AN ANALYSIS OF THE LAST PLANNER® SYSTEM IN A CONSTRUCTION PROJECT

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DEDICATION

I would like to dedicate this work to my wife for all her support. She has sacrificed so much for me throughout my career, and I hoped to provide a bit of break for her while I was in the graduate program at SDSU for one year. The program did require more time that I anticipated and couldn’t give her the help that she deserved and needed at home, taking care of our two boys. I am sorry, but at the same time, thank you for being there and making this possible for me.
ABSTRACT OF THE THESIS

An Analysis of the Last Planner® System in a Construction Project

by

Chris D. Kim

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The analysis presented in this paper was to demonstrate how the implementation of Last Planner® System (LPS®) impacted the College’s construction, which included two buildings under the scope of work, and allowed the project team to overcome the inherent shortcomings caused by contractual arrangement and delivery method. The construction was commenced in February 2011 with the anticipated completion date of December 2012; however, by the end of 2012, it was behind the schedule without a completion date in sight. The project suffered from the following underlying issues: General Contractor’s (GC’s) inability to orchestrate the team, a lack of responsible parties, limited collaboration, and an invalid/unrealistic schedule. The owner hired a new GC along with the third party LPS® consultant to save the troubled project. The team was encouraged to participate in weekly pull planning sessions and to communicate issues directly to one another. This enforced each member of the team to collaborate and be accountable for promises that they made to each other and to the project. Percent Plan Complete (PPC) and root causes of broken promises or “variances” were recorded daily and compiled weekly to monitor how the project progressed. The data were then transformed into charts and graphs to analyze any trend occurred over the seven month period, from December 2012 to July 2013. This paper found that nearly 80% of variances for this project were: incomplete prerequisite work, bad planning, failing inspection, and design issues. They were due to a lack of collaboration that was originated from the project structure as discussed. It was unfortunate that there was no reliable data collected prior to the implementation of LPS® to conduct any analysis of before-and-after impact; however, the paper was able to conclude that PPC continued to improve as the team members accept the culture of LPS® and collaboration with a common goal of a successful finish.
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CHAPTER 1

INTRODUCTION

This paper analyses a construction project in a large community college district (named “The College” in this paper) in Southern California. The project structure, specifically, award strategy, contract type, and project delivery method; selected by the College was not conducive to a collaborative working environment and ultimately delayed the project schedule. Prior to the implementation of the Last Planner® System of production control (LPS®),1 the initial General Contractor (named “GC1” in this paper) had trouble leading subcontractors (sub-KTRs) to work together (“The Last Planner” 2013). They were busy trying to find causes from others for project delays. The implementation of LPS® stabilized the troubled project and enhanced communication among sub-KTRs at weekly meetings to collectively tackle constraints and keep each other honest to commitments they made to the project. The reliability of those promises was measured daily through Percent Plan Complete (PPC)2 and analyzed weekly along with root causes of broken promises or “variances” to continuously improve the execution of the project and avoid repetitive shortcomings. This paper demonstrates how LPS® has mitigated the problems originated by the project structure and improved the project performance.

DESCRIPTION OF PROJECT

The College awarded an $89M construction project to erect two buildings (named “Building 1” and “Building 2” in this paper). Traditional design-bid-build approach was chosen to deliver the product under one GC and 32 Sub-KTRs, each of whom was a prime contractor to the owner through contractual agreement (multi-prime arrangement described

1 The LPS® is a production planning system based on application of lean principles to construction scheduling (“The Last Planner” 2013).

2 Percent plan complete (PPC) is the ratio between the number of activities planned and completed during a certain period of time and the total number of activities planned for that same time expressed as a percentage (Ballard and Howell 1998).
later in this document). They were selected through a sealed bid process, and a certain percentage of those sub-KTRs were minority, veteran, small business owned or HUB zone located as required by the State regulation. Construction work begun in February 2011, and the schedule was tracked based on Critical Path Method\(^3\) (CPM). At the end of that calendar year, the project was behind the schedule by seven months. Three sub-KTRs were either bankrupted due to stringent financial situations during the depression or removed from the site for substandard performance.

