Author: **Phillips, Dustin R.**

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STUDENT:

NAME: Dustin Phillips **DATE: 3/25/18**

ADVISOR: (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem):

NAME: Tim Becker **DATE: 3/25/18**

This section for MS Plan A Thesis or EdS Thesis/Field Project papers only

Committee members (other than your advisor who is listed in the section above)

1. **CMTE MEMBER'S NAME:** N/A **DATE: N/A**

This section to be completed by the Graduate School

This final research report has been approved by the Graduate School.

Director, Office of Graduate Studies: **DATE:**

Abstract

The effects of change order management can be felt across all aspects of a construction project. The project duration, labor productivity, material procurement and safety are impacted based on how change orders are handled on a given project. While project management systems have enhanced communication between owners, designers and contractors, the use of these tools on the change management process has lacked efficiency. This study compares new systems against traditional methods of handling this process to analyze where efficiencies can be gained.

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Chapter I: Introduction

Kraus-Anderson Construction Company (KACC) is one of the largest construction management and general contracting firms in Minnesota. Building Design and Construction (2017) ranked KACC second in the nation for construction management firms. As a whole the company has a managed volume of work over 500 million per year. KACC is a leader in construction for healthcare, K12 education as well as other primary markets including housing and retail. The company focuses on continuous process improvement to ensure our leadership in these markets and to better serve our clients.

Construction projects are comprised of multiple trades with individual scopes of work based on contract documents. It is inevitable that, during the project, changes will be made to the contract documents and the scopes of work. With the construction industry fast tracking the majority of the projects, architects and engineers are continuously pushed to expedite the design and review process. In turn this pushes contractors to bid off of drawings that may lack the required details and ultimately lead to change in costs and processes once work begins.

A typical change management process includes five critical steps once the request for change has been initiated. Each of these five can be seen in Figure 1. The first is the request for change, which is self-explanatory. The second is obtaining the price and evaluating the cost for the change. This is normally done in one to two weeks based on the size of the change. The third step is to review this with the owner to see if the change is acceptable. If it is, the contractor is directed to proceed with the understanding that a formal change order is in process. The formal change order is the fourth and fifth final steps. This step can take upwards of two months to complete and ultimately a contractor cannot bill for the work, completed or in progress, until it is signed and approved by the contractor, construction manager, architect and

owner. This lag time between implementing the change in the field and the formal paperwork has several downfalls.

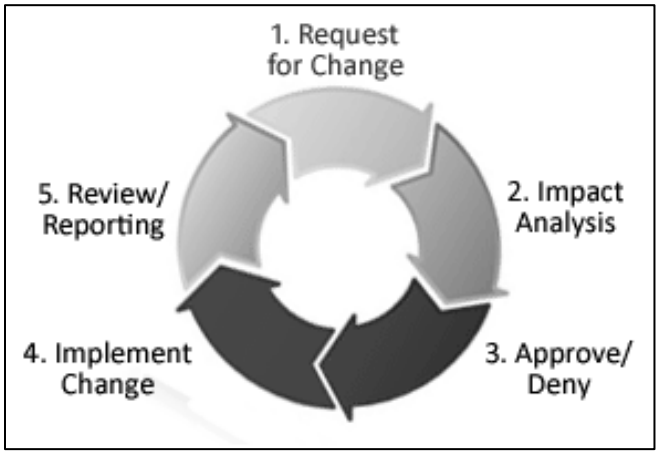

Figure 1. Change order cycle. The five major functions of the change management system. (ParsCo., 2017).

Contractors rely on consistent cash flow to cover direct and indirect expenses associated with obtaining new work while running current work. Under the standard process, contractors may have to wait more than two months before billing for work in place. It is important to keep in mind that once the contractor can bill, most contracts allow the owner 30 days to remit payment. This means contractors have a negative cash flow as a result of these delays.

As a construction manager KACC relies on a competitive bid market to drive costs down for owners. If contractors have strained cash flows due to unpaid invoices resulting from change orders, the reality is that they may not go after more work in fear of over-extending resources. A reduction in bids means less competition and increased costs. In addition, contractors may hold on proceeding with work until the formal process in underway. This creates scheduling conflicts and reduced efficiencies.

Ibbs (1997) performed a study that involved a 104 separate projects ranging from 3.9 million to 1.2 billion dollars in total construction. This study showed that after a 6% increase in

change, productivity drastically declined reaching a 15% deficiency. This is important to note as the decreased efficiency in the change management process leads to negative impacts for both the contractor and the owner. In order to not delay the project further, the owner may require the contractor to accelerate the schedule. This may require the contractor to add resources like equipment and manpower or adding overtime. In a supporting study by Woo (2016) overtime caused a 15% deficiency in labor productivity within the first week. This is important to keep in mind when evaluating change order costs because there is this productivity factor in addition to the initial higher cost of over-time rates. Most projects do not include extensive overtime as this impacts bottom line profit.

