Dynamic Performance Monitoring and Management:  
A Metric-Based Framework to Better Predict Project Success

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Abstract

Fluctuating macro-economic conditions require design and construction teams to effectively and efficiently respond to project risks through improvements in management practice. The lack of meaningful performance metrics, infrequent assessment of project deficiencies and inaccurate prediction of Client satisfaction result in misaligned project management strategies.

To develop and test the Dynamic Performance Monitoring and Management (DPMM) framework, this proposal draws on literature in the areas of organizational effectiveness for key performance indicators; strategic management for continuous improvement and client satisfaction; and applied microeconomics for measuring management practices. Proposal authors will implement the framework on several case studies to validate DPMM as a mechanism for tactical alignment. A representative set of metrics will be continuously tracked and reported. The project execution team will interpret metrics results and shift attention to deficient performance areas. Improvements in management practice are directly correlated with large increases in productivity and decreases in project risk.

Motivating Business Problem

Based on my observation of practice during six years of project management for a large-scale commercial General Contractor in California, management is predominantly ad-hoc. Project execution is based on a reference framework that is intuitive and gathered from professional experience and judgment. Initial project planning involves mental models of risks and challenges for that particular contract and those particular stakeholders. Project managers use analytical skills to adjust as needed so that the project is achieving towards project outcome objectives. The ad-hoc process is not formally documented; only informally deduced.

In current practice, performance measures tracked in the dimensions of quality, cost and schedule are not effective predictors of project success. Consequently, the project team cannot consistently interpret performance to identify deficiencies in their management process. Specifically, we observe three weaknesses with current practice faced by the project execution team regarding performance monitoring. To empirically demonstrate these issues, the authors conducted one 4-month case study in Northern California on a hospital project (approximately $80 million contract value; 2 year scheduled
construction duration; 66,000 sf). We implemented three performance metrics to evaluate existing management practices.

1. **Management process deficiencies cannot be readily identified because certain performance measures are not tracked at all.**

Client Satisfaction was introduced to the case study. The Client reported weekly on a scale of 1 to 5 (most satisfied) how satisfied they were with one party of the design and construction team on each of the following:

- Overall quality performance
- Flexibility in aligning with Client priorities
- Responsiveness in terms of efficiency
- Responsiveness in terms of effectiveness

![Client Satisfaction Diagram](image)

**FIGURE 1: Results of Client Satisfaction Metric**

From Figure 1, the Client developed an issue towards the beginning of August for the next two months. All measures of Client Satisfaction went down to a 1 and 2 satisfaction rating.

Meanwhile, the design and construction team reported on another new metric: Latency of Critical Issues. Project team members were asked at the week’s end to list 5 of the most critical issues. For each issue, they were asked to report latency defined as the time from asking a question to receiving a useful response back. I interpret Figure 2 to signify that high latency started to emerge in August – around the same time that the Client was dissatisfied.
Client satisfaction and Latency of Critical Issues were independently reported and not publically revealed. Only the research assistant received the survey results. There appears to be positive correlation between Latency and Client Satisfaction after preliminary statistical analysis.

Results of this case study shows preliminary evidence that measuring and reporting latency of critical issues on a project could indicate to the management team where their process is deficient. Management focus can be justifiably diverted. Furthermore, certain metrics can bring insight to strong correlation between management deficiencies and client satisfaction whether it is causal or not.

2. **Project teams cannot tactically align to project deficiencies and Client priorities because performance monitoring is not frequent and public.**

Six months into the project, one party of the design and construction team was replaced. Had the latency and client satisfaction metrics results been revealed each week it was surveyed to the entire project execution team, perhaps the party could have identified an issue and mitigated it.

Current measures such as monthly cost reports and weekly 3-week look-ahead schedules do not indicate if management objectives are being met. These performance measures cannot be easily interpreted and translated into actionable measures because they are not frequent enough nor public enough.

3. **Performance measures that are tracked do not effectively predict client satisfaction.**

Managers currently track latency of Requests for Information (RFIs). The average latency of all RFIs was reported during the case study.
As described above, Client satisfaction was also measured. However, there does not appear to be direct correlation between latency of RFIs and Client satisfaction. High latency of RFIs in a week was not paralleled with low Client satisfaction. Beyond RFIs, cost reports and schedule updates that are reviewed weekly or monthly do not lend themselves to an immediate identification of management deficiencies. While this may be an appropriate metric, a different way to measure and interpret latency of RFIs is necessary to better direct management focus.

