

Key Planning Steps Enabling Systematic Lean Implementation on Construction Projects

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Abstract

Question: Are there any existing processes defined specifically for planning Lean implementation on construction projects? What steps can project teams use to plan for a systematic Lean implementation on construction projects?

Purpose: Enable project teams to plan for systematic Lean implementation on construction projects and establish alignment by developing a project-specific Lean plan documenting shared vision and strategy. Define a process for the construction industry to approach planning for Lean implementation on projects consistently.

Research Method: Information related to several aspects of project level Lean implementation is gathered from the review of 42 published research studies and 16 semi-structured expert interviews. This information is organized and analyzed using content analysis. A common process is defined from this analysis, including the steps and strategies that support systematic Lean implementation at the project level.

Findings: Six key planning steps were found to enable systematic project level Lean implementation. These steps include determining the project delivery method, organizing the project team, conducting a formal Lean kick-off, strategically selecting Lean methods for implementation, developing the project-specific Lean plan, and tracking alignment to improve continuously. Several strategies aligned to these steps are also included to offer support during the planning process.

Limitations: Although the steps and strategies can be customized by an organization choosing to implement Lean on all their projects, this study mainly focused on Lean implementation at an individual project level to assist a typical construction project team.

Implications: Lean has been implemented in the construction industry since the 1990s, but the collaborative and consistent planning on a construction project remains a challenge. This study provides a starting point and the origin of a process benchmark.

Value for authors: Share the identified key planning steps enabling systematic Lean implementation with academia and industry for improving Lean adoption on construction projects. Provide a basis for future research.

Keywords: Lean Construction, Lean Implementation, Planning, Construction Projects,

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Project Teams.

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Introduction

'Lean Construction' also known as Lean Project Delivery, is defined by Abdelhamid (2009) as a respect and relationship-oriented holistic project design and delivery process with the overarching aim of maximizing value for all stakeholders; it emphasizes and realizes the customer's voice through systematic, synergistic, and continuous improvement in all aspects such as contractual arrangements, design development, construction process design, methods selection, supply chain, workflow reliability on the job-site, post-construction operations, and maintenance. The general thinking has settled upon Lean implementation as applying a set of Lean methods, but Lean construction experts emphasize that it is more than that (Howell and Ballard, 1998; Chesworth, 2015). For effective implementation of Lean, the planning process needs to be approached in a collaborative, holistic, and systematic manner (Howell and Ballard, 1998 and 2008; Howell, 1999; Alarcon and Seguel, 2002; and Marhani et al., 2013). Construction being a project-based industry, there is potential for project teams to benefit from such planning at a project level. However, due to the dynamic, inter-organizational, and temporary nature of typical construction project teams, every member is not at the same level in their awareness and understanding of Lean principles and methods (Alarcon and Seguel, 2002; Kim, 2002; Kim and Park, 2006). Therefore, when considering the use of Lean methods on a construction project, alongside significant benefits to partnering with Lean organizations, there is still a need to align the project team with a shared vision and strategy by developing a project level Lean implementation plan (Alarcon and Seguel, 2002; Chesworth, 2015; Kim, 2002; Kim and Park, 2006). The premise of this research was to specifically address the 'planning' for Lean implementation on a project level, which limited the scope of this work to Lean implementation planning and execution is considered the phase following the planning phase. Also, project level planning was the primary focus of this study, thus eliminating organization-specific planning from the scope. Denoting both scope limitations, this study identified a set of planning steps that emerged from a combination of literature review and interviews with Lean practitioners. These steps approach 'planning' for Lean implementation as a distinct process, using which the project team can develop a project-specific Lean plan prior to and for 'execution'.

Literature Review

Why Implement Lean on a Construction Project?

Lean principles have been implemented in the construction industry for over three decades to improve project delivery and performance (Abdelhamid and Salem, 2005; Aziz and Hafez, 2013), project quality (Bajjou and Chafi, 2018), customer satisfaction (McGraw Hill, 2013), worker productivity (Ogunbiyi et al., 2014; Salem et al., 2005), job site safety (Gambatese et al., 2016; Wu et al., 2019), risk management (Issa, 2013), sustainability (Bajjou and Chafi, 2018), and profitability (Thomassen et al., 2003; Alarcon et al. 2006; McGraw Hill, 2013; Lichtig, 2005; Marhani et al., 2018). Since the 1990s, due to such benefits, several studies have focused on the adoption and integration of Lean methods



into the construction project's delivery process. Some Lean methods have been modified, and expert practitioners have developed novel methods to fit the construction industry's project-based nature (Salem et al., 2006; Ansah et al., 2016). Such methods, along with their interrelated components as applicable to the construction industry, form the domain of Lean construction.

The pioneers of Lean construction have emphasized the inherent differences between applying Lean principles in manufacturing and construction projects (Abdelhamid and Salem, 2005; Paez et al., 2005; Diekmann et al., 2004). In manufacturing, the production happens in a controlled environment and is driven by fixed, organizational, and more or less permanent teams who can leverage Lean skills to improve production efficiencies and quality even from one product to the next (Jørgensen and Emmitt, 2008). In construction, however, production is completed by one team per project at a time and takes longer to implement improvements because construction teams are dynamic, inter-organizational, and temporary (Abdelhamid and Salem, 2005; Paez et al., 2005; Diekmann et al., 2004). This does not discourage the use of Lean principles but instead requires that they be applied with deeper understanding and preparation (Abdelhamid and Salem, 2005; Salem and Zimmer, 2005). Howell and Ballard (1998) elaborate on the recommendations made by Womack and Jones (1996), asserting that implementing Lean at the project level is a first step towards deriving maximum value at the system level, i.e., the construction industry for customers. This assertion is also substantiated in several other Lean implementation studies (Alarcon and Seguel, 2002; Ballard et al., 2007; Christensen et al., 2019; Kim, 2002; Locatelli et al., 2013)

What Do We Need for Project level Lean Implementation Planning and Why?

