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Developing a Project Status Dashboard for Construction Project Progress Reporting

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Abstract: Accurate and regular progress reporting of construction projects enables the project management team to know the status of their project and to make informed decisions. One way to monitor and control a project through progress reporting is to use a project status dashboard. A dashboard monitors key performance indicators relevant to the strategic business goals of a company and portrays the trend of the project's performance at-a-glance. It can reduce the amount of time taken to review reports and allows management to focus on issues that require attention. This paper presents a consensus-oriented approach for developing a project status dashboard for construction project progress reporting. A prototype project status dashboard tool developed for an industrial construction company is illustrated. Key performance indicators and appropriate thresholds are identified. The approach presented in this paper is of value to any organization wishing to establish a project status dashboard for its own progress reporting purposes.

Keywords: Construction industry, key performance indicators, progress reporting, dashboard

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1 INTRODUCTION

Reporting on the progress of a construction project is an essential component of construction project management; the project management team through regular and accurate progress reports is able to know "how the project is progressing ... budgets are respected, required quality is achieved, and safety measures are followed" (Saad 2000). This knowledge guides them in making informed decisions and taking corrective actions. Stakeholders are satisfied and retain their confidence in construction professionals when projects are completed on time and within budget. Progress reports on key performance indicators (KPIs) ensure that management can manage "by exception" - that is, deal with exceptional issues that require their attention.

Usually, the project management team reviews large volumes of reports to determine the status of their project(s). Reviewing these reports is time consuming, taking several hours or days. Chen (1994), quoting Pera and Williams (1990), emphasized that "readers complain about sifting through a stack of reports to find one or two pieces of useful information." Furthermore, by the time the project status is determined, it may be too late to implement corrective actions. Chewning and Harrell (1990) noted positive correlation between performance and the amount of information an individual is exposed to: the performance of an individual "rapidly declines" if the individual is provided with too much information. In addition, typical progress reports provide a snapshot of progress over a period of time (weekly, bi-weekly, or monthly), but in order to make informed decisions, management needs to know the trend of progress for the project up to the evaluation date. Moreover, it is important for management to focus on exceptional issues that require their attention on a given project. A project status dashboard, therefore, can be developed to save time taken to review reports, and to gain a better understanding of the trend of progress to improve the quality of decision-making and corrective actions taken. Gitlow (2005) defines a dashboard as "a tool used by management to clarify and assign accountability for the 'critical' key objectives, key indicators, and projects/tasks needed to steer an organization towards its mission statement."

This paper presents a consensus-oriented approach for developing a project status dashboard for construction project progress reporting. A prototype project status dashboard (PSD) tool developed for an industrial construction company based in Alberta, Canada is

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presented; the company wanted to improve its project progress reporting methods, extract valuable information through the trends of their projects, and improve overall performance on their projects. Rasmussen et al. (2009) noted that to develop a dashboard, various requirements need to be identified and established. To develop the prototype PSD tool, the following steps were taken, each of which is discussed in this paper: (1) the audience of the project status dashboard was identified; (2) the basic needs for the dashboard were established; (3) user requirements were established; (4) key performance indicators relevant to the strategic and business goals of the company were established; and (5) thresholds boundaries, to alert the project management team of exceptional issues that require their attention, were established.

2 BACKGROUND ON CONSTRUCTION PROGRESS REPORTING

Various contributions have been made by researchers to develop tools that enhance construction progress reporting.

Orczyk (1991) developed a generic management reporting system that communicates important project information to management as succinctly as possible. The reporting system uses mainly tables to communicate project progress to management rather than a visual approach to help management grasp the status of their projects at-a-glance. The PSD tool presented in this paper fills this gap, helping management to be well-informed of exceptional issues that requires their attention (Chen 1994).

Bognar and Schoenbauer (1999) presented an integrated reporting system and techniques implemented to manage a multi company, multitask billion dollar project. The system consists of a number of databases for scope definition, scheduling, estimating, and performance reporting. Standardized performance reports are generated by the system for various levels of project management. The PSD tool in this paper provides the added advantage of a visual advantage of a visual display of project performance as well as a trending of project performance to date.

