THE LEAN JOURNEY: IMPLEMENTING THE LAST PLANNER® SYSTEM IN CONSTRUCTION

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ABSTRACT

The Last Planner® system for production planning and control has helped construction projects improve planning reliability, production performance, and construction workflow. However, many organizations face significant hurdles when implementing the Last Planner® system for the first time. The hurdles are multifaceted and are tied to organizational, cultural, and technical factors. This paper highlights implementation issues mentioned in the literature and reports implementation challenges and failures experienced on three construction projects. Using action-based research where the author was actively involved in implementing the Last Planner® system on the three projects, the paper presents a framework for successful implementation of the Last Planner® system on construction projects drawing on previous research, lessons learned from change management, and previous lean implementations. The suggested framework will be tested on future construction projects newly implementing The Last Planner® system for proper model calibration.

KEY WORDS

Lean Construction, The Last Planner® System, Production Planning and Control, Implementation, and Change Management.

INTRODUCTION

As variability undermines project performance and disrupts workflow in Architecture, Engineering, and Construction (AEC) processes, AEC organizations often strive to maintain consistency in production flow and shield production from uncertainty in their in-house processes and their business environment (Hamzeh et al., 2007; Hopp & Spearman, 2008; Thompson, 1967).

Thus, they employ production planning and control methods to manage uncertainty and reduce variations in production systems. A production system can be described as a collection of people and resources (e.g. machinery, equipment, information) organized to design and make goods or services of value to customers (Ballard et al., 2007). An example of a production planning and control system is the Last Planner® system (LPS) which has been successfully implemented on construction projects to increase the reliability of planning, increase production performance, and improve workflow in design and construction operations (Ballard & Howell, 2004).

The system was originally intended to address reliability issues at the weekly work plan level but soon expanded to cover the four levels of planning and schedule development: 1) *Master scheduling*, which is the output of front-end planning and

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identifies major milestone dates, 2) *Phase scheduling which* involves a collaborative planning exercise that generates a detailed schedule covering each project phase, employs reverse phase scheduling and identifies handoffs between the various specialty organizations, 3) *Lookahead planning* which looks at activities within a time frame of two to six weeks, breaks activities down into the level of processes/operations, identifies constraints, assigns responsibilities, and makes tasks ready by removing constraints, and 4) *Weekly work planning* develops the lookahead plan into a weekly work plan by presenting activities in the most detailed level required to drive the production process (Ballard 1997; Ballard, 2000; Ballard & Howell, 2004; Hamzeh et al., 2008; Tommelein & Ballard, 1997).

The Last Planner® system embodies the principles and human values of lean thinking. Lean is a business philosophy and a system for organizing and managing corporate processes including product development, design, production, operations, supply chain, and customer relationships to increase value and minimize waste. Lean is a perpetual quest for perfection pertinent to organizational purpose, business processes, and developing people (Liker, 2004; Womack & Jones, 2003).

As a lean tool, LPS advocates: (1) planning in greater detail as time gets closer to executing the work, (2) developing the work plan with those who are going to perform the work, (3) Identifying and removing work constraints ahead of time as a team to make work ready and increase reliability of work plans (4) making reliable promises and driving work execution based on coordination and active negotiation with trade partners and project participants, and (5) learning from planning failures by finding the root causes and taking preventive actions (Ballard, 2000; Ballard et al., 2007).

Despite the advantages of the LPS, research has shown that many organizations face significant hurdles when implementing the system (Ballard and Kim, 2007; Hamzeh, 2009; Viana et al. 2010). An implementation framework may help such organizations develop a better implementation plan, foresee implementation hurdles, invest resources into the change process, successfully implement the LPS, and sustain this success.

A question remains unanswered: how can the AEC industry successfully implement LPS and incorporate it into day-to-day production planning and control? This paper reports implementation challenges and failures experienced on three construction projects when implementing the LPS. Organizations planning to implement the LPS on their construction projects can benefit from the framework presented in this paper. The guidelines suggested in this paper will be further tested on future construction projects as experiments in change management and implementing the LPS.

RESEARCH METHOD

This paper presents results from previous research highlighting industry challenges related to implementing LPS. It also reports research results from three construction project case-studies implementing LPS. The case studies include a health care project, a research facility, and an administration building. The first project has been employing LPS for two years during the design phase and has invested heavily in employee training in different aspects of lean construction. The owner is a strong advocate of lean and integrated project delivery systems. The author performed research on this project for 18 months assisting the project team in developing a standardized planning process and implementing LPS.