Every component and phase in a construction project is interrelated, and collaboration is key to effective Lean implementation (Sarhan et al., 2019; Small et al., 2017). Therefore, for maximum advantage, project level planning for Lean implementation needs to be approached holistically (Marhaani, et al., 2013) and collaboratively by the project team (Cano et al., 2015; McGraw Hill Construction, 2013). Furthermore, to build a holistic approach, we need to find ways to incorporate Lean into every aspect of the project delivery process and help project teams do that collaboratively (Howell and Ballard, 1998; Howell, 1999; McGraw Hill Construction, 2013; Kim, 2002).

Lean construction experts consider that learning to implement Lean is a developmental process (Bygballe and Swärd, 2014). It requires gradual changes at a mental model level, and an exact planning procedure cannot be prescribed for it (Howell and Ballard, 1998). However, literature focusing on dynamic and temporary organizations suggest that a standard set of high-level steps can be helpful to generate a processual routine that project teams can follow to build consistency in approach as well as develop the required capabilities (Becker, 2005; Bresnen et al., 2005; Burke and Morley, 2016; Feldman and Pentland, 2003; Teece et al., 1997). Based on this school of thought, we contend that defining key planning steps would enable project teams to systematically consider and address all aspects prior to the start of Lean implementation on their projects and accordingly align strategies and required resources to minimize barriers, improve consistency, and be successful.

The Impetus for This Research

Forty Two peer-reviewed Lean implementation research studies conducted between 2000 and 2020 were reviewed to investigate if there was any existing approach or process for planning for systematic Lean implementation at a project level. Most studies recommended one or more strategies for Lean implementation that are summarized in Table 1. Others focused primarily on benefits and barriers related to Lean implementation (Aziz et al., 2013; Bashir et al., 2015; Kawish, 2017; Sarhan and Fox, 2013; Wu et al., 2019).

One particular study provided a project level implementation pathway (Locatelli et al., 2013). This pathway suggested three phases of implementation, i.e., preparation, implementation, and continuous improvement, comprising nine distinct tasks. During the preparation phase, tasks include gaining top-management buy-in, defining the cross-functional project team, providing training, collaborating with a Lean consultant, and defining objectives for implementation. During the implementation phase, tasks include conducting work observations, gathering data for analysis, brainstorming improvement strategies based on analysis findings, and using visual management to report performance highlighting positives. The continuous improvement phase included consolidating results and knowledge enabling future improvements.

Further, Locatelli et al. (2013) state that - “each project requires at least an external consultant, i.e., an expert in the field of LC with prior experience of the implementation of LC in real-life projects. The role of this consultant would be to give guidance to the team during the planning phase and continued help and support during the implementation phase. Because of the essential requirement of collecting several types of data throughout the life of the project, it would also be necessary for the consultant to promote the need for ongoing analysis and evaluation and provide training in the techniques required”.

Although the need for an external consultant is justified in the above statement, it does not clarify whether or not similar functions can be performed by an in-house person with sufficient Lean education, training, and implementation experience. Therefore, although this pathway informs about key implementation tasks, by suggesting the involvement of an external consultant as a requirement throughout the project duration for successful implementation, it supposes that without an external resource throughout the project duration, project teams may not be successful in their Lean implementation.

This study focused on the preparation phase, addressing the need to align project teams with a shared vision and strategy (Alarcon and Seguel, 2002; Chesworth, 2015; Kim, 2002; Kim and Park, 2006) and building upon the roadmap proposed by Locatelli et al. (2013) in two ways. One, by adding strategies supporting high-level implementation tasks or steps to provide additional guidance for project teams when performing them. Two, by identifying a set of key planning steps incorporating such strategies that enable project teams to proactively plan for a systematic and project-specific Lean implementation. It is envisioned that by formalizing the Lean implementation planning steps through the support of the Lean Construction community, project level planning can be approached consistently among diverse project teams. This will further benchmark and discover ways to improve Lean adoption for the construction industry between one project and the next.

Table 1: Project-related Lean Implementation Strategies

#	Strategy	Source
1	Align incentives by project role and inform in advance	Christensen et al., 2019; Alves et al., 2009; Alarcon and Seguel, 2002
2	Build cross-functional teams and workgroups	Andersen et al., 2012; Locatelli et al., 2013
3	Build long-term relationships and reduce uncertainties	Sarhan et al., 2019; Devaki and Jayanthi, 2014
4	Communicate frequently within workgroups	Small et al., 2017; Locatelli et al., 2013
5	Define clear goals and client requirements to establish customer focus	Sarhan et al., 2019; Small et al., 2017; Aziz and Hafez, 2013
6	Determine key performance indicators (KPI) that support Lean principles	Al-Aomar, 2012
7	Enable teamwork and collaboration by using colocation for key team members	Sarhan et al., 2019; Small et al., 2017; Andersen et al., 2012; Alarcon and Seguel, 2002
8	Encourage decentralized decision-making	Andersen et al., 2012
9	Encourage healthy competition	Andersen et al., 2012
10	Identify control areas to avoid volume paralysis	Andersen et al., 2012
11	Identify Lean champions within the project team	Sarhan et al., 2019; Shang and Peng, 2014
12	Identify new supportive roles within a team	Locatelli et al., 2013; Thomassen et al., 2003
13	Improve client awareness towards Lean advantages	Sarhan and Fox, 2013
14	Improve continuously using data-driven approaches	Sarhan et al., 2019; Locatelli et al., 2013
15	Make visible Lean advantage to all	Locatelli et al., 2013; Alves et al., 2009
16	Perform just in time design production	Andersen et al., 2012
17	Provide just-in-time education and training for Lean champions and other team members	Sarhan et al., 2019; Omran and Abdulrahim, 2015
18	Schedule look-ahead planning meetings in advance	Andersen et al., 2012
19	Select appropriate Lean methods, align team expertise, and strategic protocols	Sarhan et al., 2019; Devaki and Jayanthi, 2014
20	Solve issues at the level where work is being performed	Andersen et al., 2012
21	Support the adoption of advanced technologies by providing simple guidelines	Devaki and Jayanthi, 2014; Sacks et al., 2010
22	Support the adoption of advanced technologies by providing visualization mechanisms	Locatelli et al., 2013
23	Support crew-needs and job-site management to improve production efficiency	Ayarkkwa et al., 2012; Al-Aomar, 2012; Andersen et al., 2012
24	Use industry standards to benchmark performance	Dulaimi and Tanamas, 2001
25	Use integrated information systems and integrative and visual technologies	Sarhan et al., 2019; Andersen et al., 2012
26	Use integrated project delivery approaches	Sarhan et al., 2019; Sarhan and Fox, 2013
27	Use off-site storage and prefabrication	Andersen et al., 2012
28	Use simplified language to convey ideas about Lean implementation	Bashir et al., 2015
29	Use work observation, data collection, and analysis to measure improvements	Locatelli et al., 2013

