Lean Construction in the Utility and Infrastructure Industry

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Purpose

Lean construction methods can play an important role in improving the success of companies involved in the Utility and Infrastructure (UI) markets. Lean methods provide significant commercial benefit and practitioners are able to achieve greater influence in managing their business. The implementation of Lean construction promotes continuous improvement, provides a framework for managing risk, increases reliability of team commitments and minimizes waste. Basic Lean implementation is focused on proactively identifying waste, optimizing resource utilization and provides simple forward looking measurement tools. Implementation of Lean construction methods reduces conflict, rework and uncertainty in a challenging industry. This is accomplished by achieving team commitment to schedules, establishing the conditions of success for handoffs to downstream work and promoting a culture of trust supported by measurement. Finally, implementation of Lean methods grows people by creating a leadership culture which strives to identify and implement productive change.

Background / Problem

Construction work in the UI markets has a unique focus on linear work. In contrast to many other construction markets the utility and infrastructure environment has a higher degree of repetitive tasks. Success is measured by our ability to optimize throughput and maximizing the quantity of high quality product that is delivered in a short period of time. Lean construction methods in the building industry have focused largely on coordinating work between various trades and eliminating conflict through more productive communication and coordination. Although these concepts are important in all construction work, UI contractors self-perform more work and build in a more linear fashion, resulting in a greater need to improve performance within its own operations. In many ways UI construction is more like manufacturing than building construction. There are five golden metrics in manufacturing that really matter: total cost, total cycle time, delivery performance, quality and safety. (Waddell, 2006) Successful UI construction work, especially linear repetitive projects are measured using very similar metrics.

Slow economic recovery continues to produce new challenges in the construction market. Increased competition for work has resulted in low margin backlog. (FMI Corporation, 2012) From 2008 to 2011 over 2 million individuals left the construction labor pool. (United States Department of Labor, 2014) Moreover an aging workforce has contributed to a shortage of skilled workers as the market recovers. These factors drive the need to embrace change and seek out ways to reduce uncertainty and increase reliability in our work. Lean construction methods provide a simple vehicle to reduce risk and increase profits.

Solution

Process

Lean construction methods consist of a toolbox of simple tools that provide basic resources for planning and coordination of the work as well as continuous improvement including optimizing workflow, resources utilization and throughput. These tools can be categorized as Planning, Measurement and Continuous Improvement.

Planning

Implementation of Lean in the construction market starts with the Last Planner™ System[1]. The Last Planner™ System requires a paradigm shift for those accustomed to traditional project management. A key component of this shift is the level of detail in the baseline or *original schedule*[2]. The original schedule on a Lean project focuses on interfaces between trades (handoffs), constraints and milestones. Sufficient detail is included in the original schedule only to ensure that the work flow is demonstrated to convey the plan to the project team. Work by a single crew that does not interact with another trade or contain interim milestones is shown at its full duration. In contrast most traditional schedules require detailed work sequences and individual activities durations are limited regardless of real constraints. A less detailed baseline increases the accuracy of the original schedule by minimizing the chance of logic errors and emphasizing the importance of work sequence, interactions between trades, constraints and activity durations. Detail is added to the schedules during Pull Planning[3] sessions described below. The Last Planner™ System is a simple tool for work planning that changes traditional authoritarian mandates from project supervision to interactive coordination sessions that seek input from the individuals responsible for executing the work, known as the last planners[4]. Typically the last planners are the individuals responsible for crews performing the work such as foreman or other crew leaders. Lean planning efforts are sharply focused on creating realistic work plans and proactively assessing the ability of work to start before it is scheduled for execution, taking into account availability of resources, approvals and acceptable completion of predecessor activities. Another significant culture shift is that project teams are taught to never to say “no”, but respond, “yes, if…” in a proactive solution oriented approach. For example, “Yes, we can complete that work two less days if another three people are added to the crew”, or “Yes, we can put the waterline in service on Monday if the inspector agrees to observe the testing on Saturday”. Implementation of Lean methods will grow leaders into solution oriented people that are not satisfied with “no”, who instead focus on how to “improve the process and find a better way” (Akers, 2012).