Statement of the Problem

The problem is that the current change management process delays payment and creates scheduling issues for individual projects and contractors. The time to print, package and mail these documents costs both general contractors and sub trades significant amounts of money and time. These expenses and cash flow impacts drive costs up, which means money cannot be used elsewhere.

Purpose of the Study

The purpose of this study is to determine if electronic software can reduce operating costs and negative time impacts associated with change management. Implementing an electronic change management system should significantly reduce time-lines associated with the change order approval process. This type of software should decrease company overhead through reduced processing time, paper and printing needs. Data collected through Docu-Sign and Viewpoint should prove better payback periods for work completed and increased cash flow for contractors.

Objectives

Utilizing new software would provide data that can be collected on the overall time-line for the reporting portion of the change management process. This will be compared to current time-lines of similar sized contracts. As this software reduces the need for hard copies and shipping, collection of existing costs associated with this process can be produced and compared. Based on the approval time-lines it can be measured if this system improves contractors' cash flows over the life of a project.

Definition of Terms

This paper will review change orders and their effect on cash flow. Below are definitions of these terms.

Cash flow. Money that flows into and out of a business as expenses are paid and receivables are received

Change order. Any change from the initial contract documents for an individual scope of work.

Limitations of the Study

The software being used as part of this study is relatively new. Data collected for comparison to current processes will be from within a year period. Based on this, it may prove unproductive to conduct a survey with contractor for feedback on effectiveness in addition to quantitative data collected.

There are inherent difficulties with comparing information from one construction project to the next. Rarely will each project have the same contractors, design teams and owners. The systems and materials utilized in the design process are chosen on a case by case basis. Each project site will have unique characteristics including soil types, layout, weather conditions and

access. All of these variables have impacts related to change management and must be taken into account when discussing relationships between projects.

Chapter II: Literature Review

Changes are a common part of construction projects. These are often unplanned and cause scheduling and cash flow issues for contractors. When companies have reduced cash-flow it can translate into fewer jobs bid and ultimately drive construction costs up. Traditional processes are costly and outdated with current software advancements in the market. The following chapters outline the impacts of delivery methods on change management in addition to the nature of change orders including type, process, impacts and advancements that have been made to reduce these adverse effects.

Delivery Methods

The construction delivery method plays a key role in determining the process by which change orders are managed. CMAA (2012) defines construction delivery methods as, "the management process used to complete a construction project" (p.6). The most common types of delivery methods in the Minnesota region are design-bid-build, construction manager at risk or as agent and design-build. While the basis for this paper will focus on the construction management change process, the following gives a brief overview of each method.

Design-bid-build is considered to be the traditional delivery method where there is a separate design and construction team (CMAA, 2012). Once the project is designed it is then bid out and awarded to the lowest bidder who then builds the project. Contracts under this model are usually a lump sum fixed price. This is important to note because the owner typically holds the construction contingency and manages the change order process outside of those contracts.

Design Build is not separated out and utilizes one contract under which the design and construction team reside. Contracts under this delivery method are normally a guaranteed maximum price or a fixed fee. The contingency in this method is typically included in the design

build contract (Solano Community College, 2016). This is important to note because the intent of the contract, having the designer and contractor in one, is to eliminate the need for the change order process (Solano Community College, 2016). While this doesn't stop the fact that changes still occur it reduces the need to involve the owner in most cases and rarely reduces schedule.

The construction management model, whether at risk or as agent, is a mix between the design-bid-build and design build methods. There are separate contracts between the design team and construction manager but both are hired at the start of design (CMAA, 2012). Award is usually based on qualification basis here in Minnesota including factors such as price, experience, reputation and capacity. The contingency is help by the owner in this scenario but places the responsibility for managing it into the both the designer and contractors hands. This is an important piece because the change management process involves all three parties but there is an inherent trust in place based on the selection process.

Selecting the right delivery method is based on many variables. Questions regarding best price, quality, safety and schedule all play into the decision making process. A study done by Moelnaar (2004) involved the Washington State Department of Transportation (WSDOT) utilizing the design build delivery method on a project compared to the traditional method of design-bid-build. This study showed that on a traditional design-bid-build 21 million dollar project the design build version of the project cost them roughly 22% more, approximately 25.5 million. This is important to note because the WSDOT required higher insurance limits based on the design build contract among other requirements. One could argue that this method didn't suit their needs whereas a construction manager might have proven a better route.