The second project implemented LPS in a hurry at the beginning of the construction phase in response to the owner's request. The author was asked to audit the implementation process for 8 months, assist in employee training, and provide improvement suggestions.

For the third project, the GC implemented the LPS at the last seven months of the project after a failed attempt to implement LPS hastily at the beginning of the project.. The author was asked to run the pull or phase session and introduce the project team to the LPS.

Research was performed in an "action research" environment where the author joined each project as a team member or insider (Coghlan, 2001), gathered empirical data, analyzed and evaluated the data with the team, searched for patterns or variations, developed various improvement alternatives, and tested these improvements empirically. The research process follows an inductive reasoning scheme adjusted to the specific situation. Accordingly, the research process comprised multiple steps of evaluating and assessing the current practice, developing guidelines for improvements, and testing these suggested guidelines.

The author highlighted 17 factors contributing to the success of LPS drawing on experience from previous implementations and research in change management (Kotter, 1996; Ballard and Kim, 2007; Ballard et al., 2007; Goh and Richards, 1993; Hamzeh, 2009; McGill and Slocum, 1993)). The study reports the presence of these factors on the three case-study projects in Table 1 and summarizes their impact on the successful implementation of the LPS on these projects.

Although the author presents objective results throughout this paper, his active role on the projects used as case studies may constitute a limitation to the method and tools used.

IMPLEMENTATION CHALLENGES

The LPS as a lean method for production planning and control should be viewed as a first step towards creating a higher-performing, more competitive lean enterprise. The critical distinction to be made is that LPS is only one tool to facilitate a new more effective way of performing production planning while lean is a much broader philosophy. However, to successfully implement a lean tool (such as the LPS), the organization must be committed to learning, changing, and focusing on people and philosophy and not only focusing on tools and methods (Liker, 2004).

Construction companies have implemented lean tools at the level of operations through the use of weekly work planning from the LPS and other tools that have low complexity without necessarily tying these tools to strategic goals (Neto and Alves 2007).

The implementation process usually faces various obstacles common to any organizational change. Researchers in the field of change management and lean have reported attempts of many organizations to implement lean practices. However, most companies either failed or only partially achieved lean production in its true form (Liker, 2004; Kotter, 1996; Ballard et al., 2007; Hamzeh, 2009). Viana et al. (2010) studied the LPS implementation in Brazilian companies and highlighted various implementation hurdles including: 1) difficulty in adapting to the new culture, 2) incompatible personnel qualifications, 3) long time spent on planning issues, 4) incomplete information, and 5) high interdependence between various processes.

The core philosophy of lean production revolves around teamwork and continuous improvement. Many organizations fail to operate with much of either. This can also be seen on construction projects that involve multiple self-interested parties, with little motivation to improve. Liker (2004) emphasizes that the secret of the Toyota Way is that it creates bonds among individuals and partners so that they can work collaboratively toward a common goal.

Lean thinking requires employees to change the way they view and execute their work (Liker, 2004). This may result in some loss of independence as the focus shifts from the individual tasks to the larger integrated team goals. Changing the status-quo can not only be seen as cumbersome, but even threatening to people who have operated relatively successfully for years within the current system. The key is preparing them to be willing to learn, to work better, and strive for continuous improvement.

Ballard et al. (2007) studied the implementation of LPS on many construction projects and reported various implementation obstacles. Projects in the study experienced strong resistance to change on the part of project team and members within the organization. In some cases, implementation challenges were the result of a lack of leadership during the process. In other cases, there was a lack of commitment by upper management or top down mandates without active support.

Hamzeh (2009) highlighted two sets of factors, local and general, impacting the implementation of new methods, in general, and the LPS, in particular. Local factors are potential challenges attributed to project circumstances and the team including: fairly new experience in lean methods, traditional project management methods, novelty of LPS to team members, fragmented leadership, and team chemistry. General factors impacting the implementation of a new process include: human capital, organizational inertia, resistance to change, technological barriers, and climate.

