IMPLEMENTING LEAN ON CAPITAL PROJECTS

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ABSTRACT

This paper reports the findings of a research project commissioned by the Construction Industry Institute (U.S.A.) to discover the secrets of successful implementation of lean principles and methods on capital projects. Findings were drawn primarily from a review of the literature and from case studies.

The best prospects for successful implementation were found in those projects driven by organizations committed to being lean enterprises; i.e., pursuing the lean ideal in accordance with lean principles, and using the best available tools and methods. As regards project implementation, findings and the corresponding recommendations are provided for contractual and organizational structures, project definition, design, supply, assembly and post project learning.

KEY WORDS

Implementation, lean, lean enterprise, lean project delivery

INTRODUCTION

Questions regarding the implementation of lean project delivery in the construction industry have become increasingly urgent in tandem with the development and application of lean principles and methods on construction projects. As yet there have been no widely accepted implementation strategies or guidelines. This paper reports the findings of research dedicated to producing such guidelines.

The research was commissioned by the Construction Industry Institute (U.S.A.). The objective was to produce recommendations for implementing lean on capital projects[3], but it was found that project implementation does not stand alone. Implementation of lean on projects is best understood as part of what organizations do in their pursuit of the lean ideal. Consequently, two sets of recommendations were produced; one for the launch and one for project implementation. The first are generally applicable to any domain and role played within a domain. The second are specific to capital projects, though arguably could apply to all project production systems.

The remainder of this paper is organized under three headings. A brief account of the research methodology is provided, followed by presentation of the recommended guidelines, which in turn is followed by a section on conclusions and a list of references.

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[3] A "capital project" is one the cost of which cannot be fully expensed in a single tax year, but rather is depreciated over multiple years. In most cases, "construction project" is an equivalent term, signifying the entire project delivery, not only the constructing phase.

METHODOLOGY

There have likely been as many answers to the question how to implement lean as attempts to answer the question. Evaluating one answer over others might be done by reference to theories of organizational change, to the empirical record, and to theories of lean itself. In an attempt to employ all three of these evaluation methods, this research was carried out through a review of the literature and through case studies[4].

Case studies of the following companies were developed from open ended interviews: Air Products, BAA, General Motors, Sutter Health, Boldt, GS Engineering & Construction (Korea), Messer Construction, Walbridge Aldinger, BMW Constructors, Dee Cramer, Ilyang (Korean specialty contractor), Southland Industries, Burt Hill Architects & Engineers, and Spancrete Industries[5]. The interview topics are shown in Figure 1:

