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Aligning Near and Long Term Planning for LPS Implementations: A Review of Existing and New Metrics

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Abstract

Questions: Q1: Can we develop a set of metrics to align short-term and long-term planning? Q2: Can we rapidly analyze LPS data and generate patterns/trends of planning performance? Q3: How does PPC correlate with long-term planning reliability? Q4: Is the PPC target of 75%-90% the right measure (target recommended by LCI)?

Purpose: Review existing LPS near-term planning metrics and assess their ability to predict long-term performance using technology. This paper also introduces new and more comprehensive metrics to balance near-term and long-term planning performance.

Research Method: An integrated database driven software tool that supports the LPS implementation was used to mine, analyze, and visualize large amount of data to review the existing metrics and evaluate the predictive nature of the proposed metrics designed to align near-term and long-term planning. The sample size ranged from two thousand activities to over 60,000 activities in total.

Findings: F1: Teams that focused on short-term MRP (3-6 weeks) without proper application of Phase Planning and adequate emphasis on resource planning exhibited cyclical patterns of PPC. F2: Initial analysis of the data shows no positive correlation between TA and TMR metrics and a team's ability to reliably achieve milestone targets. F3: Teams that constantly re-plan to maintain CL, PRCO, and PPC appear to have lower overall MV (typically below 5 days) and appear to maintain better alignment between their near-term plans and their long-term plan target milestones and are thus more reliable. F4: The study suggests that the standard deviation of forecast dates of lookahead activities captured on a rolling basis at the time work plans are created may serve as a better indicator for overall planning reliability. Correlation of this metric against late dates of the same lookahead, CL, PRCO, and MV serves as a better indicator of reliability.

Limitations: Additional research is needed to monitor these metrics on a larger project

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sample and for longer periods of time to confirm the initial conclusions of this study.

Implications: This research demonstrated some of the advantages that integrated database driven tools can bring to improve LPS data collection and presented an overview of some of the opportunities presented by those tools to align near-term and long-term planning to improve reliability. This cannot be achieved by makeshift tools commonly used in the industry to manage LPS workflows. Those makeshift tools and associated processes result in data fragmentation, redundant entry, long cycle times, and introduce errors into the process.

Value for authors: This study advances the knowledge in understanding LPS metrics and their impact on schedule performance. New metrics have been introduced to measure reliability of long-term planning and improve the association between near-term and long-term planned activities.

Keywords: Last Planner® System, Percent Plan Complete, Theory, Production Planning and Control, Metrics

Paper type: Main Paper

Introduction

The Last Planner System (LPS) improves workflow reliability by continuously aligning what will be done on projects with what should be done through collaborative planning and a systematic application of the Make Ready Process (MRP). MRP ensures that all the known constraints on the remaining activities are identified, planned, and resolved before they impact the required dates of the downstream activities (Ballard and Howell, 1997). The systematic adherence to this process, in its entirety, creates a steady stream of unconstrained work that can be performed with more certainty.

Ballard and Howell (1997) proposed characteristics for measuring the quality of Weekly Work Plans (WWP) to protect workers from variation. Namely that the work should be done in the proper sequence, that the team performs the right amount of work, and, that only the work that can be done is committed to be done. They defined the right amount of work as the work that uses the labor and equipment capacity as directed by the schedule. Original research on LPS made references to the need to control production flow (Ballard 2000) but focused primarily on shielding the last planners from variability through the collaborative planning processes of creating sound assignments, tracking commitments, and continuous improvement. Recent exploratory research suggested the potential of improving LPS implementations by introducing complementary production management techniques that emphasize workflow to improve the quality of the Phase Schedules. Examples include the combination of LPS and Location-Based Management System (LBMS) (Olli and Ballard 2010) and the combination of Takt-Time planning and LPS (Frandson et.al 2014).