Other researchers have developed systems and approaches for project progress reporting (Chen 1994; Christiansen 1997; Saad 2000; Villeneuve and Fayek 2003; Yates and Rahbar 1990). The various approaches developed in previous research aim to provide timely and accurate project progress information in the form of reports for the project management team to implement corrective actions. What previous research has failed to address is in providing the project management team with at-a-glance project status and performance trending in a visual format, which a project status dashboard can provide. Using a project status dashboard, the project management team can more effectively manage their project "by exception" and focus on only those issues that require their attention. Using threshold boundaries of variables that are indicators of project performance, the project management team can proactively address issues that affect project performance, as soon as their threshold boundaries are violated, to minimize or contain their negative impact and lead to better project outcomes.

2.1 Dashboards

According to Few (2006), dashboards have their roots in the 1980s, when they were referred to as Executive Information Systems. A dashboard is a visual interface used as a medium of communication for reporting at-a-glance project progress through KPIs that are relevant to the success of the project. Dashboards can improve the chances of keeping a project within schedule and under budget. According to Rasmussen et al. (2009), some typical benefits of dashboards are as follows:

1. Improved decision making and performance: the organization can easily identify and correct negative trends;
2. Employee efficiency gains (this includes increased productivity): it eliminates the need for multiple reports and a large numbers of static reports (time is saved); it is easy to learn and requires little training;
3. Employee motivation: detailed reports showing new trends can be generated by users, leaving more time to focus on analyzing data and less time to spend finding, compiling, and formatting data; the reports are more interesting than most "old-fashioned" tabular reports; employees understand organizational objectives, since strategies, tactics, and operational data are shared through the dashboard, and thereby make the right decisions;
4. Detection and discussion of project successes and failures: everyone is "on the same page" (Pauwels et al. 2009);
5. Dashboards help eliminate cost associated with manual intensive reporting process (Christiansen 1997); and
6. A construction project status dashboard could serve as a database system to store data for a given project and to serve as historical data for other similar projects.

2.2 Key Performance Indicators and Thresholds

Extensive research has been conducted on factors that need to be considered when establishing KPIs for a company. The relevance of each factor may differ from one company to another. In general, the KPIs should be in line with the company's strategic and business goals, and conform to the industry's benchmark and

Table 1. Thresholds boundaries for KPIs

Indicator	Units	Threshold boundaries		
		Red	Yellow	Green
Absenteeism	Percent	$> 4\%$	$\geq 1\% - \leq 4\%$	$< 1\%$
Account receivables (average days)	Days	> 40	$\geq 25 - \leq 40$	< 25
Apprentice ratio	Percent	$\leq 7\%$[1] $> 30\%$[2]	$> 7\% - \leq 10\%$[1] $> 15\% - \leq 30\%$[2]	$> 10\% - \leq 15\%$
Average crew size	Count	< 5	$\geq 5 - \leq 8$	$> 8 - \leq 11$
Cash flow (of contract)	Percent	$> 3\%$	$> 0 - \leq 3\%$	0
Change request (of contract value)	Percent	$> 20\%$	$> 15\% - \leq 20\%$	$\leq 15\%$
Defect rate	Percent	$> 3\%$	$> 0 - \leq 3\%$	0
Additional and revised design documents received	Percent	$> 7\%$	$> 0 - \leq 7\%$	0
Schedule Performance Index (SPI) (earned man-hours/planned man-hours)	Ratio	< 0.9	$\geq 0.9 - < 1$	≥ 1
Extra work order hours (of contract)	Percent	$> 15\%$	$> 10\% - \leq 15\%$	$\leq 10\%$
Productivity Factor (PF) (earned man-hours/actual man-hours)	Ratio	< 0.9	$\geq 0.9 - < 1$	≥ 1
Labour turnover	Percent	$> 30\%$	$> 20\% - \leq 30\%$	$\leq 20\%$
Modified work	Percent	$> 3\%$	$> 0 - \leq 3\%$	0
Non - compliance report	Count	> 6	$\geq 0 - \leq 6$	0
Open labour calls	Percent	$> 3\%$	$\geq 1 - \leq 3\%$	$< 1\%$
Change request/Request for information	Ratio	–	≤ 0.6	> 0.6
Average request for information response time	Days	> 6	$\geq 4 - \leq 6$	< 4
Safety-first aid	Count	> 3	$> 0 - \leq 3$	0
Medical aid	Count	> 0	–	0
Lost time incidents (per period)	Count	> 0	–	0
Weld repair	Percent	$> 5\%$	$\geq 3 - \leq 5\%$	$< 3\%$
Percent craft indirect	Percent	$> 40\%$	$\geq 25 - \leq 40\%$	$< 25\%$
Welder diameter inch per day	Count	< 7	$\geq 7 - \leq 10$	> 10
Cost/Direct hours	Percent	Varies by project		
Forecast margin	Percent	Varies by project		
Hard trades/Crane	Ratio	Varies by project		
Hydro testing	Count	Varies by project		
Overtime premium hours	Percent	Varies by project		
Percent scaffold	Percent	Varies by project		
Small tools and consumable rates	Count	Varies by project		
System turnover	Count	Varies by project		
Total/Recordable incident frequency	Ratio	Varies by project		
Margin on changes	Percent	Varies by project		
Progress (Percent complete)	Percent	Varies by project		

