LOOK-AHEAD PLANNING: REDUCING VARIATION TO WORK FLOW ON PROJECTS LADEN WITH CHANGE

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ABSTRACT

Project delivery methods have tremendous influence over the amount of design changes and revisions realized during the course of construction. Studies have found that early collaboration with cross-functional teams during design can eliminate considerable waste during construction through impeccable coordination of the construction documents. However, the traditional design-bid-build approach has notoriously produced the opposite of that, that is, projects that result in numerous document revisions creating significant schedule delays and substantial variation to work flow. To counter the negative ramifications that this approach has during construction, the Last Planner System™ (LPS™) can provide a systematic methodology to improve reliability in an environment inundated with variation. The main hypothesis of this paper is that the use of the LPS™ can bring benefits to the planning process in design-bid-build projects and ultimately to its production trades. In order to deliver in 22 months an exceedingly unique 280,000 SF cast-in-place laboratory replacement project, which employed the traditional design-bid-build approach, the LPS™ was used. The LPS™ provided a structure to assist the team in improving planning on a project that had double the amount of revised drawings than the original bid set.

KEYWORDS

Last Planner System™, lookahead planning, design-bid-build, laboratory facility, federal project

INTRODUCTION

Project delivery methods have tremendous influence over the amount of design changes and revisions realized during the course of construction (Riley et al. 2005). Studies have found that early collaboration with cross-functional teams during design can eliminate considerable waste during construction through impeccable coordination of the construction documents (Khanzode et al. 2008). However, the traditional design-bid-build approach has notoriously produced the opposite of that, that is, projects that result in numerous document revisions creating significant schedule delays and substantial variation to work flow.

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This paper presents the process of measuring reliability through percent plan complete (PPC) and analyzing root causes of problems throughout the project, which enabled the team to continuously improve. The data collected on a weekly basis along with "going and seeing" performance in the field informed and improved project planning. The process that surprisingly underwent the most development and contributed to the team's success was look-ahead planning. A concerted effort to closely plan, communicate, and coordinate with the subcontractors contributed most to the reduction of variation on a project that was laden with change. The main hypothesis of this paper is that the use of the LPS™ can bring benefits to the planning process in design-bid-build projects and ultimately to its production trades. The authors also aim to inform practitioners about the fact that the use LPS™ is not limited to more integrated forms of design such as design-build and integrated project delivery.

THE MAKE READY PROCESS – STABILIZING THE WORK FLOW

A primary function of the look-ahead planning process is to "make work ready" to enable the Last Planners to commit to activities on the weekly work plan (Ballard and Howell 1998). In order to ascertain whether work is able to be made ready, activities from the phase scheduling process are parsed into smaller detail to enable durations to be measurable. This provides a clearer definition on specific work packages that will enter the production line. Moreover, a rigorous effort is implemented to ensure that all constraints, impeding work tasks from being released for production, are identified and removed. Howell and Ballard (1994, p.1) suggest that the first step to implement Lean Construction on complex project "*is to stabilize the work environment by shielding direct production of each component function from upstream variation and uncertainty management has not been able to prevent*."

Constraints identified during the look-ahead process commonly manifest themselves through a lack of information or direction and are addressed in the form of a Request for Information (RFI), Potential Change Order (PCO), or other agency approval. The benefit of the make ready process is that it forces the project management team to emphasize the direct relationships between the administrative process and the production process. This creates a paradigm for the management staff to be acutely aware of the vital importance their support function has on the project's production line. The unification of the production process with its supportive administrative process is critical to mitigating the negative effects of variation.

In order to monitor the performance of the commitments made by the management team and other stakeholders on the project discussed in this paper, the project manager used the Percent Plan Complete (PPC) as a measure of reliability and commitment of those involved with the planning process (Ballard and Howell 1998). The PPC was measured as the number of tasks completed by a team during a certain week divided by the total number of tasks assigned to that team during the same time. The continuous measurement of PPC is instrumental in identifying problems and working to remove their root causes (Ballard and Howell 1994).