Pull Planning – Planning the work by the people responsible for execution ensures you have the right people available armed with current information. Pull planning sessions are scheduled by breaking the work into 90-120 day segments and performing the detailed planning 60-90 days prior to start of that

block of work. The key concepts to embrace during pull planning are identification of specific work activities of each trade or crew, duration of those activities, handoff points between trades/crews and constraints which are typically under the control of others. The activities are then sequenced by the last planners using a simple arrow diagram creating the logic flow for a segment of the work. This process of identifying the handoff points and negotiating the sequence by the individuals responsible for the work creates *commitment* by the team that the work flow and durations can be met by those responsible for its execution.

In contrast to traditional scheduling methods, the work is sequenced in reverse, beginning with the completion activity. This process establishes predecessors based on what is really required to be completed before the next activity starts; this is defined as a pull. More traditional scheduling starts with the first activity and creates predecessors based on what is available next; this is defined as a push. Pull vs. Push is a key Lean concept in that pull relationships define a true critical path. Sufficient detail is developed to clearly Identify interfaces between activities with focus on constraints and handoffs. It is critical that an activity that could stop work from progressing be included in this process. This includes third party obligations such as permits and approvals as well as resource deliveries. Upon completion of the pull planning session the detailed plan is compared to that segment of the original schedule to validate overall duration against the baseline. Sequence and flow are renegotiated by the last planners until the original commitment is achieved. This is an essential intermediate check point in the project that ensures timely course corrections are made and commitment to the original plan is validated. The detailed plan is now integrated into the project schedule.

6 Week Look Ahead – Traditional construction projects use a two or three week look ahead schedule as the basis of their short term planning. The Last Planner System uses *6 week look ahead* [5]produced from the project schedule that has been updated by pull planning as a tool for identification of *constraints* [6] that can stop the work. These constraints are tracked in a *Constraint Log*[7]. Each week the project team reviews new activities that appear in the 6th week for any that is not ready for execution. A list of constraints that can stop work is created with a responsible party and required completion date assigned for resolution of the issue. The responsible party must have the authority to resolve the issue and is accountable to the team to eliminate the constraint. The Constraint Log is reviewed weekly along with the 6 week look ahead. The responsible party provides an update to the team and is accountable for escalating any issue that cannot be resolved in the assigned time.

Weekly Work Plan – *Weekly Work Plans* [8]are detailed schedules for each crew performing work on the project. The weekly work plan is similar to a traditional weekly schedule used on construction sites; however, it includes detail that makes it a forward looking measurement tool to validate productivity and rapidly identify performance problems. The key concept for good weekly work plans are measurable activities that identify production quantities, manpower and equipment resources needed. Additionally activities that hand off to another trade or successor work identify acceptance criteria for the receiving trade/crew. Weekly work plans are based upon the commitments made in the pull planning sessions. They are reviewed by the crew leads during a weekly meeting and act as a final coordination of the upcoming work week. The weekly work plans are graded by the project management staff each week with a pass/fail for each activity on the list. Each activity on the weekly work plan that is not completed is assigned a Variance Code[9]. The scores are tracked as Planned Percent Complete (PPC) [10] and recorded in graphs that are shared with the project team. A baseline performance goal is established for the project (typically 85%). Any crew that does not meet this

minimum performance standard is identified for corrective actions to resolve the performance deficiency. Sharing the performance of each crew with the project team increases the accountability of the team members to each other for the commitments that are made. This is typically done by both posting the weekly results in a common area and reviewing the results during the weekly meeting. It has been demonstrated through practice that the peer pressure to meet the commitments made to the team is an effective means of improving performance and accountability.

