

A FRAMEWORK FOR INTEGRATING TAKT PLANNING, LAST PLANNER SYSTEM AND LABOR TRACKING

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ABSTRACT

This paper proposes a framework for incorporating direct field labor hours and costs into an overall production strategy centered on Takt Time Planning (TTP) and the Last Planner® System (LPS). An integrated tracking tool, vPlanner Production Tracker, has been developed to associate labor information with production activities utilizing the same database. The association of field labor hours including budgeted, estimated, and actual with production activities provides an early indicator of risk on projects. The proposed framework improves the consistency and efficiency by which the information is created and maintained so that the system can be scaled to support large projects that span multiple years. This is done to shorten the cycle time between monthly financial forecasting and field labor utilization. The goal is to improve the effectiveness of identifying and mitigating risks of field labor overruns and also the realization of savings opportunities due to improved field labor utilization. The paper outlines the improved workflow processes and presents an analysis of the data collected over several months from a pilot project.

KEYWORDS

Takt Time Planning, Last Planner System, Production Planning, Labor Tracking, PDCA

INTRODUCTION

LPS is a production management system designed to improve workflow reliability by shielding near-term work from the variability and the uncertainty surrounding downstream processes (Ballard and Howell, 1994). Detailed handoff work plans for near-term work are created through collaborative planning among those team members responsible for directing the performance of the work. One of the fundamental elements of LPS is the systematic application of the Make Ready Process (MRP). This process ensures that all known constraints that may affect planned activities are identified, planned, and resolved before the start dates of the impacted activities (Ballard and Howell, 1997). The systematic application of the system in its entirety creates a steady stream of unconstrained work that can be performed with more certainty in alignment with overall project target milestones.

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TTP aims to reduce the variability in the downstream processes themselves by pacing the production rate of standard activities across right-sized geographic areas within distinct work phases (Linnik et al. 2013). This is achieved by fixing the durations and varying the crew sizing of standard activities performed by the various trades in succession. The end objective is a steady stream of predictable work, performed in the proper sequence, across the defined geographic areas, and, with appropriately planned crew sizes. This disciplined planning approach aligns not only the workflow at the site, but also the overall flow of materials and information through the supply chain starting in design and moving into detailing, fabrication and delivery processes required to support the Takt sequence. Recent experimental studies (Frandsen et al. 2014) suggest that TTP has the potential of improving LPS implementations because of its focus on the design of predictable flow of materials and resources across clear geographic locations.

The effects of implementing TTP and LPS on improving field labor forecasting have not been explored. Currently, a long feedback loop exists between monthly financial forecasting and production labor utilization. This results in poor reaction time when attempting to adjust the production system to mitigate financial risk or recognize savings opportunities due to labor utilization. The authors have been collaborating on a new approach to reduce the duration of the feedback loop. This paper presents the results of this collaboration and introduces a framework for incorporating direct labor hours and costs into an overall production design strategy centered on TTP and the LPS. It presents this in the context of ongoing work on a large hospital project in San Francisco, California, namely the St. Luke's Campus Hospital (STL) presented later in this paper.

An integrated tracking tool, namely vPlanner® Production Tracker, has been developed to associate labor information with production activities within the same underlying database. It integrates labor information with the existing features of the base vPlanner system database. The software has been used by the STL project team since 2014 to manage TTP information on a rolling basis spanning at least six months of future activities. In addition, the team uses the system for managing LPS processes including the Make Ready Planning, Weekly Work Planning, and Daily Commitment Management.

The use of vPlanner on the project was required by the owner. Sutter Health needed a solution for production management that could accurately represent the highly complex and dynamic networks of commitments that are required to plan the design and construction of its healthcare facilities. Additionally, Sutter needed a solution that allowed rapid revisions of that complex network as challenges were uncovered during Make Ready Planning. For those reasons, among others, Sutter Health selected vPlanner as its tool of choice for planning work on its most complex and challenging projects including the STL project.

