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A BALANCED DASHBOARD FOR PRODUCTION PLANNING AND CONTROL

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Abstract: The paper proposes a concept for a dashboard to be used as part of Last Planner based production planning and control. The dashboard is constructed to be used, not primarily by management, but by the last planners. For this reason the dashboard has to be simple (it should focus on some few but important metrics), and it has to be balanced (it should give a holistic view of the status of the process and where it is heading). It is proposed that the dashboard should consist of three sections: planning, production flow and outcome. Each of these three sections should comprise one or a few metrics, put together so as to and provide a consolidated overview of both status and direction. We present a specific dashboard consisting of six metrics in all. This dashboard will be tested in a forthcoming case study.

Keywords: Dashboard, Scorecard, Metrics, Measurement, Last Planner.

1 INTRODUCTION

A dashboard is a visual management tool. The idea behind visual management is to facilitate control and continuous improvement by making the process status available to the participants in real time and in an intuitive and understandable way (Tezel et al. 2016). It is hard to imagine one single metric[5] capable of providing a holistic view of the entire process. This can be achieved only through a set of metrics, a dashboard. In this paper, we present a concept for a dashboard to be used as part of Last Planner[6] (LPS) based planning and production control (Ballard 2000). The dashboard is constructed to be used by the last planners to monitor and improve the process in the project, not by management to supervise the project or to benchmark between projects. For this reason, the dashboard has to be simple and intuitive, it should be continually updated and provide an at-a-glance overview[7].

Several lines of thinking have inspired the proposed dashboard concept: visual management; discussions within IGLC on LPS related metrics, production flow and waste;

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[5] By metric, we in this paper mean a standard measurement.

[6] The Last Planner is a registered trademark of the Lean Construction Institute.

[7] Although the topics are related, our means and ends are therefore very different from those of Sacks et al. (2016). For them the goal is to inform management, to compare alternative production management and control strategies and to compare projects with one another (pp. 46 and 48). In order to do this, they propose one single composite indicator.

the balanced scorecard approach developed by Kaplan and Norton (1996) and the use of metrics as an integral part of Virtual Design and Construction (VDC)[8].

2 How should the dashboard be structured?

As presented by Kaplan and Norton (1996), a balanced scorecard is a set of metrics / key performance indicators (KPIs) put together in such a way as to provide a holistic overview of the current state of affairs and an indication of the direction in which a company is heading. Our topic is to measure a process, not a company. The way Kaplan and Norton compose their scorecard is therefore of less relevance for us. What is relevant, on the other hand, is their focus on the scorecard being balanced, that is, that it covers the different relevant aspects in a holistic manner and that it addresses both the current state and the direction in which things are heading[9].

Construction is project-based production. In this type of production, planning is a major productivity strategy (Ballard 2000, Bølviken 2012). Therefore, monitoring the quality of the planning process should be part of our balanced dashboard.

Koskela (2000) sees production as a flow of transformations creating value in the form of a product. While the mainstream approaches to production have mainly focused on the transformation perspective, lean approaches are mainly focused on the flow and value perspective. Consequently, we seek a dashboard that reflects the production flow and the extent to which the intended outcome (the goal) is being reached. In the lean tradition, the goal is usually referred to as value and the ultimate goal is value for the customer. However, there must also be value for all others involved in the process (without value, they would not be interested in contributing to the process). The dashboard we seek is to be used by the last planners, that is, the people actually doing the production. The value we seek is therefore value for the producers.

The aim of the dashboard is to facilitate control and continuous improvement. Improvement processes in projects or companies will always be contextual. For this reason, the dashboard will also have to be contextual. This means that it should have a generic structure that can be given a specific contents relevant to the specific case. The principle of continuous improvement can be applied both internally in the planning and production process (e.g. through improved flow and reduced waste), and externally to the outcome (e.g. through increased value or reduced cost for the customer). Therefore, we have not included continuous improvement as a separate, independent section in the dashboard, but will instead integrate it into the other sections.