Due to the circumstances discussed, the owner hired GC2 in November of 2012 after GC1’s contract with the owner was not renewed. In addition to the change in GCs, another major change was the hiring of a third party consultant to facilitate the management of the project using the LPS\(^\circledR\). Weekly meetings to promote communication and sort out identified constraints among trades were led by the consultant. Active discussions eventually allowed the team to validate the milestones on the existing schedule, adjust them based on a foreseeable timeline, and develop a new finish target date of early 2014, which was quite different than GC1’s estimated completion date of December 2012. At the time of this study, the project continued to move along without any major hurdles or setbacks.

**METHOD OF ANALYSIS**

Through the help of GC2 and the owner representative, the author collected PPC and root causes of broken promises or “variances” over a period of seven months\(^4\) from December 2012 to July 2013, for both Building 1 and Building 2. All the data were recorded weekly by GC2, and the author compiled them into the graph and charts, discussed in Chapter 3. The causes of variances were classified into fourteen different categories. Each time a commitment was missed or schedule was impacted, one of the fourteen causes was assigned as the underlying problem that prevented task completion. A number of variances for each project were tallied by category and presented in percentage as well as in number to

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\(^3\) CPM – It is a scheduling method widely used in project management. It has advantages of displaying duration, interdependencies and starting/end point of activities. It lacks in handling resources or personnel required to complete activities and can be difficult to use in larger, complicated projects.

\(^4\) Root causes are assigned to each task that was not completed as planned. Root causes alongside the PPC indicator are the two main indicators of the LPS\(^\text{TM}\) discussed later in this document.
illustrate how most frequently occurred variances were due to inadequate communication or minimal collaboration, which, the author argued, was rooted from the project structure. Unfortunately, PPC and variance data were not available prior to the implementation of LPS® in December, 2012. This did not allow the author to benchmark indicators collected before and after the implementation of LPS®. However, seven month worth of data were plotted to exhibit an upper trend of production improvement in the project as the team adopted the culture of sharing information and collaborating.

In addition to the quantitative data collected, the author also interviewed the owner’s representative and the third-party consultant to gather additional information about the project. Some of the questions used during these interviews include: How the team come together during weekly work meetings before and after the implementation of LPS®, how each of the variances was defined as some could be ambiguous, i.e. pre-requisite work vs bad planning and how the project structure might have affected the team.

**LAYOUT**

This paper comprises of four parts. Chapter 1 introduces the project and the problem analyzed. Chapter 2 includes relevant literature review for the discussion presented herein, which focuses on contract, project delivery methods, and the LPS®. Chapter 3 provides an in-depth analysis and discussion of various problems that caused the schedule delay, PPC data tracked by the team, and variances associated with the PPC during the same period. Chapter 4 covers summary and recommendations.
CHAPTER 2

LITERATURE REVIEW

Construction is a product-oriented activity performed in collaboration of various parties such as owner/client, sub-KTRs and architect (Halpin 2006). They bring a wide range of background/experiences, offer expertise and have distinct roles to play with different objectives that define their success in the project. In order to achieve the common goal, they are legally bound through contractual relationships and in agreement of project delivery method. A road to a successful project is having a right type of contract and delivery method that promote a working environment in which each party is invited to collaborate and execute work with transparency. Studies have shown that collaboration and reliable promises can eliminate considerable amounts of waste and produce far superior results (Ballard and Howell 2004). In this literature review, the author attempted to limit the discussion to contractual and project vehicles that the College used to deliver the product as well as what, he thought, should have been selected as the best practices available in the industry today that reflect the lean construction principles. LPS® is reviewed in its hierarchical structure and industry practices that associate with each planning level.

AWARD AND CONTRACT TYPE

A myriad of awards and contract types are available for owners to obtain the best value from contractors. Selecting the most suitable one for a given situation is one of the most important decisions that the owners must make in the industry (Clough and Sears 1994). Competitive bid was the contract type that the College selected in its award, and negotiated contract was the one that the College could have selected to promote collaboration among contracted parties.

