'PLANNED WORK READY': A PROACTIVE METRIC FOR PROJECT CONTROL

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ABSTRACT

Traditional project controls use "percent complete" and "earned value" to assess the project status. These metrics compare the amount of work completed (DID) against the work planned to be complete (SHOULD) and indicate if the project is on or behind schedule. This paper proposes a "proactive" project control metric that is based on the Last Planner's lookahead process. The proposed metric is "Planned Work Ready" and indicates what portion of the work in the lookahead plan is expected to be ready as planned in the lookahead horizon (CAN vs. SHOULD). The metric does not include only work that is ready at that point in time, but also work that is expected to be ready as planned with a high degree of confidence. This metric indicates the "momentum" of the project and in combination with percent complete and PPC it can provide better indication of schedule performance. The paper discusses how the metric is defined, ways to quantify the metric, its relationship with other metrics (such as percent complete and PPC), and the assessment of the forecast after the fact, in order to improve the "make ready" process.

KEY WORDS

Project Controls, Performance metrics, Lookahead, Make-Ready process, Constraints.

INTRODUCTION

The project organization's ability to control the progress of the project depends on the effectiveness of the 'make ready' process. The 'make-ready' process includes all the actions and processes that identify and remove the constraints of the upcoming work (Ballard 1997). Thus, the organization's ability to identify and remove constraints is in the heart of controlling the project progress, and a critical organizational capability. The more complex, dynamic and uncertain the project, the harder it is to identify the constraints ahead of time, and the more critical this capability is. Traditional project controls do not measure or improve this capability.

The purpose of this paper is to propose metrics to measure and drive improvement of the organizational ability to make work ready. The paper first reviews the limitations of traditional controls with regards to 'making work ready.' Then it discusses the purposes of 'make ready' metrics, and finally proposes a set of indicators.

TRADITIONAL PROJECT CONTROLS

Traditional project controls are based on the thermostat model of control (Moder, Phillips and Davis 1983) and involve periodic monitoring of status and comparison of actual progress vs. the plan. The primary purpose of such controls is to identify negative deviations from the goals (mainly schedule, cost and quality) and identify corrective actions to bring the project back in line. Schedule controls use the critical path method and Earned Value (EV) and 'percent complete' to assess the project status. These metrics compare the amount of completed work against the goal and indicate if the project is on or behind schedule.

The Critical Path Method compares the actual progress with the baseline (goal) schedule, and monitors the floats on the critical and near critical activities. "Percent Complete" is based on the Earned Value (EV) method. The EV method monitors the progress of activities using dollar value as the metric—by comparing the Budgeted Cost

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of Work Scheduled (BCWS) with the Budgeted Cost of Work Performed (BCWP). For each activity, the schedule variance (SV) is calculated as the difference BCWP – BCWS. The project progress is indicated by aggregating the values of the individual activities. If the $ value of the work performed (up to the reporting date) is more than the work scheduled, the project is considered 'ahead of schedule.' Both CPM and percent complete compare the actual progress to date to the plan (compare DID vs. SHOULD) in order to identify if there is a need for managerial corrective action. Thus, a project ahead of schedule is considered good, while a project behind schedule is considered problematic. Figure 1 illustrates a project that is considered ahead of schedule. The project Percent Complete is calculated as the ratio of the total BCWP (for all activities) divided with the Total Budget.

From a lean production perspective, schedule controls have been criticized for their inability to control and stabilize the workflow. Kim and Ballard (2000) pointed out that EV does not consider the work sequence, and as a result, managerial actions driven by EV typically increase the variability of workflow. Howell & Koskela (2000) argued that current project management uses a deficient definition of control, based on controlling contracts rather than the production. Howell and Ballard (1996) point out that traditional controls do not determine the degree of match between 'SHOULD' and 'CAN' and that sophisticated project managers try to increase the visibility of future work flow.