**Intuition**

The motivating problem necessitates a need for Client-based, tactical-driven project management using real-time measurement of meaningful metrics. Project teams must tactically align with project needs during project execution to sustain Client satisfaction. The alignment has to be efficient and effective and not only be based on the perception of satisfaction but controllable performance deficiencies. These deficiencies can be identified by the implementation of performance metrics involving tracking and reporting. Relevant metrics should be defined explicitly by the Client and implicitly through evidence that they affect Client perception. Finally, frequency of measurement is in real-time to initiate fast response to deficiencies.

**Points of Departure and Theoretical Limitations**

In practice, inherent characteristics of construction projects are the sources of the overall complexities faced by the management team: projects operate in complex environments (Kreiner, 1995); teams are detached from formal authority (Cohen and Bailey, 1997); team members work on relatively autonomous tasks but in project environments that are highly reciprocally interdependent (Hartmann, 2008, Gann & Salter, 2000; Thompson, 1967). Constituents of the management team include design, construction and owner parties composed of multiple firms. Fragmentation and multi-firm non-collocation also influence the effectiveness of traditional management practices.
Many managers still execute project delivery in an intuitive fashion as they attempt to manage and allocate resources across project areas (Freeman and Beale, 1992). Current management practices (such as Integrated Project Delivery) have generated very little empirical research supporting their effectiveness beyond anecdotal evidence. This is in part because no theory on measuring management performance has been articulated to guide the empirical researcher.

In literature, the intuition calls for research in the broad area of management theory. The fields to be explored for points of departure and limitations are first in organizational effectiveness on *key performance indicators in evaluating project success*. Secondly, in strategic management research, Total Quality Management emphasizes the need for *continuous improvement and customer-oriented goal seeking*. Finally, in the area of applied microeconomics research, the relationship is empirically founded between *performance monitoring* and good management practice.

**Key Performance Indicator in evaluating project success**

Literature has explored the definition of project success but no consensus has been achieved. Chan and Chan (2004) performed a systematic critique of existing literature to develop a consolidated framework for measuring construction success quantitatively and qualitatively using Key Performance Indicators (Figure 4). Based on their findings, project success can be defined as the set of principles or standards by which favorable outcomes can be completed within a set specification. Nevertheless, definitions on project success are dependent on project type, size and sophistication, project participants and experience of owners.

![Figure 4: Consolidated Model for Project Success (Chan & Chan, 2004)](image-url)
Of the consolidated KPI model, time, cost and quality are the fundamental criteria of measuring success (Belassi and Tukel, 1996; Hutush and Skitmore, 1997; Walker, 1995, 96). These three criteria have been named the “iron triangle” by Atkinson (1999). However, controllable process factors that facilitates achieving low cost, on-time and high-quality is not well understood and will be the contribution of this proposed research.

User satisfaction is another KPI claimed by Liu and Walker (1998) to be an attribute of success. Torbica and Stroh (2001) believe that if end-users are satisfied measured post-occupancy, the project can be considered being successfully completed in the long term. The extension of this claim for this proposal is that during project execution, user or client-satisfaction is similarly important.

Variations in the definition of project success necessitate variations in KPIs. The process of developing KPIs should involve the following considerations: focus on critical aspects of outcomes; have a manageable number for regular use; having too many and too complex of KPIs can be time and resource-consuming; the systematic use of KPIs is essential to maximizing the value of KPIs; data collection must be made as simple as possible; large sample size is required to reduce the impact of project specific variables; measures must be accepted, understood and owned across the organization; KPIs need to evolve and be subject to change and refinement, graphic displays need to be simple in design, easy to update and accessible (Collin, 2002). The proposed research framework will formalize these considerations into a framework and can make advancement in organizational effectiveness research.

Total Quality Management (TQM): continuous improvement and customer-oriented goal-seeking

Deming, Juran and Ishikawa were the original researchers that theoretically founded TQM ideology. TQM provides a unique approach to improving organizational effectiveness, one that has a solid conceptual foundation while applicable to practice by offering strategies for improving performance that takes account of how people and organizations actually operate (Wruck and Jensen, 1994).