The competitively bid contract is generally based on price, and the award is generally made to the lowest “responsible” bidders (Halpin 2006). Once the bids are received, the owner will publicly announce the lowest bidder and review the qualification to ensure that
the winner is capable. The owner states the qualifying criteria in bids and, not in any priority order, they are typically (Adoranti 2009):

1. Technical competence validated by the past experience of personnel or contracts,
2. Bonding capacity,
3. Current financial position based on the firm’s balance sheet and income statement,
4. Past history of claims, litigations or defaults,
5. Current workload

Any shortcomings in any of these criteria can contribute to the disqualification of the responsible contractor.

The major advantage of this process is all the bidders are treated without any bias. Competitive bids are sealed because the only critical evaluation factor being the price does not require the contractors’ identities in selecting the lowest bidder among them. This allows the award process fair. This is typically essential for public owner, such as the college, who can be influenced by political agenda or other factors.

On the other hand, there are several disadvantages associated with the competitive bid process. Firstly, design and specifications must be completed prior to advertising for bids. This segmentation between design, bid, and build prevents communication between the architects/engineers (A/E) and contractors to potentially discuss the constructability of the design and adjust if they need to do so. This may cause cost increases at a later stage of the project due to constructability issues or schedule delay. This violates core principles related to lean construction practices aiming to promote collaboration and increase the value delivered to clients as discussed by Koskela (1992). Secondly, the fact that the construction and design cannot work in parallel significantly prolongs the completion date of the project and loses an opportunity to expedite the project.

Negotiated contracts are terms and price which are negotiated between owners and contractors to deliver the best product value at the maximum profit, creating a win-win situation for both parties without sacrificing the quality over price. Sometimes, if there are numerous bidders, the public owners would select a few lowest bidders and negotiate with them individually. This selection strategy is called “competitive range” and is recommended
by Federal Acquisition Regulation (FAR).\textsuperscript{5} The competitive range takes the best features of both contracts to select the best qualified contractor at the lowest price possible without placing too much risk on the owner or jeopardizing the impartiality of selection process.

Unlike the competitive bids, the negotiated contracts allow the owner to advertise for bids even before specifications or design are totally completed, similarly to the design-build delivery method discussed in the next section. Preliminary or partially completed plans and specifications would be available for bidders to evaluate at the time of bidding and provide a proposal with reasonable assumptions or expectations. This, of course, allows the owner to fast-track the overall project duration as the design and construction would work in conjunction. This may suggest that risks of running over budget are shifted to the contractor; however, this allows A/E and contractors to collaborate in designing and planning for construction before bid documents are issued. More importantly, this aligns with some of the Construction Industry Institute (CII) best practices\textsuperscript{6} as A/E and contractors would work out constructability and material procurement issues upfront through partnering and consequently, reduce potential increases in change orders, cost or schedule (Thomas et al. 2002).

**PROJECT DELIVERY METHOD**

Over the past 100 years, design and construction were viewed as separate efforts (Halpin 2006). An A/E firm would prepare design and develop specifications based on the owner’s scope of work. Then an owner would hire a separate construction contractor to build based on the A/E firm’s completed design. This sequence does not allow activities in design and construction to run in parallel as the construction cannot commence without a completed design in hand. This delivery method is commonly referred to as Design-Bid-Build (DBB) and this was what was chosen for the College’s project. The time aspect, as discussed, is the main disadvantage of the DBB. If the project duration can be shortened, it

\textsuperscript{5} FAR - This is a codified federal regulation that provides guidance for the government agencies to abide by when they purchase goods or services from private entities. It is a principal set of rules that provides uniform policies and procedures for acquisition in Federal contracts.