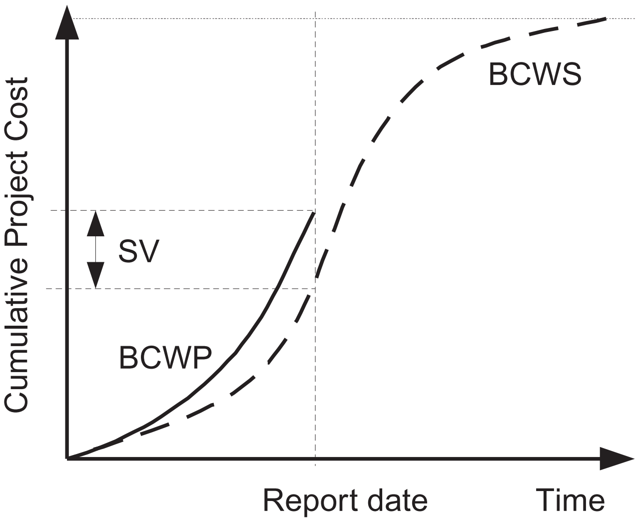


Figure 1: Percent Complete based on Earned Value

The fact that traditional schedule control systems do not provide any indication about the status of the upcoming work (how much of the upcoming planned work can be performed as planned) limits their ability to control the project progress, and their ability to identify appropriate corrective action before problems are encountered. Under this light, a project that is ahead of schedule but has only a small portion of the upcoming planned work that can be performed it should be considered problematic, while a project that is behind schedule but has a lot of upcoming work that can be performed, may be much less problematic. Furthermore, the corrective actions required in each case will be different. Corrective action taken based on progress to date may compound the project problems if they do not consider the status of the upcoming work. For example, adding capacity (crews or overtime) to a project that is behind schedule but has only small amount of work "ready" ahead of it, will only result in more wasted effort, and more unreliable work flow.

Advanced location based systems, make it easier to identify and visualize potential problems due to production rates and spatial interferences between crews that may cause disruptions and loss of continuity (Kankainen and Seppanen 2003), however they do not explicitly identify planned work that can be ready as planned (such as factors that may reduce the current production rates).

Currently, there are no established project control metrics to evaluate the status of the upcoming work and the quality of the lookahead process. In the "Lookahead planning: the missing link in production control," Ballard (1997) emphasized the critical role of the lookahead process and described performance metrics used by a mechanical contractor. Since then, there has been no further work in the area of measuring and improving the performance of the make ready process.

This paper builds on the work of Ballard (1997) and discusses project metrics that can be used to evaluate the status of the upcoming work and the quality of the lookahead process. The following sections review the importance of the 'make ready' process and propose project control metrics to assess the project's make-ready process and capability.

THE MAKE READY PROCESS

LCI defines as control "the ability to make things happen as planned." Consequently, the project team's ability to control the progress of the project, depends on the effectiveness of the 'make ready' process. The make-ready process includes all the actions and processes that identify and remove the constraints of the upcoming work. Its primary purpose is to produce sound assignments (Ballard and Howell 1998) so that the workflow is stabilized and the organization can match labor and other resources to the available work. The steps of the "make ready" process are (Ballard 1997):

1 **Develop a lookahead schedule**, based on an updated master schedule.
The lookahead schedule drives the make ready process.

2 **Analyze Constraints.** This is an assessment whether the activities in the lookahead schedule can be made ready to assign when scheduled. This requires (a) identifying the constraints and (b) performing constraint analysis.
Constraint identification requires "translating" activities into specific assignments, so that the organization can identify the requirements (constraints) for these assignments (authorizations, resources, status of pre-requisite work, etc.)
Constraint analysis involves gathering information regarding the status of the work constraints, such as the status of design (what is the status of the RFIs, submittals, change orders, or anticipated changes), the availability of materials and components needed for each activity (is the supplier going to deliver as expected?) and the likelihood that prerequisite work will be complete when needed.