The development of the Production Tracker tool is an attempt to resolve some of the workflow challenges that teams face when implementing TTP and LPS using separate processes and tools that are manually coordinated with the associated familiar problems of human error, duplication and lack of visibility of the two-way impacts of each system on the other.

This paper presents the objectives for developing and implementing this framework and the associated tool, the problem it solves, the initial findings, and outlines directions for future research to extend this approach.

OBJECTIVES

The association of field labor hours (including budgeted, estimated, and actual) with production activities improves the alignment between resource assumptions and work execution. This provides an early indicator of risk on projects that is mainly associated with overruns on field labor hours. Additionally, it provides an opportunity to involve those directly responsible for managing the work to validate and inform budgetary and labor assumptions before the work is executed. The resulting collaborative nature of the approach promotes transparency, trust, and cross team learning. Below are the main objectives for developing the framework and associated workflows and software solution:

- Reduce the cycle time for data collection and analysis so that teams can react more quickly and mitigate the risk of unforeseen variation.

- Improve collaborative planning aimed at clarity of handoffs and predictable flow by validating resource assumptions prior to work execution.

- Align TTP with resource planning and budget control.

- Reliably execute against those plans using LPS methodologies.

- Ensure uniformity and increase the consistency of data collection and tracking.

- Improve on the overall efficiency by which the information is created, maintained and tracked so that the approach can be scaled to support large projects that span multiple years.

It is important to note that while this approach has merits under a variety of contractual arrangements, it adds the most value in collaborative open-book contracting arrangements such as Integrated Project Delivery (IPD) where the interests of the team are aligned around the success of the project as a whole.

PROJECT CONTEXT

This approach is being implemented on the STL Project; a new 237,000 sq.ft., seven story hospital in San Francisco, California for Sutter Health. The \$330 million project is being designed and delivered utilizing an IPD contract. It is due to open in 2019. The open book nature of the project, its size, and the team's commitment to continually improve how they manage work provided an ideal setting for implementing this approach.

The STL team has been using LPS and TTP since the project started and has mastered both techniques. Taking those efforts to the next level was a natural next step for this high performing team. The authors are active participants in this project at different capacities. One is the owner's representative, one is responsible for production management and one is the project's Lean/IPD coach and the developer responsible for the tool used to implement this framework.

The approach was introduced into the production environment in February 2015 which marked the start of construction. Multiple work phases are complete including foundations through concrete deck construction. At the time of writing this paper, the project team has completed over 10,000 commitments and tracked labor data for over

5700 production activities. The completed activities represent approximately 24% of the risk-reward scope of work on the project. The ratio of actual hours against budgeted hours is showing a 7.5% in field labor savings.

The team is currently tracking production activities and field labor hours related to interior construction including fireproofing, MEP systems and framing with the intent to follow this process to project completion. While some risk-reward trade partners are providing labor mix rates and actual costs, the main focus of the pilot implementation was the tracking of field labor hours.

WORKFLOW AND DATA ORGANIZATION

Production Tracker was designed to support the workflows for associating labor hours with Takt activities developed in collaboration with the project team to define the overall process and the desired outcomes. Key team members collaborated over the course of several months to identify the objectives and map out the current and future state workflows for documenting and reporting on this information. The outcome of those discussions informed the design of the Production Tracker software module. The team included the owner, the general contractor's production managers and general superintendents, the financial reporting team, the project managers of the various trade partners and their superintendents. The assembly of this cross functional team was essential to cover all aspects of information flow from daily commitments to financial reporting. This section presents the definitions used to document the various activity types, standard work assumptions, and labor categories. The next section outlines the main elements of the standard future state processes required for implementing the proposed approach.

DEFINITIONS

Planned Activities: all the remaining activities on the Phase Plan including all planned Takt activities, milestones, and constraints identified after performing the make ready process.

Production Labor Activities: a subset of all the planned activities of a phase. The production manager, in collaboration with the team identifies which Planned Activities should be marked for labor tracking.