Human capital is associated with human skills and experience required on a project. It addresses the need to continuously develop new skills as new technologies, processes, and policies are implemented. Inertia increases the resistance to change in organizations. Inertia is attributed to both internal structural arrangement and external environment. Internal factors include: (1) investments that are sunk in plant, equipment, and personnel, (2) incomplete information reaching decision makers, (3) internal political constraints such as fear that change may disrupt internal political equilibrium, and (4) constraints generated by an organization's history such as standard procedures and normative agreements. External factors are equally significant and include: (1) barriers to entry and exit from markets, (2) incomplete information about external environment (demands, threats, and opportunities), (3) legitimacy constraints arising when a new norm challenges the established norms, and (4) collective rationality problems (e.g. a strategy found rational for a certain decision maker may not necessarily be rational for a large number of decision makers) (Hannan & Freeman, 1977).

Resistance to change, which is closely related to inertia, is high in an organization when individuals believe that they will do tomorrow the same thing they are doing today (Zammuto & Krackower, 1991). Technological barriers may have a substantial impact on the success of a novel process. The apparent influences include: lack of experience with new technologies, the instability and breakdowns in using these technologies, incompatibility with current systems, and investment in the form of time, cost, quality of processes, and human capital. Climate is an organizational characteristic that employees live through and experience while working for an organization. The climate shapes their behavior, performance, and the way they perceive the organization. Climate thus influences an organization's ability to change and the change process. Two overlapping types of climate considered in the literature are psychological and organizational. Several dimensions contribute to the perception of psychological climate in an organization such as: autonomy, cohesion, trust, pressure, support, recognition, fairness, and innovation (Koys & Decotiis, 1991).

IMPLEMENTING THE LAST PLANNER ™ SYSTEM: CASE STUDIES

CASE STUDY 1

The first case study is a proposed 555-bed hospital and medical campus in San Francisco, California. The $1.7 billion project includes a 16-story hospital including two below grade floors. This is a unique case study since the project is: (1) implementing integrated project delivery (IPD) and integrated form of agreement (IFOA), (2) engaging project partners who are interested in experimenting with lean practices, (3) applying LPS for production control, (4) utilizing target value design (TVD) to steer design towards meeting the owner's value proposition, (5) and using building information modeling (BIM) extensively.

A transition team was selected on this project and entrusted with developing a new planning process, identifying training needs, developing training programs, and studying deployment models. The team involved cluster leaders and managers from the architect/engineer and the construction manager / general contractor. The transition team composed a training program to teach various aspects of lean theory, methods, and tools. This program included four main sections: (1) introduction to lean history, concepts, and methods, (2) basic training modules, (3) lean project delivery, and (4) lean management. Coaches from the project were later assigned to produce and teach the basic training modules. These modules include: (1) value stream mapping, (2) 5 S (sort, set in-order, shine, standardize, sustain), (3) reliable promising, (4) learning from experiments, (5) learning from breakdowns, (6) Choosing by Advantages, and (7) A3 reports.

The collaborative implementation process on the project is the foundation for the implementation framework presented in this paper. By establishing transition teams the project management team was able to effectively generate buy-in for the process and relate the value of LPS. The training program was instrumental in aligning project team members around lean goals and developing a collaborative planning environment. Despite the success of these efforts, the project team faced many common barriers to change which limit the effectiveness of LPS. These include organizational inertia, human capital constraints, technological barriers and general resistance to change (Hamzeh, 2009). These factors are not unique to LPS implementation and will likely be obstacles to any change effort.

Although the implementation was fairly successful on the project, establishing a framework for LPS implementation will aid project teams attempting the change effort.

CASE STUDY 2

The second case study is a 232,000 square foot research center in San Francisco, California. The five story building is scheduled to open in 2011 with an estimated cost of $181 Million. Although the project's contractual structure is bound by design-bid-build agreements, the owner has been creative in looking for ways to enhance collaboration, information flow, and management processes on the project. Accordingly, the owner advocated the applications of several lean methods including LPS for production planning and control. To insure timely completion of the project, the owner offered a monetary incentive plan for the general contractor and major subcontractors.

The General Contractor (GC) started applying LPS at the beginning of the construction phase involving all subcontractors on the project. Because most of the project parties were not conversant in LPS, the GC organized training sessions to familiarize the team with lean principles and production planning using LPS. Spurred by the owner's interest in lean methods, the GC took on the challenge of implementing a new planning process and involving all project parties in phase / pull planning sessions, the open use of collaborative scheduling tool called TOKMO, and in weekly work planning meetings.