Regarding LPS metrics, the predominant measures of an LPS implementation are the Percent Planned Complete (PPC) and the Reasons for Variance (RV). Both are designed to measure the reliability of the near-term plans. PPC was first proposed in the late nineties (see Ballard, 2000) and its definition remains unchanged in the most recent set of manuals published by the Lean Construction Institute (LCI) to its membership (LCI 2016). LCI defines PPC as the basic measure for “how well a planning system is working”. It is calculated as the percent of completed commitments to the total commitments for any given planning cycle. Higher percentages are considered better. LCI recommends a target PPC range of 75% to 90%.

$$PPC = Did/Will$$

Hamzeh et.al (2012) proposed two additional metrics to align the work plan assignment with the lookahead. Namely, they introduced the Tasks Anticipated (TA) and the Tasks Made Ready (TMR) metrics. TA represents the percentage of tasks on a work plan that were anticipated in a previous work plan 14 days earlier. TMR represents the percent of completed tasks on a given work plan that were anticipated in a prior work plan. Those authors could not, however, investigate how improvements in TMR and TA would improve overall schedule performance citing inconsistent datasets.

$$TA = Will/Can$$
$$TMR = Did/Can$$

While there is demonstrated evidence that LPS improves collaboration and reduces variability in near-term work execution, the effects of LPS on long-term phase milestones and overall project schedules have been difficult subjects for systematic analysis. Moreover, the PPC, TA, and TMR metrics as absolute task counts of what can be done, what will be done, and what was done do not provide the metrics necessary to measure against what should be done at any given planning cycle.

Various researchers that attempted to study the impact of LPS on production control report common challenges to rigorous research in this area (Dave et al. 2015, Porwal et al. 2010, Hamzeh et.al. 2012). Common contributing factors include lack of standard planning workflows, lacking or incomplete data sets, and inconsistent recording (Hamzeh 2009) or inconsistent and intermittent application of the system (Porwal et al. 2010). Additionally, current industry practices for documenting LPS data using incompatible tools and the use of manual and redundant tracking systems such as sticky notes, multiple excel sheets, and scheduling software (Dave et al. 2015), makes it virtually impossible to perform any kind of systematic analysis on the data.

This study advances the knowledge in understanding LPS metrics and their impact on schedule performance. An integrated database driven software tool (namely vPlanner®) that supports the LPS implementation was used to mine, analyze, and visualize large amount of data to review the existing metrics and evaluate the predictive nature of the proposed metrics designed to align near-term and long-term planning.

Research method

The studied sample size ranged from two thousand activities to over 60,000 activities in total. On smaller projects, an average lookahead contained 300 activities with approximately 50 activities consistently added or completed on a weekly basis and observed for several months. On larger projects an average lookahead contained over 3,500 activities with approximately 400 activities consistently added or completed on a weekly basis for several years. On the larger projects the work was managed my multiple teams responsible for their work plans and coordinating with other teams on the handoffs among the various work phases from underground work to primary structure, enclosure, rough-in, finishes, and commissioning. In comparison, smaller projects utilized less complex team organizational structures.

All data was recorded using the same database driven LSP software solution. Project teams followed a variety of workflows that reflected the state of the industry and the common practices of implementing LPS. The data was documented in the same way in the database including activities, logic ties, durations, revision history, and weekly work plan data (including reasons for variance and their root causes). The system calculated the priority of all activities on the work plans in a uniform way regardless of how each project team decided to apply the process. Some teams planned complete work phases in ways that emphasized workflow and others focused on improving the reliability of near-term planning against target dates defined in the master schedule. Since the software database records the data in a consistent way over time, it provided context to evaluate LPS metrics on large datasets and compare them across various workflows. In addition, it provided the opportunity to assess these metrics against past data sets to test various assumptions about the new metrics against previously recorded data in ways not possible otherwise.

The database represents pull plan activities as directed acyclic graphs. The software tool includes an integrated calculation engine that prioritizes the activities using pull techniques. For any activity in a workstream, the software automatically calculates its priority and records its Late Start (LS) and Finish dates (LF). Therefore, this calculation identifies what should be done on the project and when. Priorities are determined by the insertion of target dates within a workstream. The system also automatically calculates the Forecast Start (FS) and Forecast Finish (FF) date for each activity based all its predecessor activities and the sequence of the work. This calculation determines when the work as planned by the last planners including all known constraints identified in the MRP can be done. When the MRP identifies constraints that cause the target dates to be delayed, the team will have to perform additional planning to realign the remaining work with the targets. During work execution, if the project team does not maintain their remaining work in alignment with the targets, then this calculation would also identify all the activities that should have been completed to support the target dates and late paths would be highlighted. In general, during the MRP step, teams are expected to perform four related activities when using the software solution:

- Review and screen the activities on the lookahead for constraints.
- Plan and integrate the constraints into the overall network (not on a separate log).
- Review the plan to ensure that the updated plan still aligns with the targets.
- Re-plan any emerging late paths to realign with the targets.

