond financing, so the team was forced to determine how to allocate the budget and time to achieve the maximum realization of the university's desired program. After an initial review, the team concluded that based on past experiences, the budget set forth in the bond was unlikely to pay for the entire program that the university was looking for. Arizona State was able to set aside an additional two million dollars from another budget to bridge the gap between what it wanted and it could afford, but even with this additional amount, it was projected that some of the interior space of the building would remain unfinished at the end of construction. To accomplish the ambitious goals of the project in such a short amount of time, team members were forced to step out of their comfort zone and perform tasks that would not have fallen under their scope in ordinary circumstances. As stated by Mathew Chaney of Ehrlich, "We do not provide quantity takeoffs in a Design-Bid-Build project, but in this project it was a daily occurrence. Because of the trust established we weren't afraid to get involved." This type of behavior is what Integrated Project Delivery intends to inspire. Co-location of the major team members was an important aspect of this process. A "Big Room" was set up in HDR's Phoenix office where the entire team would meet on a regular basis to collaborate on design decisions. According to HDR's principal in charge of the project, Michael Jackson, "Co-location works because when you work that closely together you naturally develop a relationship of trust. When everyone is in their own office and using email and staying at arms' length it doesn't allow that to happen." Another key to meeting the schedule requirements was beginning construction on the foundation prior to design being complete. The structural and foundation engineers designed a foundation system that provided maximum flexibility for design changes later in the process. By the end of the project the team had managed to provide a completely finished out building without using any of the additional two million dollars the school had set aside. According to Terry Abair with Sundt Construction, "In order to be successful we had to change the behaviors we were used to. If everyone had fallen back on their normal behavior we never would have gotten there." (Cohen).

The cases described above represent three cases where Integrated Project Delivery methods have proven successful in delivering projects on time and within budget despite encountering some of the unique challenges that face many building projects. The accomplishment of finishing within budget and on time is shockingly rare in the construction industry. According to recent studies, seventy-two percent of projects come in over budget and seventy percent of projects overrun the project schedule. Additionally, three quarters of the projects that were delivered late also were over fifty percent over the initial contract price (Miller et al). Due to the relative newness of Integrated Project Delivery, the availability of data regarding completed large-scale projects using the method is rather thin. However, the early returns on the results that have been published are encouraging. The Integrated Project Delivery solution is not yet standardized. As shown by the cases described above, there are several different routes to achieving success with this method. Teams are still experimenting with different blends of this structure; however it seems that there is consensus among participants that Integrated Project Delivery is effective at reducing overall project risk, aligning goals of key team members, and realizing the efficiencies available through early involvement of subcontractors. Integrated Project Delivery also offers the owner the opportunity to eliminate the pure waste represented by implicit contingency funds within contractor and subcontractor bids by arranging cost-plus contracts that spread the risk over the entire project team. Michael Jackson of HDR sums up Integrated Project Delivery's impact on risk well: "owners are not used to the level of commitment of taking responsibility equally with the architects and builders and accepting some risk themselves. The owner has to be at the table. In the old-fashioned relationships we're always thinking 'How can I shift that risk to the other two parties' but it's just pushing the shells around. The reality is when you're willing to take responsibility . . . the end result is the risk goes down for everybody" (Cohen).

As demonstrated by the case study results, Integrated Project Delivery can be a powerful tool for promoting teamwork and collaboration to achieve results that may not have been possible under traditional delivery methods. Integrated Project Delivery also encourages an increased level of communication between parties involved in the project. This effort is enhanced by technological advances in the industry such as Building Information Modeling.

Chapter 5: Building Information Modeling (BIM)

Fragmentation of the construction industry from master builders to specialized service providers has helped contribute to a lagging investment in research and development when compared to other industries. Less than half a percent of contract value is invested in research and development in the construction industry, compared with an average of three and half percent across other industries (Teicholz). The development of Computer-Aided Design (CAD) software in the construction industry revolutionized the way architects and engineers work. Prior to the adoption of CAD software, all drawings were hand-drawn which consumed a great deal of time and limited designer's ability to easily make revisions.

