

LAST PLANNER® SYSTEM AND PLANNED PER CENT COMPLETE: AN EXAMINATION OF INDIVIDUAL TRADE PERFORMANCES

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BACKGROUND AND CONTEXT

Construction is a dynamic and critical economic sector globally, however, it struggles to add value to its clients, it remains fundamentally inefficient, and it faces a “productivity imperative” (McKinsey 2017).

Other economic sectors have transformed their efficiency using Lean (Hines *et al.* 2018). However, construction productivity has remained stagnant or regressed, and thus the sector has looked to LC as an antidote to the ills of the sector (Koskela 1999) and as a means of delivering the requisite value that clients have been long-demanding (Koskela 1992; Ballard 2000; Hamzeh *et al.* 2009).

A key concept in LC is the provision of reliable workflow to the teams to reduce uncertainty in the delivery process (Ballard 2000). LPS is a key waste elimination and variability reduction technique that addresses that uncertainty (Hamzeh *et al.* 2009).

Last Planner[®] System

Whilst much has been written on LPS over the past 25 or more years, there appears to be a dearth of research that investigates the performance of individual trade contractors and their respective and collective contributions to the weekly plus overall project PPC.

This study explores PPC across two Projects; it examines commonalities and differences between relevant trades' PPC; and it identifies areas of improvement for implementation on future projects.

LPS & Continuous Improvement

'...from the perspective of continuous improvement, LPS's job is to stabilise operations so they can be further improved, both individually and in the processes which they comprise, but it also improves productivity. Many, perhaps most, people are satisfied with that and don't exploit the opportunity for more fundamental improvement in performance' (Ballard and Tommelein, 2016 p.59).

Howell and Ballard (1994) advise reducing workflow variation by stabilising all functions through which work flows, from concept to completion.

Hamzeh *et al.* (2009) posit formalising the planning and production operations process on the construction project.

Ensuring consideration of the eight prerequisite flows (Koskela 2000; Pasquire and Court 2013) to make the right tasks sound is an essential element of LPS: 'Progress rises and falls with PPC to the extent that tasks are made ready in the right sequence and rate' (Ballard and Tommelein 2016 p.60).

Planned Percent Complete

PPC is a key metric of LPS and measures workflow reliability – a high PPC indicates a well-planned production process with tasks screened in advance, ensuring high workflow reliability between teams (Ballard 2000).

However, Ballard and Tommelein (2016 p.59) warn against placing too much focus on PPC figures, stating ‘...PPC could be 100% productivity excellent and a project still be falling behind schedule’.

This emphasises the importance of using all functions of LPS to ensure PPC and productivity are linked to the overall milestone schedule (Hamzeh *et al.* 2009).

As PPC is positively linked to productivity (Liu *et al.* 2010), it is critical for LPS users to ensure that the trades teams executing the work are afforded the greatest opportunity of achieving high PPC.

Methodology

Mixed-Methods approach

(Creswell 2013)

- **Critical Literature Review**
- **Site Documentation Analysis**
- **Focus Groups**
- **Semi-Structured Purposeful Interviews**

Sequential Explanatory Approach

(Creswell 2009)

- **Quantitative collected during the projects**
- **Qualitative collected after project completion**
- **Analysis of primary sources informed secondary data collection**

Research Questions

1

What differences exist between individual trades' PPC?

2

How can these differences be explained?

3

What areas of improvement can be implemented on future projects to enhance PPC?

Quantitative Research Sources

Source	Project & Participants
Project “A”	LPS PPC data over 69 weeks
Project “A”	Reasons for Non-Completion of Tasks data over 69 weeks
Project “B”	LPS PPC data over 58 weeks
Project “B”	Reasons for Non-Completion of Tasks data over 58 weeks

Qualitative Research Sources

Source	Project & Participants
Focus Group 1	Project A (n6) – CMT (2); Trades Last Planners (3); Director Steel/Roofing/Cladding
Focus Group 2	Project B (n7) – CMT (4); Trades Last Planners (3)
Interviewee A	Project A – Mechanical (M) & Electrical (E) Project Manager
Interviewee B	Project A – Civil, Structural & Architectural Project Manager
Interviewee C	Project A – Cleanroom Project Manager
Interviewee D	Project B – Mechanical Project Manager
Interviewee E	Project B – Electrical Project Manager
Interviewee F	Project B – Civil, Structural, & Architectural Director
Interviewee G	Project B – Cleanroom Project Manager
Focus Group 3	Projects A & B (n7) – Senior Operations Management

FINDINGS - QUESTION 1: WHAT DIFFERENCES EXIST BETWEEN INDIVIDUAL TRADES' PPC?