\textsuperscript{6} CII Best Practices- CII is a consortium of construction industry professionals who join together to find better ways to build. The best practices have been proven effective through the past industry practices and researches by owners, contractors and scholars.
means more profit for the contractor and less cost for the owner. One other disadvantage of DBB is the lack of collaboration, which goes against what is promoted by CII best practices and lean construction principles. The owner holds a contract with the A/E for development of the design and specifications and a separate contract with the construction contractor to build a facility. Not only this separation creates dispute over constructability and change management issues during the construction, but also it leads to a tendency for both A/E and contractor to communicate through the owner, not directly with each other to resolve any issues. Both sides feel that they are obligated to the owner, but not to each other, especially when two “friendly enemies” can easily fall into a trap of criticizing each other for constructability of design and/or construction capability. This disjointed relationship impedes information flow and coordination. For the College, its contractual relationship was even more complicated and inefficient with multiple prime contracts (see Figure 1 for a representation of how organizations were related to each other in this project).

**Figure 1. Contractual relationships between project participants.**

Unlike DBB, Design-Build (DB) gives the flexibility to begin construction with the preliminary design and specifications. As A/E and construction contractors develop design together and tackle anticipated issues in advance, there is minimal risk involved in executing
horizontal work before final design is completed. Reducing waste in time by working on construction and design concurrently appeals to both owners and contractors.

More importantly, DB offers a great avenue for the owner to receive a product. One single point of contact, which would be an unified GC and A/E team to provide both design and construction services, significantly reducing administrative burdens and challenges as the owner does not play a role of a mediator in attempts to resolve issues between GC and A/E. Any conflicts are internally discussed and managed as they collaborate through partnering and commitment. As their success lies with how everyone performs as a team, there is not any incentive for the DB team not to communicate, but share any good ideas to gain a competitive edge during the bidding or provide the best value to the customer with innovative solutions at completion (Matthews, Howell, and Mitropoulos 2003). Along the same line, one disadvantage of the DB method can be traced back to the fact that one team is responsible for both design and construction, and that the owner might not have much oversight as the project might not have two impartial teams looking at the same problems.

In more recent years, Integrated Project Delivery (IPD) has become more popular in the industry and can be seen as a further step towards integrating the project team beyond what DB has to offer. It was developed in conjunction with members of the Lean Construction Institute (LCI) and based on lean construction principles, which focuses on maximizing value and minimizing waste of time, money and materials (Ballard and Howell 2003; Matthews et al 2003). A single contract bringing the IPD team to the client and involving both A/E and GC as well as major sub-KTRs early in design has very similar advantages to those a DB team has. However, an IPD contract or charter solidifies the relationship between team members through the “pact,” which provide provisions for everyone to share the risk and profit for total project performance (Matthews, Howell, and Mitropoulos 2003). Under the pact, all the team members are united to work in harmony and share innovative approaches in attempts to maximize their profits.

Despite all the cooperation and innovation in what seems to be the most desirable delivery method, there is a disadvantage related to the IPD method. Because all the risks and profits are shared, everyone suffers from it if one team member makes a mistake (Matthews, Howell, and Mitropoulos 2003). For some, this might be difficult to accept and a reason to break the pact. However, putting this team together in early design and planning indicates
that the team comes together based on their past experience working together on a long-term partnership. Overall, IPD offers important insights regarding collaboration and involvement of the teams early in the project.

**LPS®**

The LPS® is a production planning system based on application of lean principles to construction scheduling (“The Last Planner” 2013). Lean principles, originated from the Toyota Production System, have evolved as new (or alternative) production philosophy and were adapted to the construction industry by Koskela (1992) and other pioneers including the creators of the LPS®. Lean Construction principles comprise 11 principles that might improve construction throughout the entire life cycle of a project (Koskela 1992). The use of lean principles supports the management and thorough coordination of a project by helping to decrease variability, improve reliability, measuring and continuously improving performance (Ballard 2000). The LPS™ puts in practice many lean principles by creating a hierarchy of plans developed throughout a project’s timeline and continuously comparing planned and executed tasks, as well as learning from plan deviations.

