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THE PULSE OF PRODUCTION: CORRELATING PPC AND TEAM HEALTH

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ABSTRACT

Within the Last Planner® System (LPS), Percent Plan Complete (PPC) is widely used as a quantitative measure of planning reliability; however, its relationship to qualitative factors of team culture remains underexplored. This paper examines survey data from a Southern California Integrated Project Delivery healthcare project that used the Team Health Assessment (THA) to investigate relationships between PPC and several qualitative indicators, including trust, participation, and commitment, as well as several operational and project controls measures. Using Pearson correlation analysis within an action research framework, the findings reveal a strong positive relationship between PPC and trust ($r = 0.75$), as well as moderate positive relationships with participation and commitment. Conversely, PPC was moderately negatively correlated with time management, visual management, and quality measures, suggesting a potential production–pressure pattern in traditional project controls measures that warrants further investigation.

These findings suggest that PPC functions not only as a measure of planning reliability, but also as a reflection of underlying team culture. The complementary use of PPC and the THA offers a more holistic lens for diagnosing and sustaining production system health, allowing PPC to function not only as a measure of planning reliability but also as a pulse check on the condition of the production system.

KEYWORDS

Action research, benefits realization, Last Planner® System, reliable promising, trust.

INTRODUCTION

Within the Last Planner® System (LPS), Percent Plan Complete (PPC) is widely used as a quantitative measure of planning reliability; however, its relationship to the underlying conditions of team culture remains underexplored. While PPC provides a clear signal of short-term production performance, it offers limited insight into the behavioral and relational factors that shape that performance. The Team Health Assessment (THA) seeks to capture these qualitative dimensions but remains underutilized due to a lack of demonstrated connection to measurable outcomes. This gap reflects a broader challenge in Lean Construction: understanding how production metrics and team culture interact—and whether commonly used production indicators may also reflect underlying cultural conditions. This perspective aligns with broader organizational research that links trust and psychological safety to team performance and learning, particularly in environments requiring coordination under uncertainty (Edmondson, 1999; Dirks & Ferrin, 2001). It is also consistent with sociotechnical systems theory, which emphasizes the interdependence of social conditions and technical performance in complex production environments (Trist & Bamforth, 1951; Pasmore, 1988).

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This study builds on prior work by Muñoz and Cleary (2025), Muñoz et al. (2019), and Cleary and Muñoz (2018), which collectively position team culture as a critical yet often underexamined component of project performance. These works introduced the THA as a structured approach to identifying and measuring qualitative dimensions of team effectiveness that are not captured by traditional production metrics. In this context, team culture is understood as a set of behavioural conditions that influence collaboration, commitment, and the reliability of planning and execution.

The THA provides a structured means of assessing the current effectiveness of a team's culture and identifying capabilities that may require further development to improve performance (Muñoz & Cleary, 2025; Muñoz et al., 2019; Fowler, 2014). Muñoz and Cleary (2025) demonstrated that consistent use of the THA promotes shared values, aligned goals, stakeholder engagement, and participation—conditions that foster mutual trust, respect, and a collective commitment to continuous improvement. These cultural factors are associated with the quality of planning conversations, the reliability of commitments made, and the transparency with which constraints are identified and resolved. In this way, team culture is reflected in the behaviours that underpin reliable workflow.

Despite these benefits, the THA, like many Lean tools, remains underutilized, as the measurable impact of team culture on project performance continues to be insufficiently understood throughout the design and construction industry. While PPC is widely accepted as a measure of short-term planning reliability, the behavioural conditions that influence PPC performance remain underexplored.

This study observes a DPR Construction team in its use of the Last Planner® System (LPS) and the THA on a Southern California Integrated Project Delivery (IPD) healthcare project. It advances prior work by examining the statistical associations between THA indicators and PPC. This study contributes an exploratory empirical case linking a widely used production metric (PPC) with measured indicators of team culture, providing insight into how production reliability may reflect broader conditions within the production system. Observed correlations between these measures suggest that production reliability may be associated with specific cultural dimensions, such as trust, alignment, and engagement, which are reflected in PPC performance.

In practice, the complementary and regular use of these tools allows a project team to more holistically understand and respond to project impacts in near real time. By integrating production tracking with structured assessment of team culture, teams are better positioned to address both workflow disruptions and the conditions that contribute to those disruptions, thereby providing the greatest chance for sustained success throughout project execution.

