

Lean Project Deployment Planning: An Assessment of Current Practice

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LCI White Paper No. XX
Version 0.9

February 28, 2018

Executive Summary

Lean Construction emerged from the Lean Production System. While some companies and some construction projects have been transitioning their practices to align with Lean construction principles, many organizations and projects within the industry find it difficult to transform their delivery and production approaches. Through interviews with leading experts in the adoption of Lean principles on construction projects, we found that there is a significant opportunity to provide additional resources to project teams to help them define a consistent approach toward planning the integration of Lean principles into their delivery processes for projects. This paper summarizes the finding from interviewing 16 Lean experts, who are also industry practitioners, and outlines a plan to develop a structured procedure for developing Lean deployment plans for construction projects. The goal of the Lean deployment plan is to ensure that Lean principles and practices are embedded into the processes performed on each project to better deliver value for the client, and improve the overall safety, cost, schedule, and quality performance on the project. This paper is the first step toward defining a procedure, grounded in both practice and theory, to improve the lean deployment planning process.

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1. Introduction

The origin of Lean comes from the management principles followed by Toyota, where Taiichi Ohno and Eiji Toyoda developed the Toyota Production System (TPS) (Liker, 2004). The core philosophy of TPS was adopted by other organizations to deliver value to customers by eliminating waste, which later began to be known as the Lean Production System (LPS). Consequently, Lean principles were adopted by many other industries, including construction, to benefit from the principles set in motion by Toyota (Howell, 1999).

The term 'Lean Construction' was introduced in 1992 by Lauri Koskela and defined as a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value." Followed by the adoption of Lean principles in construction, several methods and concepts were tailored towards the unique needs of the construction industry (Mossman, 2009), such as the Last Planner System (Ballard, 2000) and the concept of target value design based (Lichtig, 2005).

Lean is a philosophy and is based on five principles: respect for people, continuous improvement, removal of waste, generation of value, and focus on process and flow (Womack and Jones, 1996). Several methods which embody Lean principles have been more commonly adopted and cited for their value in construction projects, including: The Last Planner System®, Target Value Design, Pull-planning, Big Room, Choosing by Advantage, Gemba Walks, Standardized Work, First-run Study, and A3 Thinking. Some of the other less frequently used methods are: Value Stream Mapping, Plan – Do – Check – Act (PDCA) Cycle, and Set-based Design. There are a variety of other methods and approaches that are associated with Lean in other industries but are not listed here due to their limited adoption into construction.

An organization that chooses to pursue benefits through Lean principles should, ideally, consider a holistic approach at various levels of the organizational hierarchy. This approach is considered more likely to breed success over the project or product level application of Lean methods as a stand-alone tactic. (Koskela et al. 2002). When considering the use of Lean principles on a construction project, although there are significant benefits to partnering with Lean organizations, there is still the need to align the project team as a uniquely assembled group of individuals; due to their inter-organizational nature everyone may not be at the same place in their Lean journey. As part of an initial investigation, a literature review and expert interviews were conducted to investigate the current challenges experienced in the adoption of Lean principles and their application within in the project delivery process.

As noted from the interview findings, while the Lean philosophy and accompanying methods have been implemented in the construction industry for well over a decade, the adoption of Lean into the project delivery process varies in approach and the formal planning of Lean implementation can vary significantly. On a construction project, where the project team composition is typically inter-organizational and dynamic it is challenging to consistently apply Lean principles and methods across the project lifecycle. This challenge has led to the misunderstanding that Lean principles and methods are difficult to implement consistently on a project. The goal of this research is to investigate such challenges and develop a structured deployment planning approach to support consistent implementation of Lean principles and methods in the delivery of construction projects.

2. Background

Findings from literature review and interviews conducted with advanced Lean practitioners suggested that consistency in the Lean implementation depends on contracting strategy, delivery method, project goals, project scale, organization type, owner needs, Lean coach, and team experience with Lean. Considering all of the above, having a Lean coach may be helpful to teams and organizations if they are at the early stages of their Lean implementation process on projects. However, this is not always feasible and despite this support, or for the lack of it, project teams often resort to selectively using methods based on their own awareness of Lean implementation without deliberate planning or subsequent changes to underlying project management processes that typically support project delivery.

The key to success that emerged in the interviews was getting the project teams to understand and start with the 'Why' for implementing Lean first and proceed, rather than starting with the 'Which', 'What', or the 'How'. For example, the questions would be: 'Why' are we implementing the Lean principles (i.e. what do we want to achieve as part of the project goals)? Followed by 'Which' methods can support the answer to the 'Why'? 'What' are the effects of each method (i.e. are the effects what we desire)? Finally, 'How' can we apply these methods to get what we want to achieve as part of the project goals?

Owing to the mentioned challenges that project teams face in consistently designing a Lean project delivery system without significant support and coaching, this research seeks to capture some of the key approaches used by expert individuals and entities. We seek to support project teams as they develop their understanding of Lean and enable them using applying the appropriate methods for their project in a systematic manner. The intent of this research is to provide organizations and their project teams

with a structured Lean deployment plan that is essentially a standardized procedure to implement Lean principles and allied methods on projects more reliably and consistently. The Lean deployment plan is envisioned to support the planning procedure for Lean implementation at a project-level, which is different from Lean implementation at an organizational level.

Lean, by most experts, is considered a way of thinking and behavior that is based upon: respect for people, continuous improvement, removal of waste, generation of value, and focus on process and flow. Although evidently general thinking has settled upon Lean implementation as applying a set of tools, experts and practitioners emphasize that it is much more than that. For successful Lean implementation, there is a need to approach the planning procedure in a systematic and structured manner. The Lean deployment plan is envisioned to support that approach while implementing Lean at a project-level, where teams can benefit from a common go-to reference in the format of a guide.

The Lean Construction Institute (LCI) has valuable resources that share more information about Lean and ongoing research efforts. In their book, *“Transforming Design and Construction: A Framework for Change”* (Lean Construction Institute, 2010), existing methods that embody Lean principles are discussed and explained. For example, “The Last Planner System® brings stability to a project by giving attention to flow while reducing variation in the hand-off of work between the specialists in a continuously improving situation”. In another book, *Target Value Delivery: Practitioner Guidebook to Implementation Current State* (Lean Construction Institute, 2016) the Lean concepts are extended from production to design and construction thus forming a basis for a reformed project delivery process beholding the Lean philosophies. The purpose of the deployment plan is to support project teams when planning for the application of these Lean principles and methods in a systematic way.