PROJECT DESCRIPTION

The building is an exceedingly unique 280,000 SF cast-in-place laboratory replacement project located in San Diego, CA, which employed the traditional design-bid-build approach. The project was planned to be completed in 22 months at a cost of $60 million dollars. The owner, the physical location of the project, and the architects were all in different cities. As described by Samudio et al. (2011):

"The new $60 million facility will provide oceanic research to assist in the management and maintenance of the marine ecosystems in the Pacific Ocean. The total constructed area will be 287,000 square feet, which includes new parking, offices and laboratory areas. The project will include an extensive aquaria area, necropsy lab, biology labs, chemistry labs, Class 100 clean room and a new 1-million-liter seawater ocean technology development tank which will expand researchers' ability to develop and apply advanced technologies for surveys of fisheries resources and their associated ecosystems. The project is funded by the American Recovery and Reinvestment Act and is seeking LEED Gold certification through numerous sustainable features, including a 250KW rooftop photovoltaic system, vegetative roofs for storm water management, recycled and regionally sourced building materials, and natural ventilation systems. Although the procurement of the project included a best-value component that considered qualifications, the contract structure is a firm-fixed price based solely upon project solicitation instructions, plans and specifications."

During the project, the LPS™ provided a structure to assist the team in improving planning on a project that had double the amount of revised drawings than the original bid set. Moreover, the project was also confronted with significant agency approval delays, required to subcontract with several small businesses with limited resources, and experienced extremely long cycle times on change order approvals. LPS™ was a vital component of achieving this aggressive schedule despite the numerous challenges experienced.

KEY PROJECT METRICS AND BACKGROUND

In an effort to enable the reader to appreciate the amount of variation on the project it is necessary to contextualize the situation with some key project metrics. The Request for Information (RFI) is a document generated by the construction team and issued to the design team to clarify discrepancies in the contract documents or request additional information needed to construct the project. On this project 1,614 RFIs have been written, that's an average of 73 RFIs per month throughout the duration of the project. The contractual time frame for the design team to issue a timely response was 5 work days. On average RFI responses were received within this time frame 45% of the time. In many instances RFIs required a significant change to the contract documents, which initiated a new document revision updating project plans, details, sections, or elevations. The original project bid set contained 445 sheets of plans, details, section or elevations. This original set incurred 835 revisions, which Figure 1 helps to depict the magnitude.

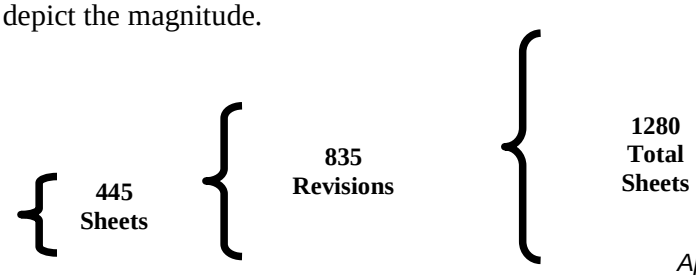

Figure 1: Escalation of project sheets due to revisions

The issuance of revised documents invariably resulted in modifications to the contract. These modifications to the contract were authorized via Potential Change Orders (PCOs), which summarize specific changes in scope to the original contract. On this project the 835 revised sheet revisions to date have resulted in a total of 443 PCOs, which on average have required 160 days to approve. Not only has this amount of change created an administrative burden for the management personnel, it also caused a tremendous amount of variation to the planning process.

As a project for the Federal government there were aggressive goals required for small business subcontracting. A total of 36% of the subcontracted value was required to be awarded to small business enterprises. Moreover, within that 36% there were also specific goals required for women, minority, hub-zone, veteran and service disabled veteran owned small business enterprises. Although the Federal government possesses good intentions by promoting economic stimulus for small businesses, the unintended consequences on a project of this size in a recession was additional variation introduced from subcontractors with limited resources and /or experience in this kind of project. The largest challenges with the group of small businesses enterprises were lack of consistent attendance at the foreman's meetings, having to consider subcontractor cash flow as a constraint, and having to batch work for small scopes in order to make it feasible for the smaller subcontractors to productively mobilize. This was only compounded by the amount of change associated with the project.

It is not possible, in this paper, to give an exhaustive account of the challenges encountered on this project. Nonetheless, there was no shortage of issues that created variation to the construction scheduling process. This is where the LPS™ process, specifically the look-ahead planning process, was well suited to create some level of work flow for the trades on a project inundated with change.

WORK METHOD

This section presents the method used to identify, manage, and remove the constraints on the project, as well as a brief discussion on how work packages were defined. The main metric used was the Percent Plan Complete (PPC) to evaluate the commitments of those in charge of addressing the constraints over the weeks. PPC results obtained for the project and for the internal management team are presented.

CONSTRAINT IDENTIFICATION

An essential element to effective constraint removal is timely and accurate constraint identification. On projects with significant amounts of change the production line can be victimized by variation unless work is properly shielded from constraints which induce it. The project referenced above certainly can be characterized as being subject to significant change. As a result, the management team had to remain diligent and aggressive in seeking to identify constraints.