Two core concepts of TQM will be extracted to lay the foundation for this research: customer-oriented goal-seeking and continuous improvement. While variations about TQM have been explored, the common view is that organizations’ primary purpose is to stay in business to satisfy its customers. To achieve quality conformance, it is essential to know what customers want and to provide products or services that meet their requirements (Ishikawa, 1985). Information about customer requirements is critical for quality improvement for organizations to be able to focus specifically on those aspects of work processes that are most consequential for customer satisfaction. The limitation of TQM is that it does not explore the specific characteristics of what customer want. Hence, this proposal will benchmark the antecedents of customer or Client satisfaction, or the perceived factors that influence satisfaction in the construction domain. Subsequently, the actual correlation of the measuring the antecedents (independent variable) will be revealed by setting Client satisfaction as the dependent variable.

One main principle in the implementation of TQM is the focus on work processes. Management must guide the organization to measure, analyze, and improve work processes (Juran, 1974; Ishikawa, 1985,
Deming, 1986). This is the concept of continuous improvement. Successful organizations commit to constant examination of technical and administrative processes in search of better methods. Opportunities to develop better methods for carrying out work always exist, and a commitment for continuous improvement ensures that people will never stop learning about the work they do (Juran, 1969; Ishikawa, 1985; Deming, 1986). The principle of continuous improvement will be used in the proposal research as the guiding motivation.

**Performance monitoring**

Good management has been difficult to define even though management literature has long stressed the importance of it. The barrier has been the absence of high quality data that are measured in a consistent way across firms. Especially on construction projects, industry heterogeneity such as differences in costs and benefits of implementing better practice prevent firms from adoption. Bloom and Van Reenen (2007) developed an innovative tool to systematically measure management practices across manufacturing firms. The methodology combined the econometric advantages of large sample surveys with the measurement advantages of more detailed case study interviews. Research findings included that better management practices are significantly correlated with higher productivity, profitability and sales growth rates (Bloom & Van Reenen, 2006). They explicitly developed indicators of managerial best practices. The research also explored why firms do not all adopt certain management practices they know are beneficial for them and why there is variation across firms and nations within industries in the practices. Reasons detected were industry heterogeneity, costly investment, contractual restrictions, managerial entrenchment and learning effects. These could explain similar obstacles to the adoption of certain management practices in the AEC industry.

Scoring management practices can be subjective as it is often contingent on a firm’s environment. While some management practices are too contingent to be evaluated as “good” or “bad”, others can potentially be defined in these terms. Performance monitoring is one of the practices that was defined as either “good” or “bad” and will be applied in the current proposal. Bloom and Van Reenen’s evaluation tool defined “good” practice if: performance is continuously tracked and communicated, both formally and informally, to all staff using a range of visual management tools; performance is continually reviewed based on indicators tracked; all aspects are followed up to ensure continuous improvement; results are communicated to all staff; regular review/performance conversations focus on problem solving and addressing root causes; purpose, agenda and follow-up steps are clear to all; meetings are an opportunity for constructive feedback and coaching. The methodology of quantifying management is general enough to be applied to other sectors. We are extending the indicators of “good” performance monitoring from manufacturing to AEC into our proposed framework.

Bloom and Van Reenen’s research design surveys managerial practices from the employer perspective rather than the worker perspective. Our study alters the survey methodology to include all of the members of the design, construction and owner team that affect the outcome of project execution.
Methods

Given the review of literature, there is a theoretical essence of project execution that calls for a new framework which measures, explains and predicts management performance efficiently and consistently. The framework is called **Dynamic Performance Monitoring and Management (DPMM)**. Figure 5 below is a conceptual model of how the components of the framework address the three industry challenges presented previously.

**FIGURE 5: Dynamic Performance Monitoring and Management Framework**

**Problem 1:** Management deficiencies cannot be readily identified because certain performance measures are not tracked at all.

**DPMM Contribution:** Performance Metrics and Client satisfaction metrics together comprehensively evaluate project execution across the dimensions of quality, cost, schedule, organization and sustainability.