One of the characteristics of the system is its ability to handle ongoing activities that overlap work plan cycles. Ongoing activities are those that do not require intermediate handoffs, start when promised, and complete when promised with durations that span at least two work plan cycles. Those kinds of activities pose an interesting challenge to teams that implement LPS as there is no documented best practice for how to represent them on work plans and how to account for them. All projects in this study implemented the same standard process for tracking ongoing activities. If an activity must overlap multiple work plans, it is tracked for starting on-time, its duration can then be reduced, and it would count towards percent planned complete if its remaining duration still fits within its promised date.

Metrics to link should/can/will/did

This study proposes additional metrics to complement the PPC, TA, and TMR that align the short term work execution planning with the overall phase schedule and master schedule targets thus aligning what should be done on a project with what can, will, and did get done. The proposed metrics are designed to be reviewed not as isolated instances but to identify trends across multiple planning cycles. In addition, the proposed metrics operate at the level of the weekly work plan tasks. They are designed based on the same principles used to calculate PPC, TA, and TMR metrics.

The proposed metrics are designed to provide insights regarding the alignment of work execution controlled by multiple competing target dates or complete workstreams of networked activities for interconnected phases of work that emphasize flow. The metrics are as follows:

Commitment Level (CL): measures the total committed required activities as a percentage of the total required activities for any given work plan cycle each time a new work plan is created. An activity is considered required if its LS date falls within the work planning cycle window of time. The criticality of an activity is the difference between its calculated FS and LS dates. Those calculations are performed automatically by the system for any given activity based on its position in the network, its sequence, and duration. This happens regardless of the kind of underlying network or the control methods used. It produces consistent results from fragmented networks with various target dates, networks with competing deadlines, or workstreams pulled from specific target dates and controlled via Takt or LBMS techniques to improve workflow. Aligning the capture of this information with the work plan creation date is important so that any adjustments made to create a reliable forward-looking plan due to the performance against the previous work plan are incorporated in the metric.

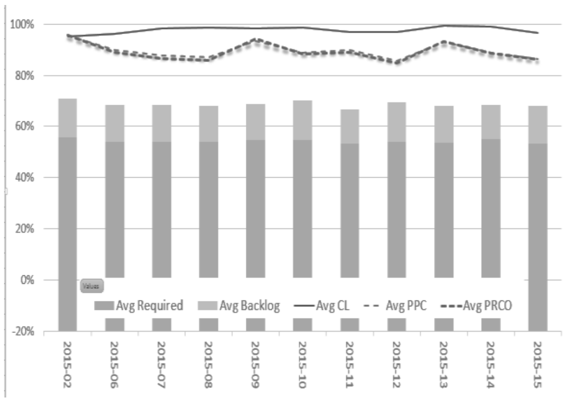
CL = Required Will / Should

Percent Required Completed or Ongoing (PRCO): This is a metric that measures the percentage of the required activities that are completed on or before their promised completion dates. This also includes the required ongoing activities that are projected to be completed on or prior to their promised completion date after the responsible team members update the remaining duration to align with the remaining work.

PRCO = (Required to be Done + Ongoing On Track) / Required Will

When PRCO is reviewed in conjunction to CL on an ongoing basis, it provides a comprehensive metric that captures that the level of completion of critical activities on the near-term plan is in alignment with the long-term target milestone dates. Criticality is automatically calculated by the system based on the plan to complete the remaining work and thus is not left to the subjective evaluation of the team. Thus teams that fail to collaborate on a regular basis and consistently plan their remaining work to achieve their target dates would begin to see a decrease in their CL as the remaining work will exceed their resource capacity after a few cycles of higher PPC trends.

Figure 1 illustrates various possible patterns of data and how they could be interpreted. Figure 1-A shows the performance of a high performing team characterized by a steady commitment count, a high CL, and equally high PPC and PRCO. This team would be expected to also hold their milestone target dates. Figure 1-B shows the performance of a team that appears to be overcommitting on a regular basis and completes more backlog activities than critical activities. They hold a high CL but lower PRCO than PPC. The steady task count indicates that they continuously shift their target dates on a regular basis to compensate for the lost time. Figure 1-C shows a team that is working on the wrong priorities. They maintain a high PPC but their CL and PRCO are trending lower which would indicate that their target milestone dates are slipping each work plan cycle without proper re-planning of the remaining work. Figure 1-D shows a team that is improving. The CL metric reflects the team's attempts to commit to more of the required work and an effort to complete as much as the required work as possible. The variance in task count indicates that the team attempts to adjust resources increase their commitment level and gain time.