3. Objectives and Methods

The overarching goal of this research is to enable project teams to implement Lean principles and methods on a project-level in a systematic and structured manner. To support this goal, three primary objectives have been identified:

- 1) To assess the Lean practices that are currently in place throughout the construction industry to assist project teams in developing their Lean plan using methods that support Lean principles;
- 2) To document the procedures to be followed and test the implementation on a project; and,

- 3) To formalize the documented procedure into the 'Lean deployment plan', also referred herein as the 'Lean plan'.

It is envisioned that as project teams follow the defined procedure, the project-related decisions and planned implementation process will be captured in this plan.

The first objective (to assess current Lean practices observed in the construction industry) was achieved by conducting open-ended interviews with 15 Lean experts, who are also advanced industry practitioners in the deployment of Lean on construction projects. Advanced industry practitioners were identified through the support of the Lean Construction Institute (LCI) Research Committee members. Recommended individuals were invited to participate. Fifteen individuals were interviewed using a semi-structured questionnaire focused on Lean implementation on projects. individuals were interviewed using a semi-structured questionnaire focused on Lean implementation on projects.

Interview participants represented a diversity of company types including design and construction firms (57%), owners organizations (29%), and consulting companies (14%). The participant sample are considered experts and advanced practitioners of Lean principles and methods, and many participants represent the role of a Lean coach on projects. Due to their significant experience in construction industry as a whole (between 8 and 45 years) as well as Lean (between 5 and 25 years), their insight is particularly valuable to this study. More than 70% of the participant sample represent more than 10 years of experience and are considered experts by the Lean community in practicing Lean principles and applying methods that embody such principles.

The semi-structured questionnaire used during the interviews sought information on several aspects critical to the areas that support Lean implementation on a project-level. In an effort to identify the gaps and opportunities in project-level implementation, the interviews focused on:

- initiation and development of a project plan aligned to Lean;
- discussion of the methods and tools representing Lean principles commonly deployed into projects;
- influence of different project delivery methods and contractual considerations;
- approaches to documenting and communicating the plan to project team;
- implementation of the project plan;
- common challenges associated with Lean implementation in present day; and,
- future needs to support a consistent and systematic deployment of Lean principles on construction projects.

The interview questions are included in Appendix A.

The interview transcripts were analyzed using formal content analysis. Each interview was audio recorded. Information gathered from each interview was translated into a content map structured by categories consistent to the interview focus areas. The content under each focus area was then summarized from all interviews to form a summary content map arranged in categories using those same interview topics. This was performed by consistently reviewing the interviews to capture all content related to each focus area based on uniqueness, similarity, and frequency with which it was included in the interviews. to encompass the breadth of all information provided by the interviewees in a cumulative and descriptive manner. The summary content map thus represents the insight from all the experts that contributed to this initial study. The following section presents the interview findings organized by focus areas.

During and following the expert interviews, an initial procedure has been developed to represent a structured approach to planning Lean deployment at a project level, titled the 'Lean Deployment Planning Procedure'. It is interesting to note that the terminology related to Lean deployment was identified throughout the interview process as well as in preliminary discussions with LCI's Research Committee members and advanced Lean practitioners. This draft Lean Deployment Planning Procedure will continue to be developed and expanded through future research to achieve the second objective of this study. Future plans include additional investigation into the various steps within the process, and testing those steps in pilot project case-studies to achieve the third objective of this study. Process-improvement domains such as Lean Six Sigma (LSS) and the Project Management Body of Knowledge (PMBOK) are reviewed to identify overlapping patterns associated with project-level implementation of Lean principles and methods and, provide a foundation for our research encompassing the best practices from allied domains of project management and continuous process improvement. Based on findings from pilot case-studies and additional investigation, the medium to develop the Lean deployment plan will be finalized.

4. Interview Results

Summary of Current Practices in Planning Lean Deployment for Projects

The following sections summarize the common elements that emerged across the discussed stages of Lean deployment into projects. Leading best practices that build upon such elements are discussed with regard to the adoption and implementation of Lean principles and methods in the industry. As noted earlier, the interview findings revealed that Lean implementation is not consistent across organizations or projects and, depends heavily on specific project goals, team experience with Lean principles, and the contractual arrangement on a project. Common elements that emerged from the interviews that improve greater consistency to some extent are:

- establishing a project plan at project inception;
- performing Gemba walks (direct observation) to evaluate if Lean is actually being practiced on the project;
- on-boarding team members early;
- providing coaching on Lean principles; and
- tracking alignment by conducting follow-up surveys among project team members having them self-report their behaviors throughout project delivery process.

Despite these efforts, challenges in achieving the desired consistency in application of Lean principles and methods on a project level still persist as project teams are temporary organizations and comprised of people from different professional background and cultures. Further expanding from these insights, key interview findings are summarized in the following paragraphs.

One of the most prominent strategies for project teams pursuing Lean was to conduct coaching at the project initiation phase. Although coaching during initiation is critical to increasing project team's awareness to Lean from the start, it is also important to continue with mentoring and supplementary training sessions. This is often conducted as part of big-room events or workshops to maintain the previously established goals. Team buy-in is considered critical to Lean implementation, and techniques to do this included team-building activities, Lean coaching, demonstrating cost-savings, word of mouth, and shared stories from leaders.

Evaluation of methods to track alignment with Lean principles on a project showed that two (owner) organizations used a scoring system based on previously established metrics that helped evaluate Lean projects and team performance. This performance score was tied to profit earnings at project completion in some cases. Other methods

included self-reported surveys and project pull plans. The metric categories that were tracked in both cases included:

- Level of adoption,
- Number of collaborative design reviews on a project,
- A3 thinking and decision-making,
- Target value design,
- Alignment with Lean values,
- Change in behavior,
- Continuous improvement,
- Team health (surveys),
- Phase planning,
- The Last Planner System®,
- Prefabrication,
- Lean learning, and
- Shared savings.