Building Information Modeling (BIM) has been around since ArchiCAD was released in 1987; however it has only begun to realize its true potential in the past five years. McGraw-Hill's 2008 SmartMarket Report on Interoperability suggests that 2008 was the "tipping point" year for BIM, making it now an inevitable technology (Kenig). Half of the construction industry is now using BIM, a seventy five percent increase over the past two years. Within the group that has not yet adopted this technology, forty-two percent believe that BIM will be "highly" or "very highly" important in the industry over the next five years (Young).

The use of BIM has exploded in recent years for good reason. BIM offers designers, builders, and building owners opportunities unlike any that they have experienced. BIM software allows designers to build a project in a virtual environment prior to builders constructing the building in the field. While it is known mostly as a three-dimensional (3-D) modeling program, BIM represents much more than that. The "I" in BIM is what truly makes this tool powerful. The information that the models are able to communicate are vast, and the industry has barely scratched the surface of the capabilities this tool offers (Young).

To begin with the basics, the benefits that 3-D modeling offers for the construction industry can help alleviate many sources of waste that were described in Chapter 3. When BIM is fully implemented the design team and the builders both contribute to the modeling. When design and construction are separate in traditional project delivery methods, architects and engineers model the materials that they are responsible for designing. For instance, heating, ventilation, and air conditioning (HVAC) engineers model the required air handling units and duct work while structural engineers model the elements that support the building. The architect is then responsible for modeling the finish out and veneers and coordinating the models from the engineers. On projects that I have worked on with BIM requirements, participants have been required to upload their latest model on a given day of the week. The architect will then compile the models in to a master model and run clash detection. Clash detection is a feature of BIM that automatically finds problem areas in the model and produces a list of these "clashes" to the user. The classic example of the usefulness of clash detection is the ability to be alerted to potential conflicts between bar joists and HVAC ducts prior to construction of these elements. Without BIM this conflict is very difficult to detect, and typically results in the subcontractor installing the ducts having to make adjustments on the fly which decreases efficiency in the field. Clash detection also assures the designers that they are dimensionally consistent throughout their elements. If a column is located incorrectly in the model, the clash detection will alert the user that there is a column fouling a piece of drywall in the model. Even more impressively, BIM software will give warnings when you model a condition that is impossible or difficult to construct. For example, if a bolt is located in a space that is too tight for a worker to get a hand in to tighten, the program will alert the designer. In addition to clash detection, BIM also allows the designer to create their drawings directly out of the model which eliminates the risk of dimensional conflicts between plans. BIM modeling also eliminates much of the rework that is required when making design changes. Using the example of changing the size of a steel beam again, rather than having to change the size of the beam on each location that it is shown in the drawings, the designer simply makes the change once in the model and it is automatically updated at each location in the drawings. When used with subcontractors, BIM also helps eliminate the risk of scope gaps or scope overlap. Subcontractors will model the parts and pieces that they are expecting to provide, allowing the contractor to visually recognize missing pieces or redundant pieces quickly and prior to the material being needed in the field.

The potential of information communication through the model is where BIM makes the leap from helpful to revolutionary. Every object in a BIM model is a "smart" element, meaning it is capable of having information associated with it. Instead of a steel beam being labeled with just the size and shape of the piece, smart elements will also communicate the grade of steel required for that piece, the piece mark that it will be labeled with when delivered to the field, whether or not it will be painted and what color, and once the beam is made, it can be updated with the piece specific test reports from the steel mill where it was formed. This becomes even more powerful when dealing with equipment that has scheduled maintenance programs. An air handling unit can be modeled along with its user manual and maintenance schedule. Within the model, a facility maintenance manager can simply click on the unit in question and immediately see when the filter needs to be changed, what part number that filter is, and a set of instructions for replacing the filter. Instead of handing the owner an operations and maintenance manual that can be thousands of pages long, with BIM contractors can simply turn over the as-built BIM model with all of this information easily available in a more user-friendly format.

The future of BIM finds even more uses for this tool. Given that the very baseline of BIM is 3-D modeling, the term “4-D BIM” is used to describe the practice of tying project construction scheduling to the model. A project manager can use the software to phase his deliveries for optimum efficiency on the job site. A simulation of the order of installation can be performed and visualized easily. Beyond project planning, there is now technology available that allows for field use of BIM models. Using tablet PCs, field workers can scan barcodes or RFID tags on an item and instantly see all the information relevant to the status, placement, and installation of that piece. Once the piece has been installed, the worker can mark it as installed in the model. This allows for offsite project managers to have real-time updates of the progression of the project. The visual representation of the model can be color coded to show which pieces have been installed, which pieces are ready for delivery, and which pieces are yet to be fabricated, allowing the project manager to more easily foresee potential issues or snags in the schedule. All updates are time stamped which allows production to be tracked and reviewed easily (LATISTA).