To clarify the study's focus, the following research question is posed: *What associations exist between Percent Plan Complete (PPC) and Team Health Assessment (THA) indicators?* Additionally, this study explores how these observed relationships may support practitioners in interpreting PPC not only as a measure of planning reliability, but also as a reflection of underlying team culture and production system health.

METHODOLOGY

This industry study was conducted using an action research framework, allowing the authors to observe and interpret production system behaviour while actively participating in project delivery. Action research aligns with Lean Construction principles by supporting experimentation, reflection, and learning within real project environments (Koskela et al., 2002; Dave et al., 2016). The analysis presented here is exploratory and intended to generate practical insight rather than establish causal inference.

The study examines the relationship between Percent Plan Complete (PPC) and cultural indicators measured through the Team Health Assessment (THA) on a Southern California Integrated Project Delivery healthcare project.

DATA COLLECTION

Two primary datasets were collected throughout project execution:

- PPC was recorded weekly as part of the Last Planner® System production tracking process and aggregated to monthly averages for comparison.
- THA surveys were administered monthly, generating Key Performance Indicators (KPIs) representing perceptions of team culture and project effectiveness.

RESPONDENTS

The THA was completed by representatives of the project's core IPD partners, including the Architect, Structural Engineer, Electrical Engineer, Civil Engineer, Mechanical/Plumbing Engineer, General Contractor, Concrete/Framing/Drywall Contractor, Electrical Contractor, Mechanical/Plumbing Contractor, and the Owner. Monthly participation averaged approximately 15 respondents, representing multiple organizations and roles such as field supervision, project management, and design leadership. Participation remained generally consistent throughout the study period, although the exact respondent cohort varied slightly month to month as project responsibilities evolved. Responses were aggregated into KPI scores using weighted averages across the survey statements.

ANALYTICAL APPROACH

Pearson correlation coefficients (r) were calculated to examine associations between monthly PPC values and each THA KPI across 11 monthly observations (N = 11). The analysis identifies patterns of association between production reliability and team cultural indicators. Correlation strength descriptors (e.g., leading, neutral, negative association) are used as heuristic interpretive categories to support practitioner understanding rather than as strict statistical thresholds. For transparency, p-values and 95% confidence intervals were calculated for each correlation; however, given the small sample size, these are reported descriptively and not used for inferential conclusions.

Given the small sample size and the number of KPIs evaluated, correlations are interpreted directionally and as hypothesis-generating rather than statistically confirmatory. The potential for spurious correlations due to multiple comparisons is acknowledged. Additionally, the time-series nature of the data introduces potential autocorrelation, which was not explicitly controlled in this analysis. Given the differing collection frequencies (weekly PPC aggregated to monthly values and monthly THA surveys), potential lag effects between cultural conditions and production outcomes were not explicitly analyzed and may influence the observed relationships. Additional limitations of the dataset and interpretation are discussed in the Data and Analysis section.

BACKGROUND

Howell (1999) noted that Lean Construction is defined by the application of production management principles derived from Lean Production. Green (1999) objected to this definition, arguing that a dependence on quantitative tools and metrics—such as PPC —is limited by "instrumental rationality" and ignores the essential human elements of Lean methods. While Howell (1999) did not ignore the human component of construction management, he cautioned that focusing on qualitative factors could be prohibitive, as the source of a problem is not as easily identifiable. To address this gap, Muñoz et al. (2019) proposed the THA as a

methodology to identify and measure these otherwise unquantifiable indices of project performance.

PERCENT PLAN COMPLETE AND PEOPLE

The Last Planner® System is recognized as the most widely utilized Lean construction tool for improving project control (Ahiakwo et al., 2013; González et al., 2014; Daniel et al., 2015). A core component of LPS is Percent Plan Complete, a quantitative metric calculated by dividing the number of completed activities by the total number of planned activities (Ballard, 2000). As a control measure, PPC serves as a visual indicator of the reliability of promises made during project execution, essentially measuring the stability of the planning system itself (Koskela et al., 2010).

Early critics of LPS and PPC noted that while the intent of these systems is to promote collaboration, they are often reduced to mechanical "tools" used solely to maximize productivity (Green, 1999; Saurin et al., 2013). This focus on *instrumental rationality* often ignores the cultural dimensions of project delivery. Furthermore, many teams implement low-complexity Lean tools without anchoring them to the larger philosophical or cultural goals (Neto and Alves, 2007). Consequently, project teams often struggle to implement and sustain Lean construction practices over the long term (Liker, 2004; Kotter, 1996; Ballard et al., 2007; Hamzeh, 2009).