A critical component of profitability is maintaining the productivity of field crews. When an unforeseen condition occurs that stops work the most effective short term solution is to productively utilize the crew elsewhere. A useful component of the weekly work plan is Workable Backlog[11]. The weekly work plan is based upon work required to meet the goals established to maintain the project schedule, but occasionally things do go wrong and work stops. Other work that is not required to be completed that week but is ready to start is listed at the bottom of each weekly work plan. Constraints have been removed and it is available should a delay or interruption occur. This backup planning can make the difference between maintaining profitability of the crew or suffering a financial loss for the day. Uncertainty is a part of UI construction. An equipment breakdown or unforeseen site condition is a reality that impacts utility work. Preplanned, executable backlog is an effective means of mitigating this risk.

Measurement

The most effective means of ensuring performance is to measure it. The Last Planner™ System is created with meaningful measurement tools at the forefront. These measurements are tied to each stage of the planning process.

- Pull planning sessions produce a detailed plan that is measured against the original schedule.
- 6 Week Look Ahead reviews result in the creation of a Constraint Log. Commitments are measured by the team each week for constraint removal and escalated if not making satisfactory progress.
- Weekly work plans are graded each week and Planned Percent Complete (PPC) Charts are used to measure and track the performance of each crews activity.
- Variances are categorized and tracked in a Variance Log when commitments are not met. These classifications include contractor obligations like material availability, labor availability, equipment breakdowns and coordination in addition to third party obligations like RFI's not answered, submittals not approved or inspections not completed.

Measurement of the basic planning processes reduces uncertainty by validating our ability to meet planned goals. Additionally these measurements provide leading indicators of systemic problems that require support from outside of the project team. Early identification of poor performance allows more focused application of limited resources to manage risk effectively.

Continuous Improvement

Lean is more than just planning but an effort to continuously improve performance and eliminate waste. It is a cultural change. Implementation of Lean methods develop leaders that grow into an understanding that, "It's rarely a huge or drastic change, but small baby steps in an endless drive to continuously improve everything every day" (Akers, 2012). Lean methods include basic tools to help

project teams enhance reliability, streamline performance and ask the right questions. Continuous improvement tools include the 5 S's[12] (Wikipedia, 2014) to reduce waste. The seven wastes are defined as Transportation, Inventory, Motion, Waiting, Over-processing, Over-production, and Defects[13] (Wikipedia, 2014). An eighth waste, Unused Employee Genius is discussed in the book 2 Second Lean (Akers, 2012). The 5 S's are a tool to improve operational efficiency of human capital by removing distractions, making the expectations for execution clear and unambiguous and encouraging recognition of waste. They are classified as:

1. Sort – removing unnecessary items, eliminating obstacles and prevent accumulation of unnecessary items
2. Straighten – Make it easy to find and pick up necessary items, prevent loss of items
3. Shine – Clean work area and use cleaning as an inspection, maintain equipment
4. Standardize – maintain workplace organization and keep in accordance with it standard
5. Sustain – keep everything in working order and perform regular audits

The tools used when Lean methods are adopted create a culture or recognition that seeks out continuous improvement. The basic framework for improving operational performance of UI contractor is *easily* learned and applies throughout the entire organization. Lean methods encourage empowering employees through a philosophy know as Kaizen, a Japanese word meaning "good change" (Wikipedia, 2014) to correct waste in their area of responsibility as well as escalate items that require more formal process improvement such as A3[14] (Wikipedia, 2014). Implementation of Lean methods requires leadership trust that although mistakes may be made the culture of improvement "will produce the desired outcome" (Akers, 2012).