Adding a cost dimension to the model gives us “5-D BIM” modeling. With this addition, costs are able to be associated with items in the model. This allows users to have real-time cost estimates as designers make changes in the model, saving the considerable amounts of time required to produce an estimate from standard construction documents. Designers and builders are able to clearly, quickly, and accurately show owners the cost and schedule implications of requested changes and allow owners to make informed decisions about the direction of the project. For long-term construction projects, builders can evaluate the project’s potential exposure to material cost increases that can occur between the design phase and the time that the material is actually procured.

As mentioned before, most in the industry feel that BIM is here to stay. The numbers support this feeling. According to a 2009 McGraw-Hill SmartMarket Report on the Business Value of BIM, seventy percent of owners reported a positive return on investment (ROI) from the use of BIM on their projects. Among users, sixty-three percent reported a positive ROI. Out of that group, seventy-two percent of the users that used a formal measure of ROI on BIM reported positive returns, indicating that reality may be even better than perception. BIM is a disruptive technology that requires a substantial capital investment up front on the software itself and training personnel to use the software, but even among users characterized as “beginners”, two-thirds reported at least a break even ROI. More advanced users reported significantly greater results as shown in Figure 10 below.

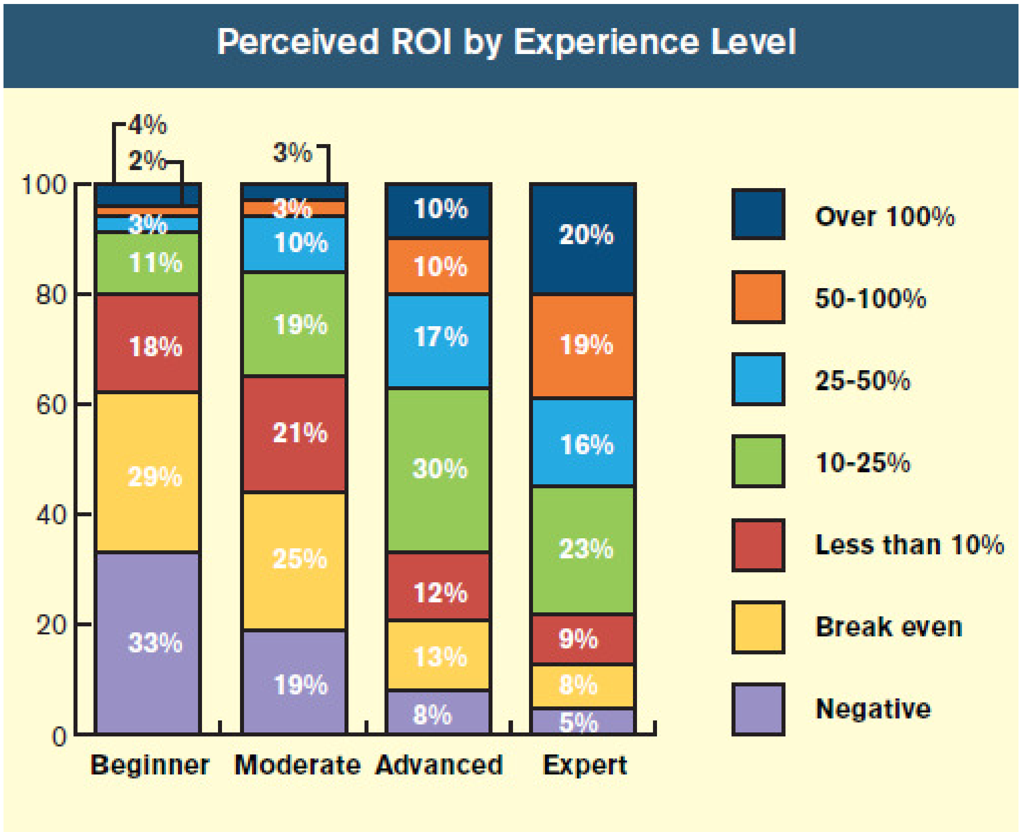

Figure 10: Perceived ROI among BIM users by experience level (Young)