The primary method employed were *regular look-ahead schedule meetings*, which were in addition to the weekly foreman's meetings. These look-ahead schedule meetings included separate discussions on upcoming activities with structural trades, exterior skin trades, and MEP trades. This allowed reoccurring forums for these groups to define upcoming work packages and analyze the constraints that needed resolution. The management team would then be thoroughly equipped to effectively communicate these project needs at the weekly OAC meeting. The look-ahead schedule meeting format included a review of the activities for a four to eight week period, allow the team to further define activity detail, and discuss constraints associated with the tasks. Moreover, it afforded the team another opportunity to further evaluate the constructability of details which invariably initiated further questions needing clarification. Ideally this constructability would have been reviewed in an earlier phase, however the demand on resources that changes had on the project never seemed to cease enough to get too far ahead. This collaboration was vital for the team to confront the variation that continually threatened the production line. Furthermore, the thorough communication helped to mediate the constant tension between the need for progress versus following the principle of only releasing screened work (free of constraints) to the production line. Finally, the meetings also enabled the weekly foreman's meeting to focus solely on the plan for the upcoming week within a more reasonable time limit.

CONSTRAINT REMOVAL

The removal of constraints on the project can be categorized into to two types, those within the *management teams control or court* and those that *required direction from the Owner or Design team*. This section focuses on the latter type and addresses the former in a separate section (Working the plan). The primary emphasis of the weekly OAC meetings on the project was focused on the removal of constraints. As a result, the agenda of the meeting was structured in a fashion to obtain commitments from the Owner or Design team to resolve these project constraints. Since the Owner was located in Seattle, WA and the Design team in Kansas City, MO the majority of the meetings were conducted via web-based teleconference. Thus, the importance of communicating project needs in a concise and effective manner was not taken lightly.

The main staple of the meeting agenda included a one page prioritized list of constraints presented in visually coded categories of red (late), yellow (require attention) and green (time still available). A sample of the constraint log was presented in a previous paper regarding this project (see Samudio et al. 2011). The constraint log optimized the presentation format in a succinct way; however the accuracy of the content was the most important item. Items in the constraint log had to be precisely identified and deadlines for their removal accurately defined the last responsible moment to act and avoid impacting the work flow.

Moreover, due to the volume of constraint issues open on a continual basis the prioritization of these items enabled the Owner and Design team to focus on key items with their limited resources. The management team achieved this by being informed through the look-ahead schedule meetings and other additional meetings with structural, skin, and MEP meetings along with other practices employed throughout the week. Although the effort to communicate the constraints was rigorous, unfortunately it did not yield the desired results in removing the constraints

that obstructed progress as explained later in the paper. This is illustrated in the constraint removal performance shown in Figure 2.

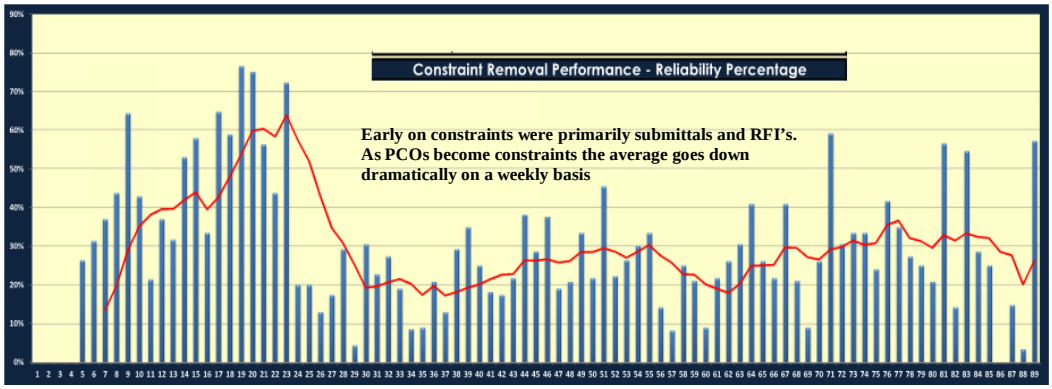

Figure 2: Weekly constraint removal performance (total)

The reliability of getting constraints removed in the OAC meetings averaged 30% of the items on a weekly basis, which complicated look-ahead planning efforts. The main reason for this poor performance was the Federal Government's process for authorizing and approving PCOs. The process had a prolonged cycle time that took several weeks (many times months) to complete as presented in Figure 2 which shows spikes with higher percentages primarily when authorizations were issued. This was the singular issue that drove the vast majority of variation on the project.