Summing up, we find that the dashboard should consist of the following sections:

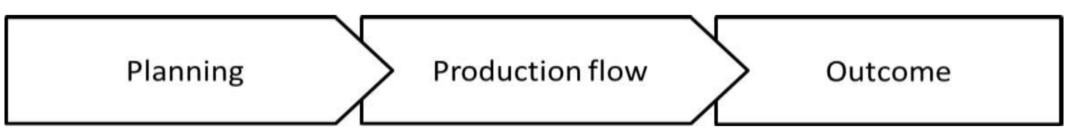

Figure 1: The three sections of the balanced dashboard

[8] VDC is a design method for effective leverage of information technology in support of product-organization-process (POP) modeling in construction (Fischer and Kunz 2004).

[9] While Kaplan and Norton use the term 'scorecard', we prefer to use 'dashboard'. The reason for this is that we perceive 'scorecard' as connoting benchmarking and measuring from the outside (management), whereas 'dashboard' denotes a set of instruments giving the driver needed information along the way (in our case giving the last planners important information needed when planning and doing the job).

3 WHICH METRICS COULD WE USE?

Within this conceptual framework, different metrics and quantities of metrics can be used. The simplest possible balanced dashboard could consist of only three metrics, one within each of these three perspectives, but this has to be considered against the need for more information than what can be given through such a limited number.

A phenomenon can be measured directly or indirectly (Bølviken & Kalsaas 2011). An indirect measure is called an indicator. When using an indicator, we measure a different phenomenon than the one about which we are seeking information. When measuring indirectly, we assume that there is a causal relationship between the phenomenon we want to measure and the indicator; we assume the indicator is covariant with the phenomenon we actually want to measure. An example of direct measurement is measuring work done by counting the number of products produced. An example of indirect measurement is using the rate of sickness-related absence as an indicator for workplace satisfaction. Indicators are normally used when direct measurements are impossible or hard to establish. A main disadvantage with indicators is that people tend to confuse the phenomena one wants to address and the indicator. The result can be that they do things that influence the indicator, even though it has negative or no effect on the fundamental phenomena one wants to address. When constructing our balanced dashboard, we will therefore seek direct measurements and avoid indicators as far as possible.

Continuous improvement can be achieved both by separating improvement activities and by integrating improvement into other activities. Improvement can be measured through improvement-related activities and as outcomes. If there are specific improvement activities in the project, the measuring of these can be included in the dashboard. On the outcome side, improvement can be measured by establishing timelines of metrics.

In the following, we will present and discuss some of the metrics we find most relevant. We will thereafter present the specific dashboard we will test out in the case company.[10]

3.1 Planning

Ballard and Tommelein (2016) include the following four metrics in their current benchmark for the Last Planner System (LPS): Percent Plan Complete (PPC), Tasks Made Ready (TMR), Tasks Anticipated (TA) and Frequency of Plan Failures (Ibid. pp. 13 and 20-21, Hamzeh et al. 2012). They argue that key factors to successful LPS implementations are having stable lookahead schedules, requesting and obtaining reliable commitments to remove constraints, and developing and implementing countermeasures to prevent repeated plan failures. They therefore recommend metrics addressing these topics to be developed, and present the following possible metrics: Percent Promises Made[11], Percent Promises Kept[12], the number of countermeasures implemented relative to the number of plan failures over some past time window and the extent to which trade crews will be able to work without interruptions (pp. 25-26).

PPC measures workflow reliability and by this the effectiveness of the planning system (Ballard & Tommelein 2016). PPC does not measure the production flow as such or the outcome of production. It is however correlated to both, and is therefore often used as an indicator of production flow and productivity. When using PPC, one has to decide whether

[10] Veidekke Entreprenør AS.

[11] The number of reliable commitments to remove unresolved constraints/total number of unresolved constraints.

[12] The number of constraints resolved in the week as promised/total number of constraints promised to be resolved in the week.

the PPC objective should be 100% or lower. A traditional view has been that one should go for a PPC of around 85– 90%. The argument for this has been that the goal is continuous improvement, and that if we go for 100% PPC, there is a risk that the weekly targets will be set too low. There are nevertheless some important arguments for setting the goal for PPC at 100%. The first is that this is a consequence of understanding planning as giving and keeping reliable promises (Ballard et al. 2009). When you give somebody a promise, you can have no other goal than to keep the promise, that is, a PPC of 100%. In recent years, we have seen an increased interest in combinations of takt planning and LPS. One important feature of takt planning is perfect handovers between trades. This is a PPC = 100% approach. The last argument is that a target lower than 100% makes PPC hard to communicate and interpret. For example, if we have a PPC of 85%, is this too low, too high or just fine? In line with Ballard and Tommelein (2016, pp. 29-30), we conclude that 100% should be the goal for PPC. This means that continuous improvement should be pursued in two steps, first to get PPC close to 100%, and then to consider decreasing the manning or increasing the amount of work to be included in the forthcoming weekly plans.