As users become more comfortable with operating within the BIM realm, the idea of paperless construction becomes a reality. As previously discussed, BIM offers designers an electronic platform for drawing coordination. Instead of printing, shipping, and manually reviewing hundreds of pages of plans for every coordination set of drawings, the team can simply upload the latest BIM models and check for coordination within the model. Instead of contractors and material suppliers printing off sets of drawings and performing a material takeoff, they can take the designer's BIM model and associate the appropriate material costs to each item. Instead of suppliers sending paper submittals to the design team for review prior to fabrication, submittals can be handled through the model. Instead of builders taking cumbersome sets of printed plans in to the field to build from, they can use tablet PCs that put all the information at their fingertips (Meibers).

Consider the results from the use of BIM on the Research 2 (R2) research facility for the University of Colorado-Denver Health Sciences Center in Aurora, Colorado. R2 was an eleven story, five hundred and forty-thousand square foot biomedical research facility similar to another research tower, R1, which had previously been built nearby. Mortensen Construction was selected to build the project with Fentress Architects acting as the designer. During the construction of R1 there were many problems related to fitting the complex mechanical systems required for the building in with other elements. Mortensen felt that the use of BIM would help the team on R2 handle these issues more efficiently. To maximize the benefits of BIM use, Mortensen pursued an integrated approach, engaging the design team and key subcontractors early on in the virtual coordination process. The team started to see significant time savings upon completion of the construction model. The structural engineers were able to transfer their model of the structural steel elements to the steel subcontractor who then quickly submitted 3-D shop drawings for review. The use of BIM for coordination between the structural engineers and the steel subcontractor led to the structural steel being erected six weeks ahead of schedule. Intrigued by the use of BIM on the project, the university and Mortensen had a University of Colorado graduate student prepare a comparison of the R1 project and the R2 project. The study demonstrated that use of BIM reduced RFI's by seventy-four percent in the foundation phase and forty-seven percent in the steel erection phase. The team was also able to reduce coordination change orders by thirty-two percent as compared with R1. By the completion of the project, R2 had finished two months ahead of schedule and six months ahead of R1. Use of BIM on the complex mechanical system reduced labor and schedule for the mechanical sub by half (Young).

Another project that benefited from the use of BIM is the U.S. Department of Energy's National Nuclear Security Administration's Pantex complex in Amarillo, Texas. CH2M-Hill was hired to provide design services on the one-hundred million dollar, forty-five thousand square foot complex. Due to the building use, considerations for blast-resistant structure as well as extensive mechanical and electrical systems were required. The project started off using conventional 2-D CAD construction documents, but when the project was put on hold for funding and scope review, Pantex decided to take the opportunity to integrate BIM requirements in to CH2M-Hill's contract. The team modeled the entire project from simulations of robotic equipment to the smallest piece of conduit. This exercise resulted in clash detection finding thousands of collisions that would not have been caught until construction was underway had the building never been modeled. Additionally, the ability to virtually "walk through" every room uncovered over five-hundred serious problems with the building layout and spatial arrangement. Independent cost estimators calculated a ten-million dollar cost savings generated by the use of BIM. With construction not yet started at the time of the study, the builder was looking in to ways to use BIM to reduce construction time and even train employees that will work in the facility virtually, taking months out of the traditional startup phase and providing added benefit to the owner (Young).

The biggest stumbling block for BIM in past years has been interoperability of software. A 2004 National Institute of Standards and Technology (NIST) study estimated that a lack of interoperability between software platforms resulted in nearly sixteen-billion dollars in annual losses (Young). Since 2004, significant strides have been made in this area due to the efforts of Industry Foundation Classes (IFC) standardization. The industry is now trying to institute standards for transfer of information between parties working together on BIM projects.

Having had the opportunity to serve as a member of the Associated General Contractors of Houston's BIM Task Force in recent years, I have been able to witness the development of this technology and help promote its use. BIM is best-suited for use with Integrated Project Delivery to allow for subcontractors to contribute to the initial modeling of the project, rather than remodeling what the designers have already done. While BIM does have the ability to produce a positive ROI for a company using it as a standalone modeling software, its greatest benefits are achieved when an entire project team is operating in a BIM environment.