Continuous improvement includes problem solving and determining the root cause of performance issues. Many performance issues encountered by UI contractors are too commonly addressed superficially. Project leaders, in many cases, have not been properly trained to dive deep enough to discover why things happen (or not). It is easy to blame cost overruns on a crew that failed to meet productivity budgets. Many superintendents first response is to tell the crew to work harder. Lean methods provide simple tools to ask the right questions and solve common construction problems. One simple method is the 5 Why's[15] (Wikipedia, 2014). The 5 Whys method is based upon the theory that the first reason why a problem occurred isn't the real problem that needs to be solved. The question why must be asked at least five times to explore the root cause of a problem. For example:

1. Why did the concrete crew miss the pour?
    a. The forms weren't ready.
2. Why weren't the forms ready?
    a. The rebar was installed late.
3. Why was the rebar installed late?
    a. The pre-tied mats were too far away for the crane to reach and a dirt pile had to be moved to position the crane.
4. Why was the rebar too far away for the crane?
    a. An excavator was parked in the rebar staging area and the rebar crew tied the mats in the next open area so they could get their work done on schedule.
5. Why was the excavator parked in the rebar staging area?

a. The maintenance truck was servicing the crane and the excavator needed an oil change. The operator parked it close to where the mechanic was located.

As you can see from the example this simple tool can help identify that coordination between crews and communication is the real problem and it isn't complicated to solve the issue with the right tool. A number of other simple tools are available for continuous improvement to help UI contractors increase reliability of their work and improve the bottom line.

Conclusion

At times contracting in the UI Industry seems like a fight for survival. Economic conditions continue to drive us to continuously improve our operations and optimize productivity to remain profitable. "The slightest advantage in one being, at any age or during any season, over those with which it comes into competition, or better adaptation in however slight a degree to the surrounding physical conditions, will turn the balance." (Darwin, 1859) Lean construction methods and processes offer simple, low risk tools to create advantage and turn the balance in favor of those who adopt and implement its principles. Utility and Infrastructure contractors are unique in the construction markets but can strengthen their organizations performance and enhance the bottom line by embracing Lean methods in their business.

How can your organization can start to Lean up operations? An excellent resource for learning about creating a continuous improvement culture is the book 2 Second Lean, by Paul Akers. Formal training in Lean practice can be obtained through The Associated General Contractors of America (AGC). The AGC provides leadership and training in the implementation of Lean on construction projects including sharing information and best practices. AGC training includes implementing the tools described in this paper. Additional information can be found on the AGC Lean Construction Forum.

About the Author

Andrew Apostolik became a student of Lean practice in 2006 and has worked more than 20 years in Utility and Infrastructure construction.

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[1] Last Planner™ System – Planning tool that relies upon those responsible for execution of the work to create the detailed list of commitments to be achieved by the team.
[2] Original Schedule – Baseline schedule for project which shows the work flow, handoffs between trades, constraints and milestones.
[3] Pull Planning – Creating a detailed list of work activities, assigning durations, identifying handoff points and negotiating the sequence of work for a segment of work with an overall duration of 90-120 days..
[4] Last planner – Individuals responsible for successful execution of the work in the field. Typically foreman or crew leader.
[5] 6 Week Look Ahead – look ahead schedule used to identify constraints
[6] Constraint – Anything that will stop work if it is not resolved.
[7] Constraint Log – log used to track items that can stop the work. A responsible party with the authority to manage the issue is assigned to each item on the log and is accountable to the team for eliminating the constraint in the time required.
[8] Weekly Work Plan – A detailed schedule for each crew performing work on the project. A weekly work plan has measurable activities that identifies production quantities, manpower and equipment requirements.
[9] Variance Code – Classification of why a commitment is not met.
[10] Planned Percent Complete (PPC) – Measurement of crew performance on weekly work plan.
[11] Workable Backlog – Work not currently scheduled to be completed but all constraints have been removed and it is available for crews.
[12] 5S's – Sort, Straighten, Shine, Standardize, Sustain
[13] Seven Wastes - Transportation, Inventory, Motion, Waiting, Over-processing, Over-production, and Defects
[14] A3, a structured problem solving and continuous improvement approach, first employed at Toyota, and typically used by lean manufacturing practitioners (Wikipedia, 2014)
[15] 5 Why's – Asking why at least five times to seek out the root cause of a performance problem.