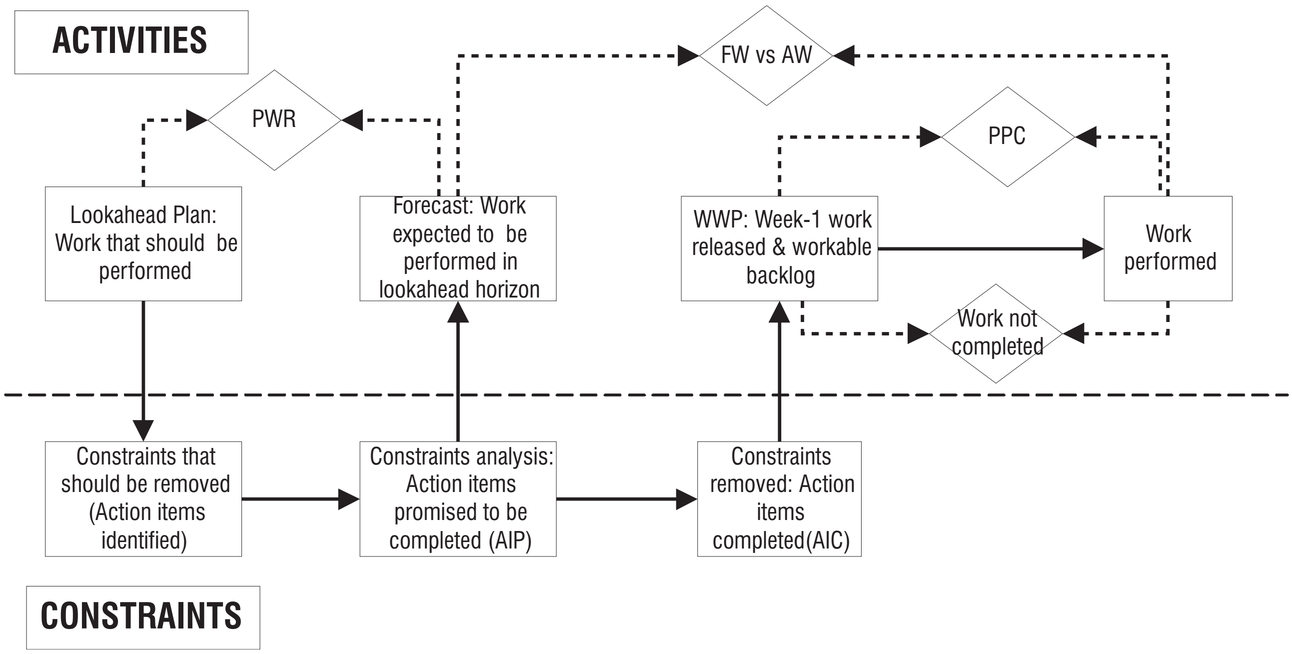
3 **Develop Action Items**. An important outcome of the constraint analysis is the development of action items (AIs) needed to remove the identified constraints and make assignments ready (such as answering RFIs, delivering the appropriate material, etc.).
Macomber and Howell (2003) based on the language action perspective, consider these AIs as 'requests' that the performers need to respond to, regarding whether they can complete their AIs as requested. If not, the team members responsible for the AIs need to assess when they will be able to remove the constraint. Many of these promises will be conditional, depending on how far in advance such promises are made.

4 **Develop WWP**. From the activities that are 'ready' (have all constraints removed), the project team selects those activities that are to be performed the following week (depending on priority and manpower availability), and this becomes the weekly work plan (WWP). Lower priority activities that are ready but not released form the 'workable backlog,' that is a work buffer to maintain labor efficiency if the planned work is not available as planned.

5 **Track PPC and analyze plan failures.** The effectiveness of the weekly planning process is measured with PPC—that is the percent of weekly activities completed 100% as planned. PPC failures may be because of plan failures (constraint not identified or not removed) or execution failures.
Figure 2 illustrates the make ready process. The lower part of the figure is the 'Constraints' level where work is made ready and determines the status and performance of the activities (at the upper part of the figure).

Ballard (1997) reported the following performance measurements used by a mechanical contractor for the improvement of lookahead planning: (1) Subjective evaluation by project superintendents/managers and consultants.