Chapter 6: Conclusions

There is little doubt that the construction industry is in need of a change. The status quo is wasting nearly half a trillion dollars per year. With nearly three-quarters of all projects coming in over budget and behind schedule, owners are spending a great deal of money on professionals that are failing to produce the results that they have promised. In my experience working in construction, I have found that the relationships between the parties working together to produce a construction project are often contentious. The culture of the industry is based on protecting your own self-interests, often at the expense of the project as a whole. The adversarial culture of the construction industry is rooted in the project delivery methods that it currently employs. A 2010 survey conducted by the American Society of Civil Engineers (ASCE) found that nearly two-thirds of the industry experts think that construction projects are not delivered efficiently. In the same study, two-thirds of respondents also stated that they believed that Integrated Project Delivery would become a widely embraced delivery method in the future (Kent and Becerik-Gerber).

The failure of traditional project delivery methods to align the interests of the parties involved in a construction project with those of the owner and other project participants has been demonstrated. This failure has created the culture of "every man for himself" that is commonplace in the industry today. Additionally, the lack of provision for early involvement of key subcontractors does not allow the system to take advantage of the expertise that subcontractors bring to their trade. The burden placed on architects to be experts on all trades in an industry that has become very fragmented and specialized is unrealistic and unfair.

Integrated Project Delivery provides an alternative to the status quo. By aligning the interests of the designers and builders with the interests of the owner, efficient practices are promoted. Instead of looking for ways to shift risk to another party, team members will search for the best solution for the project. By creating a framework in which teammates are rewarded for helping each other achieve better results, rather than punished through acceptance of increased risk, the construction industry can transform the way projects are delivered. Subcontractors will be able to ply the expertise they have earned from years of work in their trade to help architects create more efficient buildings that give the owner the greatest value per dollar spent.

With BIM technology already making headway in the industry, widespread adoption of Integrated Project Delivery is a logical next step due to the high level of compatibility between the two ideas. Both Integrated Project Delivery and BIM have been found to produce better results when used with one another (Cohen; Young). BIM gives owners, designers, and builders a key tool needed to make Integrated Project Delivery a highly effective project delivery method.

There have already been some encouraging results using Integrated Project Delivery. Making the transition to this approach will require designers, builders, and owners to step outside their comfort zone and embrace a radical change in the way they do business. However, the rewards that can be attained by adopting the new, collaborative approach provided by Integrated Project Delivery are so vast that this option cannot be ignored. While this project delivery method may not be suitable for all construction projects, the advantages described in this analysis provide solutions to the two leading causes of waste in construction projects. With recent advances in Building Information Modeling making improved collaboration and communication possible, the construction industry needs to take advantage of the opportunity to maximize the benefits provided by these technological advances.

Bibliography

Bares, Ann. 2010. *2010 Turnover Rates by Industry.* <http://www.compensationforce.com/2011/03/2010-turnover-rates-by-industry.html>

Beck, Ernest. 2010. *What's Your Time Worth?.* <http://www.architectmagazine.com/business/whats-your-time-worth.aspx>

Beck Group Website. 2011. <http://www.beckgroup.com/#/integrated-enterprise>

Bramble, Barry et al. 2011. *Construction Delay Claims.* Aspen, Colorado: Aspen Publishers. Print.

Cohen, Jonathan. 2010. *Integrated Project Delivery: Case Studies.* <http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab082051.pdf>

Collins, Kevin and Robert Rogers. 2010. *Insurance for Shared-Fault Projects Coming Soon But Costly.* Engineering News Record. Vol. 264, Issue 15.

Cook, Richard et al. 2007. *Integrated Project Delivery: A Guide.* <http://info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf>

D'Agostino, Bruce and Mark Bridgers. 2010. *FMI/CMAA Eleventh Annual Survey of Owners: Rising From the Ashes of Recent Economic Woes.* <http://cmaanet.org/files/shared/11thAnnualOS-PhoenixRising.pdf>

Design-Build Project Delivery Used for More Than 40 Percent of Non-Residential Construction Projects, Report Shows. 2010. <http://www.dbia.org/pubs/research/rsmeans110606.htm>

Eckblad, Stuart et al. 2007. *Integrated Project Delivery: A Working Definition.* <http://ipd-ca.net/images/Integrated%20Project%20Delivery%20Definition.pdf>

EC&M Magazine. 2004. *Project Owners Report Dissatisfaction With Start-Up and Project Commissioning Activities.* <http://ecmweb.com/mag/electric_project_owners_report/>

Faridi, Arshi and Sameh El-Sayegh. 2006. *Significant factors causing delay in the UAE construction industry.* Construction Management and Economics.