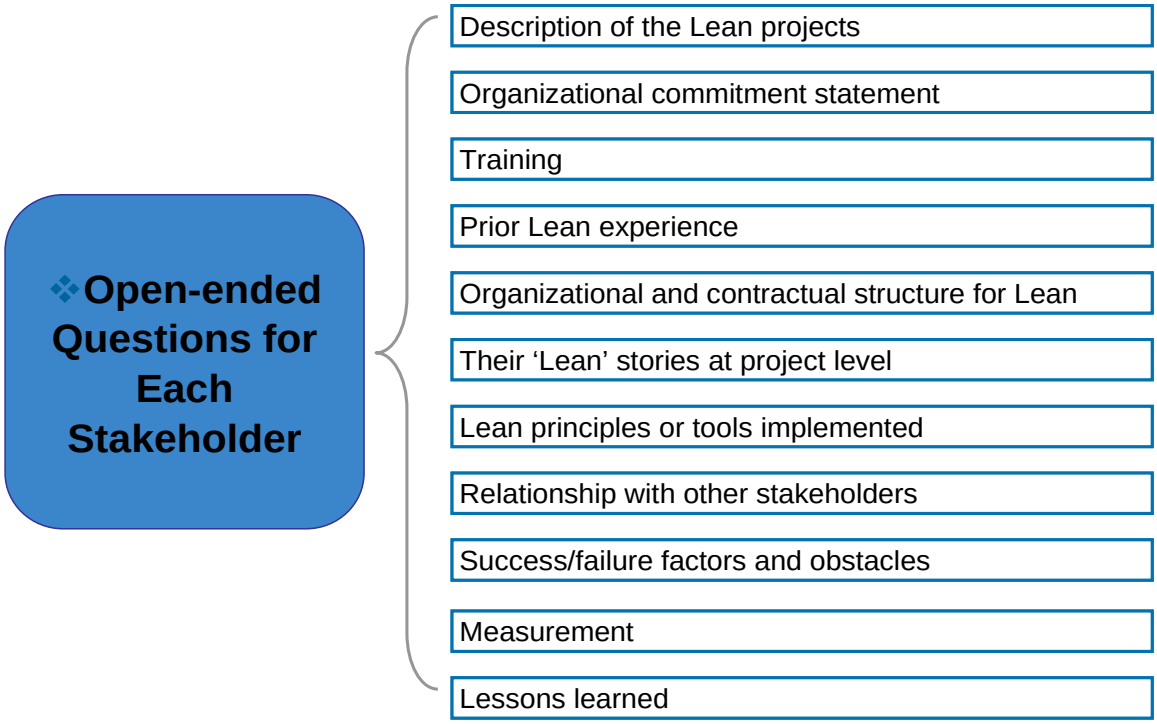

Figure 1: Interview Questions for Case Studies

In addition to the case studies, an extensive review of relevant literature was performed, organized under four main headings:

- Toyota
- What is Lean Construction?
- Organizational Change

[4] There were also field tests conducted by two research team member companies, Abbott and Dow Chemical, and statistical analysis was performed on the relationship between work flow reliability as measured by PPC and labour productivityShu-Fan *253*
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Wa, using data supplied by BMW Constructors.

[5] Air Products, General Motors, and Walbridge Aldinger had representatives on the Research Team.

- Relevant CII Research

One of the key findings was that the Toyota Product Development System is a better model for lean project delivery than is the more famous Toyota Production System. Publications concerning the Toyota Product Development System included in the review are marked with an asterisk in the References section.

Given space limitations, we can provide only a limited justification for our recommendations. To that end, in the following section, titled 'Exposition', we clarify our understanding of lean and of lean project delivery. Our recommendations are then presented for launching an organization on the lean journey, and also our recommendations for lean project delivery. Each of the latter recommendations are annotated to show whether they were drawn primarily from the case studies or from the literature review.

EXPOSITION

Lean is a journey, not a destination; a fundamental business philosophy consisting of an ideal, principles and methods. The lean ideal is to provide a custom product exactly fit for purpose delivered instantly with no waste. This is an ideal that can be approached ever nearer but never completely reached, hence the dedication to continuous improvement that is often associated with lean. Lean principles such as those stated in *The Toyota Way* are the rules one follows while pursuing that ideal. Methods and tools are the way one implements those principles. Even principles may require interpretation anew for application to new domains and conditions. Methods and tools very often must be adapted, or even reinvented, for different applications.

RECOMMENDATIONS FOR LAUNCHING YOUR LEAN JOURNEY

1. Create a sense of urgency for change.
2. Provide consistent leadership.
3. Structure evaluations and rewards to encourage desired behaviour.
4. Facilitate and coach collaborative behaviours.
5. Develop your own 'way'; your philosophy of doing business. Suggestion: reflect on the 14 Principles in Liker's *The Toyota Way.*(Liker)
6. Bring an external consultant (*sensei*) to guide your Lean journey when you start, to help with both strategy and education.
7. Don't over-theorize. Develop a preference for action.
8. Start with your own work; on processes within your control. These may not involve an interface with an external supplier or customer. When ready, extend to systems that interface with others.
9. Launch demonstration projects to adapt concepts and techniques to your situation, to provide proof of concept, to develop competence and confidence, and to build internal advocates and external partners
10. Change the company culture by changing management practice.
11. Celebrate breakdowns as opportunities for learning.
12. Don't ask people to add more to their load. Take something away; stop doing what no longer makes sense.
13. Use your rate of learning as the measure of progress.
14. Stabilize target production systems by making work flow predictable before attacking waste (*muda*).

BASIS FOR RECOMMENDATIONS

Create a sense of urgency is standard advice from writers on organizational change such as John Kotter (Kotter & Cohen, 2002). Organizations require routines in order to function, so it is necessary to somehow break up the relevant routines when change is desired. This line of thinking can be traced back at least to Lewin and his theory of organizational change, according to which it is necessary first to unfreeze then refreeze patterns of behaviour (Lewin, 1952).

Provide consistent leadership is also drawn from the literature on organizational change, but is a centrepiece of W. Edwards Deming and Joseph Juran's philosophy of management as well (Deming, 1986; Juran 1998) Saying one thing and doing another is perilously possible when those in leadership positions do not understand the implications of what they say, or when they lapse into old habits of speech or action. For example, placing verbal priority on quality and learning is contradicted by asking first or only about output.