Methodology

Literature Review and Analysis Approach

The Google Scholar database was searched to identify Lean implementation studies from multiple sources, using the keyword phrases: Lean construction planning, Lean construction implementation, Lean construction planning process, Lean construction planning procedure, Lean construction methods, and Lean construction implementation barriers. A total of 42 Lean implementation studies published between 2000 and 2020 were identified. The information gathered from these studies was recorded in a spreadsheet in columns A through E, including publication year, first author's last name, publication title, keywords, and abstract, respectively. Systematically, by reading through the abstracts, studies were identified as project level or industry-level implementation in column F. Based on the key finding of each study, by conducting a detailed review, information about project level implementation was summarized and categorized in column G. This was performed by a member of the research team by consistently reviewing each publication to capture various implementation strategies, implementation barriers, and specific Lean Construction methods. Based on similarity and frequency with which it was presented in the 42 implementation studies, a total of 59 gathered strategies were consolidated into 9 unique strategies (Table 1) by eliminating duplicates.

Expert Interviews and Content Analysis Approach

Alongside the literature review and analysis, semi-structured individual interviews (Patton, 2005; Boyce and Neale, 2006) were conducted with Lean construction practitioners, who are considered experts in the Lean community (Figure 1). The interview approach was used to compare if the information being gathered from the literature is complete and consistent with current industry practices as well as to gather more in-depth information related to planning for Lean implementation. Therefore, some of the interview questions focused on topics similar to the inquiry conducted during the literature review such as "what are your biggest challenges in designing your Lean process on projects?". Some questions focused on various aspects related to Lean process design, documentation, communication, and implementation.

The questions were used as a guideline to direct the flow of the conversation, to conduct follow-up inquiry, and to initiate in-depth conversations about topics that were of interest, based on the level of clarity and detail in a participant's response (Patton, 2005; Boyce and Neale, 2006).

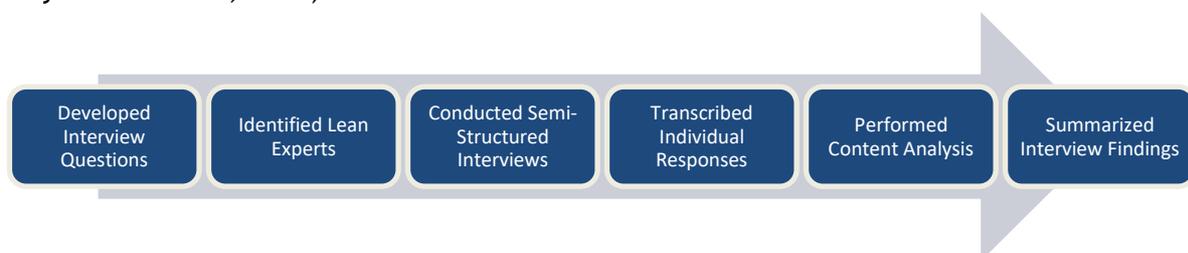


Figure 1. Expert Interview Related Tasks

The expert category was defined by an individual's role, affiliation, knowledge, expertise, years of experience in the construction industry, and years of experience in

Lean construction. Such individuals are considered as experts by the Lean community as they have actively implemented or participated, repeatedly, in planning the Lean implementation process at either various organizations and/or with different project teams. They are considered to have tactical knowledge about the different strategies used during Lean implementations, which when considered during planning can be beneficial for project teams. They are also aware of the associated challenges and hence the types of resources that might be complementary to the planning process to address these challenges. Experts were identified through the support of members of the Lean Construction Institute's Research Committee, using the purposive sampling approach, where each member of the research committee was requested to suggest 3 to 5 individuals.

Recommended individuals were contacted via email. 16 of the contacted individuals who agreed to participate were then interviewed. Interviewed experts belonged to various organization types such as design and construction firms (57%), owner organizations (29%), and consulting companies (14%). The participant sample is 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 the 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 participants have more than 10 years of experience and are considered experts by the Lean community.

Based on the participant's willingness, some responses were audio-recorded for transcription only and detailed notes were taken during all others. The interview transcripts were analyzed using formal content analysis in three steps. First, information gathered from each individual interview was translated into a content map structured by categories consistent with the interview thrust areas. Second, the contents under each thrust area from all individual interviews were accumulated in a comprehensive content map. Third, a summary content map was developed by summarizing the contents within each interview thrust area. This was performed by consistently reviewing the individual interview content maps to capture all content in the comprehensive map and then based on uniqueness, similarity, and frequency with which it was included in the interviews, a content summary was developed related to each interview thrust area. The summary content map was developed to anonymously encompass the breadth of all information provided by the interviewees cumulatively and descriptively.