Types of Changes

Not all change orders can be lumped into the same category. Change orders can be broken down into the following categories (The Constructor, 2017):

1. Change in scope
2. Unforeseen conditions
3. Errors
4. Omissions

It is important to review each type because anytime a change occurs there is a potential for conflict, delays and additional costs (Molly, 2007).

Routine changes in scope are a fairly common process that will be addressed in the next section. These can include adding walls, changing layouts or product types. This type of change is usually the most efficient because it doesn't arise out of the fault of another person.

Unforeseen conditions are also fairly common and can include items like soil corrections and abatement. These types of changes can range widely based on how much exploration work happened during the design phase of construction to try and eliminate possible unknowns. It is estimated that unforeseen conditions can account for 10-15% of construction costs (Kosloff, 2017). As they relate to the change management process, unforeseen conditions are handled swiftly as they are typically done on a time and material basis. This is due to the fact that they are usually encountered abruptly and the corrective work needs to begin immediately so as not to delay schedule. An example would be encountering unsuitable soils that need to be removed and replaced. The extent of corrections is difficult to clarify so contractors and owners prefer to track costs on time and material rather than risking a lump sum cost for work. In this scenario the change is not the result of a party's failure. These are swift to process if the contingency is

big enough. This is due to the fact that there is rarely disagreement between each party on the necessity of the change.

Errors and omissions are two types of changes that slow the construction change order process down. While errors in construction documents are common to deal with from a contractor and designer standpoint, most owners do not understand why these were not vetted before a project was bid out. An example of an error would be the wrong wall type labeling and having to switch a stud wall to a masonry wall. The owner may feel that is not their responsibility to pay for. The architect may argue that the change request is valid because a masonry wall is more expensive than a stud wall. This disagreement will make the architect scrutinize the change and state the costs are too high in order to show the owner diligence in driving cost down, causing a stalemate in the change process due to this confrontation.

According to Schoenwetter and Smith (2008), minor errors or changes in construction documents such as wall changes, structural modifications or finish changes can be categorized as general scope change orders. These are common on construction projects and while disputes may arise, the contractor usually proceeds and the costs are worked out. There are, however, changes that are outside of the general scope. These are known as cardinal changes.

Schoenwetter and Smith (2008) defines a cardinal change as a change that is “substantial and materially different” from the original scope of contract, which the contractors are not required to perform. This can alleviate the contractor from any liquidated damages assigned as part of the contract and may allow them to file a claim for additional compensation. Westcott (2016) adds that a cardinal change gives the contractor right of refusal even in the face of a construction change directive. It is important to point out that only a court can rule what is, or isn’t, a cardinal change so the risk of refusal can cost significant money if lost in court.

Cardinal changes can be the result of one significant change to the contract or be comprised of multiple changes amounting to a significant change in the contract (Estevez, 2018). These changes in the overall project plan lead back to additional resources needed to complete a project. The contractor may have the ability to add additional equipment, manpower and materials to a given change but efficiencies are lost. More resources require space, which may not be available resulting in overtime in order to accelerate a schedule.

Change Order Processes

On the surface, the change management process may appear simple. A problem arises, whether through a want or a need, and something has to change in order to solve it. Karimidorabati, Haas, and Gray (2016) stated that "many papers have been published about the change body of knowledge, however, the number of papers focusing on the processes of change management is few" (p. 6). The cycle for the change process has only a few steps, however, below the surface is a variety of documents and processes that are overseen by multiple entities and require all encompassing approval. Figure 2 illustrates the detailed processes involved in each phase of the cycle.

There are two primary causes of change orders on any given project. Bolin (2017) categorized theses causes as either deviation requests or initiator change order requests. Deviation requests are submitted by trades in response to conditions that vary from the initial contract documents. This can include unforeseen conditions in the field, weather or other schedule impacts that couldn't have been inferred from the documents. These impacts do not require that the architect or owner to issue a formal drawings for what those conditions are. More often these are handled via the request for information process or through a narrative.

Initiator change order requests are commonly categorized as construction bulletins, project supplements or pricing requests. Hao, Shen, Neelamkavil, and Thomas (2008) also called these changes either owner initiated or designer error. These are formal documents, usually created by the owner and design team to change the scope of work based on needs or wants.