Figure 2: "Levels" of the make ready process



(2) Assignments Anticipated. Measures the extent to which weekly work plan assignments previously appeared on lookahead schedules. (3) Assignments Made Ready. Measures the extent to which assignments that appeared on lookahead schedules appeared on weekly work plans when scheduled. (4) Change of scheduled dates for specific assignments over time. This is tracked using time/time charts.

This paper builds on that work and proposes project metrics that evaluate the status of the upcoming work and the quality of the lookahead process. The next sections discuss metrics to assess and improve the "make ready" process.

PURPOSES OF 'MAKE READY' METRICS

An effective project control system should monitor and increase the ability to make work happen as planned. Consequently it should address the following issues:

PURPOSE 1: ASSESS HOW MUCH OF THE PLANNED WORK WILL BE READY TO PERFORM

This is a forecast of the work in the lookahead horizon that is expected to be ready to perform. This forecast is necessary in order to: (a) match resources to work available, (b) forecast the progress, and (c) understand the obstacles that may prevent planned work to be performed.

According to the Last Planner, the lookahead horizon should be longer than the lead time of constraint removal (securing material, resources, information, etc.) or such constraints should be identified as separate activities. The lookahead horizon also depends on the nature of the project. For projects of high complexity and uncertainty, the lookahead horizon may be shorter, as it would be very difficult (or impossible) to predict the work far into the future.

PURPOSE 2: ASSESS THE ACCURACY OF THE FORECAST

The assessment of the amount of work expected to be ready is only a forecast. The value of this forecast depends on its reliability. Therefore it is important to (a) understand how accurate is the forecast (which reflects how well the organization predicts the status of future work), and (b) increase the organization's ability to make more accurate forecasts.

This requires a comparison of the work expected to be performed with the work that actually was performed.

PURPOSE 3: ASSESS AND IMPROVE THE ORGANIZATION'S ABILITY TO MAKE WORK READY

The ability to make work ready depends on the organization's ability to identify and remove constraints. On complex, dynamic and uncertain projects, constraints are many (due to complexity) changing (due to the dynamic nature of the project) and uncertain (may not be manifested until the work starts). Under such conditions, the identification and removal of constraints is much more difficult, and at the same time this ability is critical. Metrics are needed to help the organization evaluate its ability to identify and remove constraints, and identify actions and investments to increase this capability.

MAKE READY METRICS

Figure 3 illustrates the proposed process metrics.

METRIC 1: PERCENT WORK READY

The first proposed metric answers the question: "How much work we expect to be ready in the lookahead horizon?" This requires a comparison between the work that is planned to be done (should) and the work that is expected with confidence that can be done. The proposed metric is "Planned Work Ready" (PWR). As illustrated in Figure 3, it indicates the portion of the planned activities that the project team is confident that can be performed in the lookahead horizon. The metric does not include only work that has all constraints removed at the time of the forecast, but also work that is expected to be ready with a high degree of confidence.

Assessment process. During the make ready process, the project team identifies the constraints of the activities in the lookahead and the action items (AIs) that should be accomplished in order to remove these constraints. If the AI performers are confident that they can complete their AIs as planned and remove the constraints, then the activity will be considered "Ready.' If there is no confidence that the constraint can be removed, the activity will be considered "Not Ready."

The project team should focus on the high priority activities—activities with limited float (such as critical activities) and activities that release work to following trades. To prevent accounting for activities out-of-sequence, all activities that depend on a 'Not Ready' activity, will also be considered 'Not Ready.'

Metric. The PWR can be expressed in two ways:

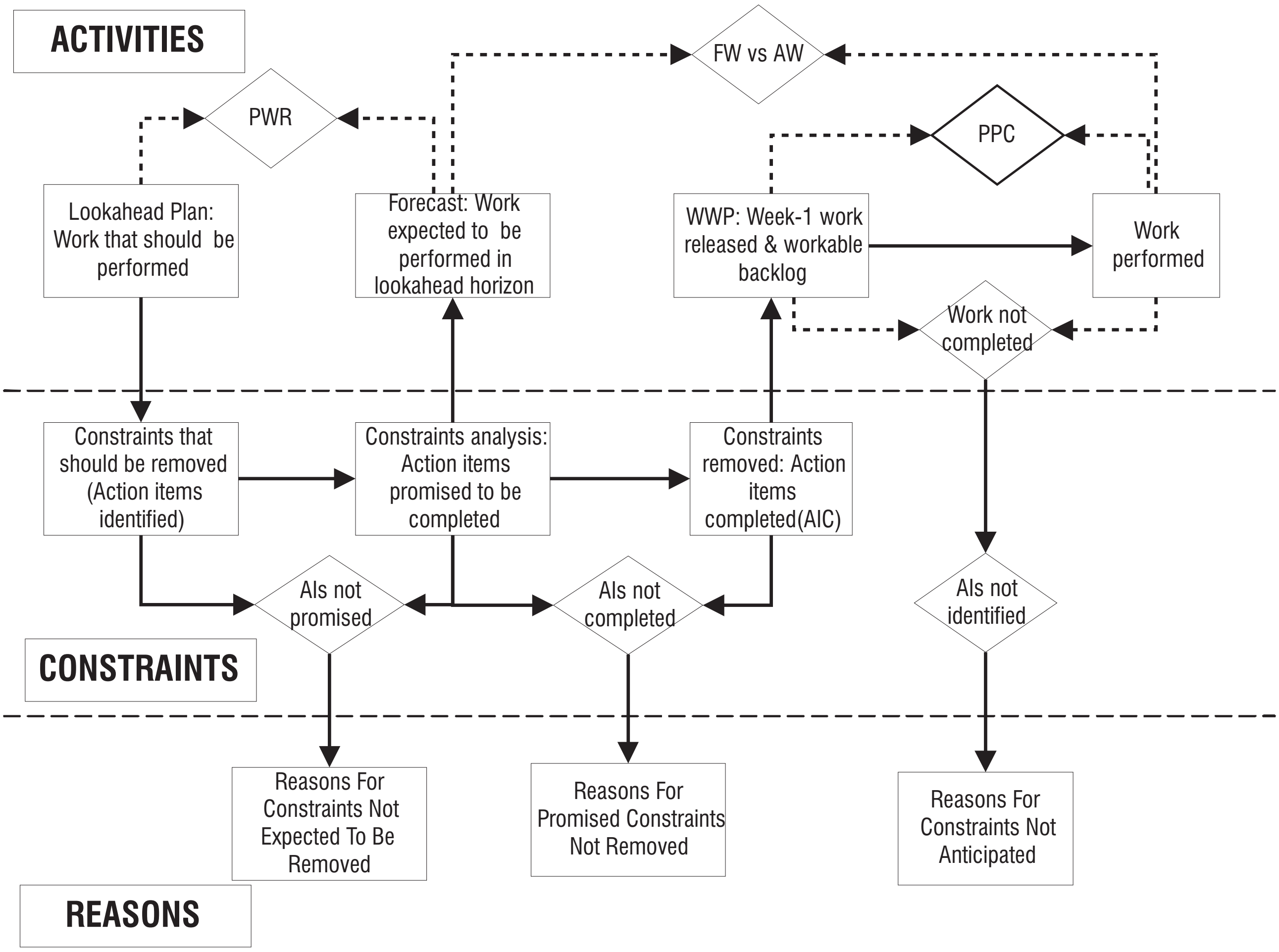


Figure 3: Elements and metrics of make ready process

a) **Percent of activities 'Ready' for each week in the lookahead**. Figure 4 illustrates the percent of activities ready for the 5 weeks in the lookahead horizon. In this example, week 1 lookahead includes 16 activities that are expected to be 'Ready' and 4 'Not Ready'. Week 2 includes 24 activities (18 'Ready' and 6 not expected to be ready).