Federal Facilities Council Technical Report No. 149. 2007. *Reducing Construction Costs: Uses of Best Dispute Resolution Practices by Project Owners.* <http://www.nap.edu/catalog.php?record_id=11846#toc>

Hale, Darren et al. 2009. *Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods.* <http://www.mty.itesm.mx/dia/deptos/cv2/cv99-130/Archivos%20Tareas/ComparandoDCCyDC.pdf>

Hedley, George. 2006. *Submit Better Bids to Get More Work: There are Several Strategies for Improving the Bid-Hit Ratio.* <http://findarticles.com/p/articles/mi_m0NTA/is_8_19/ai_n16728047/>

Hedley, George. 2011. *Construction Risk is a 5 Letter Word!.* <http://getyourbusinesstowork.wordpress.com/tag/productivity/>

Hendrickson, Chris. 1998. *Project Management for Construction.* Carnegie Mellon University. <http://pmbook.ce.cmu.edu/>

Howell, Gregory and William Lichtig. 2008. *Three Opportunities Created by Lean Construction.* <http://www.leanconstruction.org/pdf/Three_opportunities_92508.pdf>

Kenig, Michael et al. 2010. *Integrated Project Delivery: For Public and Private Owners.* <http://www.agc.org/galleries/projectd/IPD%20for%20Public%20and%20Private%20Owners.pdf>

Kent, David and Burcin Becerik-Gerber. 2010. *Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery.* Journal of Construction Engineering and Management. ASCE.

Korkmaz, Sinem et al. 2011. *Assessing Project Delivery for Sustainable, High-Performance Buildings Through Mixed Methods.* Architectural Engineering and Design Management. Volume 7.

LATISTA and Tekla Take BIM to the Jobsite. 2009. <http://www.tekla.com/us/about-us/news/pages/latista_tekla_take_bim_to_jobsite.aspx>

Levy, Sidney. 2004. *Construction Superintendent's Operations Manual.* Highstown, New Jersey: McGraw-Hill Professional. Print.

McIntyre, Marla. 2007. *Why Do Contractors Fail?.* <http://www.constructionbusinessowner.com/topics/construction-insurance/why-do-contractors-fail.html>

Meibers, John. 2009. *How Paperless Construction Management Benefits Your Bottom Line.* <http://www.constructionbusinessowner.com/topics/compliance/regulations/how-paperless-construction-management-benefits-your-bottom-line.html>

Miller, Rex et al. 2009. *The Commercial Real Estate Revolution.* Hoboken, New Jersey: John Wiley & Sons. Print.

Molenaar, Keith and Douglas Gransberg. 2001. *Design-Builder Selection for Small Highway Projects.* ASCE Journal of Management in Engineering.

Mullins, Thom. 2011. *Keep and Eye on IPD.* Pro AV Magazine.

National Research Council. 2009. *Advancing the Competitiveness and Efficiency of the U.S. Construction Industry.* <http://www.nap.edu/catalog.php?record_id=12717>

Shapiro, Bryan. 2004. *Construction Claims and Contracting Strategies.* <http://www.maxwideman.com/guests/claims/intro.htm>

Teicholz, Paul. 2004. *Labor Productivity Declines in the Construction Industry: Causes and Remedies.* <http://www.aecbytes.com/viewpoint/2004/issue_4.html>

Turner, R.L. 2011. <http://rlturner.com/services/construction-manager-as-agent/>

Turner, R.L. 2011. <http://rlturner.com/services/construction-manager-at-risk/>

Turner, R.L. 2011. <http://rlturner.com/services/design-build/>

Young Jr., Norbert et al. 2009. *The Business Value of BIM.* McGraw Hill Construction SmartMarket Report.

Vita

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This thesis was typed by the author.