Structure evaluations and rewards to encourage desired behaviour is again organizational change advice. How people are evaluated and rewarded exerts enormous influence on behaviour. Unfortunately, it is often quite difficult to predict exactly what that influence will be. The rule of thumb is to reward the behaviour that moves the organization towards its goals. That should be interpreted as applying not only to pay raises and promotions, but also and as importantly to the way supervisors interact with employees. Top down modelling of desired behaviour is critical. This is no place for 'do what I say, not what I do.' Further, the very role of supervision is revamped into mentorship, with the supervisor helping employees learn how to behave in your organization.

Facilitate and coach collaborative behaviours is necessary because of the importance of collaboration in lean project delivery and because of the lack of collaboration in traditional practice.

Develop your own 'way'; your philosophy of doing business. Liker's 14 Principles may capture the Toyota Way, and may be relevant in some fashion to all organizations, but as Liker himself insists, imitation is not the way to become lean. Every organization must develop its own way. Reflecting on Toyota's principles is a good starting point for that process.

Bring an external consultant (sensei) to guide your Lean journey when you start, to help with both strategy and education is standard advice from those who write about Toyota and serve as lean consultants. Lean is complex and multi-faceted. Those early in their learning can easily confuse muscle and fat, and so make fundamental errors at the outset of their journeys. An external consultant also has the benefit of not being under the sway of the existing organizational culture. Spancrete, a case study developed in this research, is an exception to this rule. However, they found someone internal who happened to have the characteristics of an external consultant. He took advantage of opportunities to educate himself, and brought his learning into the Spancrete culture. They got lucky. In every other case study in the research, an external consultant played a pivotal role.

Don't over-theorize. Develop a preference for action. Though lean is essentially a change in thinking, changing practice can change thinking, enabling more fundamental

changes in practice, and so on in a virtual cycle. Individuals differ in learning styles. Many learn best by doing, and everyone must complete their mastery of new behaviours through doing. Learning to 'do lean' can be likened to learning to ride a bicycle—get on the bike and start pedalling.

Start with your own work; on processes within your control. These may not involve an interface with an external supplier or customer. When ready, extend to systems that interface with others. At least two good arguments can be made for this advice: 1) A general principle of leadership is to lead from in front, and 2) Learning from working on processes within your direct control makes you better able to help your customers and suppliers. Support for this advice is primarily of the negative variety. For example, Sutter Health launched their commitment to lean project delivery by working with their suppliers of design and construction services, leaving Sutter's own project managers unprepared and feeling overlooked.

Once you are ready, *launch demonstration projects to adapt concepts and techniques to your situation, to provide proof of concept, to develop competence and confidence, and to build internal advocates and external partners.* Protect demonstration projects from the normal demands of the organization—treat them like babies learning to walk and talk. In some case studies, organizations chose to 'give lean a try' and called such explorations 'pilot projects'. The inevitable result is that the lean initiative fades away in the face of organizational resistance.

Change the company culture by changing management practice. Classroom training may be necessary, but will not be sufficient. A key to cultural change is for supervisors to serve as mentors (Mann, 2005)

Learn from failures. This again is standard advice in the literature on lean implementation, and was also evident in several of the case studies. Learning from failures is part and parcel of the scientific experimentation approach described in Spear and Bowen's *Harvard Business Review* article (Spear and Bowen, 1999; Spear 2004).

Don't ask people to add more to their load. Take something away; stop doing what no longer makes sense. The traditional approach to management inevitably accumulates procedures and reports one on top of another like an ancient garbage dump. As organization's embrace an alternative method of managing, they should be careful to get rid of the garbage; procedures not needed when people are capable of doing their jobs and reports intended only to apply pressure on those reporting, without creating useful information for them or others.

Use your rate of learning as the measure of progress. There is no measure of 'leanness' and no answer to the question 'How lean are we?'. The only comprehensive metric is the rate of learning.

Stabilize target production systems by making work flow predictable before attacking waste (muda). This is standard advice from lean guru's such as Liker (2005). What's more, it makes sense. If we start tinkering with processes before they are stable, there is no assurance that we will get the desired benefits. What looks like waste under one set of conditions may be a buffer necessary for absorbing variability under another set of conditions.