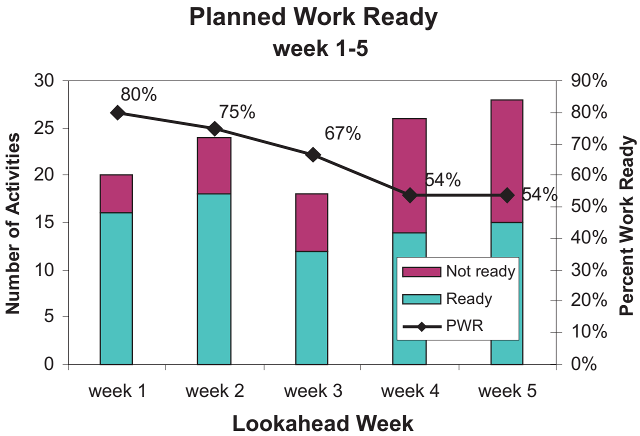


Figure 4: Planned Work Ready for lookahead period

b) **Earnable Value**. At an aggregate level, PWR can be expressed as the 'Earnable Value' Ballard (1997) in the lookahead horizon, as shown in Figure 5. This involves calculating the earnable manhours of the work in the lookahead horizon and comparing with the available labor capacity in order to decide if the project needs more or less manpower.

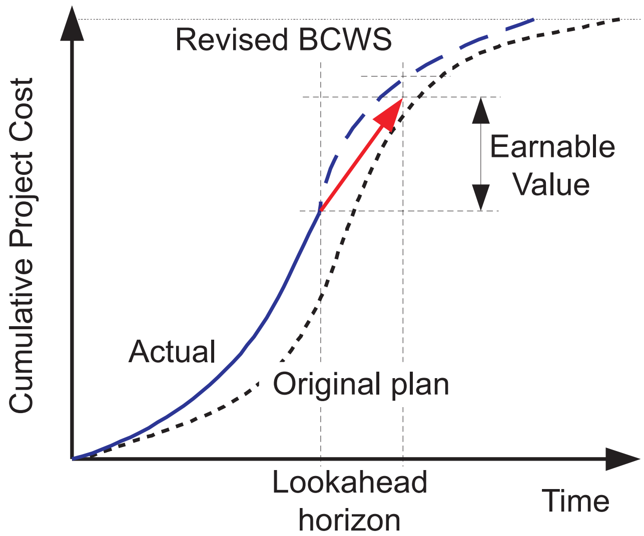


Figure 5: Earnable Value

Figure 5 illustrates the "Earnable Value" of PWR in the lookahead. Thus, the PWR metric can indicate the "momentum" of the project and in combination with percent complete it can provide a better indication of schedule performance.

METRIC 2: ASSESS FORECAST ACCURACY

The PWR metric is only a forecast. The value of the forecast depends on its accuracy. Predicting accurately what work will be ready and what not, is essential in order to match work with labor and understand if preventive actions are needed (as opposed to corrective actions that traditional controls emphasize).

Consequently, the organization needs to measure the accuracy of the forecast and analyze the difference in order to improve the quality of the make ready process. This requires comparisons of the work expected to be performed with the work that actually was performed. Such comparisons will indicate how well the organization forecasts the work within different lookahead horizons (e.g., 1 week into the future, 2 weeks into the future etc.). This comparison can be done using time-time charts (Ballard 1997). Figure 6 shows a time/time chart. It captures the forecasts developed each week and indicates what work was performed each week.

Each square i-j indicates that we 'are' in week 'i' and we are looking at week 'j'. Row 0 shows a 6-week forecast developed on week 0 for weeks 1 thru 6. F0-1 is the forecast developed on week 0 for week 1. F0-6 is the forecast developed on week 0 for week 6. The diagonal squares (i-i) show the actual work that is performed on week i (AWi).

Comparisons between forecasts and actual work for a specific week (squares in the same column) show the difference between expected work and actual work, and how accurately the organization predicts the upcoming work. For example, the difference between F0-6 and AW-6 reflect the delta between 'what work we expected to perform during week 6, according to the forecast developed on week 0' vs. what work was actually performed on week 6. This way, the forecast accuracy for different lookahead horizons can be tracked.