WORKING THE PLAN

The constraints within the management team's control including preparation of RFIs needing direction, preparation of PCOs needing authorization, coordination of manpower, procurement of materials, and all other constraints not needing Owner or Design team attention were also tracked on a weekly basis. The main forum to discuss and coordinate these issues was in the *management team's weekly internal staff meetings*. The management team's performance was measured throughout the project to identify the percentage of assignments completed on a weekly basis (Figure 3).

Tracking administrative performance in this manner helped to provide objective data to support the need for added resources to address the increased workload. Although the project benefited greatly from collaborative look-ahead planning meetings, internal and external weekly update meetings with an emphasis on removing constraints, the volume of change on the project demanded more to protect the production line from variation. These types of meetings are analogous in a sports game as being on defense. Continuing with the analogy no team can win the game on defense alone, which is why offense is equally important. Thus the rest of the week the management team's method of confronting variation was "go and see" the production line to actively ensure the weekly plan (described in more detail in Samudio et al. 2011). Also known as "planning the work and working the plan". The benefits of "going and seeing" are to obtain a more thorough understanding of the issues and personal verification of facts. The collaboration and coordination of the project were not confined to the meeting room. On the contrary, some of the most

productive collaboration and coordination were conducted out in the field. Moreover, continual verification and validation of the status of planned activities throughout the week provided the management team with essential real time information to defend against variation.

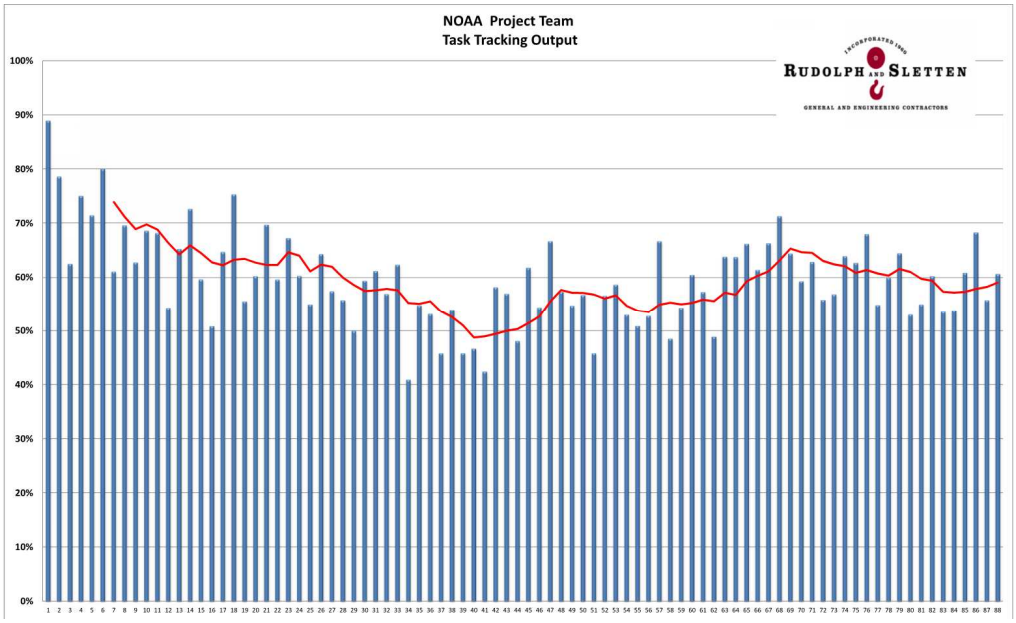

Figure 3 Weekly constraint removal performance (management team)

In an effort to optimize communication amongst the management team, a *daily briefing* of 30 minutes with all office and field staff was employed. This provided a convenient forum to identify any adjustments that needed to be made to the plan. It also informed the management team on where their efforts could best assist the production line and allowed the office and field to be more in sync.

DEFINING WORK PACKAGES

During the *look-ahead schedule meetings* a lot of discussion in defining specific work packages occurred. The work packages would identify the extent of the work that was free of constraints and determine the best flow achievable. Due to the amount of change and variation experienced on the project the conditions were never ideal. Moreover, in most situations the team would have to concede to "make do" (Koskela 2004) with the unconstrained work in the best flow attainable. Defining the work packages would enable the team to understand the expectation of what work was made ready and available to be completed. It also helped to parse large duration activities into more finite and measureable portions. This was especially difficult for the exterior skin trades, which had more handoffs than desirable due to intersection of many specification sections. Moreover, the need to coordinate these handoffs accurately was exacerbated by the amount of change incurred along with special needs by some of the subcontractors who were small businesses.