[1]Note: Lower value;
[2]Note: Upper value;
The lower and upper values indicate the threshold's boundary (on the lower side and upper side) that, when exceeded, the relevant alerts would be triggered for management's corrective actions.

standards (Rasmussen et al. 2009). Cox et al. (2003) defined KPIs as the compiled data measures used to measure the performance of construction operations. They categorized them as both quantitative, including cost, lost time accounting, and punch list, to mention a few, and qualitative, including safety, turnover, absenteeism, and motivation. Radujković et al. (2010) classified KPIs as: (1) leading performance measures (e.g., motivation, continuity to work, attitude to claims and debts, numbers of owners, and communication); (2) lagging performance measures (e.g., quality, cost, identification of client's interest, rework, and organization growth); and (3) perceptive performance measures (e.g., client satisfaction, employees' satisfaction, and satisfaction of project). Chan et al. (2004) was of the view that KPIs can be classified as (1) objective (e.g., construction time, speed of construction, time variation, net present value, unit cost, and environmental impact assessment scores), and (2) subjective (e.g., end-user's satisfaction, functionality, quality, and project team's satisfaction).

Building thresholds into the monitoring and control systems of a project can help indicate troublesome performance before a situation gets out of control. Some threshold values are commonly accepted in the construction industry whilst others are company

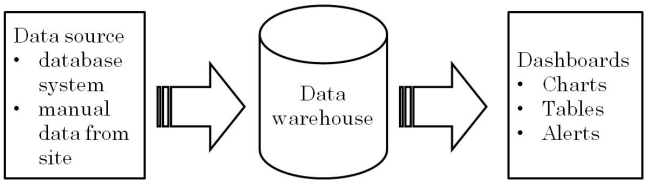

Figure 1. Components of a dashboard

specific. For example, the productivity factor (earned man-hours divided by actual man-hours) is generally accepted to be good performance if its value is greater than one. Thresholds for KPIs can be built in the construction project status dashboard to provide alerts for each key performance indicator when the set threshold is violated. With the KPI alerts, management is able to quickly identify problems and take corrective action(s) to prevent the project from getting off track (Alexander and Walkenbach 2010; Rasmussen et al. 2009). The alerts can be classified into red, yellow, and green, as discussed under development and classification of the thresholds.

3 RESEARCH METHODOLOGY

To develop the dashboard, first a literature and web review was conducted to identify KPIs and various formats of dashboard design that are used in the construction industry. It was observed that most status dashboards were developed as web portals. Other status dashboards were developed with Microsoft based applications like Excel® and Access®. Second, interviews were conducted with key management personnel of the industrial construction company based on their role in managing projects and in preparing progress reports to (1) identify the audience for the project status dashboard, (2) establish their basic needs for the dashboard, (3) identify the user requirements, and (4) identify the KPIs relevant to the strategic goals of the company. Third, two separate questionnaires were developed and administered to these key personnel to: (1) survey the impact of the selected KPIs on productivity, cost, schedule, safety, and quality (2) to obtain threshold boundaries for each KPI.