To improve the forecasting ability, the organization needs to examine the reasons for the differences between forecast and actual work. This requires understanding of why constraints were not removed, or if new constraints were discov-

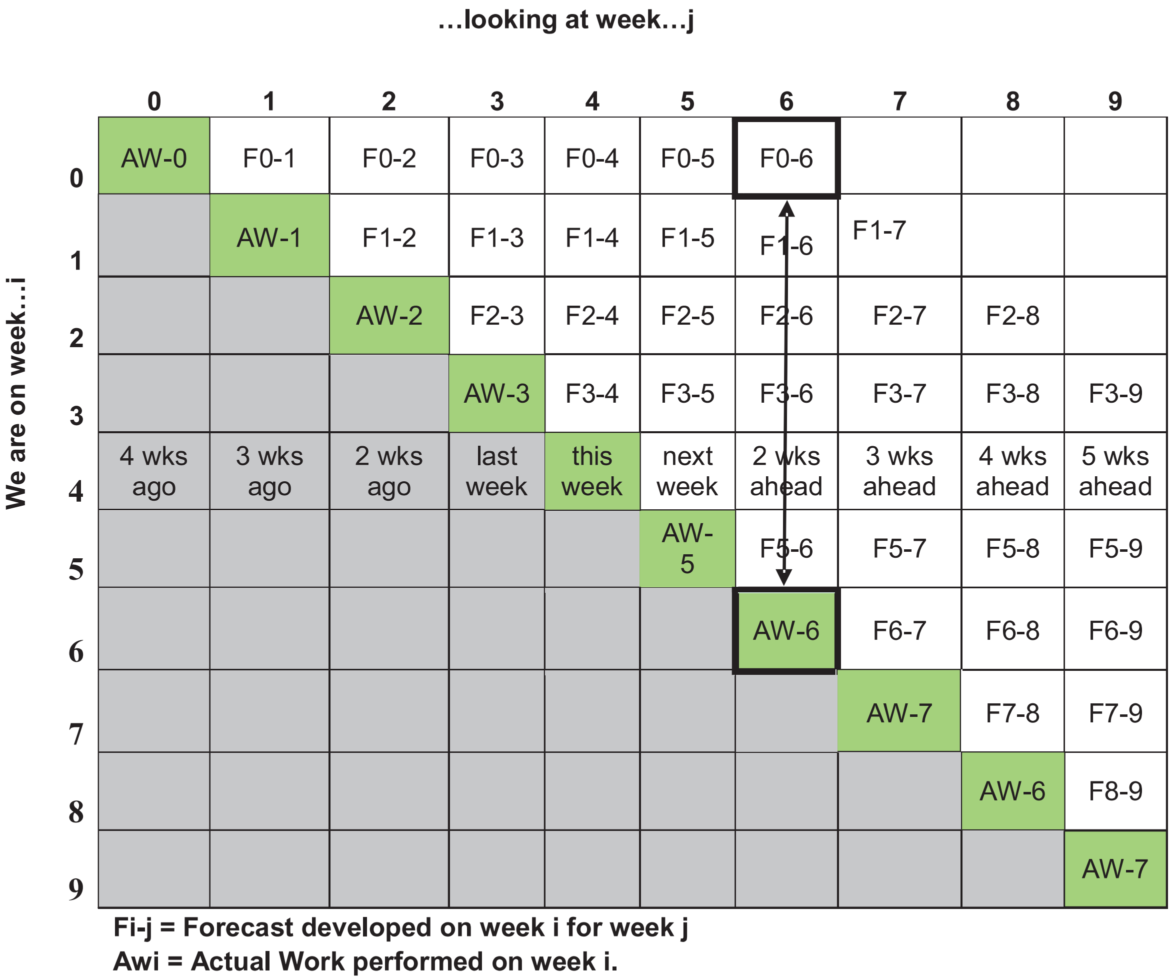


Figure 6: Time-Time chart showing work forecast and work performed.