The use of PPC is often combined with cause analyses to identify the main constraints causing delays or interruptions. For dashboard purposes, we find it expedient to include only the constraint directly causing an interruption in the production progress (e.g. by using the seven preconditions for a sound activity (Koskela 1999)), whereas a root cause analysis typically will include several dimensions and factors. Some projects have used a moderated PPC indicating whether or not a delayed task prevents subsequent tasks. Moderated this way, PPC can also be seen as an indicator of production flow. For a further discussion of the more sophisticated Last Planner related metrics, we refer to Emdanat and Azambuja (2016) and Sacks et al. (2017).

Aslesen et al. (2013) propose a model to integrate safety analyses as part of LPS. The model indicates how safety risk should be identified and thereafter eliminated or mitigated at each plan level in LPS. The model is now under implementation in our case company. A metric indicating how well this process is going would be very relevant to include in the dashboard. As far as we know, such a metric has not yet been developed.

3.2 Production flow

From the perspective of transformation, the conceptualization is to transform resources (inputs) into products (outputs). This perspective entails a tendency to see increased input as a main strategy to increased output ("to get more out of more"). In contrast to this, the flow perspective is predominant in lean approaches. From the flow perspective, the main strategy for productivity is to improve the flow and reduce the waste ("to get more out of less"). In the production part of our balanced dashboard, we therefore seek metrics focusing on flow and the waste in the flow.

Bølviken and Koskela (2016) find that while waste in manufacturing tends to be present and visible over time, waste in construction tends to come as a parade of singular (unique), evanescent events. This makes waste in construction harder to see, understand and combat. How can we capture an evanescent phenomenon? We think the answer is to track it over time. We therefore seek metrics that track the overall level of waste in the workflow. Kalsaas (2013 and 2016) reports on measuring the amount of direct work, indirect work and lost time. The measuring is done through both shadowing[13] and self-assessment[14]. In the self-assessment case, the workers were also asked for the reasons for the time losses.

[13] Researchers following and observing workers.
[14] Workers estimating the daily amount of direct work, indirect work and lost time.

From a practical and economic perspective, shadowing can only be done in a limited number of research projects. It is therefore interesting that Kalsaas (2013) finds that the figures obtained through shadowing correspond quite well with the self-assessment of the workers. In addition, we see it as an advantage that self-assessment compels the workers to reflect over what they have been doing during the day. There are however two preconditions that have to be met, in order to make self-assessment viable approach. The first is that it presupposes trust, motivation and an improvement culture among the workers and between the workers and the management. The second is that even though the self-assessments are done on an individual level, the result should be aggregated to the team level and discussed collectively within the team.

How should we then include safety in the dashboard? To count the number of injuries might seem an obvious choice, but would not work simply because there at the project level are so few injuries that the figure would very often be zero and not say much about the safety situation in the project. To count near misses is another possibility, but could just as well reflect the level of reporting as the level of safety. A tidy work area is related to safety (Aslesen et al. 2013, Srinivasan et al. 2016), and obviously also to productivity and production flow. A relevant metric could therefore be the level of tidiness.

Good flow is a combination of high production volume (throughput) and uniform production volume per time unit (smoothness) (Bølviken & Kalsaas 2011, Schmenner 2012). Metrics related to both throughput and smoothness are therefore relevant. In manufacturing, the product flows through production, and the main focus is therefore on this particular flow, called 'process' by Shingo (1988), and 'product flow' by Bølviken et al. (2014). In construction, the production (work) flows through the product, and the main focus should therefore be on this specific flow, called 'operations' by Shingo (1988) and 'workflow' by Bølviken et al. (2014). In construction, the product flow can be understood as the overall progress of the construction process. The throughput dimension in the product flow can be reformulated as the length of the construction period or the project's ability to comply with the due dates, and can therefore be included not only as part of the production flow section of the dashboard, but also of the outcome section.