3.1 Identifying and Selecting KPIs

Through the literature review conducted, there were 48 KPIs that were identified. Thirty-two KPIs were selected as relevant to the strategic and business objectives of the company. These KPIs were selected using a consensus-based approach of personnel in the industrial construction company that are users of such KPIs. The 32 KPIs that were selected as most significant are listed in Table 1, together with sample threshold values for each category (discussed next).

To survey the impact of each key performance indicator on productivity, schedule, safety, cost, and quality, a first questionnaire was administered to five management personnel in the industrial construction company. These management personnel included a vice president, project and operations managers, and a superintendent, ranging from 10 years of experience to over 30 years of experience.

3.2 Development and Classification of the Thresholds

A second questionnaire was developed to determine thresholds boundaries for the various indicators (see Table 1). It was observed that threshold boundaries are company specific. A red, yellow, and green classification was adopted from the concept of traffic light color coding. The thresholds compare the planned value of a KPI to its actual value. Depending on whether the actual value violates the upper or lower planned value, or is within the specified thresholds, the color red, yellow, or green appears next to each of the KPI on the dashboard. The color red indicates bad performance, or that corrective actions are required; yellow indicates average performance, or a need to improve the performance indicator; and green indicates good performance, or to stay the course (Prieto 2011).

For example, with a non-compliance report as a performance indicator, a construction company may desire that, for a particular project, green should be zero (i.e., no recorded incident of non-compliance report); yellow should be greater than zero to six incidents; red should be greater than six reported incidents (see Table 1). At the end of the reporting week, once the data on the KPI have been updated in the dashboard, if the actual number of incident(s) reported on a non-compliance report is zero, a green status indicator (good performance) appears next to the performance indicator. If the number of actual incident(s) reported is three, a yellow status indicator (average performance or warning) appears, and if the number of reported incident(s) is seven, a red status indicator (bad performance) appears. Using the indicators, the project management team gets to know, at-a-glance, which performance indicators require their immediate attention and is therefore able to control the project by "exception".

4 COMPONENTS OF A DASHBOARD

A project status dashboard should have: (1) a data source, (2) a data storehouse (data warehouse), and

Week	Planned man-hours	Planned progress	Planned PF
1	1200	15%	0.80
2	1500	30%	0.90
3	3500	45%	1.00
4	1200	46%	0.80
5	1500	48%	0.95
6	3500	50%	1.00