**Problem 2:** Project teams cannot tactically align to project deficiencies and Client priorities because performance monitoring is not frequent and public.
**DPMM Contribution:** Cyclic process of measuring performance and Client satisfaction, reporting results publically, assessing formally and informally and finally identifying and tactically aligning with performance deficiencies and Client priorities.

**Problem 3:** Performance measures that are tracked do not effectively predict client satisfaction.

**DPMM Contribution:** Statistical correlation between Performance Metrics tracked and measured Client satisfaction. Assessment of the impact if dashboard metrics to actual client satisfaction.

**Research Tasks**

**PERFORMANCE METRICS**

A representative set of performance metrics make up the Performance Metrics Dashboard (See Figure 6). These metrics will first be established by a set of cross-sectional industry interviews. Designers, contractors and Clients will be asked about their perception of metrics that are antecedents (have influence) of Client’s perceived satisfaction. These metrics will serve as the independent variable in the experimental intervention. Meanwhile, the Client will be surveyed across multiple dimensions of subjective satisfaction (Figure 6) regarding the project execution process.

**IMPLEMENTATION**

Implementation will follow KPI research standards noted by Collin, 2002 and described previously. Using Bloom and Van Reenen’s performance monitoring model of tracking, reporting and reviewing, weekly online surveys on each performance and Client metric will be distributed to the project team (all members of the design, construction and Owner parties). Results will be reported in a graphical format.
and made public immediately after reporting. Then, informal comments will be initiated on the research project website.

The framework will be implemented on three prospective case studies and one retrospective case study for baseline comparison (no DPMM).

1. Sutter Health’s Palo Alto Medical Facility, San Carlos
2. Walt Disney Imagineering’s Little Mermaid Ride (for comparative case), Cars Land Ride
3. Stanford University’s Lucille Packard’s Children’s Hospital

PRELIMINARY WORK

The Sutter Health case study began in February, 2011. Some initial work is presented below.

SurveyMonkey was used as the metrics web-based survey tool. Seven metrics have been sent out weekly to members of the IPD team (~40 members). Since the project is in preconstruction, not all of the metrics are yet implemented. A sample survey question is shown in Figure 7.

![Sample Metric Survey](image)

**FIGURE 7: Sample Metric Survey**

Reporting of the results has been in graphical format as shown in Figures 9 & 10. Results are emailed in PDF format and posted on a research website managed by the Research Assistant. The website also includes a discussion forum for comments to be posted. Any member of the project team can view and
comment (See Figure 10). Executives at each firm who are perhaps detached from project are also invited to view the results to assist in the examination of any high-level issues.

**Target Value Design Conformance**

*How do you feel the IPD Team within the Cluster participated in driving value into the Project this past week?*

![Graph showing ratings for different aspects of project](image)

- **Core**: 2
- **Sitework**: 5
- **MEP**: 4
- **Permits**: 4
- **Equipment**: 3

**Ratings:**
- 5 - Exceptional
- 4 - Excellent
- 3 - Good
- 2 - Fair
- 1 - Poor

**Examples of significant progress made on TVD:**
- "development and pricing of AJs"
- "organized Core Gas A-3 for CG approval (2.5 yr payback and will save PAMF $30,000/year); finalized availability of Big Room space"
- "identifying immediate tasks and schedule for completing tasks; assigning responsible persons"
- "determined Pro-X header is not a cost savings but king studs at window jambs is, and requested KHSS to provide more accurate cost difference"
- "it is too early in the project start-up to judge"

Click here to view detailed responses:
[link](http://www.surveymonkey.com/s/MXG7PYCdc3bfDLgYEAAtSGB6u_2fxUMhe2vM0WggNERw14_3d)

**FIGURE 8: Metric Results for Target Value Design Conformance**

**Client Satisfaction Metrics**

![Graph showing satisfaction metrics](image)

- **Average Ratings from Sutter and PAMF**

Click here to view detailed responses:
[link](http://www.surveymonkey.com/s/9zPV1OUi5BqCETvU6k_2fpqiuXGTGhv1TRfLA4P1_2fo3d)

**FIGURE 10: Metric Results for Client Satisfaction**
The purpose of this research is not to directly identify a causal relationship between the use of DPMM and Client satisfaction. The use of DPMM is expected to influence behavioral change. Variations in that change can be rationalized by differences in the interpretation of metrics data. Regardless, simultaneous measurement of Client satisfaction will show degree of influence by the metrics data. Regression analysis will be used to find correlation between individual performance metrics and Client satisfaction. The hypothesis is that while certain metrics were gathered from interviews to be antecedents of Client satisfaction, they may in fact not be. Stronger correlation will probably be found with metrics such as Latency of Critical Issues, weaker with Constraints resolution based on preliminary analysis in the motivating problem case study.