The five components or phases in the LPS® hierarchical structure include (Ballard and Howell 1998; Ballard and Howell 2004; “The Last Planner” 2013):

1. **Master Schedule** – establishes project durations with major milestones and identifies long lead items with acquisition strategies
2. **Phase/Pull Scheduling** – specifies handoffs between trades and identifies operational conflicts through collaborative planning
3. **Look-ahead Planning** – comprises the planning of four to eight weeks ahead to ensure the constraints are removed and the work is made ready by shielding production against unreliable flow of inputs and commitments.
4. **Weekly Work Plan** – reassures assignments are sound with proper manpower, equipment and material and committing to perform in a certain manner and sequence as planned. The quality of assignments can be improved by meeting five criteria: definition, soundness, sequence, size and learning criteria, which are discussed further in the later part of this chapter (Ballard and Howell 1998).
5. **Learning** – measures PPC, analyzes roots causes of any unfulfilled promises and develops lessons learned to successfully re-engage in incomplete tasks

As shown in Figure 2, LPS® transforms what SHOULD be done into what WILL be done through feedback or collaboration of those involved in planning (Ballard 2000). SHOULD is what the owner/client requests and what becomes requirements for a GC. In
order to deliver a product that meets the requirements within a reasonable budget in acceptable construction duration, the GC identifies major and intermediate milestones in master schedule with help of major sub-KTRs and suppliers. The master schedule is critical in two ways that, first, this is what owners typical use to evaluate potential GCs prior to awarding a contract (Fernandez, Neuman, and Kim 2013). And, secondly, it serves as building blocks for the next level of scheduling – phase/pull planning (Tiwari and Sarathy 2012). Therefore, although it is an estimate, the GC must develop with reasonable assumptions and past experience.

Planning backward from the milestones, all the sub-KTRs participate in initial pull sessions to discuss what phases should be identified to reach specific milestones. Still without too much detail available at this level, the team is focused on developing phases to make milestones feasible. As shown in Figure 3, they work as a team to communicate what they need for themselves and from each other. Each and every participant in the project team becomes a “customer” and simultaneously “supplier” as they schedule to start or complete their activities based on others’ commitments and input. Every constraint identified by a
“customer” has a “supplier” who promised to deliver it to ensure the next identified activity can take place without any delay (Tiwari and Sarathy 2012). Figure 3 shows a planning room during a pull planning session.

As the team continues to improve the schedule with each other’s feedback and more information becomes available, the pull planning focuses on a more short term of four-to-eight-week look-ahead. Representatives in the session are empowered “last planners” who manage workflow in the field as foreman or superintendent and have experience to make commitments with high reliability. Their commitment is displayed on the wall using color-coded sticky notes as shown in Figure 4. Every sticky note represents one day of production with a name of company, responsible representative, activity and pre-requisite activity as well as the duration. A pull planning session is often described as “stating the obvious,” and yet this transparency eliminates rework and allows the team to stay collaborative and flexible (Tiwari and Sarathy 2012).

Transitioned from four to an eight-week look-ahead to weekly schedule, it is critical that all participants are committed to WILL perform the work from CAN. WILL requires the conviction that the work is ready to be performed with all the resources and pre-requisite work required to make this a quality assignment. Every phase of LPS® is faced with a certain level of uncertainty based information available at that time. However, the ultimate objective of LPS® is to continue working towards quality activities (assignments) for execution and do not disturb the flow of production.
So what makes a quality assignment? According to Ballard and Howell (1998), that is any activity or task that meets the specific requirements of definition, soundness, sequence, size and learning (Ballard and Howell 1998). Definition alludes to how specific a task is so that work can be coordinated with right resources and be identified as complete when it is done. Soundness indicates how ready a task is before execution. It could be in regard to prerequisite work that comes before, completeness of design or availability of materials. Sequence is in what order a task is executed. It should be in accordance with constructability or customer’s preference. Size refers to how big a crew size or capability is assigned to a task. Tasks are reviewed based on the aforementioned criteria at the weekly work plan and committed by the team members. As shown in Figure 1, even at the weekly work plan level, there is still uncertainty that could possibly disrupt the work flow. Material delivery might not be made on time or a crane might be down multiple days for a repair. Consequently, all the tasks, whether completed or not, would be tracked and analyzed for reasons. Finally, the Percent Plan Complete (PPC) indicator is calculated by dividing the number of completed assignments by the total number of assignments. Reasons are identified in categories and corrected for completion.