Figure 2. PSD tool planned page

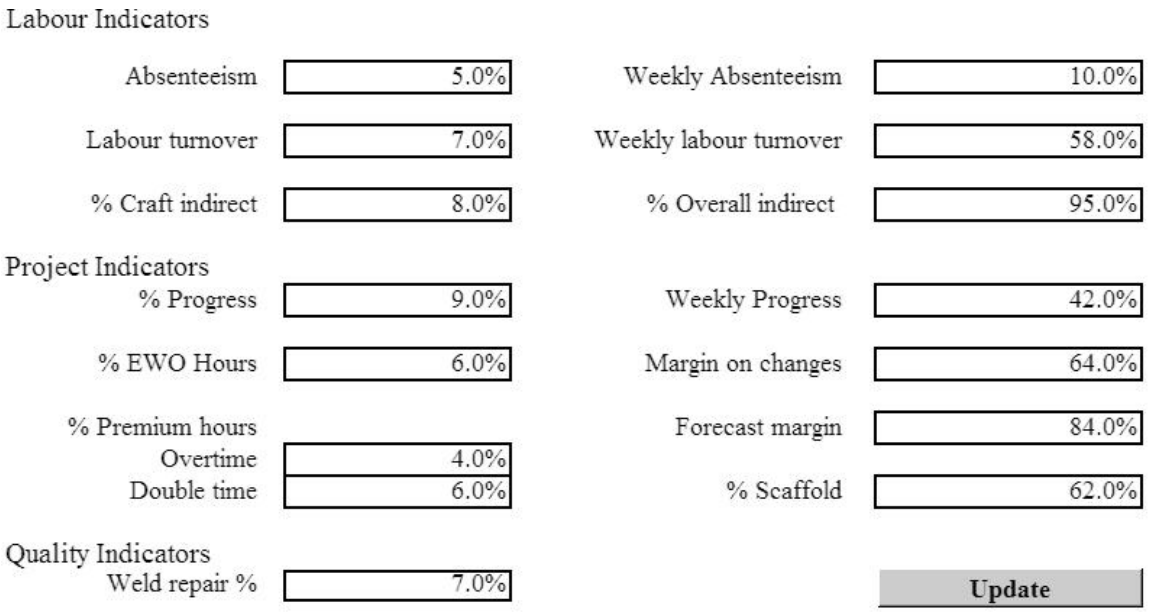

Figure 3. PSD tool project update page

(3) a dashboard, as displayed in Figure 1. The data source is usually available in the form of an automated database system, or it can be manually updated. The data storehouse houses the project data updated into the dashboard at the time of the reporting period. The dashboard is a collection of charts and tables that plot the various project data. It is therefore important, in establishing the requirements for a dashboard to identify: (1) the sources of data, (2) where and how the data will be stored, and (3) the right charts that best display the data (Rasmussen et al. 2009; Alexander 2010).

5 PROTOTYPE PROJECT STATUS DASHBOARD TOOL

The various worksheets (tabs) of the prototype PSD tool developed for the industrial construction company are described below. The Home Page: This is the default start page of the tool. It was designed to enable users to quickly navigate to the introduction page, project update page, data page, planned and thresholds page, and dashboard page.

The Introduction Page: The introduction page provides a brief overview of the PSD tool, plus data fields for users to provide basic project information: project ID/name; client; project location; project manager; project start date; project completion date; budget cost; and contract sum.

The Planned Page: The planned page provides a platform to capture, for a project, on a weekly basis, (1) planned earned hours, (2) planned hydro testing, (3) planned cost, (4) planned progress, and (5) planned productivity in the PSD tool. The planned values are plotted on the dashboards against the actual values to indicate whether the actual values fall above or below the planned values. The project management team is alerted to any "exceptions" accordingly (on the thresholds page). Figure 2 displays an updated planned page.

The Project Update Page: This page provides the platform to capture information on the status of each KPI for a project at the end of the reporting week. Once information has been added to this page, the PSD tool automatically updates the information for the project data presented on the dashboard. Figure 3 displays the project update page. A weekly project status report, summarized from the daily reports, should be prepared. The summarized weekly project status report is then keyed into the status dashboard through the project update page.

The Data Page: This page stores the updated data

Week ending	% Craft indirects	Labour turnover	Non compliance report	Open labour calls
8/1/2010	4%	6%	1.00	5.00
15/1/2010	12%	7%	2.00	7.00
22/1/2010	18%	8%	0.00	8.00
29/1/2010	15%	10%	0.00	9.00
5/2/2010	20%	9%	1.00	4.00
5/2/2010	45%	25%	0.00	4.00

Figure 4. PSD tool data page

entered into the Project Update Page; the data are then fed to the charts on the dashboard. The data page can be used to navigate to the actual values for KPIs that are expressed in (i.e., frequency, ratio, percentages, productivity, cost, and hours). Figure 4 displays the data page.

The Dashboard Page: The dashboard page displays charts for the KPIs being monitored. The dashboards are grouped into eight groups including: (1) project, schedule and productivity, (2) cost status, (3) cost metrics #1, (4) cost metrics #2, (5) changes and extra work, (6) documents, testing and turnover status, (7) environmental health and safety, quality, and (8) labour status. The dashboard page displays the trending of project data for: (1) cumulative data to date (since the start of the project), and (2) the past weeks in specified time periods: the past 6 weeks, 26 weeks, or 52 weeks. Figure 5 displays examples of past 6 weeks trending of data.

The Thresholds Page: The thresholds page provides the status of the KPI being monitored and an alert depending on where the actual value falls within the thresholds classification. The alert adopts the concept of traffic light color coding. The color red (⧫) indicates bad performance, or that corrective actions are required; yellow (▲) indicates average performance, or a need to improve the KPI; green (•) indicates good performance, or to stay the course (Prieto 2011). Figure 6 displays the thresholds page for sample KPIs. Percent craft indirect has a red status because the actual value (45%) falls within the red threshold boundaries (see Table 1); labour turnover has a yellow status because the actual value (25%) falls under the yellow (warning) threshold boundaries; non-compliance report has a green status because the actual value (0) falls under the green threshold boundaries; and open

