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LEAN DESIGN MANAGEMENT IN PRACTICE WITH THE LAST PLANNER SYSTEM

Roar Fosse[1] and Glenn Ballard[2]

ABSTRACT

Although mostly applied to planning of construction work, projects have also benefitted from adopting the Last Planner System® (LPS) to the design phase. This paper investigates how LPS applies lean principles in design management by presenting a case study of a project changing from traditional planning of the design process to using LPS.

Before the transition, the project struggled with several common challenges in design and was in danger of not submitting the design proposal on time. After implementing LPS, performance significantly improved, with the design proposal not just submitted on time, but also performing very well in terms of customer requirements regarding cost and quality.

It was clearly stated from the design team that they benefitted significantly from LPS. Better team alignment, clearer task description, better sequencing and increased process transparency were some effects, as well as potential problems better identified and solved in time through a weekly plan “check, correct and lookahead”-routine in design meetings.

The aim of this paper is to contribute to the practical understanding of how LPS can be applied to design and what outcomes can be achieved. Previous research has established LPS’ potential to counter common challenges in the design process, and the authors hope this paper further strengthens this notion by contributing with additional empirical findings.

KEYWORDS

Last Planner System, Lean Design, pull planning, PPC.

INTRODUCTION

The construction industry has for long shown significant room for improvement (Teicholz, 2001; Ingvaldsen and Edvardsen, 2007; Thune Holm and Johansen, 2006; Kalsaas, 2013). Forbes and Ahmed (2011) claim that the construction industry has for years become less efficient while other industries have improved, and that the industry is in strong need of improving approaches to several central processes.

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Apart from years of improvement potential in the planning and execution of construction, there is undoubtedly potential in the processes underpinning efficient production, such as design management (Haymaker and Flager, 2009). One central aspect of design management is planning and controlling the design process itself. This paper addresses how managing the design process by applying LPS can provide desired outcomes in the design phase through answering the two following questions:

- How applicable is LPS to plan and control design processes in practice?
- What results can be achieved in design management with LPS?

THEORY

LEAN DESIGN

The term "lean design" has for some years been used for the application of lean principles and methods in the design process (Hamzeh et al., 2009). Some characteristics of a lean design process are: A strong focus on early customer involvement, maximizing value by thoroughly identifying customer needs, minimizing waste in the process by early clarification of needs and objectives between project parties, establishing both product design and process design, making design decisions at the last responsible moment and optimizing sequencing of design tasks to reduce rework through unnecessary iterations (Khanzode et al., 2006; Ballard, 2000; Hamzeh et al., 2009).

Furthermore, lean design management often uses modern techniques and tools such as Target Value Design (TVD), Set Based Design (SBD), Building Information Modeling (BIM), Choosing By Advantages (CBA) and the Last Planner System (LPS) as means for realizing lean principles in practice (Munthe-Kaas et al., 2015).

PREVIOUS RESEARCH ON IMPLEMENTATION OF LPS IN DESIGN

Hamzeh et al. (2009) state that LPS is applicable to construction design processes and offer several benefits. Ballard et al. (2009) identify the differences between designing and making things, for instance that design tasks can be reciprocally dependent, and through two case studies present how LPS successfully impacted design work. Although the number is relatively small compared to that of construction work, there are published cases of LPS applied to design processes at least back to 1998 (Ballard, 2000).

In a case study, Kerosuo et al. (2012) observed increased completion rates of design tasks with LPS, with the design team becoming less reactive and more proactive, focusing on discussing interdisciplinary input needed to complete tasks than spending unnecessary time discussing uncompleted tasks. Koskela et al. (2002) argue that projects often realize that LPS is not only a better system for ensuring reliable promises, but that the lack of reliable promising itself had for years been a roadblock for efficiency in all project phases.