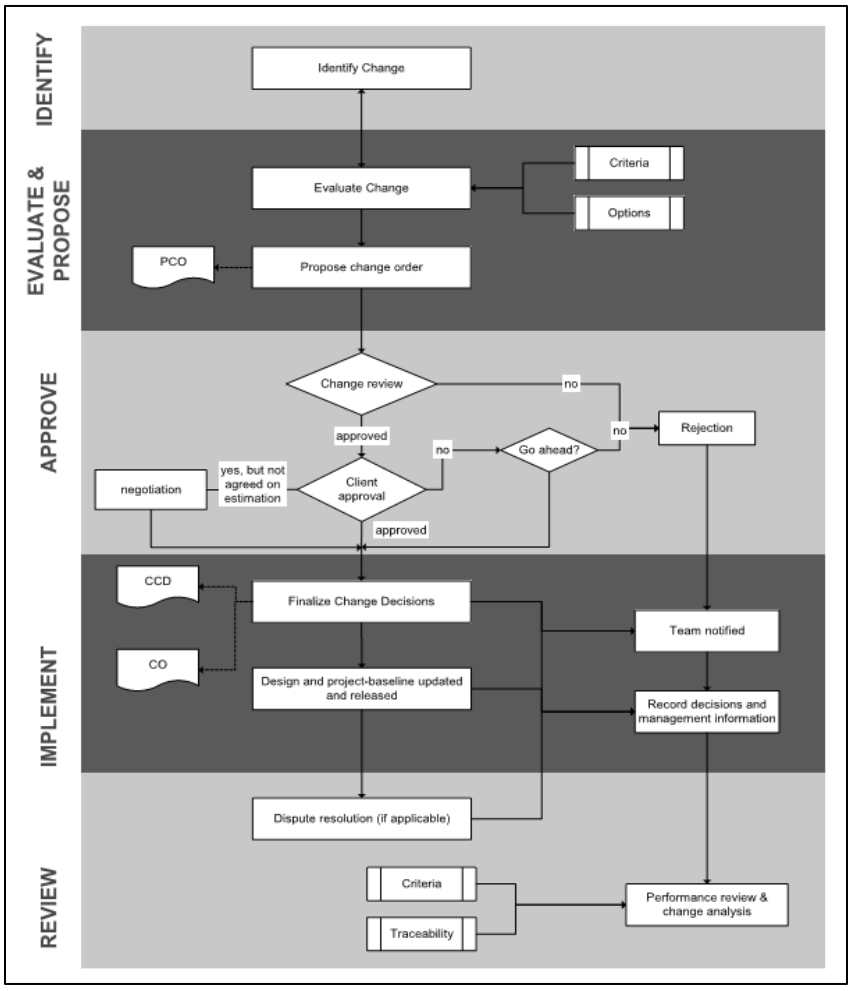

Figure 2. Change order process. Flow chart illustrating the various process within the change order management system. This chart also illustrates the cause and effect of approval and rejections at certain stages. (Hao, Shen, Neelamkavil, & Thomas, 2008).

Deviation requests are normally submitted from the sub-trades directly to the construction manager (CM) or general contractor (GC) for evaluation. Initiator requests are issued by the GC/CM to the sub trades for pricing and usually take more time to procure. Costs are made up of numerous components including subcontracted costs, equipment rental, overhead, labor and material. Bolin (2017) goes on to discuss the importance of trust and confidence required by the owner of the GC/CM in the evaluation process. Usually the owner doesn't have the ability to analyze the different cost. If the owner doesn't trust that the contractor is fair this hinders the ability to move forward. The next step would be to track this time and material or remove this from the project scope and have someone else bid on the work.

Once the evaluation process is complete, the next steps would be owner approval and implementation. In the simplest scenario the owner accepts the cost and the contractor is notified to proceed knowing that a formal change order will be processed. Material prices can be checked against competing suppliers while overhead and equipment rental rates are usually fixed costs. The most common disagreement falls on labor costs. Labor is subjective as each company has different skill levels and processes for installation. This is coupled by the fact that contractors may account for worst case conditions in the field, which increases cost. The contractor will always make sure to cover their risk to prevent further losses.

Alfan (2015) outlined how contractors should cover their risk based on understanding of the project conditions. This includes time extensions or accounting for over-time to stay on track. This can also include loss of productivity due to re-sequencing of activities. These variables all play a role in the pricing effort. When labor costs are difficult to quantify due to unknown scope, it is typically chosen to proceed on a time not to exceed basis.

In the event that a mutual agreement is unable to be made, work is directed to proceed either on a time and material basis, tracking actual costs, or a construction change directive (CCD) is issued. A CCD is typically issued by the owner and directs work to proceed without a review process and then may result in a change order once a dispute is settled through the legal means of a contract (Hao, Shen, Neelamkavil, & Thomas, 2008).