The strategy developed by Ballard and Howell (1998) to improve the quality assignment process is shielding production, shown in Figure 5. The bolded line is the shield which acts as a buffer to ensure that the assignment selected from look-ahead schedule is driven by the make-ready process (which screens tasks for constraints and work to remove
them before tasks are assigned to trades) and made into weekly work schedule with increased certainty. It may seem additional time is required as a result of screening; however, this process potentially reduces the overall time of work flow as rework or incompleteness of assignments would be eliminated after the buffer (Ballard and Howell 1995). Furthermore, as the strategy is imbedded in the weekly planning and the culture of communication flourishes among the team members, the project continues to improve productivity. As proven in the past study by Ballard, Howell, and Casten in 1996, a major refinery expansion project in Venezuela, PPC increased from 65% to 85% over a period of several months as a result of implementing the shielding process and improving the quality of assignments.

**SUMMARY**

This chapter presented the literature review to develop the conceptual basis for this project. Different contract types and project delivery methods were discussed. Specifically, the author introduced competitively bid and negotiated contract for contract types and DBB, DB, and IPD for project delivery method. Furthermore, the LPS® was closely examined through its different levels of planning and principles that support them.
CHAPTER 3

IMPLEMENTATION OF LPS®

The College’s project construction was begun in February 2011. The estimated completion date (ECD) projected at the commencement was December 2012. That ECD was not upheld, and GC2 came in after GC1 was waived. Through the aggressive implementation of LPS®, GC2 and sub-KTRs subsequently turned the corner and were able to re-establish the target ECD for early 2014. Unless LPS® was introduced, the project could have been terminated for default as GC1 and owner appear to have lost control of the project and sub-KTRs could not work in collaboration. Prior to analyzing PPC for their performance, it is essential to identify underlying problems that disrupted the work flow and caused the schedule delay.

UNDERLYING PROBLEMS

Based on the data collected from documents and interviews, four main problems were identified which were traced back to how the project was structured from the perspective of the delivery method and contract. The analysis was substantiated by the quantitative data collected for PPC and root causes of broken promises or “variances.” As described in Chapter 1, weekly work plans along with PPC and variances were tracked by GC2, and the raw data from the weekly work plan were compiled to develop pie charts and a graph, in which the frequency of variances was analyzed. Variances were measured in a number of occurrences that took place and in percentage. Each problem is presented and discussed in more detail in this section.

Problem 1: GC1’s Inability to Orchestrate the Work

There were 32 KTRs in this project altogether, and each one of them reported directly to the owner in the multiple prime contract structure. The GC was more like a project manager in this structure without contractual power to dictate contracted sub-KTRs, who played a role of prime KTR. With this systematic relationship as shown in Figure 1, these KTRs could not see the significance of teamwork and were sometimes hesitant to collaborate
at the sacrifice of potential loss in their profit. Issues and concerns were not addressed on the field or at the coordination meetings between sub-KTRs under the leadership of GC1. Rather, sub-KTRs looked towards the owner, who had the direct contract with each, to resolve issues. GC1 did not have direct control or financial influence over sub-KTRs as its position in the multiple prime contract structure put them in the same footing as all the sub-KTRs. Even after the implementation of LPS®, 42% of overall missed commitments or 211 cases in Building 1, and 173 cases or 54% in Building 2 were recorded as a result of prerequisite work that could not be coordinated (Figure 6, 7, 8 and 9).