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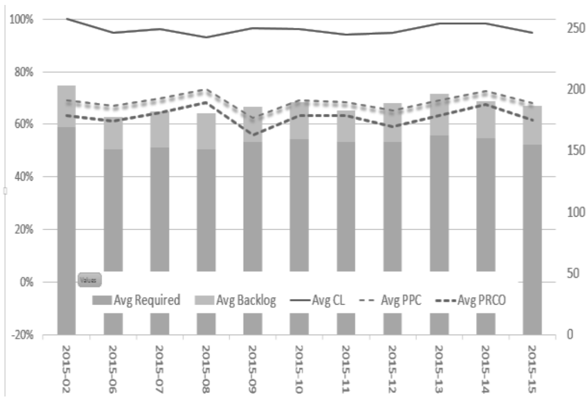

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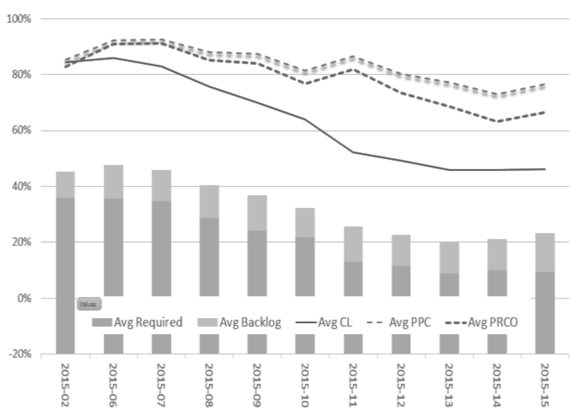

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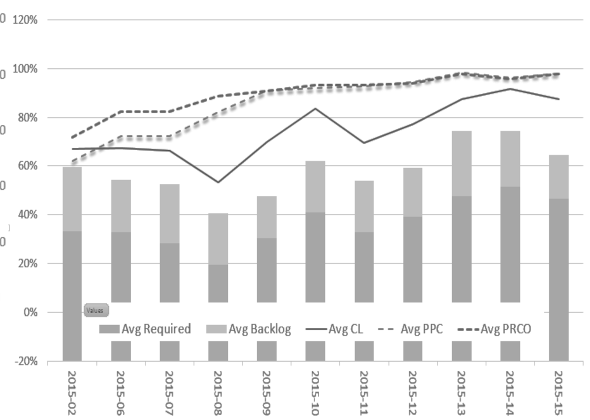

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Figure 1: PPC, PRCO and CL patterns

Milestone Variance (MV): reports on the variance in days between the forecast to complete all remaining activities against the milestone required date. It is designed to be reviewed in conjunction to the CL metric to provide context to the reported CL percentages and ensure that the remaining work is in alignment with the original milestone targets. MV records any changes to the milestone target dates as well as the forecast to completion for each milestone. Figure 2, for example, represents the standard deviation of all the milestones associated with a given team. The trend illustrates the team's efforts align the remaining work with the target milestone dates. However, for an extended period of time, the late paths in their plan ranged between 5-15 days.

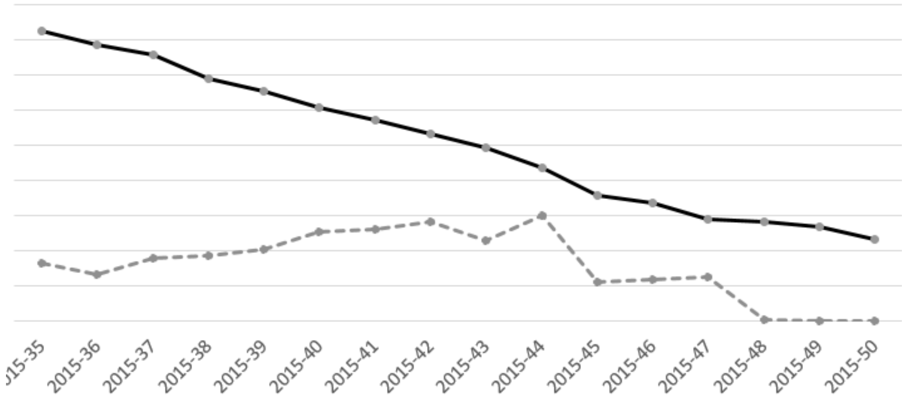


Figure 2: Milestone Variance

The CL, PPC, PRCO, and MV are complementary metrics designed to provide a rolling snapshot of how the team's short-term plan aligns with the overall project targets. The metrics are designed to capture, on an ongoing basis, how well teams keep their promises, their ability to commit to the right amount of work each week, and their ability to maintain alignment between the remaining work and the targets.