The change order process is important for many reasons. Schoenwetter and Smith (2008) found that change orders:

1. Gave clear consensus to all parties involved
2. Documented responsibilities and ownership amongst these parties
3. Are a critical step to payment for extra scope
4. Are a pro-active approach to dispute resolution

Change orders often revolve around misunderstandings of intent or unclear direction provided by the contract documents. It is common for people to avoid conflict, which is why there must be a process that allows open discussion between all parties. This process is crucial because it provides a setting to discuss project cost impacts and involve those from the sub trades, GC or CM, owner and design teams.

Change Order Impacts

In a study performed by Hanna, Lotfallah, and Lee (2002) it was discovered that there was a $50 billion annual disbursement associated with construction change orders in the United States. This is important to note because it shows the significance of costs associated with change orders. These costs are comprised of labor, material, equipment and multiple other resources that were not anticipated at the start of these projects.

An initiator based change request involves planning by the owner and design team. This includes design meetings with each parties effected by the change and ultimately document creation in order to send out for pricing. Then the contractor has to issue this change to the appropriate sub trades to price out and return. Each time a change happens the change order cycle starts again.

Schoenwetter and Smith (2008) found similar deficiencies with the planning and replanning process associated with change orders. They concluded that the change order process also impacted schedule as work could not move forward in the impacted area until the process was completed. This would mean sub trades would have to pull off and move to other areas, interrupting the flow and sequencing of projects, until approval was given to go back. If additional scope is approved, this would have its own impacts including additional work force to complete the work, material suppliers to obtain the material and ultimately transportation to and from factories and the site. Indirect impacts is the rework required by Superintendents and project foreman to reallocate trades around the impacted area until work can be performed.

Whether additional scope or change in design, both influence the project schedule and an owner's budget. Another important aspect to consider with any change is the cost impact and payment that is due to the contractor for the work. The change order request does not necessarily constitute a change as it is not the formal change order. In Figure 2, Hao et al., (2008) show the implementation process and the final result of a change order. It does not show is the possible time gap that happens between the change order request and the formal change order. If the cost is not agreed to, it may require the work to be completed on a time and material basis. This means the work happens with the intent to finalize the change order once the work is complete. The contractor has to pay the costs of the change over an undisclosed amount of time. This

impact can be devastating to the cash flow for contractors and suppliers depending upon their size and number of projects that this occurs on.

Having positive cash flow allows companies to be able to pay their labor and material costs. Moskowitz, (2015) illustrates that 85% of a construction companies cash comes from current work in progress. If that particular contractor is proceeding with change orders that it cannot bill for due to the change order process it is incurring labor and material expenses that it must front the cash for. This creates negative cash flow, which Moksowitz (2015) states that if a company continues to operate at a negative cash flow it could fail.

"Few studies have attempted to quantify the impact of change orders on project cost and schedule" (Hanna et al., 2002). Eldosouky, Ibrahim, and Mohammed (2014) showed that typical projects account for roughly 3% contingency to cover the cost of potential change orders. Take an example of a 20 million dollar project. That means that one could expect to spend approximately $600,000 for change orders. Considering most change order work proceeds before the formal paperwork is processed, this could leave the contractor to finance the work for months before recouping the money causing cash-flow problems.

Rahlf (2014) provides insight into the importance of cash flow for contracting companies finding that 85% of a company's cash assets are related to current work in progress. The ability to manage costs efficiently and create positive cash flow is crucial for all companies' success. Rahlf (2014) reviews debt to equity ratios and quick ratios, among others, to show how a company's lending capacities are driven by cash-in-hand. This is what drives the amount of work contractors bid on and ultimately the price that makes the project worth bidding. This information would provide many general contractors and construction managers with data that would reinforce the need to discover a more efficient change order management system.

Serag, Oloufa, Malone, and Radwan (2010) found that it was fairly common for contractors to expect their base contract to increase by 5 to 10%. This is important because it adds to the overall importance of the timeliness of the process. Construction managers and general contractors' fees are typically lower than 3% as supported by Designing Buildings (2017). This shows that often times more scope is added to the contract than a contractor intends to manage overall. If the contractor doesn't get paid in a timely manner the company is essentially paying bills off of lender money or depleting its own cash resources.

Time, in addition to cost, is major factor for construction companies to take into account. A study on public construction projects by Alnuaimi, Taha, Mohsin, and Al-Harthi (2010) showed three case studies on change orders that ranged from 8 to 33% time extensions due to changes in original scope. Each of the case studies showed the importance of preplanning as the change orders affecting the time-line and budget could have been avoided during design. In addition to the frustrations for the owner this can play havoc on contractors' labor, material and equipment availability for work in progress or guaranteed commitments over time. It is important to evaluate these changes in a timely manner so as not to further delay and tie up a contractors resources.