LPS can be seen as a system encompassing several components, with each of them being effective countermeasures towards what has traditionally been challenges in design management (Ballard, 2000; Mossman, 2013, Jørgensen and Emmit, 2009):

- **Planning**: Pull-planning sessions involve relevant project participants to create a plan based on needs across the team. Ownership of the plan is increased among participants as people can better explain and solve task sequencing of complex problems with visual post-it plans. This increases transparency of how design work must fit within the available time given by the plans for construction, resulting in plans more likely to be executed.

- **Lookahead**: In contrast to traditional planning, where problems are solved after they arise, one of the strengths of LPS is always focusing on making tasks ready in the coming weeks and solving problems proactively.
- **Checking**: Tracking PPC and root causes for failed commitments provides information on how work actually is performed compared to how it was planned.
- **Learning**: Analysis of PPC and root cause analysis over time provides useful insight into plan reliability trends so that we can implement counter-measures for problems that systematically cause failure to complete tasks as planned.

CASE STUDY

Workplace Oo

Skanska Norway both owns and develops the project, which is an 8-story, 22 000 sq.m., 380 MNOK (approx. $45M) office building in Oslo. The case study took place in the development phase, where initial design was developed within the owner's cost and quality requirements and then submitted for evaluation and negotiations to establish the final project scope. The design team was from several companies and consisted of two bid managers, an owner's representative, an architect, a structural engineer and several technical engineers as well as some specialty disciplines.

From Traditional To Lean Design Process Management

Initially, the bid phase was planned and managed traditionally, with the bid manager planning every design discipline's tasks and trying to control the process. Within a short amount of time, however, several unwanted, although not uncommon, effects occurred:

- **Unclear handoffs and need for input***:* Tasks seemed poorly described and not in the optimal sequence. Several team members felt a number of their assignments were not broken down correctly, and they were lacking input from each other.
- **Little or no confidence in the time allocated**: Fairly early it became a stressed notion in the group that there was not enough time to do the design work. Consequently, the deadline was extended. But, after another few weeks the same situation arose, and another extension was granted. However, when the team argued that a third extension was needed, this was denied by the owner.
- **Low volume of deliveries per week***:* It seemed like the design team continuously fell behind schedule due to a low level of completed work per week. The assistant bid manager had a suspicion that the cause was poor planning and control.

- **Decreasing group atmosphere**: As can often happen in a poorly performing group, the level of incipient friction and poor communication increased.

The assistant bid manager involved his regional lean manager (the lead author of this paper) to establish a new system for planning and controlling the design process. LPS was not specifically requested, but "some sort of post-it planning methodology" was discussed as he had positive experiences with at least putting post-its on a wall. However, the bid manager had experienced an attempted post-it planning session that had not gone too well, which could explain the hesitation to contact a lean advisor.

Due to the state of the process at the time, the lean manager strongly recommended a very structured management philosophy with a few specific focus points that needed to be endorsed by the two bid managers before initiating the LPS implementation:

- **High focus on structure***:* In the design meetings, a clear separation of process discussion (first 30-60 minutes) and design discussion (remainder of meeting) was important. This was to avoid stopping for lengthy design discussions in the process portion of the meeting unless it had significance to the plan.

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- **Involvement and equality of disciplines***:* With a clear need for information, clarifications, decisions and deliveries across the team, all disciplines were gathered for the pull planning and the weekly design meetings. Owner and design management were handled as trades, equal to the others and similarly held accountable for the deliveries they had towards the team. An owner representative being faced with the same questioning for commitments as the fire consultant is uncommon and could initially feel uncomfortable, but was essential.
- **Metrics had to be understood and embraced***:* For example, none of the design team members were familiar with PPC. It was therefore critical to introduce this correctly, as an indicator of *to which extent we as a group performed as committed*, not a measure of the quality of work performed and certainly not a metric used to single anyone out.