It was expressed that some metrics are harder to track than others such as BIM use, collaboration, retrospectives, Lean coaching, big-room, IPD use, soft start, interactive planning, and team qualification on Lean expertise.

When considering the impact of project delivery method on Lean implementation, the key driver is the contract structure. Alongside the contract structure, based on the project delivery strategy, three levels of Lean implementation were pointed out, level three being the most supportive. First, where the project delivery methods such as design-build or construction manager-at-risk are partially supportive as they limit the project teams' choices with regard to Lean implementation with methods such as the Last Planner System® (LPS), where LPS® focus on workflow reliability and coordination on the construction side from week to week and therefore, cannot do more due to limitations in the contract between design and construction. Lean can still be implemented on design-bid-build projects despite the inherent boundaries between design and construction, however the applications are highly restricted due to inherently fragmented project team structure. Second level, which is more supportive than level one is when the owner allows early involvement of stakeholders, i.e., in pre-design and not just pre-construction. This is driven by the owner's interest in having the construction management inform the design providing input versus request an output from the design. For example, a 'production system design' would be a Lean practice given that production is being considered during design, which is proactive versus 'constructability review', which is an after-fact of design development.□ Third, when the project is structured upon relational contract, e.g. integrated project delivery or integrated form of agreement and, involves all stakeholders jointly sharing the project risks and rewards. Such projects are considered most supportive of Lean due to their integrated contract structure allowing the production system to be integrated through the supply chain.

In summary, the leading best practices in the adoption and implementation of Lean principles and methods are identified from discussions with advanced industry practitioners. Each practice is considered in the design of the planning procedure as

shown in the following section named 'The Design Approach to Lean Deployment Planning Procedure'.

Challenges to Lean Adoption at a Project Level

Based on insights gathered from literature review and interviews, it is evident that the concept of Lean is beyond the mere use of tools and is grounded in the principle: 'respect for people' above all and, thrive upon successful application of strategies and methods that support waste elimination, value creation for customers, and continuous improvement at all levels. Experts believe that Lean is inherently applicable to any unit of action whether at a task-level, a project-level, or at an organization-level. Projects uniquely relate to tasks as well as organizations since, projects are essentially task-based, which can be bundled in multiple ways to show responsibility, phases, etc. and, the project team is essentially a temporary organization that is active for as long as the project is on-going. This renders a project as a group of organizations, coming together, to develop and build a series of integrated systems by performing specific tasks. Resolving the challenges to adoption of Lean principles and methods on a project-level should naturally encourage the adoption of Lean within the construction industry as a whole, by allowing member organizations to see direct benefits from Lean implementation. The goal of this study is to contribute to minimizing the Lean adoption challenges identified and, mentioned in the following paragraphs, by designing the procedure to plan Lean implementation on a project-level.

Results from interviews show that adoption of Lean principles and methods at a project-level is currently hindered by several causes, such as lack of supportive infrastructure, lack of leadership buy-in from project team member organizations and owners, lack of a standardized on-boarding strategy, lack of assigned project budget to support the coaching and training needed to truly benefit from Lean, and lack of systematic thinking towards Lean implementation on projects.

To transfer Lean principles, grounded in theory, to methods in practice, a supportive infrastructure can be initiated by pursuing three things:

- 1) Having clear working definitions of all Lean related terminology;
- 2) Relating all Lean terminologies to a sound structure that differentiates the Lean principles systems, Lean systems from methods, and Lean methods from Lean tools distinctly; and
- 3) Defining a process that gives Lean implementers a starting point to initiate planning for Lean on a project-level.

As noted earlier a project team represents a group of organizations that come together to build a series of integrated systems and sometimes the resistance comes from the organizational leaders with regard to Lean implementation and not the project leaders. Therefore, unless all member organizational leaders are convinced with a well-defined Lean plan, seamless implementation will remain a challenge. Lean experts, from their experience and interaction with organizations, have found that a clear and well-defined strategy to Lean implementation from project inception is beneficial in helping organizational leaders understand the commitments required. Once the project team has leadership buy-in, it contributes in multiple ways to build a supportive infrastructure for Lean implementation downstream.

Experts recommend that providing Lean training during initiation and on-boarding project team members is critical to increasing the project team's awareness to Lean from the project outset. It is also important to continue with supplemental coaching, mentoring, and training sessions via Big-room events and workshops to maintain alignment with the previously established project goals and objectives. Although primary stakeholders or contractual parties are engaged earlier in most projects, some members may be on-boarded later in the design or construction process. Despite the timing of their involvement or the scope or role in the project overall, they may have a significant impact on project outcomes through shared understanding of the project plan. Although new members may not receive as thorough training as earlier cohorts at project initiation, they still need to know the past on the project to better align themselves to the present and the future. To enhance on-boarding strategy along the project lifecycle, some organizations initiate mini on-boarding series in phases, which rely heavily on the visual management techniques, such as Big-room displays.. This is helpful when there are limited resources to conduct on-boarding sessions, especially for the less experienced teams.

In conclusion, responding to the identified Lean adoption challenges and future needs is envisioned as the most promising path to maximizing a successful Lean implementation on a project-level. The following section highlights the future needs suggested by the Lean practitioners.

Planning Steps from Lean Expert and Industry Practitioner Interviews

When asked about Lean implementation for new projects, there were diverse suggestions gathered. However, there were six elements that often emerged from the interviews. The emergent elements will serve in part as the basis for determining the scope and approach to the planning procedure. The common elements cited include: 1) identifying and organizing the project team members and stakeholders; 2) identifying the project delivery strategy; 3) conducting a Lean project kick-off; 4) mapping the

project delivery process; 5) identifying methods and processes to support project objectives; and, 6) tracking the alignment with the plan to support continuous improvement. The following section breaks out the information garnered from the interviews regarding the 6 elements in more detail.