Standard Work: a statement of all the assumptions regarding the activities that a specific trade must perform as part of a Production Labor Activity. A clear standard work definition ensures consistency when trades provide labor estimates as it defines the conditions of satisfaction for completing those activities.

Budgeted Labor: the estimator's view of the project budgeted labor. It represents the hours, mix rate, and dollars associated with a given production activity as defined in the original project budget, or, the Estimated Maximum Price (EMP). Data captured in the EMP is used to assign applicable cost codes to production activities. When the data does not align with Takt geographic locations (most often it will not due to EMP being set before geographic locations development), the responsible trade project managers will distribute the cost codes to the Takt areas based on their best knowledge of the work.

Estimated Labor: the superintendent's view of the field labor hours required to perform the work. It includes the hours, mix rate, and dollars associated with the Production Labor Activities as defined in the standard work description of the

activity. Estimated Labor information is not the same as that of the EMP. It is determined by each responsible trade superintendent after detailed analysis of geographic areas, complexity and method of the work, and Takt plan duration assumptions for pacing the work.

Baseline Labor: a copy of the Estimated Labor after each trade partner completes the Estimated Labor for a phase. It is used for comparative purposes as the trade partners are required to keep the estimated labor for Planned Production Activities up to date in accordance of their best understanding of the remaining work.

Actual Labor: the actual hours spent and the labor mix rate associated with the Production Labor Activities. Actual Labor is provided by each trade partner after the commitment status is updated in the system to reflect that the work has been completed on a weekly work plan.

Remaining Labor: the calculated value of the total of all the estimated labor values for the planned production labor activities of a given phase. It does not include the estimated labor of the completed activities.

Projected Savings or Overage: the calculated difference between the budgeted labor and the total of remaining and actual.

WORKFLOW PROCESSES

Key participants from the project team (project managers, estimators, and superintendents from the various trade partners) collaborated for several weeks to map out the overall process for integrating financial reporting, Takt planning, and labor tracking. The resulting process identifies quality control gates to ensure that the right data is being captured, at the appropriate level of detail, and at the appropriate time.

For any given phase, and at least six weeks prior to the start of labor tracking, the production manager ensures that the Production Tracker captures all the planned production activities for the phase by creating associations with the existing production activities in the plan. This configures the system with all the planned activities that should be assigned labor hours.

The production manager schedules a work session with the team to confirm the standard work assumptions for each production activity. This ensures that the team is still in alignment regarding how to estimate or aggregate Estimated Labor information for each activity based on a clear understanding for the work sequence, geographic location, and the conditions of satisfaction.

At least four weeks prior to the planned start date of a phase each trade partner's project manager reviews their budgeted labor hours and inputs the budgeted labor hours and mix rates in Production Tracker in accordance with the budgeted amounts of the Estimated Maximum Price (EMP). This step allocates the appropriate budgeted labor hours in the system according to the estimator's view of the work.

Two weeks prior to the planned start of a phase, each trade partner enters the estimated labor hours and crew mix rates in the Production Tracker tool based on his or her best understanding of the effort required to perform the work in those specific locations in accordance to the standard work definitions. This step sets the Forecast Labor information based on the Last Planner's view of the work.

One week prior to the start of a phase, the Production Manager reviews the information for completeness and locks the estimated labor to set the baseline estimated hours and labor mix rates based on the trade partner data. This establishes the Forecast Labor Baseline in the system for comparative purposes.

No later than one week after Production Labor Activities are marked completed as a result of the LPS Weekly Work Planning (WWP) process(i.e., 100% of work done in one area), each trade partner inputs the actual hours for their completed activities. It is important to note, that the system automatically reflects the status of the WWP tasks in the production tracker. This ensures that completed labor hours can only be associated with completed activities on the WWP.

On an ongoing basis, trade partners keep their remaining estimated hours up to date in accordance with their best understanding of the field labor hours required to complete the work in each Takt area.