Although the inexperience of most project parties in lean methods and LPS was an impediment to collaborative planning, the general contractor took the lead in changing the traditional methods of project management. These traditional methods relied heavily on contractual structure and functional silos inhibiting coordination and collaboration. The training sessions and the general contractor's conduct during collaborative planning meetings helped send the right message and bring the rest of the team on board.

The project faced many challenges when implementing LPS especially the lack of an implementation plan, lack of experience with lean, unclear strategic goals, and the lack of training despite the fact the owner was sponsoring the implementation process.

CASE STUDY 3

The third case study is a 218,000 square foot administration building in Denver, Colorado. The $64 million dollar design-build project was completed in June 2010. The GC pushed for implementing the LPS during the last seven months of the project although an earlier attempt to implement the LPS ended in failure. The implementation team fell short of gaining support and buy-in from management and leaders in the field. Although the project benefited greatly from pull sessions where many wrong assumptions on the master schedule were detected and corrected, the implementation team reported various implementation challenges such as: strong resistance to change, lack of leadership, limited buy-in from superintendents and project managers, lack of experience with lean and the LPS, lack of training, and lack of an implementation plan. As a result the system was abandoned as the project was close to completion.

SUGGESTED FRAMEWORK FOR IMPLEMENTING THE LAST PLANNER® SYSTEM

The Last Planner® system challenges the old practices of developing schedules and pushing them from top management down to frontline people to execute. It advocates collaborative planning, performing collaborative constraint analysis, and learning from plan failures. The Last Planner® system is not only a system for production planning and control but also an enabler for social exchange on construction projects. It institutionalizes coordination and communication by incorporating them into everyday activities and into a managerial structure for project planning and control, team building, and continuous improvement.

Researchers in the field of lean construction identify common implementation barriers to lean construction and the LPS including: lack of leadership, resistance to change, and poor implementation planning (Ballard and Kim, 2007; Hamzeh, 2009; Viana et al. 2010). However, as the case studies indicate, little attention seems to be paid to developing a thoughtful plan for integrating LPS into a project. There is commonly an effort to train people in the system as a tool, but implementation plans seem to fall short in regard to philosophical and social considerations.

Because learning in the LPS is vital for continuous improvement, the author believes that the best place for LPS to thrive in is a learning organization where the culture fosters continuous experimentation, acknowledging failures and learning from them, collaboration and transparency between project teams, sharing information, rewarding innovation and taking responsibility, hiring employees who are able to always learn, growing leaders who are regenerating and willing to deal with new challenges.

Applying LPS on a project is a lengthy process and requires strong commitment from the owner, top management, and all others involved. The framework presented in this paper is a suggested method that should be tailored to project circumstances and conditions. It draws on experience from previous implementations and research in change management (Kotter, 1996; Ballard and Kim, 2007; Ballard et al., 2007; Goh and Richards, 1993; Hamzeh, 2009; McGill and Slocum, 1993)). The recommended implementation framework is shown in Figure 1 and includes the following steps:

- **Develop a clear vision to implement the LPS as a strategic goal and create a sense of urgency for implementing it**. The organization should have a clearly articulated purpose for implementing the LPS and increasing the reliability of production planning and control. It should be part of strategic goals not just operations. Creating a sense of urgency shows the implementation team the detrimental impacts of poor planning and the urgent need to implement the LPS.

- **Harness the support of the project's owner and your organization's top management**. Change is next to impossible without strong commitment from the head of each organization, the division managers, and even middle level managers.

- **Establish an enthusiastic/knowledgeable cross-functional nucleus team and develop goals to accomplish**. The nucleus team should be entrusted with the implementation process before it starts and during the implementation life. Thus the team should develop goals, identify training needs, recognize implementation hurdles, develop implementation steps, and perform necessary adjustments. The team should involve front line managers and last planners from different disciplines and trades. The team should also put the opinion leaders in charge and work on involving as many individuals in the organization as possible. Without the momentum of many individuals, little meaningful change will occur. Team incentives for reaching the stated goals may also be formulated by the team after securing buy-in from top management.