1. Organize project team members and stakeholders

The process of organizing the stakeholders and team members for a project differs greatly from project to project. While the exact ‘who’ for each project varies, it is important to identify the stakeholders and service providers most affected in the programming, design, construction, and operations of the facility in question. In addition to identifying those affected, it is also important to engage those stakeholders that can change and influence the implementation process. If key stakeholders are not engaged in the planning and adoption, it can lead to critical breakdowns when it comes to implementation of Lean into a project. As one expert noted, in referring to work from Robert Fritz’s book The Path of Least Resistance, ‘structure determines behavior’ – suggesting that people inherently learn how their work is structured and organized, and they play to the incentive, roles, and measures that are created to align their work with their firms goals. Thus, to influence how people behave and support their role in Lean projects, the structure needs to be made clear to the firms and individuals to align the Lean process and to match the incentives with project goals and objectives.

2. Identify the Project Delivery Strategy

One of the most commented elements from the experts was the importance of the delivery strategy and contract in supporting the team and process for adopting Lean into the project. Almost unanimously the experts endorsed the use of Integrated Lean Project Delivery (ILPD), however many noted that this was far from the most common option used in industry. As one expert noted, “You can do (Lean) in any contractual arrangement, such as Design-Bid-Build, but it’s difficult.” The project delivery strategy serves as one of the first and most important decisions by the owner to help align the motivation and incentives of the designers and contractors toward supporting the ultimate value the owners and clients are seeking from the desired facility.

As one of the experts noted, less integrated project delivery strategies inherently limit some of the principles and engagement needed in adopting Lean. Despite these limitations, it was still suggested that some principles and methods can, and should, still be pursued to improve reliability of the process, such as the use of Last Planner. In addition, owners and teams interested in employing Lean need to be proactive and make their plan as clear to the firms pursuing the project as possible. This can be

simple, with a request regarding defining experience and Lean training in the request for qualifications (RFQ) or proposals (RFP).

3. Conduct a Lean Project Kick-off

The kickoff of the project was frequently noted as a key opportunity for engaging the project stakeholders with the Project Delivery Strategy. Sometimes referred to as a 'soft-start' the experts commented on the need for a workshop, typically spanning several meetings or days, with some of the workshops spread out through the project. The workshop should target orienting and training the project team in Lean, ensuring a consistent minimum understanding and familiarity with Lean principles, and the alignment of terminology needed to allow project team members to successfully participate. Critical to these workshops is the need for a coach or facilitator experienced in Lean that works with and stays with the project team to support their adoption of Lean.

In addition to the project overview and discussion of the approach, the workshop should have a strong focus on education and planning that engages the team members. The focus should be on 'Why' Lean is being adopted and ensuring a consistent vision that helps support the follow-on planning and implementation of Lean. In addition, the training and activities in the workshop are also often cross-purpose by also serving as team-building activities that can parallel the learning with the familiarization of the team members with each other. This creates interpersonal engagement amongst the team members, and through the activities it creates shared experiences and vocabulary that can reinforce the Lean principles moving forward.

It was commonly emphasized by the experts the need to emphasize the philosophy and principles of Lean, rather than specific tools or methods. Their experiences highlighted that the focus on methods was a recipe for failure when not properly underpinned by driving understanding for why the tools were being used. After the understanding of 'Why' is clear in the project context, the 'How' for the targeted processes can be customized to the project and stakeholders, followed by the implementation of the behaviors, practices, and methods identified.

4. Identify Lean Methods to Apply

Experts commented on the need to apply specific methods as elements to support Lean Principles on a project. As such, the experts were often hard pressed to create explicit rules or timing for the different methods to be implemented. Emerging from the interviews, there were some methods that were more common than others, with Last Planner and Target Value Design noted as some of the most commonly adopted methods. In addition, the other methods and techniques were discussed in slightly

different contexts that led to broad categorizations that may be helpful in orienting project team to the various ways the methods and techniques can support the application of Lean Principles.

Thus the Lean practitioners familiar are able to suggest the methods or techniques, but had difficulty defining universal rules for novices to be able to quickly and easily select or adopt them. For example, some activities are performed one time, and the overall process can be mapped as a discrete process, e.g., the performance of discrete work activities in the field. Other processes are performed on a cyclical basis, e.g., the cycle that we see in the implementation of the Last Planner System, or leveraging an Agile approach toward design management with defined, cyclical sprints. There are other Lean strategies that are instantiated based upon certain conditions or opportunities within a project that highlight an opportunity to leverage Lean strategies to improve a process or make an effective decision, e.g., leveraging A3 or visual management approaches to make a specific decision or communicate a process. These strategies first require the identification of the opportunity to leverage Lean principles, followed by the process for performing the method or technique. Some methods are used when working on a specific problem, for example, Choosing-by-Advantages is used to help make complex decisions involving trade-offs between alternatives that need to be explored systematically

It is also interesting to note that some Lean strategies are an approach toward performing a typical project management process where the process is changed due to a Lean approach, e.g., projects have typically developed look-ahead schedules, but the Last Planner System allows for a different approach toward performing this process. In this manner, the actual goal of the task has not changed, although you may say that it has become more specific and refined, but the method to achieve the goal is. Other Lean strategies require the addition of project processes or tasks to achieve a new goal. Examples include the Target Value Design approach, or the creation of visual dashboards. These tasks do not need to be performed in the management of a project, but the additional use of the strategies is viewed as an opportunity to improve the management and delivery of a project through Lean principles. Due to this variation in application, it is critical to design a standard approach, which can support increasing adoption of Lean into projects.

5. Map the Process

One of the methods given high value and priority by some experts for engaging the stakeholders and improving the transparency and understanding of Lean is through process mapping. The specific methods of process mapping varied, but the key was to facilitate the team to engage in defining their target processes. Process mapping serves

to help define the expectations of the team, to clearly communicate the planned methods and tasks, and to help identify the needed engagement of different stakeholders and their roles in supporting key decisions. The development of the process map also serves as a baseline against which the team can refer back to as they progress, both in tracking their progress and serving as the baseline plan when identifying opportunities for improvement (this is similar to the Lean six sigma 'measure' phase and PMBOK 'planning' phase as identified in the literature). Finally, process mapping also supports communication amongst the team members, both in teaching them methods for communicating their tasks and deliverables that are often abstract, as well as on-boarding new team members mid-stream.