RECOMMENDATIONS FOR IMPLEMENTING LEAN ON CAPITAL PROJECTS

The ability of individuals and organizations to follow these recommendations will vary with position and circumstance, but to the extent possible, the following should be done to implement lean on projects:

- select partners or suppliers who are willing and able to adopt lean project delivery – *case studies (BAA, Sutter Health) and literature review on the Toyota Product Development System*
- structure the project organization to engage downstream players in upstream processes and vice-versa, and to allow money to move across organizational boundaries in pursuit of the best project-level returns - *case studies (BAA, Sutter Health, Burt Hill, Southland Industries) and literature review on the Toyota Product Development System and lean construction*
- do target costing: define and align project scope, budget and schedule to deliver customer and stakeholder value, while challenging previous best practice – *primarily an extension from the literature on the Toyota Product Development System, substantiated by a few case studies*
- encourage thoughtful experimentation; explore adaptation and development of methods for pursuing the lean ideal – *primarily from the literature review on lean construction, the Toyota Production System, and the Toyota Product Development System, substantiated by a few case studies*
- celebrate breakdowns as opportunities for learning rather than occasions for punishing the guilty - *case studies (users of the Last Planner system of production control) and literature review on lean construction, the Toyota Production System, and the Toyota Product Development System*
- do set based design: make design decisions at the last responsible moment, with explicit generation of alternatives, and documented evaluation of those alternatives against stated criteria - *primarily an extension from the literature on the Toyota Product Development System, substantiated by a few case studies*
- practice production control in accordance with lean principles such as making work flow predictable and using pull systems to avoid overproduction - *case studies (Abbott, BAA, BMW Constructors, Dow Chemical, GS Construction, Il-Yang, Messer Construction, Southland Industries) and literature review on lean construction*
- build quality and safety into your projects by placing primary reliance on those doing the work of designing and making, by acting to prevent breakdowns, including use of pokayoke techniques, by detecting breakdowns at the point of occurrence, by taking immediate corrective action to minimize propagation, and by acting on root causes in order to prevent reoccurrence - *primarily an extension from the literature on the Toyota Production System*
- implement JIT and other multi-organizational processes after site demand for materials and information is sufficiently reliable - *case studies (BAA, BMW Constructors, Dow Chemical, GS Construction, Il-Yang, Messer Construction, Southland Industries) and literature review on the Toyota Production System*

- use First Run Studies: on processes that transform materials, use to design and test process capability to meet safety, quality, time and cost criteria - *literature review on lean construction*
- use computer modelling to integrate product and process design, to design construction operations in detail, and for use by the customer in facilities management - *case studies (BAA, GM, Sutter Health) and literature review on lean construction*

These can be organized by the phase of the Lean Project Delivery System (Figure 2), preceded by a pre-project phase in which the organizational and contractual structure of the project is created:

PRE-PROJECT PHASE :

- Structure the project contractually and organizationally for pursuit of the lean ideal, using relational contracts and cross functional teams.

PROJECT DEFINITION PHASE:

- Align ends, means and constraints
- Set targets for scope and cost based on aligned ends, means and constraints
- Set other targets for experimentation and learning

DESIGN PHASE:

- Make work flow predictable through reliable promising and lean production control
- Follow a set based design strategy
- Design to target scope and cost
- Design product and process simultaneously; design for sustainability and buildability, including safe and defect-free fabrication and assembly
- Pull detailed engineering to the use of its outputs: product specifications, fabrication instructions, installation instructions and system specifications
- Produce detailed engineering's outputs from an integrated database

SUPPLY PHASE:

- Make work flow predictable through reliable promising and lean production control
- Prefabricate and preassemble
- Apply appropriate lean tools and methods in fabrication shops; e.g., 5S, value stream mapping, point of use materials and tools, cellular manufacturing
- Fabricate at the last responsible moment to reduce the risk of design change
- Produce assembly packages by kitting fabricated materials with commodities not maintained in site stores
- Deliver assembly packages to site just-in-time