- **Evaluate and map the current planning process.** Use process mapping to highlight both deficiencies and opportunities for improvement in the current planning process.

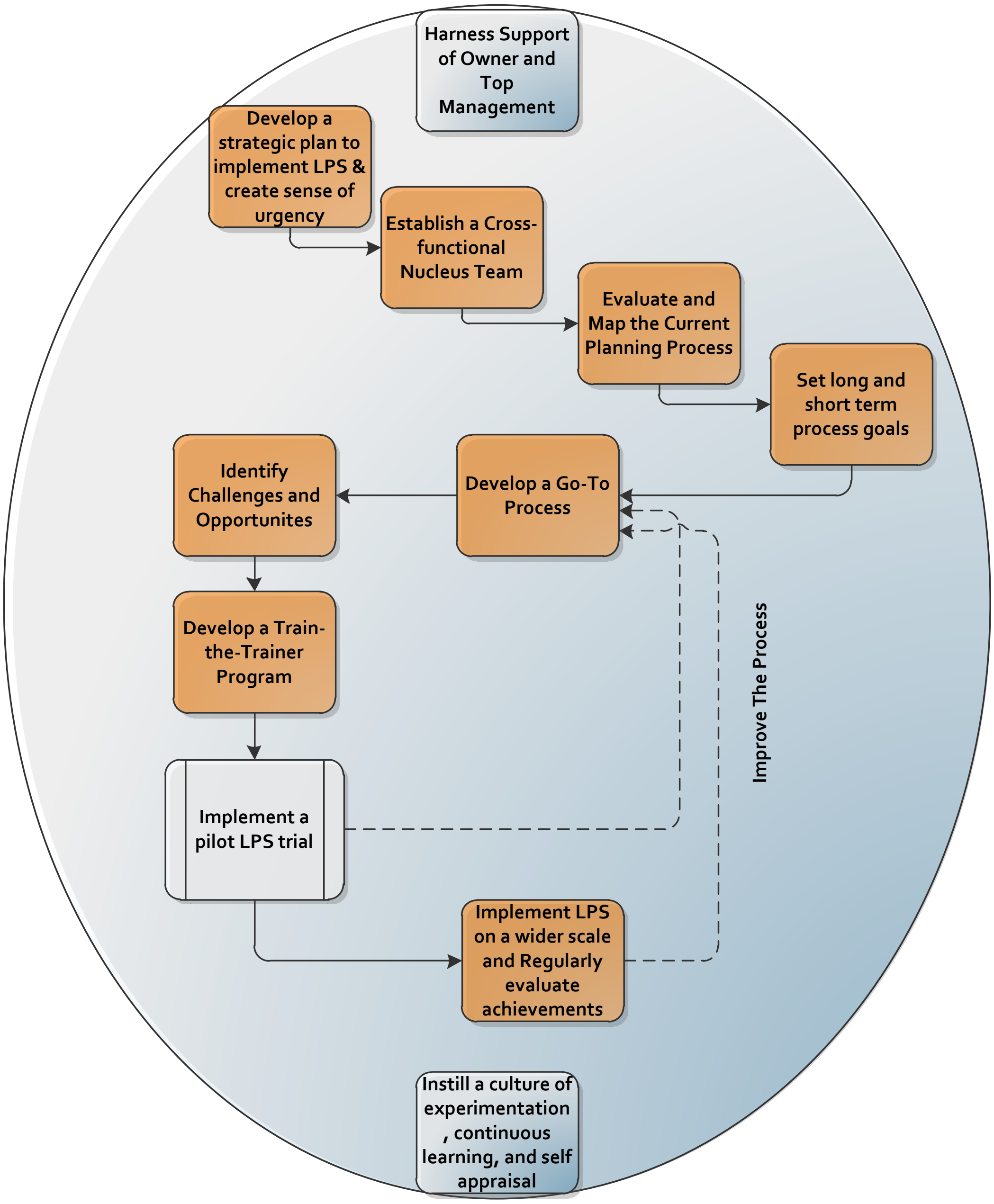

Figure 1: Suggested framework for implementing the LPS in construction.

- **Set long term and short term aspirations that match the company/project strategic goals.** The nucleus team should set the short and long term goal for implementing the LPS.