6. Monitor the Plan / Continuous Improvement

Once the initial plan and processes have been developed, the process is far from over. One of the key principles that needs to be embedded is the drive for continuous improvement. There were a variety of approaches discussed regarding how to embed this principle, but it was highlighted in nearly every interview. First, coaching was commonly mentioned as a technique of both pursuing improvement and providing ongoing support for the implementation of Lean. Another approach that aligns with ongoing coaching was the idea of having mini-training sessions with the team on a rolling basis. The training sessions can be used to introduce or re-fresh on strategies, methods, and techniques supportive of Lean principles, but can be timed to support changes in project phases or upcoming events or decisions. Some teams and owners created scorecards or dashboards that are tracked and reported as a means of observing common metrics or topics for consideration on a consistent basis throughout the project. The monitoring approaches can be tied to 'team-health' surveys that report self-perceptions of the team regarding how specific efforts are progressing, or they can pull key performance indicators (KPIs) from ongoing techniques, such as planned percent complete (PPC) from Last Planner implementation. One final strategy noted was the creation of study action teams that bring together diverse team members to help plan and track performance in different areas. For example, one study action team was created to track productivity in construction, but by engaging different trades and designers the team members learned how key interactions from design and different trades influence the implementation of one trade in the field, while also bringing new and creative perspectives to the trades means and methods for construction.

5. The Design Approach to Lean Deployment Planning Procedure

Any process is essentially a sequence of varied tasks with a defined start and finish to accomplish a goal or an objective. Every process is unique and thus requires committed planning towards achieving specific goals and objectives. Key sub-processes identified from interviews with regard to Lean implementation for new projects included:

1. identifying and organizing the project team members and stakeholders;
2. identifying the project delivery strategy;
3. conducting a project kick-off;
4. mapping the project delivery process;
5. identifying specific processes and methods that would support project goals and objectives; and,
6. tracking the alignment with the project plan to support continuous improvement.

In the project management body of knowledge (PMBOK), the process of managing a project has five phases: initiating, planning, executing, monitoring and controlling, and closing. Therefore, when designing the process for planning Lean deployment on a project, alignment with the five phases of project delivery makes it intuitive for project teams. Additionally, aligning the planning process with process improvement initiatives, such as Lean Six Sigma, offers further opportunities for efficiency and effectiveness of the approach through Lean principles. Therefore, the design for the Lean Deployment Planning Procedure is based on the information gathered from the three cornerstone topics overlapping in theory: Lean principles and methods, project management processes, and Lean Six Sigma techniques. The intent towards using this approach is to take the best from the project and the process worlds and, apply them in the design of a planning process to enable project-level deployment. The following paragraphs present a summary of the content leveraged from the three cornerstone topics. The next section describes in more detail the integration of these overlapping areas that support the design of the Lean Deployment Planning Procedure.

Based on the literature review and the interview findings, the Lean principles and methods have been summarized in this paragraph. Lean implementation focuses on holistic optimization of the five principles: respect for people, continuous improvement, removal of waste, generation of value, and focus on process and flow. These principles are embedded on a project by using methods like: pull-planning using the Last Planner System, reliable promising, using an integrated form of agreement, groups clustering, hand-off work planning, daily huddle planning, production system planning and design, collaboratively planning for budget management, value stream mapping, work structuring, continuous estimating, and A3 thinking for decision-making.

Detailed steps on how to apply these methods are included in the literature sources published by the Lean Construction Institute. The process designed herein represents a method for selection of such methodologies and their detailed application are beyond the scope of this document.

The **Project Management Body of Knowledge (PMBOK)** is a well-known resource in the project management profession. PMBOK represents the project management life-cycle as five distinct phases: initiating, planning, executing, monitoring and controlling, and closing. Along the five phases, the project management process focuses on project constraints relating to scope, quality, schedule, budget, resources, and risk. The **initiating** phase is when the specific project is defined based on input from all stakeholders, a project charter is developed, and a budget is established. The project charter is used to begin the **planning** phase and a project execution plan integrating all the constraints is developed by the project team. The purpose of the project **execution plan** (PEP) is to capture the project goals and objectives or requirements and transform them into strategic actions that can be taken to achieve the desired project outcomes. The PEP typically branches out to a more detailed management plan for project scope, time, cost, quality, risk, procurement, communication, and human resources. The purpose of the detailed management plan is to help the project team understand the steps that they need to take or the methods they need to follow to manage project constraints and to pursue the project goals and objectives along the project delivery process. A longer list of the project management processes, their key inputs, and their key outputs can be found on the website - (<http://www.itinfo.am/eng/project-management-body-of-knowledge-pmbok-guide/>). The process designed herein will also use a similar phased process addressing the project constraints for the Lean deployment planning on a project to maintain alignment with the project management body of knowledge and render a stronger foundation in theory and in practice.

Lean Six Sigma (LSS) is a marriage between waste elimination (Lean) and variation reduction (Six Sigma) to improve quality of a product and the product development process. The implementation of LSS follows a process similar to Six Sigma's process that includes the phases: define, measure, analyze, improve, and control (DMAIC) to improve existing processes (Abdelhamid, 2005; Basu, 2008). For new processes, the DMADV methodology is preferred as it is inherently designing for six sigma (DFSS). The key distinction between DMAIC and DMADV/DFSS is the last two phases, which is design and validate for the later. The 'define' phase focuses on defining the project thus leading to the completion of the project charter as a key deliverable. The 'measure' phase focuses on establishing the project baseline and setting up measurement systems by transforming the requirements from the project charter into a structured appraisal process. The 'analyze' phase focuses at the variation sources and distinguish between special and common causes of variation in a process. Common cause

variation leads to major changes and special cause leads to minor changes to a process. The 'improvement' phase focuses on addressing the identified variation sources and finally the 'control' phase involves applying solutions to eliminate such variations. The 'design' phase focuses developing detailed design for process or product from concept. The final phase 'validate' in the DMADV / DFSS is to pilot test the designed prototype and record lessons learned for future improvements.

Concluding this section, the principles, methods, and best practices from the three cornerstones: Lean, Project Management, and Six Sigma were gathered and applied to support the design for the Lean Deployment Planning Procedure. The following section describes the preliminary design for this process in further detail.