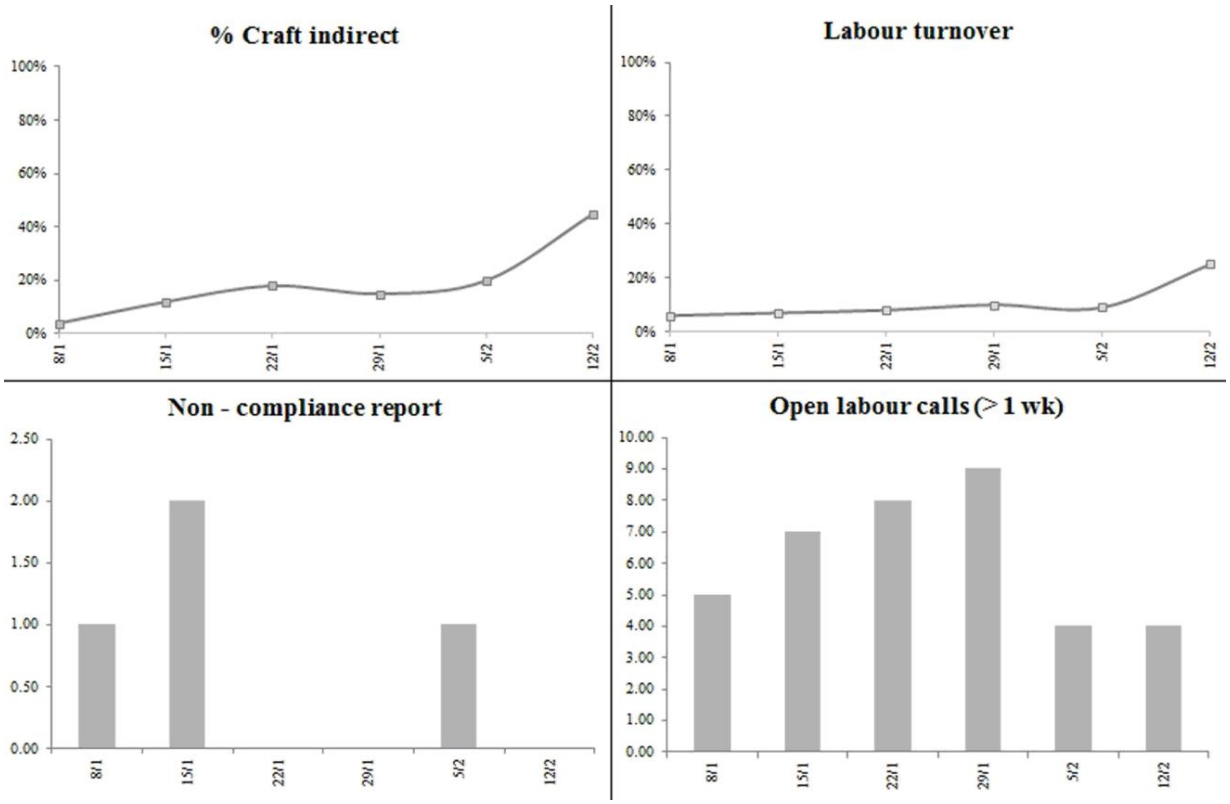

Figure 5. PSD tool dashboard page

Indicator	Planned	Actual	Status
% Craft indirects	25%	45%	◇
Labour turnover	20%	25%	△
Non compliance report	1	0.00	●
Open labour calls	1	4	◇

Figure 6. PSD tool thresholds page

calls for union craft has a red status because the actual value (4) falls under the red (action required) threshold boundaries. The values displayed in Figure 6 are for illustration purposes and would vary by company.

6 IMPLEMENTATION

A number of issues need to be addressed to successfully implement a project status dashboard. Rasmussen et al. (2009) categorized these issues into people-related items and technical-related items. The people-related items include identifying the primary users, executive sponsor, members of the implementation team, and individuals responsible for coming up with key performance indicators for the dashboard. The technical-related items include establishing the categories of dashboard users' needs, main components and metrics in each dashboard, whether there is a particular color and layout scheme desired, data sources to feed each dashboard, how often the dashboard would be updated, and what software and hardware are needed and when they need to be in place.