Trades	Project A			Project B		
	Weeks on Project	Av. PPC	Per Cent of Total Project Tasks	Weeks on Project	Average PPC	Per Cent of Total Project Tasks
CSA	69	84%	43%	58	80%	29%
Cleanroom	27	86%	2%	54	84%	22%
Steel/Roofing/Cladding	54	80%	15%	45	72%	2%
Mechanical	34	92%	15%	54	90%	23%
Electrical	34	92%	21%	50	89%	22%
Sprinkler	40	91%	4%	46	79%	2%

SUMMARY OF KEY QUANTITATIVE FINDINGS

Themes	Findings
Trade Contractor PPC	<ul style="list-style-type: none"><li data-bbox="685 325 2219 425">• M&E (different contractors on both Projects) achieved the higher PPC on both Projects A and B.<li data-bbox="685 461 2308 561">• Sprinkler (different contractors on both Projects) achieved a high PPC on Project A and a lower PPC on Project B.<li data-bbox="685 596 2262 696">• CSA (different contractors on both Projects) achieved a lower PPC than M&E on each Project.<li data-bbox="685 732 2328 832">• Cleanroom (different contractors on both Projects) achieved a lower PPC than M&E on each Project.<li data-bbox="685 868 2313 953">• Steel/Roofing/Cladding (different contractors on both Projects) achieved the lowest PPC on each Project.
PPC ranges	<ul style="list-style-type: none"><li data-bbox="685 968 1447 1011">• M&E ranged between 92% and 89%.<li data-bbox="685 1046 1335 1089">• CSA ranged from 84% to 80%.<li data-bbox="685 1125 1454 1168">• Cleanroom ranged from 86% to 84%.<li data-bbox="685 1203 1921 1246">• Steel/Roofing/Cladding ranged more widely from 80% to 72%.<li data-bbox="685 1282 1709 1303">• Sprinkler had the greatest range from 91% to 79%.
RNC	On both Projects, “schedule/coordination”, “resource availability”, and “prerequisite work by others” were the top three RNC.

FINDINGS - QUESTION 1: WHAT DIFFERENCES EXIST BETWEEN INDIVIDUAL TRADES' PPC?

On Project A, there was a noticeable gap in the average PPC between the CSA, Steel/Roofing/Cladding, and Cleanroom trades on one end, and the M&E and Sprinkler trades on the other end. CSA were on site for almost twice the duration of other trades and they committed 43% of the work tasks to the weekly work plan (WWP). Steel/Roofing/Cladding, despite completing only 15% of the work tasks, achieved 80% PPC. M&E and Sprinkler, achieved 91-92% PPC each on a combined 40% of the work tasks.

It is noteworthy that the M&E company and Sprinkler company on Project A were knowledgeable and practiced in LC.

Similar gaps were evident on Project B. The CSA were longest on site, completing 29% of tasks and achieving 80% PPC. Mechanical (90%) and Electrical (89%) were the highest PPC achievers with 23% and 22%, respectively, of total tasks committed to the work plan.

The M&E companies on Project B (different to that on Project A) were also knowledgeable and practiced in LC. However, the Sprinkler company on Project B – a locally-based incumbent contractor – had a poorer PPC performance, and it is noteworthy that it was neither knowledgeable nor practiced in LC

FINDINGS – QUESTION 2: HOW CAN THESE FINDINGS BE EXPLAINED? (Key Focus Group Findings)

Time required for, and commitment to, LPS - Lack of adequate trade management time to adequately plan WWP. No dedicated and trained Last Planner management resource.

Late receipt of WWP from trades - Much greater coordination is needed where trades overlap and late receipt of WWPs left little time for CMT supervision to proof and coordinate the plan.

Specialist resource availability - The local region is currently experiencing a construction boom in the Pharma sector, and availability of specialist resources was a major challenge for clients and management teams.

Not using all functions of LPS - Inconsistency of implementation of all functions of LPS. Project A successfully implemented all functions of LPS, while Project B experienced implementation issues due to its size and complexity.