All of these expert-recommended strategies along with those gathered from literature (Table 1) were incorporated into the identification of the key planning steps that enable systematic Lean implementation on construction projects. Such steps and strategies were validated using a focus group discussion conducted with a group of 8 expert Lean practitioners, comprising 2 previous participants and 6 new participants. Table 2 includes some key quotes from the validation focus group, supporting incorporated strategies into the contended planning sequence. The focus group discussion was considered as cumulative feedback in combination with the initial interviews to incorporate expert opinion in a consolidated way.

Results and Discussion

Findings from Individual Interviews and Focus Group Discussion

This section describes the steps and strategies used in the planning and implementation of Lean principles and methods as identified from discussions with Lean construction experts. Every unique strategy addresses one or more aspects of Lean implementation, including barriers, consistency, and drivers. Therefore, they need to be considered during the preparation or the planning phase, when the project team is embarking on a plan for why and how they want to implement Lean on the project, thereby, establishing a customer-focused common vision and strategy.

Lean Construction experts indicated that while the involvement of an expert consultant the or entire project duration may seem beneficial, different project teams may want to deploy Lean differently based on the specific project needs and available resources. Three participants, who are enterprise-wide Lean experts for major construction management organizations said that they supported a variety of project teams, incorporate Lean into their day-to-day routines, and did not always involve external consultants. They also stated that in some cases, a large owner wanted to deploy Lean on multiple ongoing or subsequent projects, involving the same major stakeholders and hence wanted to develop internal Lean champions, who could guide with planning and execution throughout, in all projects, maintaining continuity and continuous improvement.

Bashir et al. (2015), Locatelli et al. (2013), and Höök and Stehn (2008) suggest that this would not only reduce the overall implementation cost but also support team development, reduce change resistance short and long-term, and improve team engagement. An external Lean consultant also confirmed that some teams he coached implemented Lean on fairly smaller projects where the budget only allowed their involvement to supporting initial education and training and not continued engagement. It was concluded that while external coaches are needed under special circumstances by novice or less-experienced project teams such as when aiming for an extensive Lean implementation on a large project or multiple projects, it is not a necessity for all teams. This is where a set of key planning steps can render value to project teams who are seeking independence and creativity while planning their Lean implementation.

Table 2 provides some key comments gathered from the validation focus group discussion, substantiating this conclusion. The quotes are slightly modified to maintain the anonymity of participants. Experts were asked what were their style when they started planning Lean implementation on construction projects, how they decided on a method-selection approach, what were their thoughts related to the proposed planning steps and strategies, and if they had any suggestions to refine them.

Table 2: Quotes from Focus Group Discussion with Lean Expert Practitioners

#	Quotes from Focus Group Discussion with Lean Expert Practitioners
1	“Starting with Lean implementation planning assumes that the team has already been assembled, the contract has been signed, and project validation is complete.”
2	“90% costs are performed by the trades and therefore need to be included in the planning of methods that require their participation.”
3	“Useful for teams that are pre-contract or at the beginning of design, when they can explore different strategies such as offsite construction. Depending on the target audience, a novice team or an experienced team, we can be either very specific or flexible and allow teams to choose their own adventures. The capacity of a team to incrementally ramp up and do something more is important.”
4	“A method-selection approach can be what problem a team is trying to solve. So, if there are workforce challenges, offsite construction can be helpful.”
5	“When discussing method-selection approaches with teams it is an assessment from knowing about the project, knowing about the capabilities, strengths, and weaknesses of the team, and some awareness of the various methods. It’s almost like match-making and given the stage of the project and the talent of the team, one might say let’s go focus on Daily Huddles and Weekly Work Planning or let’s go focus on doing Phase Plans because we are not identifying issues soon enough. It is very situational and really a dialogue.”
6	“We need to think about how we affect behavior. Therefore, an approach to select methods can also be based on what cultural behavior are we trying to establish in our people. Also, the desired behavior can be woven into the planning by mentioning them as a requirement for the specific methods.”
7	“The reality is that most new teams aren’t familiar with or can’t spell LPS and they are not comfortable with it. If they are not comfortable with it themselves, they are not going to be comfortable in being vulnerable to learning with their subcontractor. They want to know first because they don’t want to look stupid in front of the people, who are supposed to take direction. That’s not the right attitude but that is a reality. So, if a team is new then that may be an internal discussion but there needs to be a roadmap of how they plan to bring the entire team into it.”
8	“Most large companies will have a gated process involving risk assessment and some owners ask about it. This also creates an opportunity to feed this discussion and method selection as part of the normal review process.”
9	“Start by looking at where we are in the project and what or who are the existing knowledge sources? What’s going to benefit this project the most? What’s needed to get there? A lot also depended on my expertise. It wasn’t always, we do everything at once. We would start doing something and then add something more and something else. It wasn’t always out the gate you are doing everything, it is impossible for especially newer teams.”
10	“Sometimes we need to select methods based on what constraints they will help address, including behavioral issues. Novice teams may not recognize their own resistance.”
11	“A Conditions of Satisfaction for the planning can be who needs to be in the core planning team. Clarify and define ‘who’ is your project team? Who needs to be part of this discussion? The strategy developed early on by the team and the methods are chosen also can inform who they want to bring on the project. It is effective either way in setting the right expectations from the start.”
12	“That’s the biggest challenge as to when you would be implementing the steps because if you’re going to try to map this early in the process, you’re not always going to have all the people in the room.”
13	“When we get to methods, selection revolves around two aspects: project objectives and project team expertise. What capabilities do you need to improve to support selected methods, to incorporate the enabling behavior?”
14	“Just because that’s the way we work now may not be the most productive way. Probably one of the best ways is that the team figures it out while developing the contract or be more intentional about learning from the get-go and select methods upfront.”