Also, training should be organized for personnel after developing and testing the status dashboard to ensure smooth implementation. In order to obtain their buy-in, users need to be informed about the time saving benefits and other benefits of the tool. Information needs to be provided to users on how the tool contributes to the company's goal of improving overall project performance and how it can help users to improve their own projects' performance. Easy to use features and functionalities, when addressed in the project status dashboard tool, could reduce personnel reluctance to use the developed tool.

Dashboards can be developed internally (by the company) or by a third party (vendor). Various factors need to be considered by the company to decide whether to develop the dashboard internally or use a third party. Companies should consider the cost associated with developing a project status dashboard tool using a third party and the maintenance requirements of the dashboard tool in making this decision (Rasmussen et al. 2009).

The company for which the PSD tool was developed is in the process of implementing it; it was therefore developed and tested using dummy data to ensure it meets the user requirements. Key areas that require further development were identified and recommended, as discussed next.

7 DISCUSSION AND FUTURE RESEARCH

It was observed during the development of the prototype PSD tool that companies do not have an established framework for deciding thresholds boundaries for key performance indicators. Threshold boundaries could differ from project to project and from company to company, due to the unique nature of construction projects and the construction industry as a whole; it is therefore essential that a framework be developed for determining the threshold boundaries in a structured and systematic way. Without an established framework, varying thresholds boundaries could be obtained from different project management personnel on a typical project. The framework, when developed, could assist the project management team to reach a consensus on the threshold boundaries to (1) maintain consistency in reporting and communicating project status, (2) avoid any conflict that may arise among the team members in the interpretation of project data, and (3) ensure that appropriate and timely corrective actions are implemented.

Further research needs to be conducted to establish standard threshold boundaries for KPIs in the construction industry. These could serve as benchmarks for construction companies to adopt. For example, in the construction industry, productivity has a standardized threshold value above or below 1 (depending on how the productivity factor is defined) to indicate good performance. However, this threshold value is dependent on the company's definition for productivity and the specific conditions of the project. Additionally, further research should be conducted to identify the correlation between the values for the various KPIs being monitored using the project status dashboard. This could assist the project management team in identifying the relationship that exists between the KPIs and how changes in the values of some KPIs could affect other performance indicators as well as the overall project performance. The results of this correlation could assist companies in setting better thresholds val-

ues for the KPIs.

The project status dashboard should be automated to extract data from the database system of the company. This saves time and reduces errors in keying in the values into the dashboard and computing the various inputs from the week's activities. It also provides a means of preparing summary level reports for the KPIs at the project or company level, for any length of reporting period. Linking the PSD tool to the company database also provides valuable historical data for future projects and for internal and external benchmarking of project performance. An automated database system should also be created to summarize daily site data to produce weekly data that would be used to populate the PSD tool. Some project data are collected daily and some are collected weekly. It is important that the daily data collected be summarized into weekly data or order to automatically populate the PSD tool.

Project status dashboards should be adopted as a standard approach for project progress monitoring and reporting in the construction industry. Status dashboards have been adopted and accepted in industries other than construction, such as manufacturing, and health. Due to the unique nature of the construction industry, it is important that further research be conducted to: (1) establish how status dashboards can be effectively adopted by construction companies, and (2) establish the numerous contributions status dashboards can offer to the improvement of the construction industry as a whole. Future research should compare the various benefits, in terms of cost and time savings as well as improvements in the KPIs, derived from implementing a PSD tool. User satisfaction surveys could be used to identify areas of improvement in subsequent dashboards developed.

8 CONCLUSIONS

This paper presents a consensus-oriented approach for developing a PSD tool for construction project progress reporting. A prototype PSD tool, based on thirty-two KPIs, was developed and illustrated for an industrial construction company. Using this tool, the project management team can determine the status of their projects at-a-glance based on the KPIs and their threshold values for more effective monitoring and control of their projects. The KPIs selected for monitoring should be aligned with a company's objectives and strategic goals. The threshold boundaries for each KPI are company- and project-specific and should be developed on a case-by-case basis to ensure that timely and effective corrective actions are implemented on a project. Monitoring and controlling projects through a PSD can save the project management team valuable time in reviewing extensive project status reports, and improve the quality of decisions made regarding the status of a project, leading to better project outcomes.

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