Electronic Change Order Management Systems

Technology has provided contractors with an avenue to speed up various processes of the change order cycle. Karimidorabati et al., (2016) showed that traditional methods of change management are paper based and dependent upon the speed of the postal service used. These methods of change management occur between the contractor, subcontractors, designers and owners. In a study by Charoenngam, Coquino, and Hadikusumo (2003) found the time to identify, evaluate and approve a change to proceed was reduced by 50%, from 12 days to 6 days,

in web-based applications compared to traditional methods, between each party involved. This cut is based on the reduced transportation time to move the documents to and from each approval party. This increased speed allows contractors to replenish cash assets expended on change order work.

Karimidorabati et al. (2016) analyzed the entire change management process with the impacts of automation procedures to find a contradiction in that it rarely decreased the overall time of a given change. This is important to note because the market currently doesn't have a software capable of handling the predicament of human nature. No software to date allows for the quick response to questions regarding the "how" or "why" a change is occurring along with pricing. These negotiations between the three parties is what holds the process hostage.

Under most scenarios there is different software for different stages of the change order process. A GC or CM will generally have a system that logs design change requests with a cover sheet that gets sent out to contractors for pricing. This process is a potential change order (PCO). This is a culmination of RFIs, change requests, and notices (Karimidorabati et al., 2016). A PCO is the main communication between the GC/CM and the sub trades. Sub trades will submit pricing back to the GC/CM for evaluation of accurateness and appropriate back-up material. Examples these types of software are Viewpoint and Procore.

Once the GC/CM approves the change the next step is to review it with the designer and owner. This process is known as the Change Order Request (COR). While there are systems out there that would allow this process to happen electronically, it is problematic as designers and owners will have a hard time understanding the complexity of information that supports each cost proposal. Misunderstandings can come from interpretation of the intent of the drawings, background knowledge of certain tasks. This leads to emails getting left unanswered until the

team meets as a group and the process bogs down. This conflicts with the study performed by Charoenngam et al. (2003) that found that mismanagement of documents were avoided with electronic software. Each change is complex with multiple factors driving costs. This complexity is what drives teams to want to discuss this portion of the process as a group rather than through an on-line mechanism.

Once the COR is approved by all parties the work can proceed while the formal change order can be created. This document, once signed by all parties, is what allows the sub trades to bill for the work. As mentioned earlier, delays to this process result in negative cash flow for organizations. Electronic software can have its biggest impact in this section with approval of electronic signatures.

Process Improvement

In 2000 the federal government passed the ESIGN Act, which allowed for contracting parties to utilize electronic signatures if everyone agreed (DocuSign Inc., 2017). In the past, legalities have driven the need for original signatures from all parties on each change request. This generates a substantial amount of paperwork and indirect costs associated with shipping and handling. As technology has progressed, use of electronic signatures have become more common and are now widely accepted. The construction industry as a whole has yet to catch up to this with change order and other processes.

Email and other internet based software have allowed construction companies to become more efficient with communications including cost sharing, submittals, requests for information etc. The change order process is no different in this regard. The key is finding the correct implementation for electronic software throughout the different processes of the change order cycle.

Each organization has preferred project management and accounting software that work well for the PCO and COR stages of the change management process. Viewpoint, Inc. (2017) is an electronic software that allows electronic transfer of many construction documents including RFIs, submittals and invoicing. What it currently lacks is a formal electronic change management system as part of the team process but companies like this are realizing that this where the industry is headed.

Kraus-Anderson has not had great success with electronic signatures associated with the COR review and approval yet. The COR could get through the design review and approval only to get rejected at the owner level due to a lack of understanding. Change orders include detailed back-up including information the approvers have little background in. This lack of understanding creates questions that require a conversation. This conversation is what most programs lack. This would require further explanation and back-up along with the entire process starting over for all signatures again. For this reason initial approval of the COR is best to be part of an owner, contractor, and architect meeting held at least once a week.

Once the COR is signed and approved an electronic signature software should be utilized to complete the change order. Charoenngam et al. (2003) found that these systems eliminated inter-office handlers and directed the forms directly to those responsible. The GC/CM could track where the change order is at and follow up with the individual if the change order sits in their email too long. Some software also allow automatic follow up emails to re-notify individuals that the change order needs attention.