The amount of direct work, indirect work and lost time is a measure of the waste at an individual level inside each trade. It can, to a certain degree, also be considered a flow metric. Complementarily to this, we therefore propose to use a flow metric that is focused on the flow between the trades. The number of deviations in the handovers between trades is a metric that can be captured relatively easy. This metric is basically measuring the smoothness in the product flow, but will also reflect the making-do waste (Koskela 2004) and quality.

3.3 Outcome

The main outcome dimensions are traditionally seen as quality, cost and time. In the production flow perspective, we discussed the number of deviations in the handovers between trades. As mentioned, this can also be seen as a quality metric. What about cost and time? Both PPC (from the planning perspective) and the waste metrics (from the production flow perspective) are also related to cost and time. Nevertheless, they focus only on cost and time so far in the process and provide limited information on the likelihood that the project will meet its total time and cost budgets. We therefore propose to include forecasts on total duration and cost on the dashboard. The forecast on duration should relate to the milestones in the master or lookahead schedule as a baseline.[15] From the last planners' perspective, cost boils down to working hours. In most cases, the construction company will have worked out a cost estimate/budget for the work. Explicitly or implicitly, this is based on estimates of total working hours. A forecast of the total working hours could therefore be included on the dashboard, with an agreed estimate as the baseline.

4 WHICH METRICS WILL WE USE IN THE PILOT STUDY?

Our plan is to test the dashboard concept presented in this paper in a pilot study. Based on the arguments presented here, we plan to include the following six metrics in the test version (Figure 2): In the planning section, we intend to use PPC as the only metric. PPC is both a well-established and intuitive metric. Although it basically measures the planning process, it can also be seen as an indicator of production flow. In the production flow section, we plan to include three metrics. The first is a self-assessment of direct work, indirect work and lost time. The second is the number of deviations in the handovers between trades, and the third is the level of tidiness. The first is mainly a metric related to waste, the second to quality and the third to safety. All three can however also be seen as indicators of production flow. Because we have one metric related to quality in the production flow section, we have chosen to limit the outcome section to two forecasts, one on time and one on cost.

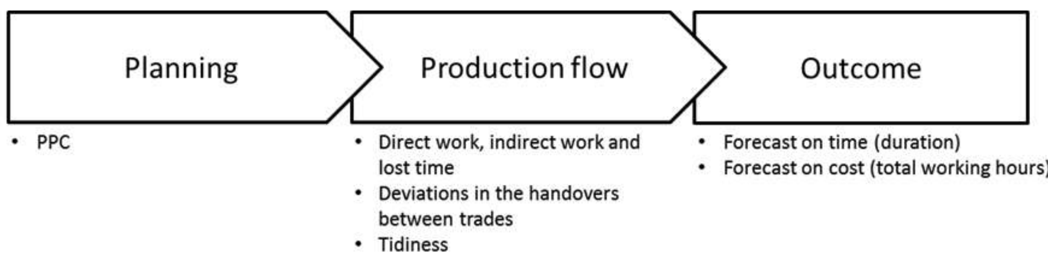

Figure 2: Test version of the balanced dashboard

5 CONCLUSION

In this paper, we have conceptually presented a dashboard, designed to be used by the last planners in their day-to-day planning and control. We have argued that the dashboard should be simple, intuitive and balanced, meaning that it should address the most important aspects of the process in a holistic way and provide an overview of both the status of the project and the direction in which it is heading.

The presented concept comprises the three sections Planning, Production flow and Outcome (for the producers). Within each of these sections, there should be a limited number of metrics, and the metrics should be combined so as to complement one another and provide an overview of both status and direction.

Our next step is to test a version of the dashboard with six metrics (Figure 2) in a case study. The aim of the case study will be to test the overall structure of the dashboard, how

[15] Here we make a firm distinction between a baseline and a goal. Budgets and cost estimates include the normal/established level of waste (Koskenvesa et al. (2010), Glenn Ballard (private communication)). Due to this, they should be seen as baselines or forecasts based on the current state of affairs, but not as goals.

useful the different metrics are, how well they complement one another, how the dashboard should be presented, how it should be used to support planning, control and improvement and to what degree it all in all turns out to be useful for the last planners. As part of the case study, we also hope to develop a metric indicating how well the safety analyses integrated into the LPS process are running.

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