On a few occasions the look-ahead planning meeting turned into a "*go and see" field trip* to more accurately define the work package. Although, these planning

efforts were successful in enabling work to be made ready and executed, on some occasions variation was still encountered precluding the plan from reaching fruition. As a result, it was a common practice while defining these work packages to formulate workable backlog as a back-up plan. This was especially important to maintain some level of productive work for crews while awaiting the removal and resolution of the constraints on the project. As many of these discussions would take place during the look-ahead planning meetings, it expedited the negotiations during the weekly foreman's meeting conducted prior to acquiring commitments.

PROJECT RESULTS

The goal of all of these efforts was to achieve a reliable work flow by protecting work activities from variation, which creates disruption, loss of productivity, and delays on construction projects. When projects are inundated with change and variation the progress in the field invariably falls prey to these demoralizing developments. The efforts to prevent the negative ramifications caused by change and variation were measured on this project. The metric employed to identify reliability of planning efforts was done by identifying percent planned complete (PPC) on a weekly basis. Ideally if the look-ahead and its make ready process were effective then commitment to the tasks entering the production line could be achieved at a more reliable percentage. PPC was the primary metric used to measure reliability on this project and for the entire duration the average on this project has been maintained at 71% over 86 weeks. Figure 4 illustrates the PPC over the duration of the project and some important milestones.

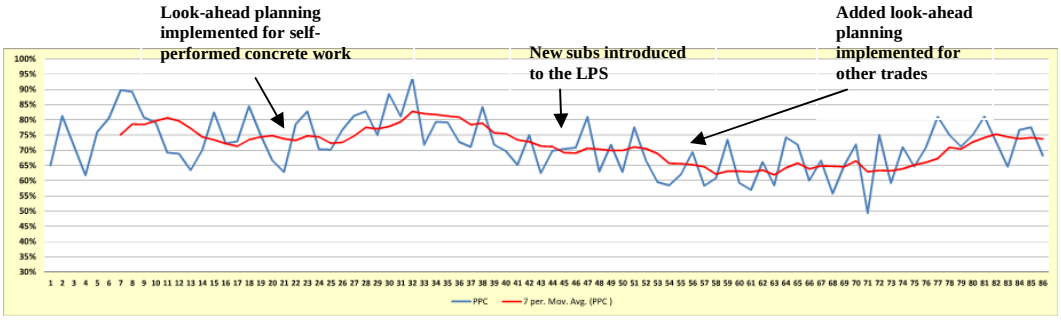

Figure 4: Project PPC over 86 weeks

The LPS as a paradigm provided the management team with an understanding that only made-ready work is acceptable for trade foreman to make commitments. This understanding made *the foreman's meeting* a forum to set reasonable commitments within the midst of an environment plagued with variation. The LPS™ afforded the management team with the metrics necessary to make reasonable adjustments to the oversight methods (Figure 4). The evaluation of performance was an essential element to informing the management team on where to focus their attention.

CONCLUSIONS

It is impossible to know for certain how much the process employed improved performance on the project. It is reasonable; however, to assert that if the LPS™ were not used on the project the negative effects of variation would have been much worse.

In general the feedback from the subcontractor's foreman has been positive. Although the ideal flow was not achieved due to unresolved constraints, flow was created for many of the major subcontractors. It was also observed that many of the later subcontractors benefited from the earlier efforts to generate a work flow in an environment with much variation.

The tracking of PPC, which measures reliability in the LPS™, allowed the entire team to visualize what was causing variation. Additionally, the identification of constraints tied to specific tasks in the schedule provided a sense of how much letting constraints unresolved would impact field work. The systematic meetings with trades and the management team promoted shared understanding of constraints facing the project and definition of solutions in a collaborative section. As stated by one team member with the General Contractor: "*it is good to have all trades in the room…when everybody is in one room it saves a lot of time for us.*"

It should be concluded that this project benefited greatly from the philosophy and implementation of the LPS and should be a testament to other projects with similar delivery methods to embrace LPS. The success that was achieved in this environment very well could have been better if the project was procured via a more collaborative delivery model. This would have likely enabled the project to be delivered in a shorter duration. At a minimum it would have greatly reduced the waste and rework experienced on the administrative side of the equation. Nonetheless, in the opinion of the authors that LPS™ was implemented because it was best suited to control variation and help the management team deliver a difficult project in a difficult environment.

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