The Production Tracker tool automatically aggregates the data into visual report graphs that are configured to budgeted, actuals, remaining as well as projected savings or overages. **Figure 1** shows a summary view of labor hours by floor. **Figure 2** shows a detailed view of the same information organized by floor and then grouped by Takt area for a more detailed analysis. As the STL team implemented this process, they focused primarily on field labor hours. Reporting on crew mix rates and actuals was not always required.

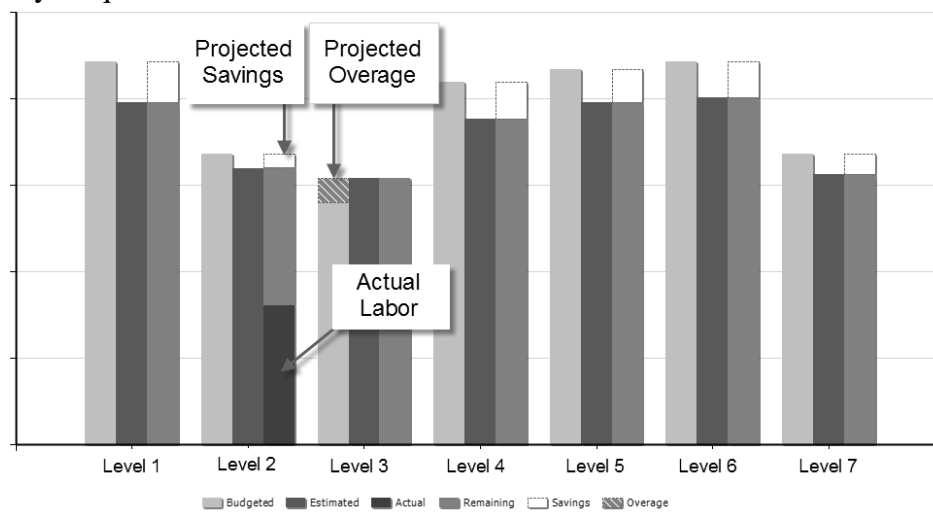


Figure 1 Labor Tracking for a Phase Summarized by Floor

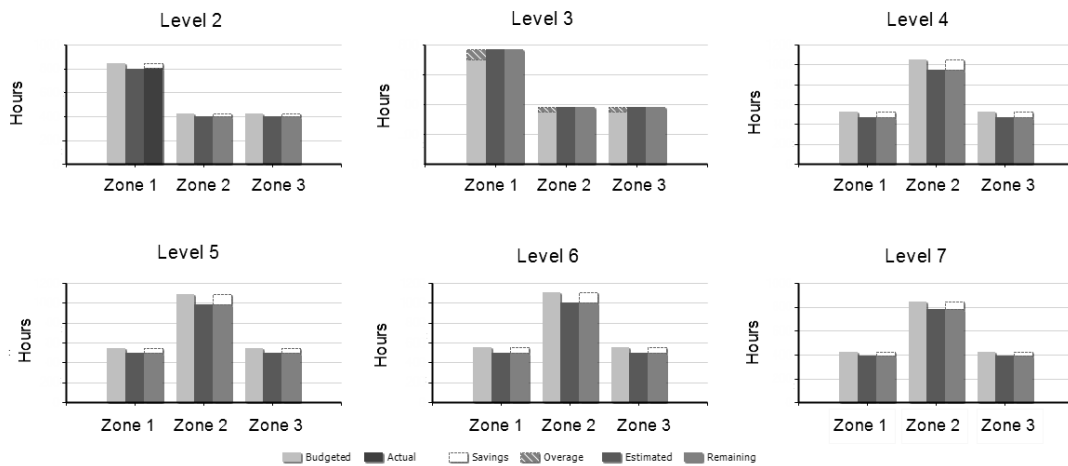


Figure 2 Detailed View by Floor and Takt Area of the Data Shown Figure 1

REVIEW CYCLE

The close alignment of data collected from following the TTP and LPS processes and the proposed systematic tracking of labor hours associated with those same activities provides rapid feedback on how resource utilization aligns with planned and completed activities and how weekly work execution planning aligns with the overall project budget.