While PPC was originally designed as a direct measure of field-level work, Ballard (1994) acknowledged that the root causes of failure often reside in higher organizational levels or functions. However, it was much later that Ballard and Tommelein (2016) explicitly emphasized that PPC is not merely a workflow reliability metric correlated with productivity; it is also a measure of a team's ability to plan and execute work reliably. In this context, "ability" can be defined as a qualitative capacity for collaborative problem-solving, continuous learning, and adaptability within the framework of a team's culture. It is the authors' observation that PPC has evolved from purely a project control measure towards a more holistic approach—one that integrates Respect for People and team culture as essential components of the overall production system.

TEAM HEALTH ASSESSMENT

Muñoz et al. (2019) observed the problem in failing to identify, measure, and monitor the human component (i.e., team culture) in the delivery of a Lean construction project. DPR Construction, a global self-performing general contractor and construction management firm, developed the Team Health Assessment to evaluate these qualitative measures of project effectiveness. The THA employs a survey-based methodology to invite stakeholder feedback on perceptions, requirements, and value alignment. Survey frequency is dynamic to project intensity, ensuring that data collection and subsequent reflection remain responsive to the specific needs of the project team throughout the delivery lifecycle.

The survey questionnaire is project-specific, consisting of statements designed to measure perceived efficacy in meeting collaboratively defined Conditions of Satisfaction. **Figure 1.** is representative of this survey format.

KPI		HELP US IMPROVE, PROVIDE HONEST FEEDBACK Completely Anonymous	SCORE 1 to 5
COMMUNICATION	1	Information is requested and transmitted in a timely manner. Right information to the right person.	
COMMITMENT	2	The Team makes reliable commitment to each other to support the project schedule.	
PROJECT DOCUMENTS	3	The Team successfully utilizes the design documents and BIM to execute the coordinated work and communicates back to the design team.	
INNOVATION	4	I am encouraged to seek out and bring innovative ideas, solutions, and processes to the project.	
COLLABORATION	5	The team is effectively collaborating to ensure all issues are brought up as soon as they arise and dealt with quickly.	
VISUAL MANAGEMENT	6	Team successfully utilizes visual control methods-dashboards, A3's, logs, drawings, etc.	
AWARENESS	7	I fully understand the construction schedule for the project and when my response is critical to the schedule.	
QUALITY	8	The team defined clear and measurable definable features of work. Quality expectations of the projects are understood and implemented by all.	
TRUST	9	Team members demonstrate trust and respect across all levels of the team.	
LEARNING	10	The project team embraces an open, collaborative learning process and implement lessons learned.	
END USER SATISFACTION	11	The Team values End User and Member experience as a priority.	
SAFETY	12	Do you feel safety is demonstrated as a top priority?	
COST	13	Are all team members consistently integrating project budget and forecast in their daily decision making ?	
PARTICIPATION	14	Do you feel openly that you have a voice and are an important member of this project team?	
TIME MANAGEMENT	15	Are we spending time in meetings that add value?	
ENJOYMENT	16	Would you chose to work with this team again?	

Figure 1: Example of Team Health Assessment Questionnaire

Stakeholders provide responses via a Likert-type scale, with specific verbiage tailored to each Key Performance Indicator (KPI). For example, the scale for KPI No. 9 (Trust) utilizes anchors specific to interpersonal and professional reliability. **Figure 2**. is representative of the Likert-type scale on which Trust is measured. Individual responses are aggregated into weighted KPIs and visualized using trendline charts. This format facilitates a simplified comparison of Team Health over time.