While there are still key elements of construction projects that struggle with integration of electronic processes there are areas that greatly benefit from their use. When discussing change orders the biggest upfront improvement is in the implementation part of the change order

process. Once the cost is agreed to, spreading that message of approval and allowing contractors to procure and bill for materials is crucial. While this won't eliminate negative impacts with associated change orders, it can certainly reduce them.

Chapter III: Methodology

The traditional change order management systems utilized in the construction industry are slow and obsolete. Today's projects are being built faster than ever with shorter design and construction schedules. This speed has increased the amount of change orders prevalent on job sites. Turn-around on approved change orders needs to be improved to not hamper the project schedule and the contractor's ability to be reimbursed for unplanned changes.

Subject Selection and Description

The test project for the electronic change order system includes prime contractors performing construction work on an $80 million dollar school project in Wisconsin in 2017. All projects that were compared were from the K12 education sector including classroom and multi-use spaces. They included addition and renovation scope. Each site had its own unique layout. Some were built on sandy sites while others on clay. These contractors were all individually contracted with the school district in a construction manager as advisor model. The pool included various trades from concrete, drywall, mechanical and other trades consistent with the Construction Specifications Institute (CSI) divisions.

Data Collection

Data was also collected from Kraus-Anderson's internal change order management system. This system provides dates the change order was created, date to and from the contractor, to and from the architect along with the final executed date once the owner signed off. The duration of the change order approval process was collected from three past projects of similar size and scope regarding schools utilizing traditional change order methods. Data was then collected from the electronic change order methods utilized in the test project. The same information regarding to and from dates for each party were provided.

Data Analysis

The data collected from the internal change order logs are compared against each other to quantify the reduced time-lines associated with the electronic software. Data will also show the amount of unplanned changes to each company's contract compared to their base contract amount provided by internal software tracking. This will allow comparison to the survey data on whether the company felt an impact to their cash flow.

Limitations

Data for electronic change order methods is limited to the one test project due to its roll-out date. This is inclusive of the survey as it involves only the trades associated with the test project. While the data collected proves shorter durations for the final step in the change management process, it has not been tested across multiple project.

Regardless of the reason for the project change, the data will prove the increased speed in the implementation of an executed change order. It will show the timing from the date the change order request was created until it's approval. This shouldn't vary across work scopes or project.

Summary

All projects were of the similar size and from the school sector of the construction industry. All data was broken into work scope categories to better illustrate the effectiveness electronic software across multiple divisions of a project regardless of company.

Chapter IV: Results

Changes impact multiple, if not all, trades on a project site. Handling changes in a thorough, but expedited, process is crucial to minimize negative impacts associated with these changes. This chapter will illustrate electronic verses traditional methods for expediting the formal change order approval process.

Data Presentation

In order to research how electronic software impacted the change order process Test Project A was set up to solely use electronic signature software for the final change order execution. Projects B and C utilized traditional creation and postal service methods. Each project was a high school addition and remodel. The results are shown below.

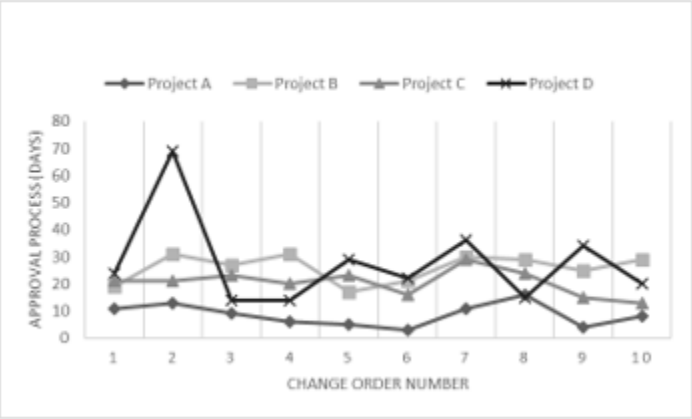

Figure 3. Mechanical comparison of electronic change order approval (Project A) compared to traditional methods (Projects B, C and D). Graph illustrates number of days to complete the change order process for each change.

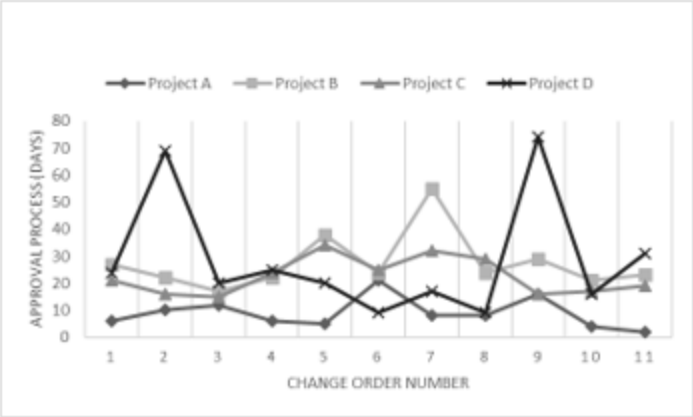

Figure 4. Drywall comparison of electronic change order approval (Project A) compared to traditional methods (Projects B, C and D). Graph illustrates number of days to complete the change order process for each change.