IMPLEMENTATION OF LPS AT WORKPLACE OO

In the spirit of lean, the design managers and lean manager started by identifying which parts of the LPS were value-adding in the process at hand and which were not. The following choices were made from the conventional LPS:

- **Only one plan level**: For the development phase of nine weeks, there was no need to split the plan into different plan levels. A high level of detail of tasks was chosen, which was consistent for the entire plan.
- **Alternative lookahead process**: As part of the plan check routine in the weekly design meetings, every trade needed to check if all necessary predecessors for their

activities were in the plan. Although more prerequisites might be needed for tasks to be sound activities than what can be presented as predecessors, it was deemed sufficient due to the experience that design commitments usually fail due to preceding activities (drawings, lists, decisions etc).

- **No root cause analysis***:* With limited time for learning and the entire methodology being new to the entire team, this was considered an excess tool.

Pull-planning

The entire design team gathered for a two day pull-planning session. This is longer than usual for planning such a short phase, but there was a need to stop the ongoing process at Workplace Oo, get the team aligned and establish a good plan.

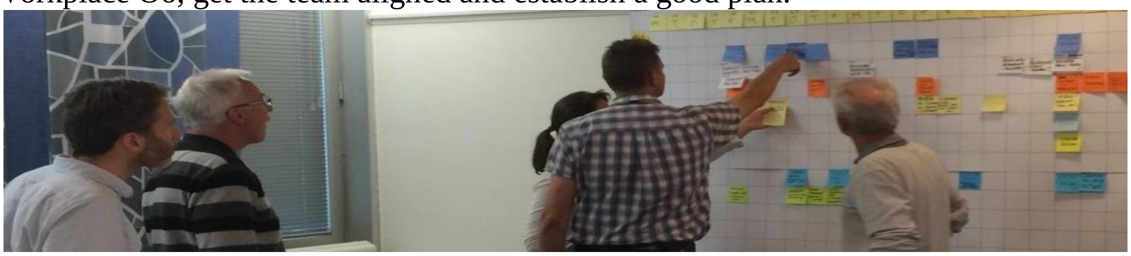

Figure 1: Pull-planning session at Workplace Oo

There were some guidelines used in the pull-planning session:

- Every post-it is an *output*, a "delivery" (e.g. drawing, list, decision) from that person into the group, not an *input* (something the person needs from the group).
- Post-its symbolize the moment of completion, not put over the entire time span work is performed. The latter is usually done for planning production work, to visualize the duration of tasks, which helps in managing logistics and safety by signaling what work is being done when. In design, however, a post-it rather signals the specific moment in time a task is complete (the time of the handoff).
- People can only handle their own post-its. If someone needs another discipline to add or move a task in the plan, they need to ask the person representing that discipline to do so. This creates a high ownership of tasks, as no person could ever say a task has been assigned to them without them knowing and agreeing.

After an initial quick training in lean principles, the session was split into four stages:

1) Writing well-described post-its and putting them in sequence on the wall.
2) Everyone checking each of their own post-its to make sure that all predecessors are to the left of that post-it, generating more post-its if necessary.
3) Marking a "v" in the top right corner of each of their post-its to truly commit to having checked that each post-it has the necessary predecessors. More post-its appear as disciplines feel more obligated to truly check and commit.
4) Post-its are moved from the blank plan onto a plan with rows (time) and columns (disciplines), allowing for more accurate estimates of time needed per task.

Through the entire design process, the plan was accompanied by a question matrix, used for questions that design team members were unable to answer right away and that could not be formulated as commitments on the plan. Questions remaining in the matrix for weeks became very apparent, so these issues were handled quicker than in traditional design processes, where forgetting or delaying a response is much more acceptable.