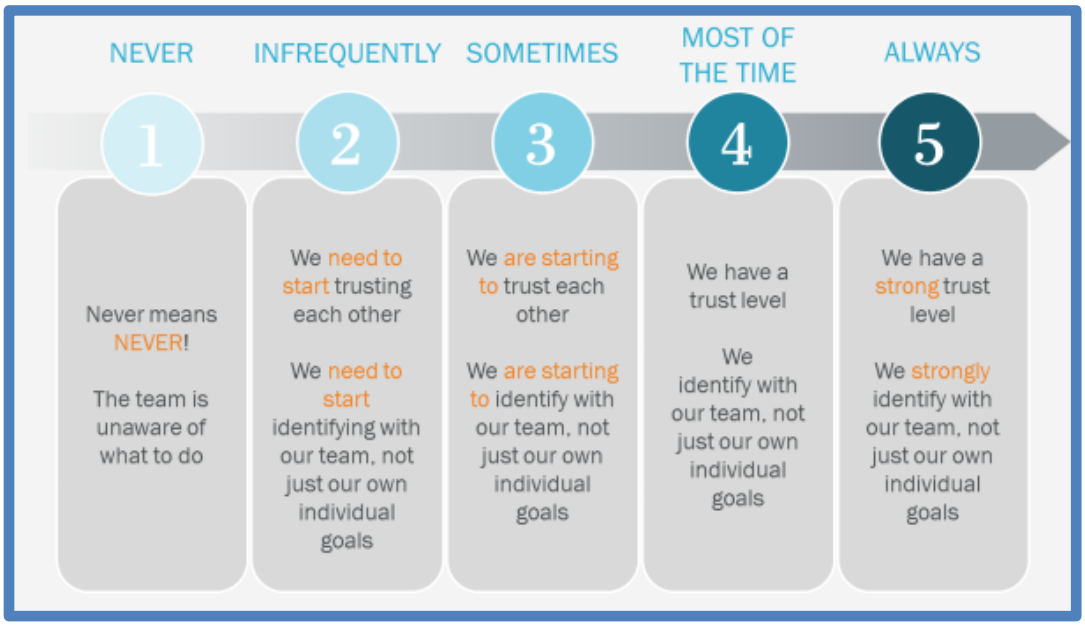

Figure 2: Team Health Assessment Likert-type Scale as Presented for KPI No. 9: Trust

The THA generates KPIs across various qualitative fields as dictated by the assessment statements. Consistent with established Likert scale methodologies, the key value of this tool is found in the subsequent reflection and behavioural adjustments prompted by observed trends, rather than the raw numerical values themselves (Kniberg, 2014). Foundational to this approach is the belief that team culture is bolstered by the proactive identification of and response to underlying issues. For a comprehensive discussion regarding the development and theoretical framework of the THA, the authors defer to the mechanics outlined by Muñoz et al. (2019) in *Team Health: A Measured Approach to Collective Learning*.

PROPOSITION AND ANALYTICAL FRAMING

Building on this foundation, this study explores whether PPC may also reflect underlying team culture. While PPC primarily measures the reliability of a project's short-term planning process, it may also serve as an indicator of team culture. The complementary and regular use of both tools allows a project team to more holistically understand and respond to project impacts in near-real-time, providing greater opportunity for success throughout the project's execution.

To support this position, the authors participated in and collected data during the execution of a Southern California Integrated Project Delivery (IPD) healthcare project. This data was analysed for correlative relationships between PPC and the various THA KPIs. The intent is interpretive insight rather than statistical generalization. A strong correlation between PPC and a given KPI suggests that production reliability is sensitive to changes in that specific cultural dimension; this reflects shared underlying behavioural conditions rather than a direct causal influence.

PROJECT BACKGROUND

The case study focuses on a 41,000-sq.-ft. expansion of an operating behavioural health hospital in Southern California. Permitted under OSHPD 1, the project added 51 beds and critical support services. The project team was selected via a no-competition award based on their proven culture and success in complex healthcare environments. The project was delivered under an Integrated Form of Agreement, with ten key partners—including major design and trade contractors—placing their profit at risk. These partners were further incentivized by an enhanced profit pool tied to specific performance criteria. To monitor these criteria, the

project's Community of Practice collaboratively identified KPIs and defining statements; the previously provided **Figure 1.** is representative of KPIs and statements used for this project. The THA was used to provide a structured mechanism to evaluate the effectiveness of the team's culture throughout the project lifecycle.

DATA AND ANALYSIS

Both PPC and the THA were collected at different, but regular intervals: weekly for PPC (aggregated to monthly averages for comparison) and monthly for THA KPIs. Data collection was embedded within project routines to reflect authentic system behaviour. Pearson correlation coefficients were calculated to assess relationships between PPC and each indicator. **Table 1.** presents the data collected and analysed. Validity was strengthened through triangulation of PPC logs, survey responses, and practitioner reflection. Limitations of this study include the small sample size (N=11), making statistical significance more difficult to achieve due to low statistical power. As such, *r*-values are interpreted directionally rather than inferentially. Authors' engagement within the project supported a deep understanding of emergent patterns. These methods were intended to support reflection-on-action rather than to establish causal inference.