6. Lean Deployment Planning Procedure - Exploring a Theoretical Foundation

While several elements were commonly proposed by Lean practitioners, there was not a consistent process identified. Therefore, a more detailed analysis of the various theoretical foundations is presented for the development of an integrated approach for the Lean Deployment Planning Procedure at a project-level. Based on the theory and origins of each theory, there is significant overlap amongst Lean principles, Lean Six-Sigma methodology (LSS), and the project management body of knowledge (PMBOK) from PMI. This overlap is mapped using elements extracted from the interviews and literature to show how the Lean process and Lean methods can begin to align to a project planning procedure to support Lean implementation. Per insight from Lean practitioners, the identified planning elements are also considered in the frameworks to show the significance of the overlap and demonstrate relationships among the three domains. These initial mappings will be further developed in support of the process of refining the procedure for adoption into projects.

Connecting Lean, Six Sigma, and The Project Management Process

There are many connections among Lean Principles, Lean Six Sigma Methodology, and project phases defined within PMBOK.

Integrating Lean, Six Sigma and Project Management Phases at a Project Level

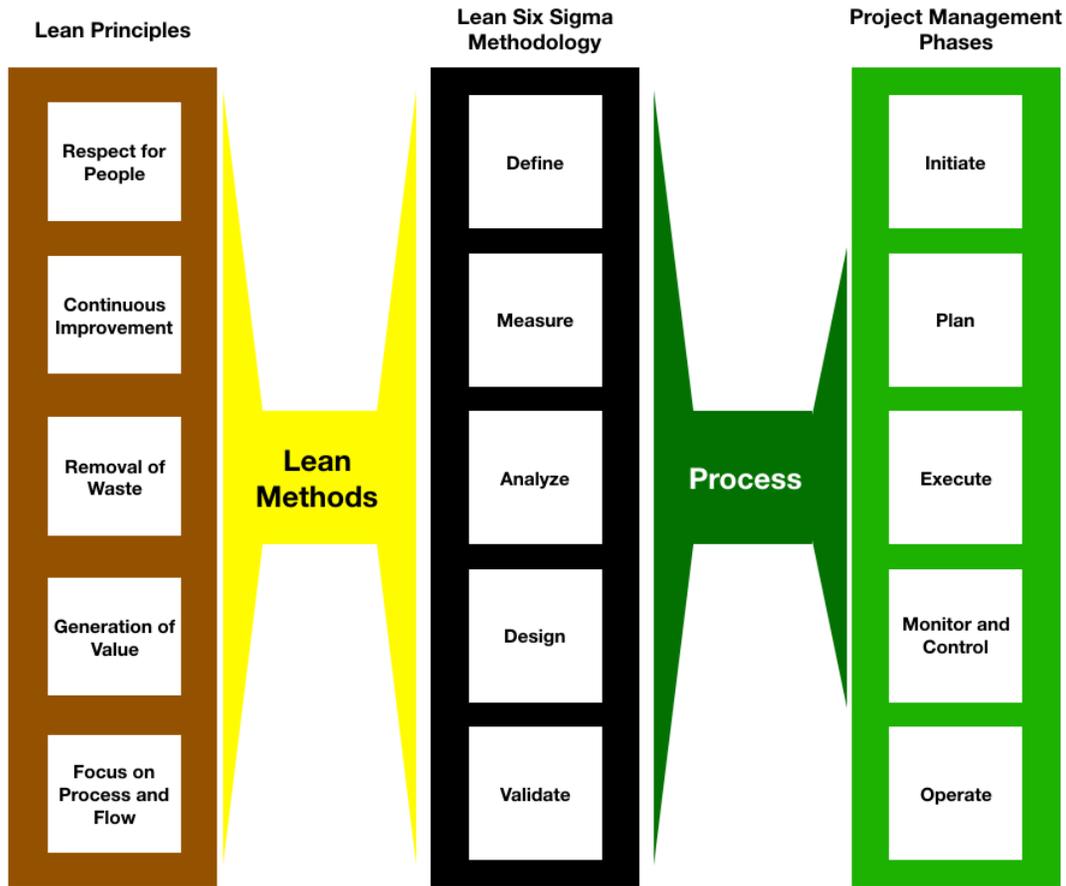


Figure 1: Framework for Integrating Lean, Six Sigma and PMBOK Concepts at a Project Level

Figure 2 maps the five common planning steps and some additional practices that emerged from the interviews along the project management phases. The five phases are shown across the top, on the arrow. The boxes that are aligned under each phase are Lean elements, expanded beyond the five most common, that should occur in those phases based on the context provided in the expert interviews. In particular, this representation helps clarify the ‘Plan Project’ elements related to the development of a Lean deployment planning procedure for projects. Elements such as partner selection and delivery strategy are quite important to the potential success of Lean implementation on a project, however they are often considered in advance of the specific project plan where more detailed Lean methods are integrated into the execution of a project. In considering the planning phase, six elements stand out – selection of Lean methods, determining the application strategy for those methods, designing the Lean process specific to that project, defining metrics, developing the education and training plan / requirements, and documenting and disseminating the plan.