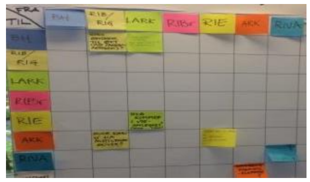

Figure 4: Question matrix at Workplace Oo

Weekly plan check and update

Every design meeting started with a 30-60 minute process section consisting of 3 steps:

- **Plan check***:* Checking the post-it plan if committed tasks are complete (marked "OK") or not (marked "X") and calculating PPC. It was a clear shift in mindset to parts of the design team that "partially complete" was considered "incomplete".
- **Correction**: Incomplete tasks had to be changed from past to future commitments. They could be moved, rephrased (perhaps task definition wasn't accurate enough) or split into several post-its. If other future tasks had to be shifted accordingly, participants owning these post-its would come to the wall and do these changes.
- **Lookahead**: The design team checked if future commitments were realistic. Changes included improving task description, splitting or merging tasks and adding predecessors. Focus was especially on the next few weeks, but this was also an opportunity for discussing issues further down the plan.

This weekly routine was in fact a plan-do-check-act approach to the design process: During the week, the design team worked with their commitments (do), then in design meetings PPC was tracked (check), incomplete commitments corrected from past to future (act) and a lookahead process performed for the upcoming weeks (plan). The question matrix was also checked and updated as part of the weekly plan check.

RESULTS

A successful bid submitted

The design team at Workplace Oo went from struggling to performing very well, going from being in risk of not delivering an acceptable bid within the time to not only delivering the bid on time, but doing so within the accepted cost, breaking records on cost per sq. meter and satisfying all client needs. The project is currently in the final stages of establishing the final project scope before commencing.

Benefits of pull-planning

In reviewing the design phase, pull-planning was considered imperative for establishing a good plan as basis for effective collaboration. This is further supported by findings from projects across the region, where design teams have ranked how they feel pull planning, as opposed to traditional planning, increased the following factors on a scale from 1 to 6:

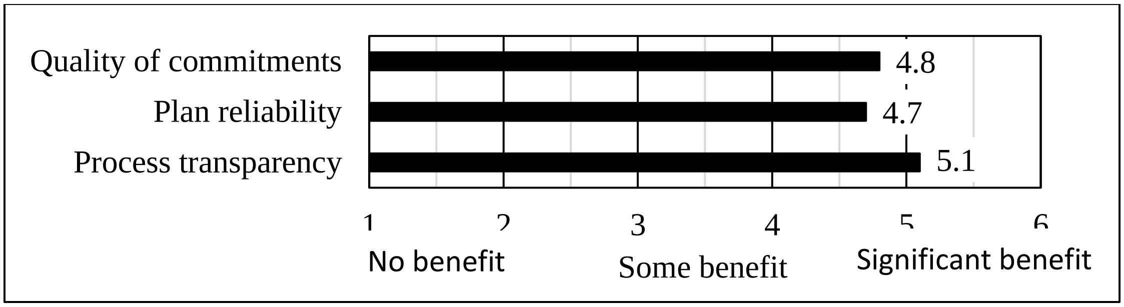

Figure 2: Survey of effects from pull-planning vs traditional planning (60 answers)

Percent Plan Complete (PPC)

The design team at Workplace Oo started with a high PPC. As so often in construction, teams have a good idea what to do in the near future and perhaps somewhat forget the more distant future. Also, the team had even started several of the committed tasks before the pull-planning session, making them very likely to be complete in the first plan check one week later. After 3 weeks of less impressive PPC scores, the design team had an increasing level of average PPC, indicating that they became better at planning throughout the process, finishing with a strong average PPC of 75,53%.