An integrated team comprised of representatives of the at-risk partners reviews the Production Tracker charts on a bi-weekly basis during the production tracking meetings. Each trade reports on their production tracking graphs. They overview production progress, bring forth challenges, and discuss improvement ideas. These discussions spur many useful suggestions from one trade to another and allows early adjustments of the production plan to improve the overall production flow efficiency.

For example, in many instances, the trades would propose solutions where one trade will make a sacrifice (i.e. spend more labor hours) to increase the production efficiency for several other trades to yield an overall saving for the phase. The financial forecasting team reviews the same rolled up information on a monthly basis and correlates labor assumptions with overall budget forecasting.

MANAGING LABOR RISK

The alignment of field labor estimated hours with Takt geographic locations makes it possible for the various teams responsible for planning and delivering the Takt phases to better manage their risk and maintain alignment with the overall budget targets. Overages by certain risk-reward participants are often offset by savings by other Risk-Reward participants with a net savings to the at-risk work in the phase. For example, when the approach was first applied to the early slab pours, the team immediately identified areas of potential improvement and implemented counter measures to mitigate the risk including, among other things, improved management of crane time.

This approach frees the overall project management team to focus on issues that impact the overall project while making it possible for each phase team to manage the risks within their production phases in alignment with the overall budget against clearly stated targets.

CHALLENGES AND LESSONS LEARNED

CHALLENGING ESTABLISHED NORMS

When the concept of field labor tracking was first introduced to the project team, many were reluctant to participate out of concern that the effort would be redundant since each trade already tracks their field labor in great detail. However, the close examination of the current state revealed that while each trade tracks their own field labor, the tracking was not consistent across the trade partners, performed at different times, and it was not in alignment with the Takt geographic locations. This meant that the at-risk partners would not know the overall shared risk until many months after the work has been completed. Thus limiting their ability to manage that risk in any meaningful way. The review of the future state revealed that this new approach presented a significant benefit to everyone. In addition, it was noted that this approach would improve the transparency, consistency, and alignment of the data across each project phase and thus improve ownership and trust.

PROACTIVE MANAGEMENT VS PASSIVE MANAGEMENT

Field labor estimates are not typically aligned with TTP and LPS processes. The team made the commitment to estimate in accordance with production areas, and, to have the superintendents directly responsible for managing the performance of the work produce those estimates. In other words, Estimated Labor would not be simply a percent of the budgeted hours distributed over geographic areas. This is important to build a sense of ownership of the proposed estimates and also to ensure that the reporting captures the most up to date understanding of the work in accordance with the definitions of standard work within a Takt geographic location.

Generally, current labor tracking practices do not involve setting targets or tracking by production area. The estimator's quantity take-offs used to set the budget targets are performed much earlier in the project and prior to the completion of the Takt planning. The production team executes the work based on the needs of the site and in accordance with the Takt plan. Without the proactive updating of the estimated values, it would be very difficult to have an accurate forecast on what will take place in the field vs. what actually took place. Traditionally, this contributes to the long lag between budgeting and work execution and results in surprises during monthly financial meetings held months after the work has been completed. Thus limiting the team's ability to re-plan and manage this risk and left with the only option of recording such items, each time, as lessons learned to avoid on the next project purposes.

GO-BACK WORK

Go-back work is a general term that describes new activities associated with previously completed production activities where a trade partner has to go back and perform unplanned work in the form of rework or to complete certain tasks within the standard work of a completed Takt area that could not be completed due emerging constraints and that are not significant enough to interrupt production flow. Assumptions about go-back work are often included in the estimated activity duration and labor estimates. Go-back work contributes, to a large extent, to the common budget reporting issue when the cost codes show that 95% of the work is complete but the last 5% is the most costly. Without clear documentation of go-back work, the team

would be at risk of making inaccurate forecast assumptions and this poses a risk to a project.