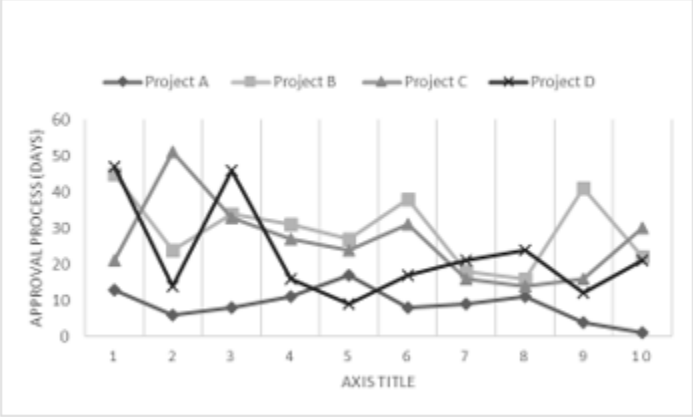

Figure 5. Concrete comparison of electronic change order approval (Project A) compared to traditional methods (Projects B, C and D). Graph illustrates number of days to complete the change order process for each change.

Analysis

Regardless of scope of work, Project A showed significantly faster execution times when compared to traditional projects. Project A averaged 8.8 days to fully execute the change order while Projects B, C and D averaged 27.6, 23.1and 26.4 days

respectively. Based on these comparisons electronic software cut the execution time-line by 65% on average.

Unless an Owner creates their own contracts, most industry contracts have legal restrictions on allowing a contractor to bill for costs incurred from a change order until it is fully executed. This reduced time-line is important because it would allow contractors to bill for work in place one full billing cycle ahead of the traditional methods currently in place. In addition to this reducing possible schedule impacts involved with the change order process this would allow for the contractor to have more positive cash flow.

It is important to note that this study is based on the approval time-line once the change order request has been approved. The change order request process was not tested with electronic software due to the complexity involved with analyzing cost, schedule impacts and understanding of the entire change across the key role players of the designer, architect and contractor.

Of the data collected, the average change order consisted of 37 pages. While each project is unique in the amount of change orders processed, the test projects used as part of this study averaged 275 change orders. Under traditional contracts there are three copies required including one for the owner, architect and contractor. This equates to 30,000 pages worth of documents. Indirect costs associated with this would be over $3,000 per project with shipping doubling that. At approximately $9,000 savings on one project alone, multiplied across the company could add up to significant savings. Direct costs come from savings in project coordinator time. On a given change this could save roughly 10 minutes per change order created. This could add another $2,000 in savings in labor alone per project.

Chapter V: Discussion, Conclusion and Recommendation

While the construction industry is striving to reduce the number of unplanned change orders through the use building information management software, change orders will likely still occur on most construction projects. When they do occur, it is important that they are dealt with swiftly to keep costs down and reduce the impact to all parties involved. Integration of electronic software into this part of the construction process will prove difficult due to the complexity of construction changes and the differing knowledge level of the approving parties. Most changes require conversation and a question and answer period that is hard to address via electronic software.

This study has proven that, when compared to traditional methods, electronic approval process of change orders can reduce execution time by two thirds. This reduction in time creates a more positive cash flow for contractors while reducing negative impacts associated with project changes. This can include time-loss, reallocation of resources or increased costs associated with overtime to accelerate schedules.

Through this research it was found that not all project managers follow the same processes with change management. Change order requests are not completed in all cases. This can negatively impact the approval time-line by not documenting when the cost was given to the owner and architect to approve. In addition, this means there isn't supporting documentation outlining the impacts of the change on the project. This is an area that could benefit from future training on a consistent process for handling change orders.

While Docu-Sign has proven itself as a good change order execution tool, it lacks integration with our project management software, Viewpoint. Docu-Sign also does not provide a good electronic platform for the question and answer portion that occurs in the change management process. Viewpoint Team, part of the Viewpoint system, is working on allowing document mark-up and conversation capabilities through a web-based platform. This may be a good alternative to further increase the approval time-line in the change order request process prior to electronic signatures. This could allow for a complete integration of all five steps associated with change management.

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