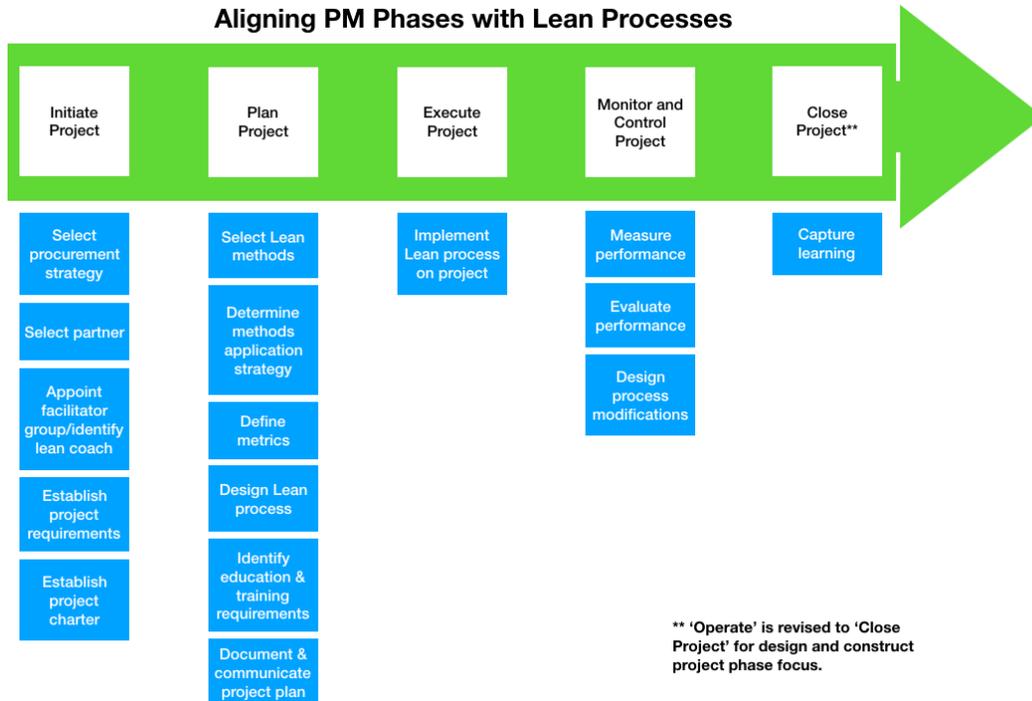


Figure 2: Aligning PM Phases with Lean Processes

Figure 3 shows a different representation of the mapping of the detailed planning tasks to support the development of a Lean Deployment Plan for a project.

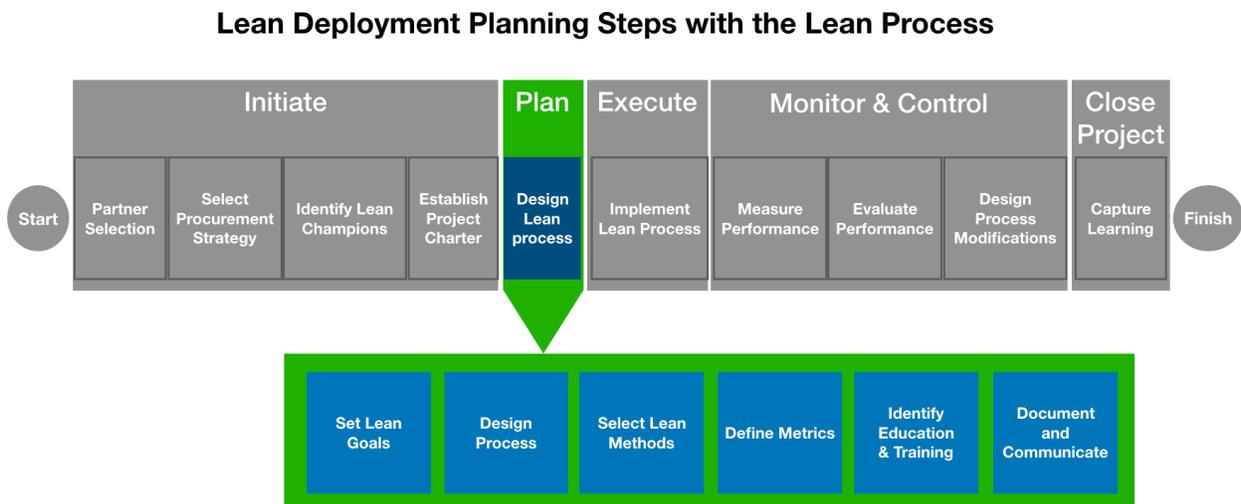


Figure 3: Lean Deployment Planning Steps Including Lean Planning Process

Structuring the Lean Principles, Strategies and Methods

A critical step in the planning procedure is the identification, evaluation and selection of Lean methods to integrate within the process. To perform this step, it is important to provide a structure to frame the questions that need to be answered by the project team. Throughout the industry interviews along with analysis of literature, it became clear that there was not a consistent framework to support the definition of the intersection of Lean principles with the specifics of implementation at a process level. Figure 4 shows an initial effort to being mapping the Lean principles with some potential strategies and corresponding methods. While Figure 4 only includes several methods, the goal within the next phase of development will be to provide a resource for teams to identify the methods they implement. We will develop a clear taxonomy that documents the types of methods, when they will benefit the project, and a structure for making a decision regarding their implementation on a project.