![Building 1 Variance Breakdown in Percentage](image)

**Figure 6. Building 1 variance breakdown in percentage.**

Before progressing into the next underlying problem, it is important to clarify the definition of “prerequisite work” and “planning,” which are the two leading causes of missed commitments, as they might seem to be interchangeable. According to the LPS® consultant, bad planning represented situations in which a KTR inaccurately estimated on the amount of time required to perform an activity, whereas pre-requisite work applied to situations where an activity could not start due to pre-requisite work not being done. From the perspective that the bad planning would typically lead to incomplete pre-requisite work, or incomplete pre-requisite work would be a direct result of bad planning, these two variances should have been differentiated with more distinctive identification such as “scheduling error,” “sequencing error”, or “inadequate definition of man power” instead of just “bad planning.”
Building 1 Variance Breakdown in Number

- Bad planning: 104 occurrences
- Prerequisite work: 211 occurrences
- Weather: 14 occurrences
- Contract: 6 occurrences
- No update, unforeseen, miss tag: 0 occurrences
- Submittals (RFIs): 48 occurrences
- Equipment issue: 6 occurrences
- Material issue: 22 occurrences
- Labor issue: 23 occurrences
- Failed insp: 48 occurrences
- Design issue: 22 occurrences

Figure 7. Building 1 variance breakdown in a number of occurrences.

Building 2 Variance Breakdown in Percentage

- Prerequisite work: 54%
- Bad planning: 11%
- Weather: 2%
- Failed insp: 7%
- Design issue: 9%
- Labor issue: 3%
- Material issue: 3%
- Equipment issue: 1%
- Submittals (RFIs): 7%
- Forgot, contract, no update, unforeseen, miss tag: 0%

Figure 8. Building 2 variance breakdown in percentage.
Problem 2: Contract Method Discouraged Responsible Parties

The College chose the competitively bid contract for award, which likely attracted more bidders at low costs, but might have deterred those contractors that charge more for high quality work. Because public sectors have stringent requirements of fair bidding selection process and small minority owned business, they often become a victim of their good intention. In this contract, the College ended up with a few local sub-KTRs who never had an experience with projects of this scale or went bankrupt during the recent economic depression. In construction where the work is extremely interdependent, having uncommitted sub-KTRs in a team is detrimental to maintaining the project on schedule. This affects, not only the work that troubled sub-KTRs do, but also reduces the performance of others. As indicated in Figure 7 and 9 there were 48 broken promises caused by failing inspection in Building 1 and 19 in Building 2 since variances were tracked in December 2012. Furthermore, bad planning, which accounted for 104 broken promises and 35 in Building 1 and 2, respectively, might be an indication of errors resulting from lack of experience or knowledge of a few sub-KTRs in planning work sequences and workloads. All these directly impacted the work sequence, which was reflected under pre-requisite work.
Problem 3: Project Delivery Method Limited Collaboration

DBB was selected as project delivery method. The main drawback of DBB is a poor or inexistent information flow between the A/E firm and construction contractors. As shown in Figure 6 through 9, RFI and design issues were noted among the top four variances. Even after two years since the construction had begun, the A/E and KTRs were still inquiring about and getting clarification on the constructability of design and struggled to have an effective flow of communication between them. However, it should be noted that the A/E representative was present for all the pull planning sessions in an attempt to provide the prompt responses to questions raised by sub-KTRs and to continue dialogues on and off pull planning sessions.

Problem 4: Invalidated Schedule

GC1 bid the project using a CPM schedule developed without input from other project participants. Because of the multiple prime contract structure, GC1 internally developed the schedule without any input from major sub-KTRs on the milestone or phase planning. CPM was developed without any commitment from the contracted parties in this project; therefore, it could not realistically be enforced on anyone once the project started moving. Sub-KTRs could not perform at the pace and in the sequence of the schedule that they did not involve in developing. Within the first year of construction, the project was nine months behind its proposed schedule, and the duration of the project grew by over 400 days. Once GC2 took over the project, they made every effort to adopt pull planning sessions in the weekly meetings to slowly reshape the schedule. Because the project was already in progress without an accurate schedule, GC2 had to sort out the weekly planning first to keep sub-KTRs from running into each other and work backwards to develop a phase and then a milestone schedule.

WORKING TOWARDS SOLUTIONS

Per the owner’s request and GC2’s attempt to get this project back on track, they mutually agreed to implement LPS® with help from a third party, who participated as a LPS® consultant and mediator. Every week all the team members, including A/E and owner, met to engage in pull planning sessions to develop weekly schedules and discuss constraints.
Because GC2 was thrown in the middle of the project to fix the schedule problem, instead of going from master schedule to weekly work plans as shown in Figure 2, the team was focused on weekly work plans to get everyone back on track and slowly work backwards toward developing master plan that could give the owner the new estimated completion date of the project.