Barriers to Project level Lean Implementation

Although some Lean experts believe that Lean can be introduced one method or even one strategy at a time to a project team, who is new to Lean principles, they emphasized that it is grounded on ‘respect for people’ above all. Thereafter, Lean implementation thrives upon the successful application of strategies and methods that support waste elimination, value creation for customers, and continuous improvement at all levels of the project delivery process. Especially considering that project organizations greatly contribute to any progress in the construction industry, resolving the barriers to Lean implementation at the project level should naturally encourage the adoption of Lean within the construction industry. From experience, experts claim that major project level implementation barriers include:

- lack of awareness and thorough understanding related to Lean principles,
- lack of leadership buy-in from project team member organizations and owners,
- lack of a standardized onboarding strategy,
- lack of assigned project budget to support Lean education and training, and
- lack of a consistent and systematic planning approach on projects.

Most of the above-mentioned barriers can be minimized by systematically planning for Lean implementation, incorporating strategies that address project-specific limitations and requirements. If a team is lacking in their awareness and understanding related to Lean principles, foundational training can be provided before planning the implementation itself. If the project lacks leadership or team buy-in, some initial Lean advantages from minimal implementation can be made visible or even information from other successful projects can be used as an example. With successful buy-in from both the leadership and the team, progress can be made into setting aside a project budget to support Lean education and training, which inherently supports the development of a well-informed Lean implementation plan.

Improving Consistency in Project Level Lean Implementation

The interview findings confirmed that the implementation approaches are not consistent across project organizations. Where some teams may implement only a handful of Lean methods along with the project duration, others implement Lean as part of their daily routines. This variation is a result of the unique project goals, the project delivery method, and the project team’s ability to design the Lean implementation process. It is not expected that Lean will ever diminish the uniqueness of projects. On the contrary, the uniqueness renders an opportunity to be creative and innovative when planning for Lean implementation on individual projects. For effective implementation, all strategies need to mutually support each other (Kim, 2002; Kim and Park, 2006). Strategies that emerged from the interviews, which improve consistency to some extent include:

- the project team collaboratively establishing a **project-specific Lean plan** at project initiation;
- **onboarding** team members early and identifying Lean champions, who will drive the implementation process;
- provide **initial and ongoing coaching** related to Lean principles and methods;
- **tracking alignment** by conducting follow-up surveys among project team members, having them self-report their behavior throughout the project delivery process; and

- performing **Gemba walks** (observational walkthroughs) to evaluate if Lean is being practiced on the project.

On many occasions, the resistance towards Lean comes from the leaders of project team member organizations and not the project leadership. From their experience and interaction with organizations, Lean experts have found that establishing a **project-specific Lean plan** at project initiation 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.

Having established a supportive infrastructure, the project team should onboard team members as early as possible and also identify Lean champions, who focus on the implementation process. Experts recommend that providing Lean training during initiation and **onboarding** project team members is critical to increasing the project team's awareness of Lean from the project onset. Primary stakeholders or contractual parties are engaged earlier in most projects, but some members may be onboarded 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 a shared understanding of the project plan. New members may not receive the same level of training as earlier cohorts at project initiation, but they still need to know the past on the project to better align themselves to the present and the future. To enhance onboarding strategy along the project lifecycle, some organizations provide mini onboarding series in phases, which rely heavily on visual management techniques, such as Big-room displays. This is helpful when there are limited resources to conduct onboarding sessions, but teams still want to maintain their engagement with Lean implementation.

Many times, Lean experts have found that just based on the popular perception that Lean implementation is a complex process, teams become resistant. This resistance manifests even more deeply downstream making Lean implementation challenging even after planning for it. Hence putting methods in place ahead of time to **track alignment** throughout the implementation is imperative. Two (owner) organizations used a scoring system based on metrics that helped evaluate the overall project and process performance. This performance score was tied to profit earnings at project completion in some cases. Other methods included self-reported surveys and project pull plan updates. Per experience, Lean implementers find that some aspects such as BIM use, big-room planning, IPD use, interactive planning, Lean coaching and expertise, retrospectives, soft start, team collaboration, etc. are considered harder to measure than some others such as A3 thinking, continuous improvement, prefabrication, shared savings, and team health. When experiencing such difficulties, performing **Gemba walks**, also known as observational walkthroughs, to evaluate if Lean is being practiced on the project can be effective. A thorough and well-documented walkthrough can help detect breakdowns early and provide an opportunity to maintain or bring back the alignment. It is also important to continue with supplemental coaching, mentoring, and training via Big-room events and workshops to maintain alignment with the previously established project goals.

Driving Project level Lean Implementation

We learned from the experts that three aspects drive the Lean implementation success right from the project onset: **project goals, project delivery method**



(contractually established), and **the project team's ability** to develop a thorough and well-informed project-specific Lean plan. Therefore, it is critical to reflect upon them and make assessments early on, putting in place the infrastructure needed to develop a plan that is effective and realistic.

The **project goals** are those conditions in a project that need to be satisfied to conclude that the project was successful. This implies that in addition to capturing the client's needs, the project goals also need to represent what matters to the project team.

Experts pointed out Lean implementation is most effective when an **integrated project delivery strategy** is chosen for the project and contractually established. An integrated delivery approach best allows for collaboration and cooperation with minimal contractual disruptions and therefore empowers Lean project delivery. It is best when the owner allows early involvement of stakeholders in pre-design and not just in pre-construction. Then, the construction team can support the design team during the development process providing input versus requesting 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 post-design development. Lean can still be implemented on projects where delivery approaches are less integrated due to contractual boundaries between design and construction phases, by minimizing the fragmented project team structure using methods such as cross-functional Work Clusters, Big Room, and Colocation.