Findings

Impact of Lack of Proper Long Term Phase Planning: Teams that focused on short-term MRP (3-6 weeks) without proper application of Phase Planning and adequate emphasis on resource planning exhibited cyclical patterns of PPC similar to what is shown in Figure 3 which illustrates data compiled from work plans generated from multiple parallel work phases.

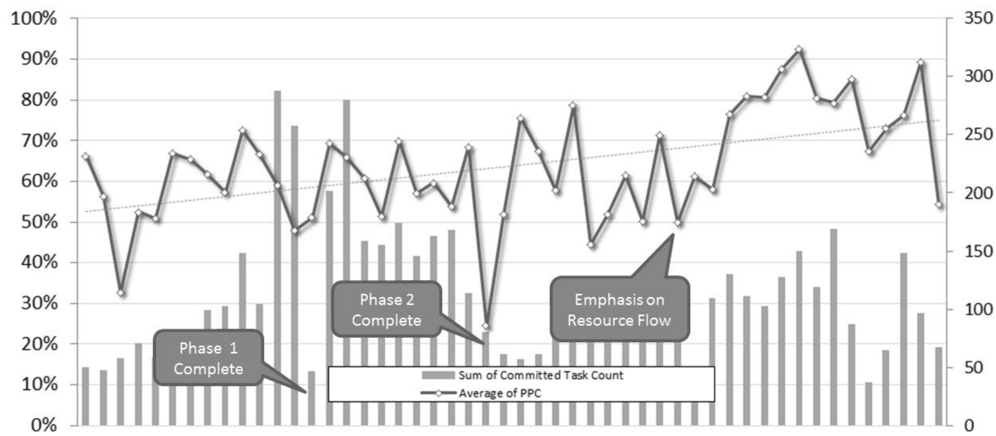


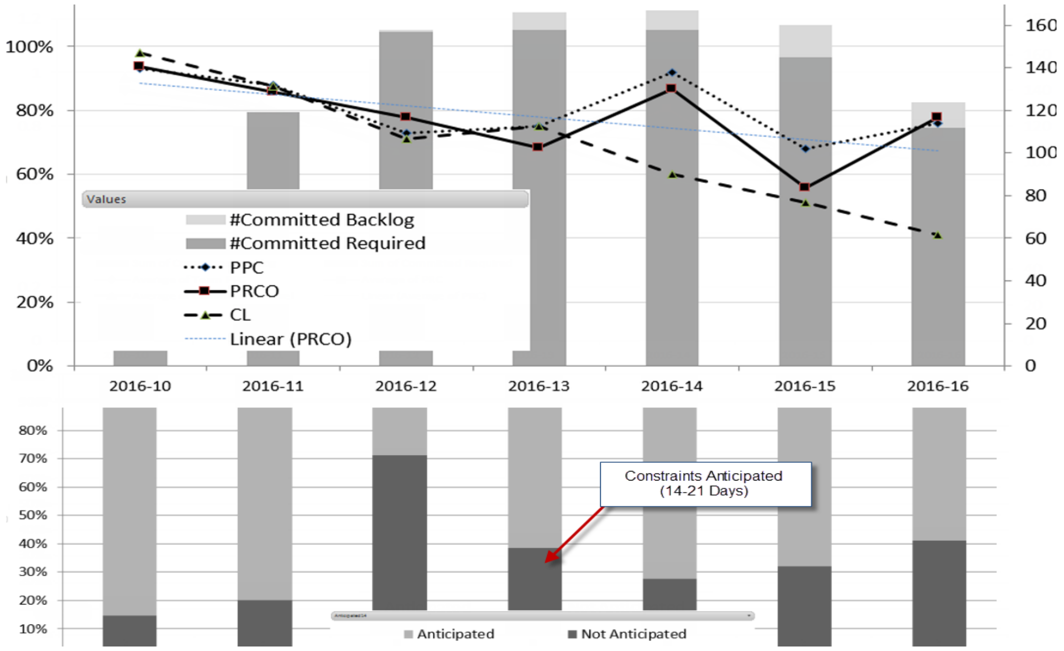
Figure 3: PPC graph with focus only on near-term performance

Initially, task priorities were set by the project superintendents based on what was planned in the master schedule. The master schedule was maintained in an external tool and the Make Ready Planning was performed against those priorities at a greater level of detail. The figure shows a cyclical pattern of a short-term increase in the average number of committed tasks accompanied by an improvement in PPC followed by a decline. Initially, the team focused on work sequencing and identification of constraints during MRP. They were, however, reluctant to link many of the constraints to the specific workstreams in the database, and, instead continued to follow the conventional LPS practice of creating separate constraint logs in excel and assigning various team members to track and resolve those constraints.