Design-related issues - Incomplete design led to delays in resolving design-related constraints. Delayed appointment of trades meant a lack of trade involvement in early planning, scheduling, and design coordination decisions.

FINDINGS – QUESTION 2: HOW CAN THESE FINDINGS BE EXPLAINED? (Interviews)

M&E adopt a productivity-based and metrics-focused approach and mindset to construction delivery. CSA approach is more reactionary, with an acceptance of the peculiarities and traditional problems associated with construction work execution.

The LC-practiced M&E contractors have developed management systems and structures enabling them to set their own agenda on a project, and they lead out their own design, schedule, and workflows. CSA appear to be under-resourced at site management level with immediate problem-solving prioritised over short- to medium-term planning.

Late and incomplete design, as well as contractors commencing on site in advance of design being sufficiently developed, had an impact on the smooth flow of work tasks. Early engagement of the M&E contractors in the design development process was considered a key advantage in maintaining reliable flow and contributing to higher PPC.

FINDINGS – QUESTION 2: HOW CAN THESE FINDINGS BE EXPLAINED? (Interviews)

Engagement with, and preparation for the LPS process, as well as using all functions of the system, is critical for successful project delivery. Poor lookaheads lead to inadequate preparation of workplans, resulting in missed tasks being categorised as ‘schedule/coordination’ and ‘prerequisite work by others’, impacting on other trades’ PPC.

The embracing of ICT advancements in construction software, allied to the utilisation of handheld applications and devices, enables more efficient solutions to data storage and acquisition.

Prefabrication and Modularisation offers distinct advantages by reducing onsite activities and the associated coordination issues.

FINDINGS – QUESTION 3: WHAT AREAS OF IMPROVEMENT CAN BE IMPLEMENTED ON FUTURE PROJECTS TO ENHANCE PPC?

Procurement - Feature LC in prequalifications, tenders, and actual contracts. Contractor selection needs to be restricted to proven LC companies. Ongoing assessment systems should incentivise process excellence and continuous improvement.

Trades differences - Provide greater attention and involvement at design stage for CSA, Steel/Roofing/Cladding, and Cleanroom. Review contracting strategy to accommodate early appointment and involvement of these trades as early as possible, and engage them across the design process. No contractor should be permitted to commence on site without a clearly defined and agreed design in place. Develop a trust-driven, transparent, collaborative relationship amongst parties at design stage.

LC training & education – Deliver LC training & education to the client, the EPCMV team, and contractors to ensure a productivity-based and metrics-focused mindset is embedded amongst the construction delivery partners.

FINDINGS – QUESTION 3: WHAT AREAS OF IMPROVEMENT CAN BE IMPLEMENTED ON FUTURE PROJECTS TO ENHANCE PPC?

Off Site - Demand more off-site fabrication and assembly processes. Contractors should propose a greater variety of options, and clients should ensure modularisation is respected to avoid requirement for bespoke solutions.

LPS Training & Education - Schedule more detailed LPS training and refresher courses into the project duration and have these supported by the client. Focus to be placed on enabling flow with the Tasks Made Ready (TMR) metric and the creation of sound, constraint-free tasks ahead of committing them to the WWP.

ICT - Adopt site-wide technological solutions across all contractors to improve visualisation (BIM), process improvement (RFIs, punch-lists, submittals), planning and coordination (LPS software), and the efficient accessibility of project documentation (cloud-based platforms).

Conclusions & Recommendations

LC contractors deliver better PPC performances than non-LC contractors.

Clients and EPCMV companies should select LC contractors and should use alternative contracting strategies like IPD and relational forms of contract like Integrated Form of Agreement (IFOA) to encourage more widespread use of collaborative working practices.

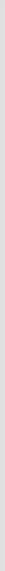
This would help eliminate the siloed approach amongst project parties towards LPS implementation, and embed a “project-first” mindset that aligns project team shared goals with the outcomes valued by the client.

Conclusions & Recommendations

Clients & EPCMV companies should encourage the use of prefabrication and modularisation while respecting the prerequisites required to achieve the efficiencies offered.

A more holistic adoption of advanced ICT-based applications and platforms should be utilised.

Finally, future research is recommended to investigate the obstacles and barriers restricting a more complete adoption of LPS on projects, as well as the wider utilisation of collaborative forms of contracting.



Questions