Finally, to improve **the project team's ability** to develop a thorough and well-informed project-specific Lean plan, experts recommend that a concerted effort is needed at the project level as well as at the industry level. At the project level, the team needs to first start with Lean fundamentals training as part of the onboarding, and then do more detailed and method-specific training, as needed on an ongoing basis. At the industry level, Lean training needs to be institutionalized among owners as well as design and construction companies. This would expedite the improvement of awareness and understanding related to Lean principles and methods, which would address all aspects of Lean implementation: barriers, consistency, and drivers.

Key Planning Steps and Strategies Enabling Systematic Lean Implementation on Construction Projects

Based on the feedback gathered from Lean Construction experts, this study emphasizes that although Locatelli et al. (2013) proposes the need for involving an external consultant throughout for successful Lean implementation, it does not have to be so for every project. Considering that every project and the team delivering it are unique, planning for Lean implementation needs to be project-specific to align the team to a common vision and strategy (Alarcon and Seguel, 2002; Chesworth, 2015; Kim, 2002; Kim and Park, 2006). As a result, the interview responses were reviewed to dig deeper into what steps are being taken and what strategies are currently being followed in the industry as part of Lean implementation.

This study focused on the preparation phase, by identifying the key steps for developing a project-specific Lean implementation plan that would align project teams with a shared vision and strategy. This helped to build upon the roadmap proposed by Locatelli et al. (2013) in two ways. One, by adding strategies supporting high-level

implementation tasks, i.e. steps to provide additional guidance for project teams when performing them. Two, by identifying a set of key planning steps incorporating such strategies that enable project teams to proactively plan for a systematic and project-specific Lean implementation. It is envisioned that by formalizing the Lean implementation planning steps through the support of the Lean Construction community, project level planning can be approached consistently among diverse project teams. This will further benchmark and discover ways to improve Lean adoption for the construction industry between one project and the next.

Six high-level planning steps emerged from the interview discussions when inquiring about how teams approach Lean implementation on a project level.

1. Determine the project delivery method
2. Organize the project team
3. Conduct a formal Lean kick-off
4. Strategically select Lean methods
5. Develop a Lean plan
6. Track alignment to improve continuously

These steps do not eliminate the need for initial and ongoing training that better supports the implementation process. However, by deeply understanding what each of these steps means, the project team can independently plan for Lean implementation, possibly without external consultants. Each of these high-level steps is further elaborated into collective strategies that were identified from the expert interviews as well as the literature review and summarized in Figure 2.

1. Determine the Project Delivery Method

One of the most popular recommendations noted by Lean experts is the importance of using an integrated project delivery approach and contractual arrangements to support Lean adoption into the project (Sarhan et al., 2019; Sarhan and Fox, 2013). Almost unanimously, Integrated Lean Project Delivery was endorsed as being the most conducive to Lean implementation. Many noted that this was not however the most common option used in the industry, due to lack of awareness and understanding related to Lean principles and lack of project team's ability to design a process for incorporating Lean methods (Bajjou and Chafi, 2018; Sarhan et al., 2018; Small et al., 2017). The project delivery strategy serves as one of the first and most important decisions by the owner to help align the motivation of the designers and contractors toward supporting the ultimate value that the owners and clients are seeking from the project (Li et al., 2017; Sarhan and Fox, 2013). In addition, owners and project teams interested in Lean implementation need to be proactive about informing the larger team and communicating the plan in simple terms (Bashir et al., 2015) as part of the request for qualifications (RFQ) or proposals (RFP).

2. Organize the Project Team

While the exact 'who' may vary based on the project specifics, it is important to identify the stakeholders and service providers who are most affected by the project. Especially, those whose decisions can most influence the actual implementation need to be engaged when planning for Lean and thus, preventing critical breakdowns. As one expert noted, in referring to Robert Fritz's book, *The Path of Least Resistance*, that 'structure determines behavior' - suggesting that people inherently learn how their work is

structured and organized, and they play to the incentives, 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 (Christensen et al., 2019; Alves et al., 2009; Alarcon and Seguel, 2002).

Alongside identifying the key players, identifying champions from within the project team, who can drive the Lean implementation beyond the initial planning further ensures success. Such individuals can be identified as volunteers or personalities who emerge as natural leaders demonstrating a Lean mindset. Depending on the project size and complexity, having the right number of champions can make a significant impact on the overall team's engagement and participation during the implementation. Such champions need to undergo deeper education and training to also serve as internal Lean coaches on the project. This approach also renders cost-savings, which would otherwise be spent on hiring external consultants. Hiring experts for initial education and training is less expensive than requiring their services throughout the project duration, especially those extending to more than a year. In such cases, investing in developing the project team's expertise related to Lean principles and methods goes a long way to establish long-term commitments (Sarhan et al., 2019; Devaki and Jayanthi, 2014).

3. Conduct a Formal Lean Kick-off

Conducting a formal Lean kick-off also referred to as a 'soft start', is much like a typical project kick-off, only it is more tailored towards 'Why' Lean is being adopted on the specific project. The Lean kick-off is conducted in various ways based on the availability of the organized project team. It can be a collaborative session or a workshop, spanning an entire day or several days. Regardless of the format, the purpose is to orient the project team to the 'why', i.e., the Lean goals and, provide initial education and training to ensure a consistent minimum understanding and familiarity with the Lean principles as well as the Lean terminology. This will allow members to successfully converse and participate in discussions. Experts emphasized that having a well-designed agenda and a proficient facilitator is critical to the kick-off. It is even better if the facilitator has experience with Lean implementation but is not a necessity. The kick-off session when purposefully made cross-functional, can support team-building activities that parallel learning with familiarization among members. Such activities improve interpersonal engagement and create shared experiences and build vocabulary, which further reinforces the Lean implementation moving forward. This sort of approach naturally builds a deeper understanding of the philosophy and principles of Lean versus standalone methods and tools. In their experiences, experts highlighted that the focus on standalone methods and tools was a recipe for failure when not properly underpinned by driving the understanding for 'why' they were being used and how they support the Lean principles.