Significant effort was required to maintain alignment between the lookahead plans, the constraint logs, and the master schedule. In addition, the cycle time to synchronize near-term plans, constraints, and update the master schedule exceeded the duration of the planning cycle time. This meant that the team was uncertain about their new priorities when they attempted to commit to the next set of work plan activities. The average PPC improved but remained below the 75% mark. This meant that many assignments on a work plan could not be completed as promised and also meant that the number of late paths continued to increase making it increasingly more difficult to maintain alignment across the various tools used to track constraints, make ready plans, and the master schedule.

The team implemented a number of improvements to the workflow to reduce the cycle time and integrate the tracking tools. Many constraint types including RFIs, change orders, and design revisions, were integrated into the workstreams and removed from the individual constraint tracking logs. Construction work was re-planned into smaller batches that maximized the opportunity for workflow in the least constrained areas of the project first to allow more time to resolve issues in the more complex areas of the project that obstructed workflow. Those changes resulted in an observed steady improvement of PPC between 70% and 90% (see last third in Figure 3). This was accompanied by a steady increase in the number of tasks committed for each planning cycle. In addition, the cycle time between finalizing a previous work plan, analysis of late paths and variances and the start of the next plan based on new priorities was reduced to a few hours instead of several days. These findings confirm the original observations made by Ballard and Howell (2007) and by Hamzeh et.al (2012) that better integration between near-term planning and long-term planning can improve workflow reliability.

Evaluating the Lookahead Reliability: Initial analysis of the data shows no positive correlation between TA and TMR metrics and a team's ability to reliably achieve milestone targets. Figure 4-A, for example, shows that a relative increase in Tasks Anticipated within a 14-21 lookahead window could result in work demands that may exceed the team's resource capability as evident in the decline in CL and PRCO metrics during the next few work plan cycles. This had an adverse impact on MV for the same period (see Figure 4-B). However, it was observed that the measurement of the standard deviation of the forecast start date for the same activities on the lookahead tracked on a rolling basis of 21 days and the standard deviation of the FS and the LS dates within the same lookahead window appears to be a better indicator of lookahead stability[3].



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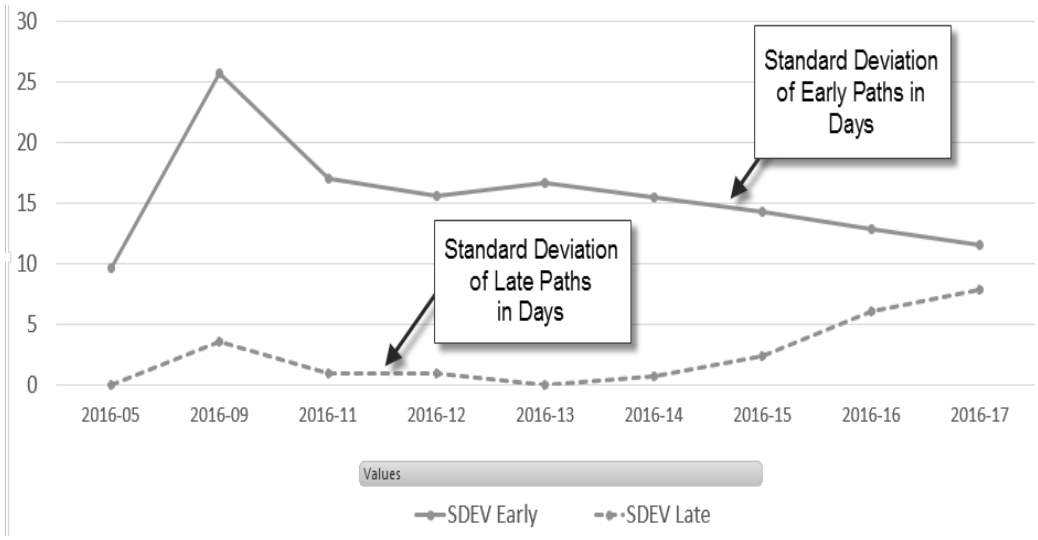