Table 1: Proposed metrics

Purpose	Metric	Analysis
Assess how much planned work will be ready to perform in the lookahead period.	a- Planned Work Ready (PWR) % of assignments expected to be ready as planned b- Earnable Value (Ballard 97) $ Value of work expected to be performed	Reasons for planned work not expected to be ready.
Assess and improve the forecast	Actual Work vs. Forecasted Work for different lookahead horizons. • % of assignments in both Fi-j and AWj.	• - Reasons for differences between forecast and actual • - Reasons for differences between forecasts.
Evaluate and improve the organization's ability to identify & remove constraints.	1- AI Promised / AI Needed 2- AI Completed / AI Promised 3- Constraints not identified during make-ready process.	1- Reasons for constraints that cannot be removed as needed 2- Reasons for constraints not removed as promised 3- Reasons for constraints not anticipated

ered. This is addressed in the third metric related to the ability to remove constraints

METRIC 3: ABILITY TO REMOVE CONSTRAINTS

The organization's ability to remove constraints and 'make work ready is reflected on three 'deltas.' These deltas are shown in figure 3 in the 'Constraints' section of the figure:

(a) The delta between the constraints identified vs. the constraints expected to be removed (promised). These are the constraints for that prevent planned work to become ready. Ths delta can also be expressed in terms of Action Items identified and AIs expected (promised) to be completed. The proposed metric is AI promised / AI identified.

(b) The delta between the constraints expected (promised) to be removed vs. the constraints actually removed. The proposed metric is AI completed / AI promised.

(c) The delta between constraints identified and actual constraints found when the work was released. This is the case where the constraint analysis failed to identify all constraints during planning. In the Last Planner system, this is captured as "planning failures" (as opposed to execution failures). The proposed metric is number of New constraints (AIs) discovered during execution/ Constraints identified.

A low ratio in these indicators would indicate a discrepancy between the project team's capacity to identify and remove constraints and the project constraints.

Reasons analysis

Increasing the organization's ability to identify and remove constraints requires discovering and addressing the root causes (reasons) for these deltas. Analysis of the reasons of these deltas will indicate:

- Why some identified constraints cannot be removed as needed.
- Why some constraints were not removed as expected.
- Why some constraints were not anticipated.

An analysis of the reasons is needed to better understand why the identified constraints cannot be removed, why constraints were not removed and why constraints were not anticipated. As shown in Figure 6, the lower section 'Reasons' is the level where learning occurs. The root cause analysis will indicate the bottlenecks (e.g., timing of identification, personnel workload, contractual issues, etc.) and provide direction on how to increase its ability to 'make work ready.'

The analysis will identify the key sources of uncertainty that the organization faces (soil conditions, as-built conditions, manpower, design, technology, etc.) and will guide organizational investment decisions to address such sources of uncertainty, such as investment in gathering more information. Table 1 summarizes the proposed metrics.

POTENTIAL IMPLEMENTATION PROBLEMS

The previous section proposed metrics to measure and improve the make-ready process. This section considers potential problems in using the metrics. Two problem areas are identified: problems with the metrics and problems with their use.

1 Is the measurement task too tedious? The number of metrics proposed may require significant tracking effort. The key question is which metrics are most meaningful and important to

track. The ones with the potential to add more value are the ones that drive learning. Thus, the metrics addressing the ability to remove constraints appear to be the most valuable.

2 Is forecast development feasible? The development of the forecast is based on promises by those actors who remove constraints. If the planning process does not involve such promises, then the value of the forecast will be limited.

Furthermore, the use of forecasts may be problematic for the contractors. On one hand they may not want to promise too much progress (managing expectations), on the other hand they also do not want to promise too slow progress to the owner. This may result in manipulation of the forecast to manage expectations. The question is how will the forecast be used; as a tools to manage expectations and assign liability, or as a tool to manage production and improve the organizational capabilities? The potential problem in this case is not with the tool itself, but with the users.

CONCLUSION

This paper proposed project control metrics to measure and improve the make ready process. These metrics can force systematic lookahead, increase the project team's awareness of the project status, direction and obstacles to progress, and increase the capability to identify and remove constraints. At the same time, there are questions regarding the feasibility of implementing these metrics. The next step is to find project organizations willing to use these metrics in order to evaluate their feasibility and value.

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