Once go-back work was identified as a risk factor, the team collaborated and identified a plan to mitigate that risk. This resulted not only in improvements to the field labor tracking process, but also in improvements to the standard processes of TTP and LPS. A new activity status, namely Completed with Go-back Work, was introduced and implemented into the commitment cycle. During weekly work planning, the team was asked to apply the new status code to any activity that requires go-back work and record all the known go-back work against the completed activity. Both the original activity and the go-back work itself are tagged with special codes so that they can be identified later for labor tracking and process improvement efforts as increasing trends of go-back work could be a symptom of larger quality issues.

This new process helps the team to keep go-back work very transparent and allows the superintendent/foreman to assign estimated hours for go-back activities, not as percentage of budgeted but actually estimating labor hours considering the go-back strategy. This results in an accurate forecast for go-back work and improved risk management.

CONCLUSIONS

This paper presented a framework for aligning field labor hours tracking with the processes of TTP and LPS. This approach improves current practices. It presents an integrated process that increases the consistency and accuracy of the data and the efficiency by which the data is managed. The approach resolves many of the issues that teams face in practice due to the complexities of incompatible reporting tools, methods, and processes which make it impractical to perform any type of integration or analysis on the data.

The implementation of the proposed approach on the STL pilot proved effective and allowed the team to maintain the information across the various phases of production planning in alignment with the overall project budget. It promoted transparency and provided an improved process for managing field labor risk especially in IPD projects where there are shared risk and reward arrangements. Moreover, the simplicity of the approach makes it more likely to be implemented on future projects and improved.

Future improvements on the approach would entail more attention to the tracking of quantities within the Takt areas. The systematic tracking of field labor hours, across Takt geographic locations, and the statement of clear standard work definitions, when augmented with reasonably accurate quantities would serve the basis for building a robust knowledge base for measuring the effect of Takt and LPS on labor productivity. While the current implementation allowed for rudimentary tracking of area quantities, additional work remains to be done to improve material quantity tracking and analysis.

While the focus of this paper has been on the tracking of field labor hours for Takt activities, the approach could be extended along similar lines to other types of production work including that of fabrication, materials, design and pre-construction activities and to improve resource planning at the supply chain level.

ACKNOWLEDGMENTS

The authors would like to acknowledge the active participation of team members from Sutter Health, Southland Industries, Rosendin Electric, Harrison Drywall, RLH Fire Protection, Pankow Builders, Herrero Builders, and The Boldt Company who shared their processes and best practices. Without their participation and commitment to support this effort, this research would not have been possible. Additionally, the authors would like to acknowledge; the STL project core group for their leadership and for their permission to document this effort; and Carrie R. Wilson, Ph.D. for editorial contribution to this paper.

REFERENCES

- Ballard, G. and Howell, G. (1994) "Implementing Lean Construction: Stabilizing Work Flow", *Proceedings of the 2nd Annual Meeting of the International Group for Lean Construction*, Pontificia Universidad Catolica de Chile, Santiago, September 1994. Pp 101-110.
- Hamzeh, F. (2009). "Improving Construction Workflow – The Role of Production Planning and Control." *PhD Diss.*, University of California, Berkeley, CA.
- Hamzeh, F., Ballard, G. and Tommelein, I. (2012) "Rethinking Lookahead Planning to Optimize Construction Workflow", *Lean Construction Journal 2012*, pp 15-34. www.leanconstructionjournal.org.
- Linnik, M., Berghede, K., and Ballard G. (2013). "An Experiment in Takt Time Planning Applied to Non-Repetitive Work", *Proceedings of IGLC-21*, July 2013, Fortaleza, Brazil, 609-618.
- Frandsen, A., Berghede, K., and Tommelein, I. (2014) "Takt-Time Planning and the Last Planner System" *Proceedings of IGLC-22*, Oslo, Norway. pp.571-580.