- **Develop a go-to process**. Customize LPS to the current project/organization by developing a standard process for collaborative schedule development from the master schedule to the weekly work plan, schedule disseminating, schedule updating, and learning. The nucleus team embeds into the go-to process goals and vision of the future.

- **Identify challenges and opportunities for implementing the new process**. In developing the vision for the future the nucleus team identifies possible challenges and communicates them to the organization. The team also highlights the opportunities and ways to seize them.

- **Develop and perform a train-the-trainer program and a diffusion plan**. The nucleus team with the help of a lean coach/consultant identifies training needs, develops a training program, trains the future trainers who are mostly last planners (superintendents and foremen), and communicate the goals to the organization. People won't help with the change process unless they believe it is both useful and possible. The team also develops a plan for a wider application of the LPS beyond the pilot trial.

- **Implement a pilot LPS trial and create a positive team experience during initial implementation**. People need to see compelling evidence of success during initial implementation stages on a pilot LPS trial so that they can build on these successes. However, improvement should not stop when reaching interim goals. Therefore, the team needs to introduce regular incremental adjustments and improvements to the process in order to meet the end goals. The new process should become part of standardized project/organizational procedures. However, these standardized procedures are there for people to improve on.

- **Implement the LPS on a wider scale, incorporate lessons learned, and Evaluate achievements regularly:** Implement the LPS in other parts of the project or on other projects after incorporating lessons learned from the pilot LPS trial and introducing the necessary process adjustments. A regular evaluation of the process and comparing results to the set goals is required to sustain success and drive continuous improvement.

- **Instill a culture of experimentation, continuous learning, and self-appraisal.** Developing a learning organization requires adopting a new culture which facilitates experimentation, encourages taking responsibility, acknowledges failures and learning from them, and rewards innovation and willingness to take risk.

CASE ANALYSIS

The implementation framework is expected to help organizations better plan and organize their implementation efforts, increase the chances of successful implementation, and sustain this success.

The three case study projects were examined to evaluate the availability of factors, presented in the framework shown in Figure 1, enabling a successful implementation of the LPS. The results summarized in Table 1 show that project 1 had the majority of the success factors available which might have increased the chances of a successful implementation. Projects 2 and 3 had major implementation issues and had a small number of the enabling factors available.

While table 1 is useful in assessing the importance of the enabling factors mentioned in the suggested implementation framework, further research is required to evaluate the framework and introduce adjustments if need be.

Table 1: Factors enabling the successful implementation of the LPS on three case-study projects.

Factors enabling a successful implementation of LPS	Project1	Project2	Project3
1-Link the implementation of LPS to strategic goals	√		
2-Support and Commitment from top management	√	√	
3-Having the appropriate human capital (skills, training, etc.)	√		
4-Establishing a knowledgeable cross-functional transition team	√		
5-Map the current planning process	√		
6-Set long term and short term process goals			
7-Develop a go-to process	√		
8-Full implementation of LPS	√	√	
9-Develop and perform a train the trainer program	√		
10-Implement a pilot LPS trial	√		
11-Implement LPS on wider scale & incorporate lessons learned	√		
12-Instill a culture of experimentation & continuous improvement	√		
13-Train and empower last planners	√		
14- Reward successful performance		√	
15- The contractual agreement fosters collaboration	√	√	
16- Using the PPC indicator properly	√		√
17- Learning from plan failures			

CONCLUSIONS

There is a common misconception that LPS is a stand-alone tool that can be picked up and put into operation as needed. However when embedded in a lean culture, the LPS offers a framework for enabling a much more radical transformation in the way an organization functions and communicates with its partners. The LPS offers a systematic process for construction planning, given that the organizations involved have embraced a “lean” philosophy. Without this pre requisite, LPS may be viewed by all those employees upon whom its success is determined, as another empty management initiative that will soon pass. Successful implementation of LPS requires a deeper organizational shift in mindset, culture, and willingness to depart from the status-quo.

Moreover, a meaningful participation by all parties involved is a key ingredient to the recipe of successful implementation. Therefore, a proper consideration should be given to the scope and scale of the required transformation. Implementing LPS is not simply applying a tool to a project, but changing the way people think, work, and execute tasks.

When implementing the LPS on construction projects, identifying and managing implementation issues in advance should lead to a more successful and less painful transition for a project team. The framework proposed in this paper accounts for the significant organizational change required to successfully implement the LPS. The process steps aim at achieving buy-in from managers and workers of all project parties, ensuring a smooth transition into the new production planning and control system, and establishing a process for feedback and improvement.