Table 1: Monthly Average of Measured KPIs

	Month										
KPI	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
PPC	1	0.84	0.97	0.91	0.82	0.78	0.84	0.88	0.68	0.76	0.8
COMMUNICATION	3.83	4.27	4.33	4.8	4.18	4.18	4.38	4.64	3.5	4.38	4.33
COMMITMENT	4.33	4.45	4.22	4.56	4.18	4.27	4.5	4.58	4	4.38	4.11
PROJECT DOCUMENTS	4.33	4.45	4.44	4.67	4.36	4.64	4.75	4.92	4.6	4.88	4.67
INNOVATION	4.58	4.82	4.89	5	4.64	4.73	4.75	4.83	4.5	4.75	4.89
COLLABORATION	4.25	4.64	4.33	4.56	4.27	4.36	4.88	4.82	3.7	4.5	4.22
VISUAL MANAGEMENT	3.75	3.9	4	4.75	4.55	4.45	4.63	4.91	4.7	4.75	4.67
AWARENESS	4.36	4.18	4.44	4.44	4.55	4.45	4.63	4.7	4.6	4.88	4.89
QUALITY	4.33	4.36	4.22	4.44	4.55	4.73	5	5	4.7	4.75	4.89
TRUST	4.58	4.73	4.78	4.8	4.64	4	4.38	4.75	3.8	4.38	4
LEARNING	4.42	4.64	4.67	4.78	4.27	4.64	4.88	4.82	4.5	4.5	4.78
END USER SATISFACTION	4.42	4.91	5	4.88	4.82	4.91	5	5	4.7	4.88	5
SAFETY	4.83	4.91	5	5	5	5	5	5	5	5	5
COST	4	4.27	4.44	4.33	3.82	3.9	4	4.25	4.1	4.13	4.33
PARTICIPATION	4.75	4.73	4.78	4.67	4.73	4.64	4.88	5	4.4	4.75	4.78
TIME MANAGEMENT	4.45	4.55	4.56	4.4	4.64	4.64	4.88	4.92	4.8	4.88	4.89
ENJOYMENT	4.58	4.64	4.67	4.9	4.55	4.64	4.63	4.75	4.4	4.75	4.33

STATISTICAL CORRELATION SUMMARY

Table 2. presents the Pearson correlation coefficients (*r*) between the monthly average PPC and each THA KPI. These values quantify how production reliability fluctuates in relation to the team's cultural and operational perceptions.

Table 2: Categorization of KPIs Correlation Strength with PPC

Category	KPI	*r* Value	Strength of Relationship
Leading Indicators	Trust	0.75	Strong Positive
	Participation	0.5	Moderate Positive
	Commitment	0.43	Moderate Positive
	Enjoyment	0.41	Moderate Positive
Neutral/Lagging	Innovation	0.36	Weak Positive
	Collaboration	0.35	Weak Positive
	Communication	0.32	Weak Positive
	Cost	0.31	Weak Positive
	Learning	0.11	No Correlation
Stress Indicators	End User Satisfaction	-0.19	Weak Negative
	Project Documents	-0.39	Weak Negative
	Awareness	-0.45	Moderate Negative
	Safety	-0.52	Moderate Negative
	Quality	-0.55	Moderate Negative
	Visual Management	-0.59	Moderate Negative
	Time Management	-0.59	Moderate Negative

DISCUSSION

The observed correlation patterns suggest that PPC reflects underlying dimensions of team culture. KPIs were categorized based on their Pearson correlation coefficient to identify the nature of their relationship with planning reliability (PPC):

1. Leading Indicators (*r* = 0.41 to 0.75): These KPIs correlate positively with PPC and represent cultural conditions associated with reliable planning performance. The strong correlation between **Trust (*r* = 0.75)** and PPC is consistent with the language-action perspective of the Last Planner® System, which emphasizes the role of reliable commitments in project delivery. As argued by Macomber and Howell (2003), project outcomes are strongly influenced by the quality of commitments. When trust is high, the willingness to perform may align more closely with technical capability, reducing the transactional friction that can contribute to planning failure.