4. Strategically Select Lean Methods

After understanding the 'Why' project teams shift their focus to the 'how' and the 'what'. One expert stated - "this is when teams realize that they don't know how to implement Lean, which is good because that's when they start asking the right questions". The 'how' is addressed by applying strategies that support the selection of methods that

align with the project goals. The 'what' is addressed by applying strategies that support the planning and implementation of the selected methods and tracking alignment to the plan. Emerging from the interviews, this step was noted as one of the hardest, and most time-consuming, but also the most crucial step in planning the details of the Lean implementation.

Some methods such as A3s, Big Room, Gemba Walks, Last Planner System, and Target Value Design, stood out as being more commonly implemented than others such as Set-based Design, and Value Stream Mapping. Thus, Lean practitioners are able to suggest Lean methods, but most of them acknowledged that they had difficulty defining universal rules for novices to be able to quickly and easily select methods for application. Because, some methods are performed one time, and the overall process can be mapped as a discrete process (e.g. 5 Why, Daily Huddle), while some are cyclical by nature of the implementation (e.g. Set-based Design, Plan-do-check-act Cycle), and others continuous (e.g. Visual Management, Big Room).

Apart from the nature of implementation, some strategies are instantiated based upon certain conditions or opportunities within a project that highlight an opportunity to leverage Lean principles. For example, leveraging A3 or visual management to make a specific decision or communicate a process. These strategies first require the identification of the opportunity to leverage Lean principles, and then followed by the process for performing the method. 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 the same 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.

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 these strategies is viewed as an opportunity to improve the management and delivery of a project through Lean principles. Due to this variation in the application, it is critical to design a standard approach, which can support the increasing adoption of Lean into projects.

5. Develop a Lean Plan

After a thoughtful and thorough approach has been applied to selecting the specific methods for implementation that align with the project goals, experts recommend that the project team needs to collaboratively develop a plan, elaborating the details of what the implementation process looks like, including a task-level breakdown along with a list of required resources to support each task. This plan can be developed during an extended Lean kick-off session or as a follow-up set of multiple collaborative sessions. As part of developing the plan, the team can use multiple approaches. For example, start with a simpler method to analyze the immediate benefits and make them visible to the team. With potential advances in team motivation, the rigor of the implementation can be increased by implementing more complex methods. Another approach highlighted was the

use of cross-functional study action teams or work clusters to plan individual methods in detail and then combining them to develop a project level plan for monitoring alignment and continuous improvement.