REFERENCES

Ballard, G. (1997). "Lookahead Planning: The Missing Link in Production Control", *Proc. 5th Annual Conf. Int'l. Group for Lean Constr., IGLC 5*, July, Gold Coast, Australia, 13-26.

Ballard, G. (2000). *The Last Planner System of Production Control*. Ph.D. Diss., Faculty of Engineering, School of Civil Engineering, The University of Birmingham, UK.

Ballard, G., & Howell, G. (2004). An Update on Last Planner, *Proc. 11th Annual Conf. Intl. Group for Lean Construction*, Blacksburg, Virginia, USA, 13.

Ballard, G., Kim, Y.W., Jang, J.W., and Liu, M. (2007). *Road Map for Lean Implementation at the Project Level, Research Report 234-11*, Construction Industry Institute, The University of Texas at Austin, Texas, USA, 426.

Coghlan, D. (2001). "Insider Action Research Projects: Implications for Practicing Managers", *Management Learning*, 32(1), 49-60.

Goh, S., and Richards, G. (1997). "Benchmarking the Learning Capability of Organizations", *European Management Journal*, 15(5), 575-583.

Hamzeh, F.R. (2009). *Improving Construction Workflow – The Role of Production Planning and Control*, PhD Dissertation, University of California at Berkeley, Berkeley, CA, 273.

Hamzeh, F.R., Ballard, G., & Tommelein, I.D. (2008). "Improving Construction Workflow- The Connective Role of Lookahead Planning", *Proceedings of the 16th Annual Conference of the International Group for Lean Construction, IGLC 16*, 16-18 July, Manchester, UK, 635-646.

Hamzeh, F.R., Tommelein, I.D., Ballard, G., & Kaminsky, P. (2007). "Logistics Centers to Support Project-Based Production in the Construction Industry", *Proceedings of the 15th Annual Conference of the International Group for Lean Construction, IGLC 15*, 18-20 July, East Lansing, Michigan, USA, 181-191.

Hannan, M.T., and Freeman, J. (1977) The Population Ecology of Organizations, *The American Journal of Sociology*, 82(5), March, 929-964.

Hopp, W.J., & Spearman, M.L. (2008). *Factory Physics*, 3rd Ed., Irwin/ McGraw-Hill, Boston, 720.

Kotter, J. P. (1996). *Leading Change*. New York: Harvard Business School Press. 187.

Koys, D. J. & Decotiis, T.A. (1991) “Inductive Measures of Psychological Climate”, *Human Relations*, 44 (3), 265-285.

Liker, J.K. (2004). The Toyota Way- 14 Management Principles from the World’s Greatest Manufacturer. New York: McGraw Hill.

McGill, M.E., and Slocum, J.W. (1993). “Unlearning the Organization”, *Organizational Dynamics,* 67-79.

Neto, J.P.B., and Alves, T.C.L. (2007). “Strategic Issues in Lean Construction Implementation”, *Proceedings of the 15th Annual Conference of the International Group for Lean Construction, IGLC 15*, 18-20 July, East Lansing, Michigan, USA, 78-87.

Thompson, J.D. (1967). *Organizations in Action*. New York: McGraw-Hill.

Tommelein, I.D. & Ballard, G. (1997). “Look-ahead Planning: Screening and Pulling.” *Technical Report No. 97-9,* Construction Engineering and Management Program, Civil and Environmental Engineering Department, University of California, Berkeley, CA, USA.

Viana, D.D., Mota, B., Formoso, C.T., Echeveste, M., Piexoto, M., and Rodrigues, C.L. (2010). “A Survey on the Last Planner System: Impacts and Difficulties for Implementation in Brazilian Companies”, *Proceedings of the 18th Annual Conference of the International Group for Lean Construction, IGLC 18,* July, Haifa, Israel, 497- 507.

Womack, J.P., & Jones, D.T. (2003). Lean Thinking: Banish Waste and Create Wealth in your Corporation, New York: Free Press.

Zammuto, R.F. and Krakower, J.Y. (1991) Quantitative and Qualitative Studies in Organizational culture, *Research in Organizational Change and Development*,5, 83-11.