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Figure 4 Increase of TA and negative impact on Commitment Level

This observation was confirmed by reviewing other datasets. Figure 5-A shows the PPC, CL, PRCO, MV metrics for a project team captured over several planning cycles. Despite a stable short-term plan, the team initially struggles to commit to the appropriate

[3] This observation was first made by Hongseok Cha, Business Intelligence Manager, Boulder Associates Architects in collaboration with one of the authors while evaluating data collected using vPlanner from various lookahead plans on one of his company's projects.

amount of work that would satisfy the critical chain. Fluctuations in CL correlate in an increase in late paths and a decrease in float (Figure 5-B).

Teams that constantly re-plan to maintain CL, PRCO, and PPC appear to have lower overall MV (typically below 5 days) and appear to maintain better alignment between their near-term plans and their long-term plan target milestones and are thus more reliable. Very reliable teams maintain an overall average standard deviation of 2.5 days or less across all their phase milestones. Design phases seem to show higher variance than construction phases.

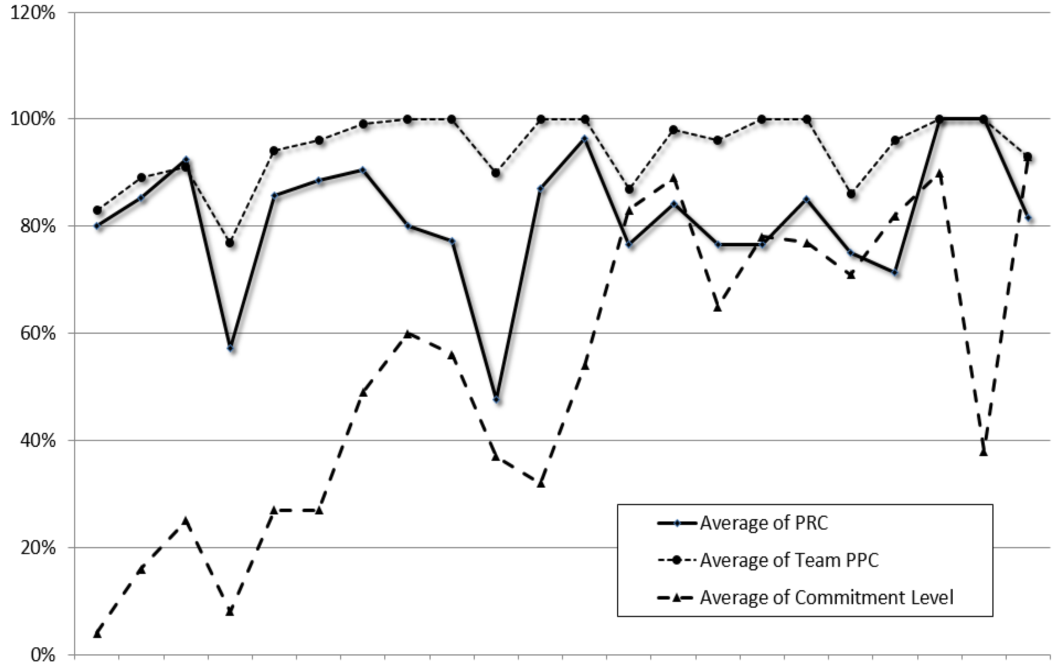

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Figure 5 Measuring lookahead stability