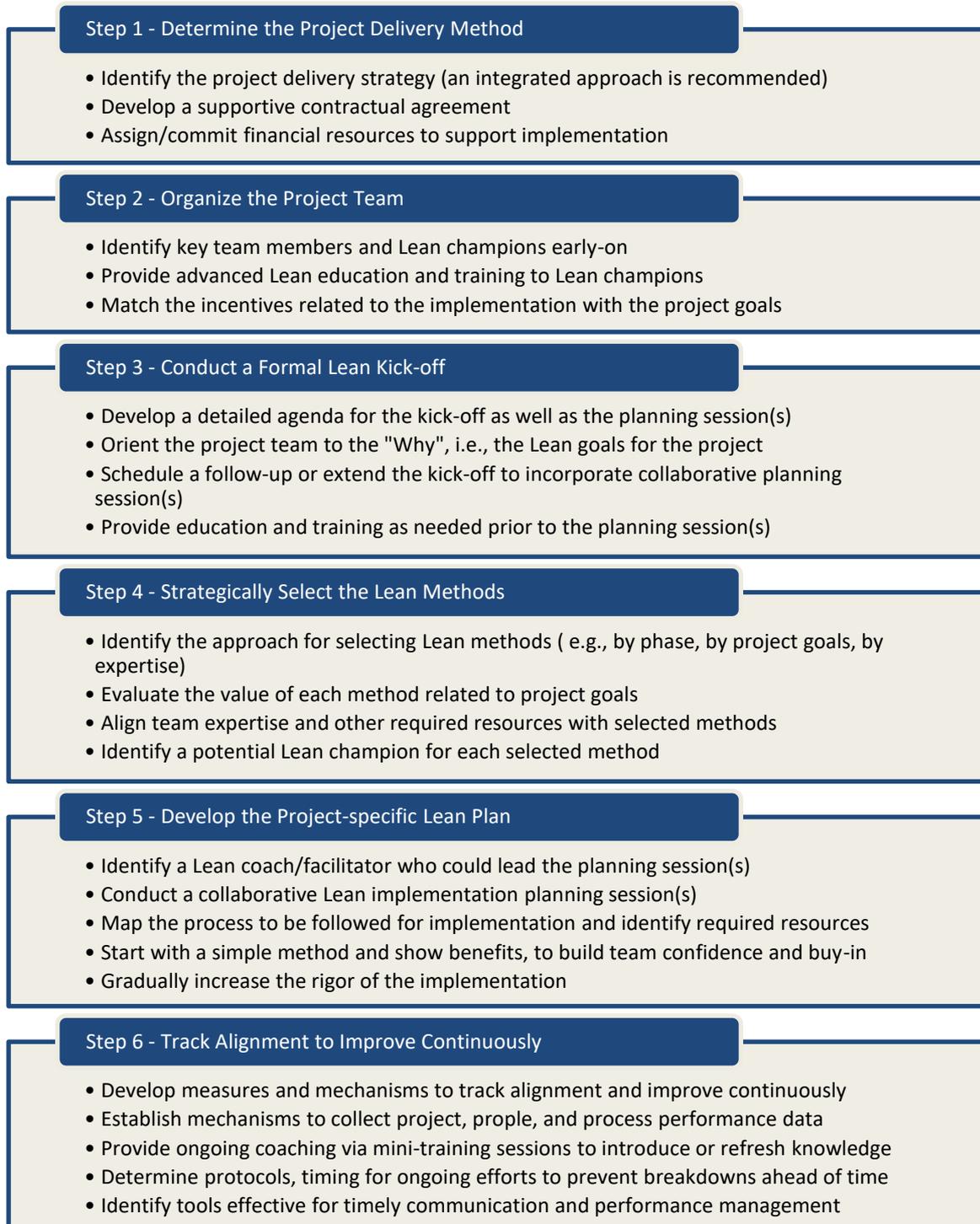


Figure 2. Key Steps to Systematically Plan for Lean Implementation

6. Track Alignment and Continuously Improve

Once a Lean plan is developed, the next step is to identify strategies that will be used to track alignment and continuously improve (Sarhan et al., 2019; Locatelli et al., 2013). Experts pointed out that a variety of tools such as monthly scorecards, project dashboards, and self-reported surveys can be used to track alignment. Simultaneously, providing ongoing coaching via mini-training sessions enable the implementation process and supports continuous improvement. Such training helps to introduce new or refresh old methods supportive of Lean principles, to better enable the transition between project phases or major milestones. Among a few others, the creation of study action teams is well-known for bringing together diverse team members, to 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.

Future Resources Needed for Lean Implementation

Experts contend that while pursuing Lean implementation, with the right resources, Lean can be incorporated into any unit of action whether at a task-level, process-level, project level, or even at an enterprise level. Based on this contention, previous implementation studies noted in the literature, as well as the expert interview responses, were reviewed, to identify such resources that would potentially assist project teams during Lean implementation:

- **A set of high-quality educational videos** for supporting an onboarding process and initial or ongoing training sessions;
- **An implementation roadmap** for guiding project teams and help them visualize the process they need to follow to implement each Lean method;
- **A consistent planning approach** for developing an implementation plan as well as designing the implementation process considering all drivers;
- **An appropriate contractual strategy** for supporting collaboration and incentives for all parties at the right level; and
- **A formal measurement system** for tracking all aspects of Lean implementation at the project level thus enabling continuous improvement.

Research Limitations

As part of the scope, this study addressed only the 'planning' phase of Lean implementation, and 'execution' is considered the phase following the planning phase. The identified 'planning steps' approach 'planning' for Lean implementation as a distinct process, using which the project team can develop a project-specific Lean plan prior to and for 'execution'. 'Lean implementation planning' for this study is defined as all activities that help the project team develop a project-specific Lean plan. 'Lean plan execution' is defined as all activities that help with implementing the Lean methods identified in the project specific Lean plan.

As part of the methodology, various types of researcher and participant biases were minimized by structuring the interview questions to be open-ended in the majority and, did not include any form of advocacy related to the research topic, scope, or any mechanism to solicit favorable responses. In addition, during analysis, information was systematically summarized to uniformly represent all responses cumulatively without any form of advocacy or partiality in the representation of ideas or suggestions. However, considering that we solicited participants with the help of the Lean Construction Institute's Research Committee, who are also members of the sponsor organization, sponsor bias may not be entirely eliminated.

As part of the research protocol established with interview participants, this study presented all findings from the individual interviews in a summarized manner, not listing any quotes or projected opinions. Only the focus group discussion validating the findings are presented in a slightly modified statement form substantiating the research contribution.

As part of the results, although the key steps included in this study can be modified for use by an organization choosing to implement Lean on their projects, this study mainly focused on aspects related to the planning of Lean implementation at an individual project level that could assist the project team. Additionally, one of the steps proposes multiple strategies in selecting Lean methods, which is based on current practices mentioned by experts. A domain-specific, i.e., an ontological approach has been provided by Bhawani et al. (2020) for organizing the information related to Lean Construction methods to inform and support teams with method selection.

Conclusion

Summarizing this study, from an initial literature review, it was determined that when considering Lean implementation on a construction project, alongside significant benefits to partnering with Lean organizations, there is still a need to align the project team with a common vision and strategy by developing a project level Lean implementation plan (Alarcon et al., 2006; Chesworth, 2015; Kim, 2002; Kim and Park, 2006). This plan needs to be developed collaboratively (Cano et al. 2015), using a holistic (Marhaani et al., 2013) and a systematic approach to derive maximum Lean advantage (McGraw Hill Construction, 2013). Due to the dynamic, inter-organizational, and temporary nature of typical construction project teams, every member is not at the same level in their awareness and understanding of Lean principles and methods, which makes it challenging to develop such a plan (Alarcon et al., 2002; Kim, 2002; Kim and Park, 2006). Thus, to help project teams drive implementation by developing such a plan, this study investigated to see if there was an existing approach, set of enabling strategies, or a standard process, which support the planning for systematic Lean implementation.

From the review of 42 Lean implementation studies conducted between 2000 and 2020, 16 semi-structured individual interviews, and focus group discussions with 8 experts we identified 6 high-level planning steps comprising of several strategies that provide a starting point to plan a systematic project level Lean implementation. Although the different strategies suggested within each step are not compulsory, the steps are somewhat essential and connected to enable a process-like flow.

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Appendix: Interview Questions

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, 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

1. Interviewer Background (3 min)

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

2. Lean Process Design on a Project (20 min)

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

3. Lean Process Documentation and Communication (10 min)

- a. How do you document the results of your lean process design for each project?
 - i. Do you use a standard template for documentation?
 - ii. Do you leverage visualization tools in the documentation?
 - iii. Would it be possible to receive an example of the lean process design?
- b. How do you communicate the plan to all the team members?

4. Lean Process Implementation (15 min)

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

5. Future Suggestions and Needs (10 min)

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

6. Plus / Delta: (2 min)

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

Thank you!