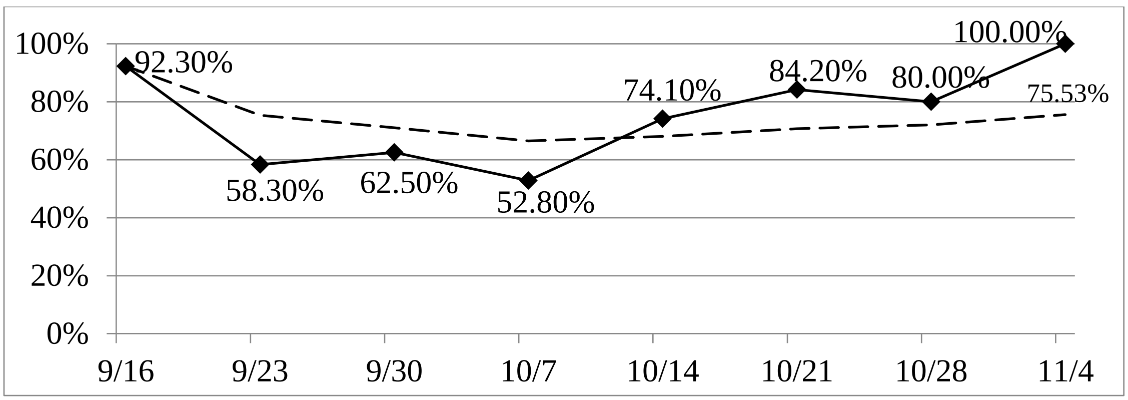

Figure 3: The weekly (solid line and nodes) PPC and average (dotted line) PPC.

Task Completion Curve (TCC)

Although not a tool from LPS, this tool was used to visualize the volume of tasks delivered in the process by breaking a burndown chart (known from the SCRUM planning methodology) down into its two components: Total volume of tasks on the design plan (the number of post-its on the wall) and accumulated number of completed tasks (the number of "OK" post-its on the wall). The Workplace Oo delivery curve (dotted line) shows a stable, even delivery volume per week.

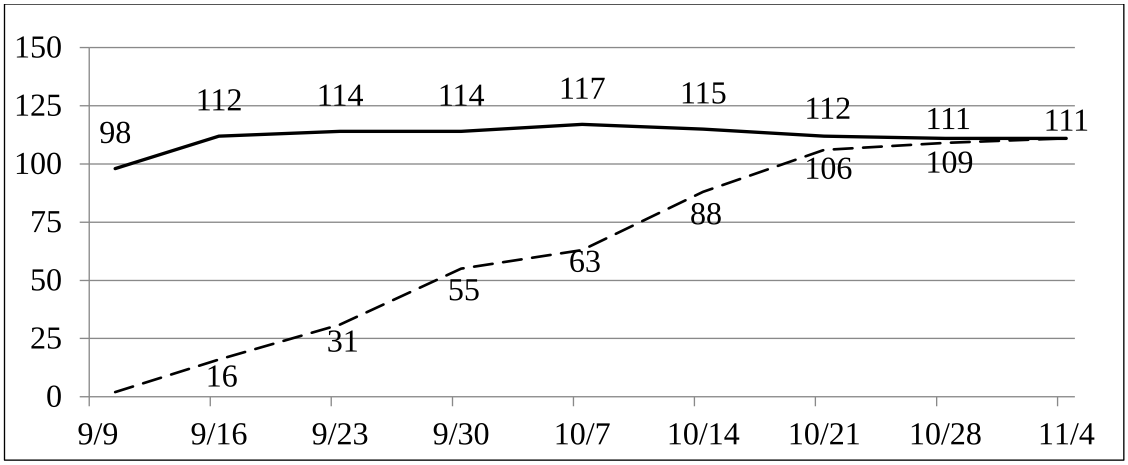

Figure 4: Total number of tasks on design plan (solid line) and accumulated number of completed tasks (dotted line).

Failed commitments

In the weekly plan checks, completed post-its were marked “OK”. Non-completions were marked “X”, and the number of X’s on a post-it could accumulate, since incomplete activities were moved to future commitment dates and being subject to future plan checks. Of the 111 total tasks, the final distribution at Workplace Oo in terms of X’s was as follows:

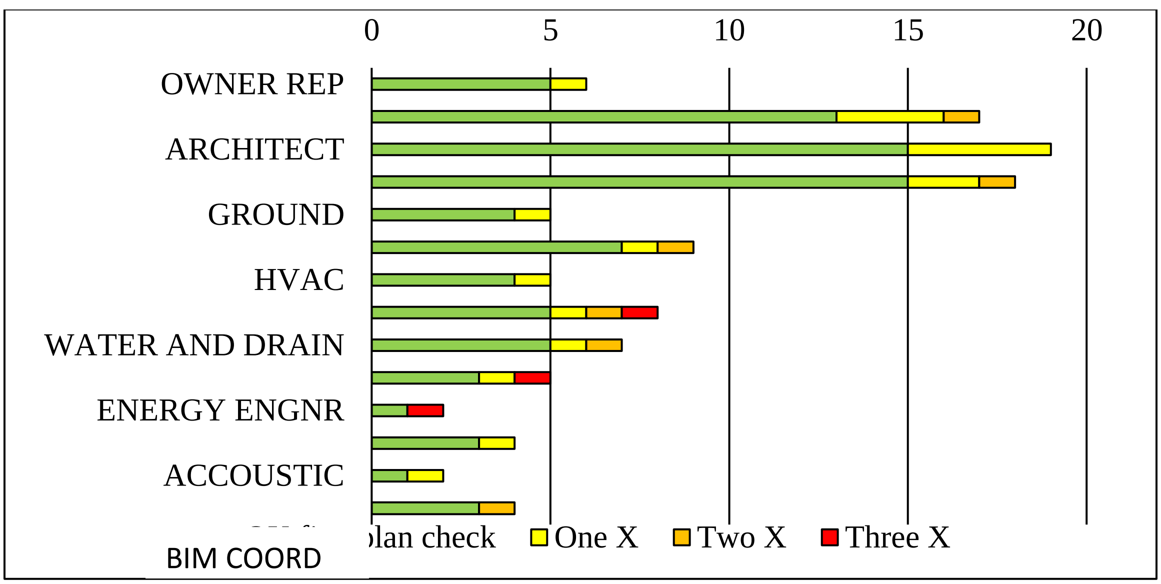

Figure 5: Distribution of accumulated X’s of commitments.

This figure shows that overall, most trades had a healthy distribution of tasks completed on the first attempt to commit (green bars) vs failed commitments. It was noted by the design management that the team had gained from the reliable promising of the owner’s representative and the architect, which is supported by figure 5.

DISCUSSION

The two research questions posed in the introduction were:

- How applicable is LPS to plan and control design processes in practice?
- What results can be achieved in design management with LPS?

LPS is undoubtedly applicable, with some adjustments compared to planning construction, such as post-its representing the time of handoff rather than visualizing the entire duration of time a task is worked with. The case study did not utilize all the components of the LPS. For instance, only one level of detail for the entire phase proved sufficient, due to the design phase at hand lasting only 9 weeks. Root cause analysis was also seen as an excessive tool for the case study, but it is an ambition to establish this tool for learning throughout the rest of the project. There are no indications that these elements of LPS should not be applicable as well.

The desired effects of applying LPS as outlined by previous literature could definitely be identified as outcomes identified from the case study:

- Increased process transparency, quality of commitments and confidence in plan reliability among design team with pull-planning with post-its.
- Work scheduling from pull of assignments from a client-supplier mindset in the design team, clearly seen in the process of pull-planning with post-its.
- Learning through tracking amount of non-completions and identifying which deliveries struggled to be completed. At the time of submitting this paper, the contractor has implemented LPS as described in this paper on over 10 projects, and by tracking their non-completions, we are hoping to learn *which* commitments projects struggle to deliver on. Root cause analysis has recently been implemented in some of these projects, and will hopefully providing information on WHY these failures in commitments occur.
- Process control was achieved with metrics such as PPC and delivery volume control, giving the design management data to understand if the design process was going in the right direction or if corrective actions needed to be taken.
- Plan-do-check-act mindset through the steps of weekly work planning and plan checks in design meetings.

CONCLUSION

The case study clearly indicates that the Last Planner System® is not only applicable to design processes in practice, but also has very beneficial effects for projects, supporting the findings of previous research. Since some elements of LPS could not be included in this case study, future research should investigate if adding these bring additional benefits to managing design processes.

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