2. Neutral/Lagging Indicators (*r* = 0.11 to 0.36): These KPIs show weak or no correlation, representing latent improvements that do not immediately impact weekly production. The lack of correlation in **Learning (*r* = 0.11)** reflects a common challenge: the "learning debt." As Pikas et al. (2020) noted, the benefits of collaborative learning often have a non-linear relationship with immediate production metrics. This disconnect highlights the danger of relying solely on quantitative tools; without the THA, these essential long-term gains could remain undetected.

3. *Stress* Indicators (*r* = -0.19 to -0.59): These KPIs correlate negatively with PPC and are interpreted as *reflecting perceived production pressure within the system*, although stress or workload is not directly measured in this study. These patterns may reflect perceived trade-offs between production output and process control. The moderate negative correlations in **Time**

Management (*r* = -0.59) and **Visual Management (*r* = -0.59)** suggest a potential tension between production output and process health. Saurin et al. (2013) warned of "mechanical lean," where the focus on targets increases cognitive load. In this context, high PPC scores may coincide with declining perceptions of process stability, suggesting that the THA can serve as an important counterbalance within the production system.

Overall, the correlation patterns suggest that PPC reflects more than the reliability of a planning system. The positive correlations with trust, participation, and commitment indicate that reliable planning tends to appear alongside strong team health and engagement. At the same time, the negative correlations observed in several control-related KPIs suggest that strong production performance may occasionally coincide with declining perceptions of process control. PPC becomes not just a production metric, but a pulse check on the overall health of the production system.

CONCLUSION

This paper sought to bridge the gap between the quantitative focus of production management and the qualitative "human elements" of Lean Construction. By examining the correlation between Percent Plan Complete (PPC) and KPIs measured through the Team Health Assessment (THA), the study suggests that production reliability is associated with several dimensions of team culture.

The analysis shows a strong positive relationship between PPC and Trust (r = 0.75), along with moderate positive relationships with participation, commitment, and enjoyment. At the same time, several control-related KPIs show moderate negative correlations with PPC, including Time Management (r = −0.59). This pattern suggests that while PPC reflects what a team is producing, the THA provides additional context for understanding the conditions under which that production occurs.

Together, these observations suggest that production reliability appears to be associated not only with planning systems but also with the quality of relationships and commitments within the team. When used alongside the THA, PPC can therefore serve as more than a production metric—it can also provide insight into the broader health of the production system. Pairing these tools helps teams move beyond purely instrumental measures of performance toward a more holistic understanding of project delivery.

PRACTICAL APPLICATIONS

This study supports the authors' position that the integrated and complementary use of PPC and the THA provides a more holistic lens to view the health of a production system wherein PPC can be utilized as a learning and diagnostic tool rather than simply a production target. Additionally, this study suggests that Lean leaders should prioritize a foundation of trust and participation in a team's culture before introducing additional management controls as these qualitative factors are associated with higher levels of planning reliability and may function as leading indicators pending further validation. Ultimately, a decline in PPC may serve as an indicator of degrading team conditions—particularly when accompanied by declining THA trends—prompting reflection and constraint management to improve overall team health and effectiveness.

OPPORTUNITIES FOR ADDITIONAL RESEARCH

Future research should expand on these findings by identifying where production pressure begins to work against the system. The negative correlations observed in several control-related KPIs suggest there is a tipping point—where the pursuit of production starts to erode the very conditions that support it. Understanding where that threshold exists, and how it manifests, is a critical next step.

There is also an opportunity to test whether these relationships hold across different delivery models. This study was conducted within an Integrated Project Delivery environment, where alignment and shared risk are foundational. Comparative analysis across more traditional contractual structures would help determine whether these correlations are inherent to production systems or amplified by collaborative frameworks.

The findings suggest that the relationship observed between PPC and team health likely extends further into actual field performance. Just as PPC was shown to correlate with THA KPIs, it is reasonable to expect that craft-level production may be influenced by the same cultural conditions. In practice, breakdowns in trust or reliability at the Owner–Architect–Contractor (OAC) level are often felt downstream, potentially impacting coordination, flow, and ultimately productivity in the field. Conversely, when commitments are reliable and trust is established, production tends to outperform baseline expectations.

Future work will focus on testing this hypothesis by correlating both positive and negative survey trends with PPC and field production metrics. The intent is not only to reinforce the relationship between culture and planning reliability, but to demonstrate that these conditions have a measurable and direct impact on production outcomes.

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Lessons learned provide greatest value when others could learn from them.

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