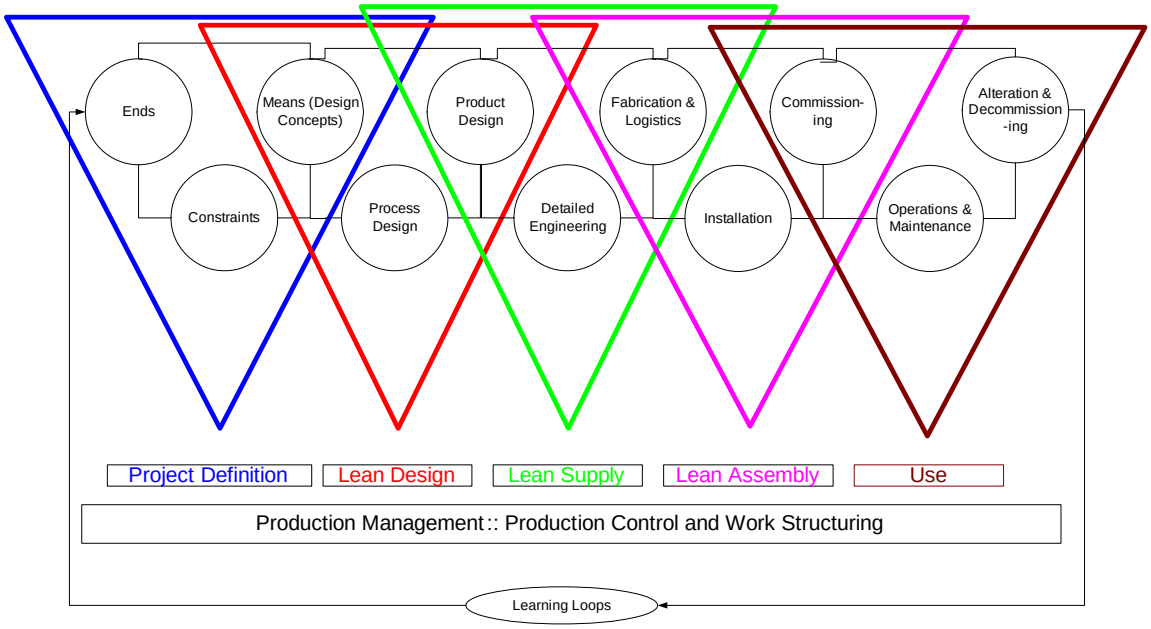

Figure 2: The Lean Project Delivery System

ASSEMBLY PHASE:

- Implement the principle of providing materials and tools at the point of use through site stores and assembly packages.
- Maintain commonly used and relatively small items (safety equipment, small tools, consumables, fasteners, etc.) in site stores. Replenish using kanban or vendor managed inventory.
- Do first run studies to improve the safety, quality, time and cost of operations (placing concrete, pulling cable, setting equipment), involving craft workers in operation design, testing and improvement.
- Build quality into your production processes through preparation, detection, correction and prevention.
- Get feedback on the effectiveness of production management and suggestions for improvement from craft workers through surveys and interviews.
- Apply other appropriate lean tools and methods in site assembly; e.g., layout for minimal travel time and 5S.

USE PHASE:

- Use commissioning and start up to verify delivery to requirements
- Transfer information (model, as builds, equipment manuals) to operators for use in operations and maintenance
- Conduct a post occupancy evaluation to verify understanding of the purpose of requirements and the adequacy of design and construction.
- Collect feedback from members of the project delivery team and other stakeholders on lessons learned.

The recommendations for implementing lean on capital projects were drawn primarily from the literature on the Toyota Product Development System (TPDS), the Toyota Production (manufacturing) System, and also from the lean construction literature and case studies.

The TPDS contributed target costing, cross functional teams, integrated product/process design, and set based design. The lean construction literature and cases contributed relational contracting, computer modelling, post occupancy evaluation, lessons learned, commissioning, and craft surveys. Applications or adaptations from the Toyota Production System include 5S, Built-in Quality, First Run Studies, kanban-replenished inventories, JIT deliveries, point-of-use materials, tools and information; visual controls, prefabrication and preassembly, value stream mapping, cellular manufacturing, and the Last Planner system of production control.

CONCLUSION

Organizations play various roles on project delivery teams: owner, owner agent, architect/engineer (process manager), consulting engineers (design specialists), construction manager/general contractor (process manager), and construction specialists. Each of the organizations playing these roles have different opportunities and face different challenges. Power to implement the project roadmap is distributed roughly in the following order:

- Owner
- Owner agent
- Process manager (design and construction)
- Specialist (design and construction)
- Supplier

The basic finding of this research is: No one is a helpless victim of fate. Everyone can act within the limits of their own power to create more value and less waste.

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