Although the basic project structure did not change, implementing LPS® bridged the communication gap between all the sub-KTRs and encouraged them to collaborate in producing a successful result. The first PPC was taken after the week of December 10, 2012. The PPC at the Building 1 was tracked at 55 percent while the Building 2 showed 61 percent. Although a steady uptrend in PPC was not observed with a bit of spikes in numbers as shown in Figure 10, it was clear that the team had started to work across boundaries that were set by the project structure and discuss problems on the spot during weekly pull planning sessions. The last PPC recorded for this paper was 81% and 80% for Building 1 and Building 2, respectively, in the week of July 5, 2013. Based on the linear graph incorporated in the data, it demonstrated an improvement of roughly 13% in PPC in this period.

**SUMMARY**

This chapter presented two key discussions: the underlying problems that the College experienced due to the inherent misfit project structure and the team working towards solution to keep the project moving forward. Identified were four main problems; which included GC1’s inability to coordinate, a lack of responsible parties in the team, limited collaboration due to project delivery method, and the invalid schedule. GC1’s inability to orchestrate work resulted from its limited authority or control over the sub-KTRs in the setting of the multiple-prime contract. The best qualified and responsible parties were dissuaded in competing for competitive bid, which based the source selection merely on pricing and small business criteria. The project delivery method (DBB) limited coordination between A/E and KTRs. Finally, an invalid or unrealistic CPM schedule developed solely by the GC without input from contracted parties was not supported by sub-KTRs who performed activities. The four underlying problems were substantiated by the analysis of variances and additional qualitative information collected during interviews with project members. Despite the challenges, the team was able to implement LPS® with help from
Figure 10. PPC from 18 Dec 12 to 12 Jul 12.
the third party consultant and tackled issues collectively at the pull planning sessions. During the seven-month period, it was observed that PPC continuously improved and the team collaborated in keeping promises and completing activities.
CHAPTER 4

CONCLUSION

The College’s construction was commenced in February 2011 with the expected completion date of December 2012. However, by the end of 2012, the project was behind the schedule without a completion date in sight. GC2 came onboard in November to get the project back on schedule with the help of the third party LPS® consultant. The team was encouraged to participate in weekly pull planning sessions where issues were introduced, discussed and addressed promptly. At the beginning of LPS® implementation last December, the team kept approximately a half of their promises. After seven months of the implementation, the team improved the percentage to nearly 80% for the both buildings under this project. Although the data plot did not indicate the gradual increase in PPC with irregular spikes and pumps, it was clear that the team continued to strive in keeping promises. At this point it was not about whose fault it was, but it was more about working as a team to get the project done.

The analysis presented revealed that the project suffered from the following underlying issues: GC’s inability to orchestrate the team, a lack of responsible parties, limited collaboration, and an invalid/unrealistic schedule. These issues likely resulted from the erroneous choice of contract type and project delivery method for this project. The project was delivered in DBB by KTRs who were selected in a price-only competitive bid (some with small business preference). Additionally, in the multiple-prime contract environment defined by the owner, the GC did not have any authority to orchestrate the team. Lack of collaboration and communication made it difficult to work towards the common goal of finishing the project. To substantiate that, 76% for Building 1 and 80% for Building 2 of broken promises were traced back to incomplete prerequisite work, bad planning, failing inspection, and design issues.

If there were reliable data that demonstrated the PPC and variances prior to the implementation of LPS®, the author could have analyzed the before-and-after impact of LPS®; however, there was not any tracking because the project was failing without any
mechanism to track commitments and promote a collaborative and transparent work environment. At the time this document was developed it was clear that the team was working together to deliver promises as indicated by the continuous improvement trend displayed by the tracking of the PPC indicator and that the project was on track to finish in early 2014.
REFERENCES