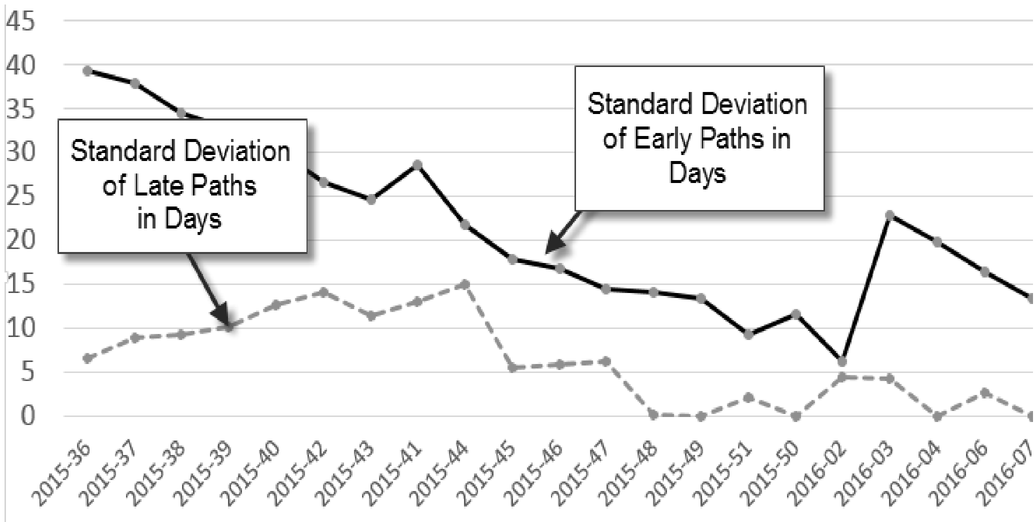

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Figure 6 Measuring lookahead stability

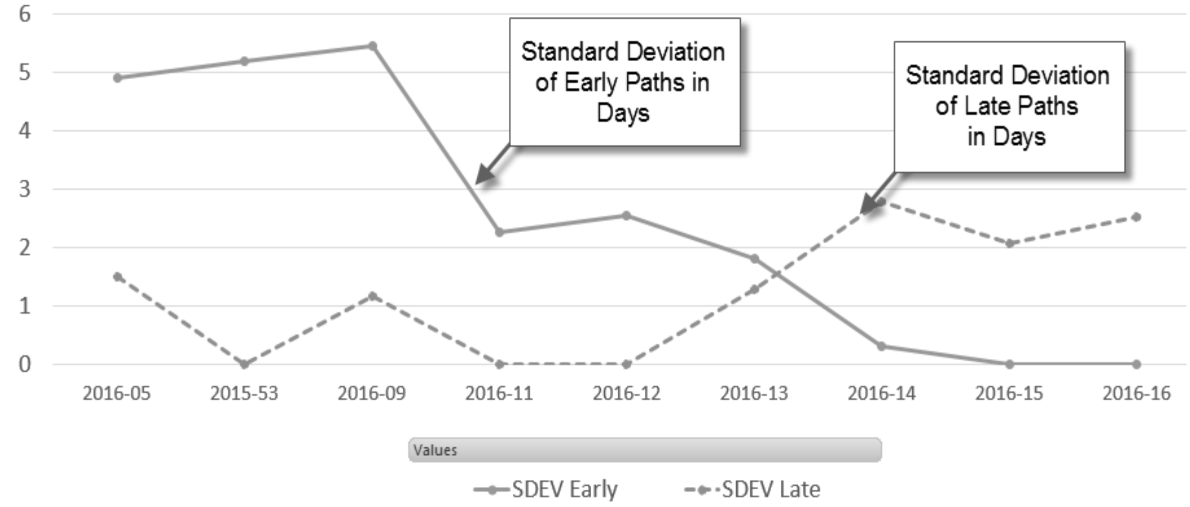

Figure 7: PRCO focused teams

Conclusions

This paper presented an overview of the common LPS metrics designed to measure near-term planning reliability and introduced new metrics designed along the same principles to measure the reliability of the long-term planning and improve the association between near-term and long-term planned activities. The initial findings do not support the hypothesis that TA and TMR, as commonly defined in the literature, correlate to improvements in long-term planning reliability. The study suggests that the standard deviation of forecast dates of lookahead activities captured on a rolling basis at the time work plans are created may serve as a better indicator for overall planning reliability.

The correlation of this metric with the standard deviation of forecast dates against late dates for the same lookahead activities serves as a better indicator of reliability especially when reviewed against the proposed CL, PRCO, and MV metrics that are captured at the same time as the capture of the standard deviation metrics. Additional research continues to monitor these metrics on a larger project sample and for longer periods of time to confirm the initial conclusions.

The alignment of near-term and long-term planning requires a systematic adherence to the processes of the LPS workflow from Phase Planning to Weekly Work Planning and Commitment Management, and, the continuous capture of the data in an integrated and uniform way. This cannot be achieved by makeshift tools commonly used in the industry to manage LPS workflows. Those makeshift tools and associated processes result in data fragmentation, redundant entry, long cycle times, and introduce errors into the process. This research demonstrated some of the advantages that integrated database driven tools can bring to improve LPS data collection and presented an overview of some of the opportunities presented by those tools to align near-term and long-term planning to improve reliability.

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