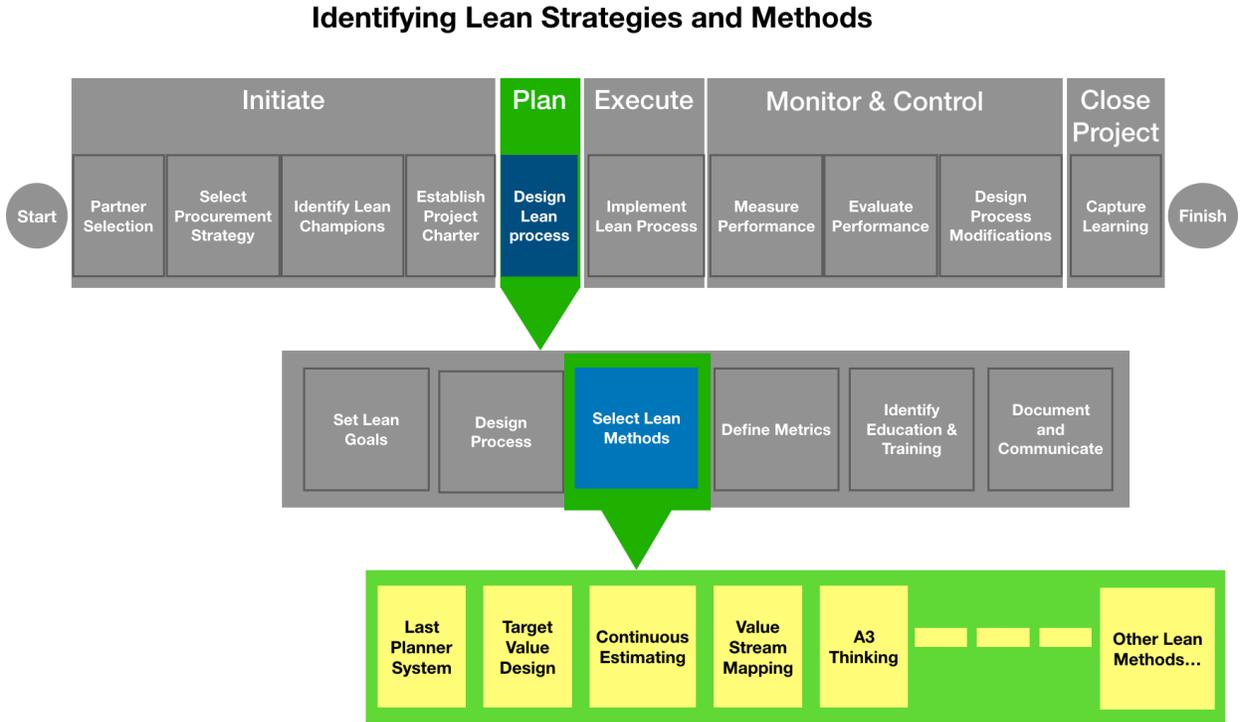


Figure 4: Identifying Lean Strategies and Methods

7. Draft Lean Deployment Planning Procedure

From the interviews, background analysis, and through additional research efforts, we have developed an initial structure for the Lean Deployment Planning Procedure. This procedure is specifically focused on the 'Plan' portion of the Lean implementation process (see Figure 4). This planning procedure will consider impacts of procurement method selection and team partner selection, with a focus on how these decisions influence the ability to implement Lean strategies and methods on a project.

The initial structure for the Procedure contains the following steps:

- 1) Define Goals for Lean Process;
- 2) Design Implementation Process;
- 3) Select Lean Strategies and Methods;
- 4) Define Metrics and Timeline for Continuous Improvement Evaluation;
- 5) Identify Education and Training Needs; and
- 6) Document and Communicate Plan.

These steps will be further developed and refined throughout the next phase of this research, and documented in the Lean Deployment Planning Guide. The procedure and Guide will be developed through an Agile approach, leveraging significant industry involvement and feedback.

8. Concluding Remarks and Next Steps

Our initial evaluation of the approach that practitioners use to plan their implementation strategies on projects illustrated a lack of consistency in the approach to Lean implementation on projects. This lack of standard procedures for planning hinders Lean adoption, but also is a source for inefficient resource utilization. The goal of this study is to respond to this gap by proposing an integrated approach to planning and designing the Lean implementation process on a project level. In this paper, an initial version of the process and foundational research is explained, and future steps are identified based on findings from interviews with Lean experts along with additional sources. As part of our future work, a detailed procedure will be developed by targeting the underlying steps of Lean implementation and designing a structure procedure for planning Lean deployment on a project. An exhaustive set of methods will be identified that target Lean methods, built upon Lean thinking and principles. The developed process and methods will be tested on pilot projects, and Lean experts who previously participated in the interviews along with others will be contacted to gather feedback to

further improve the procedure and deployment planning templates before final release of a Lean Project Deployment Planning Guide.

Acknowledgements

We wish to thank the Lean Construction Institute for their support of this research and development activity. We also wish to thank the LCI Research Committee and specifically the Lean Deployment Planning team, including Glenn Ballard, Tariq Abdelhamid and Clarence Waters. Finally, we wish to thank the industry experts who shared their insights and experience.

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Appendix A: Interview Overview and Questions

Project Summary (Overall goal and objectives of the project)

You have been selected to speak with us today because you have been identified as someone who is a core Lean implementer within design, construction, and/or owner organizations. Our research project focuses on the development of a structured Lean construction strategies planning procedure that a team can implement at the early project stages to leverage Lean strategies and tools, e.g., last planner, target value design, value stream mapping, etc. Once a team follows the planning procedure, they will be able to document a project plan with embedded Lean strategies and approaches. As part of the research, we want to learn about the approach used by you when deciding which Lean methods and strategies to implement on a project, along with how you plan the implementation. We also want to learn about your approach toward assessing the value of implementing these practices, along with project criteria which influence your decisions.

Introductory Protocol Script

Interviewer Background (3 min)

- What is your name and affiliation?
- What is your current role and how long have you held this position?
- How long have you been working in the construction industry?
- How long have you been associated with Lean or used Lean practices?

Lean Process Design on a Project (20 min)

- How do you design your Lean process for a new project?
- Do you use a consistent process on all projects, or do you adapt a different approach to each project?
- What steps do you typically follow when determining your Lean process?
- Who should be involved in the development of the Lean process design? How long does it take to design your Lean process for the project?
- How does the project delivery strategy influence your approach toward Lean process design?
- Which Lean tools do you implement on your projects, with frequency (always, frequently, sometimes, rarely, never)?
 - Planning Tools: Value Stream Mapping, Big Picture Mapping, Last Planner, Standardized Work, Short Interval Production Scheduling (SIPS)
 - Decision Tools: House of Quality, Choosing by Advantages, A3 (A3 thinking), PDCA Cycle, 5 Why's, Set-based Design
 - Continuous Improvement Approaches: Quality Circles, Ohno Circles, 5 S's, Spaghetti Diagrams, First Run Studies, Gemba Walks

Lean Process Documentation and Communication (10 min)

- How do you document the results of your Lean process design for each project?

- Do you use a standard template for documentation?
- Do you leverage visualization tools in the documentation?
- Would it be possible to receive an example of the Lean process design?
- How do you communicate the plan to all the team members?

Lean Process Implementation (15 min)

- What steps do you follow to execute the Lean process design?
- How do you ensure that your designed Lean process is implemented consistently throughout the project execution?
- How do you determine the training strategy for people on the project, for example, training content, frequency, and delivery approach?
- How do you measure the level of success for adoption Lean approaches on a project?
- How does the implementation evolve as the project proceeds through different phases?
- What are important considerations to get team buy-in and adoption to practice Lean?

Future Suggestions and Needs (10 min)

- What are your biggest challenges in designing your Lean process for projects?
- What additional resources would you like to see from LCI or other organizations to help support the Lean process design?
- Do you have any additional suggestions or information that you would like to share with us?

Plus / Delta: (2 min)

- What did you like about this interview, and what could we do better?

Thank you!