Validation

Internal validation for robustness of DPMM will be evaluated on how much it effects behavioral change (based on continuous improvement research) and how well it can predict Client satisfaction over time. Longitudinal case studies on three projects over six months each will provide sufficient evidence of variations in performance and Client metrics results. Comparison to the Little Mermaid case study as a control case with no intervention will show relative impact of DPMM.

External validation on the representativeness of the Performance Metrics Dashboard will be ascertained by resurveying different industry members by a different interviewer. In addition, repeatability of results on varying case studies with varying Clients and project execution teams will also show external validation.
**Relationship to CIFE Goals**

The purpose of this proposal seeks to propel practice ahead of formalized theory in the field of management research applied in the construction industry. Yet, the formalization of the theoretical context of Key Performance Indicators, continuous improvement and performance monitoring is essential to articulate the DPMM framework for implementation in practice. Given uncertainties in use of innovative technologies (BIM), economic limitations and facility demands, project execution must tactically focus attention on the way they are managing the job. DPMM enhances existing practice through efficient and effective measurement and review for tactical alignment throughout project execution with Client needs.

Consequently, DPMM can dramatically improve project outcome performance with respect to both project and industry objectives. Quality, cost, schedule and sustainability are dimensions within the Dashboard to be improved during project execution. Improvements in process measures will lead to improvements in outcome measures. Incremental improvements across projects, firms and nations on each of those dimensions will directly attribute to the achievement of CIFE breakthrough business objectives by 2015. The scalability of DPMM will naturally facilitate globalization for maximum impact.

**Industry Involvement**

CIFE members currently involved with the case studies are Skanska and Disney. For the Sutter Health case study, the entire IPD team is involved with responding to the metrics surveys and interpreting results. The intent of the research is to have 100% participation with the project execution team during preconstruction and construction. For the Stanford Hospital, we hope to involve CIFE member DPR. Any other industry firms interested in the research is also welcome to be involved.

The funding requested includes participation in two conferences abroad to discuss the DPMM framework and case study findings to a global industry network.

**Research Schedule**

<table>
<thead>
<tr>
<th>Research Tasks</th>
<th>Month</th>
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<tbody>
<tr>
<td>Sutter Case Study</td>
<td>Winter, 2010 - Spring, 2012</td>
</tr>
<tr>
<td>DPMM website and survey automation development</td>
<td>Spring, 2011 – Fall, 2011</td>
</tr>
<tr>
<td>Disney Cars Land Case Study</td>
<td>Spring, 2011 - Spring, 2012</td>
</tr>
<tr>
<td>Stanford Hospital Case Study</td>
<td>Spring, 2011 - Spring, 2012</td>
</tr>
<tr>
<td>Analysis of Little Mermaid Retrospective Case Study</td>
<td>Summer, 2011</td>
</tr>
<tr>
<td>Initial Analysis of Results - Sutter, Cars Land</td>
<td>Winter, 2011</td>
</tr>
<tr>
<td>Initial Analysis of Results – Stanford, CS 5</td>
<td>Winter, 2011</td>
</tr>
<tr>
<td>Final Analysis</td>
<td>Spring, 2012</td>
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<tr>
<td>Publish Findings</td>
<td>Summer, 2012</td>
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Major risks include the development for the website, automated surveys and reporting. These tasks will be the most time-consuming; thus, the research team is requesting funding for a computer science graduate student to assist. Another risk is starting the proposed case studies. Project teams have to
cooperate and participate. Any resistance will slow down the implementation and compromise the effectiveness of DPMM. Finally, the analysis of the results requires understanding of regression analysis and other statistical methods. Hence, we are requesting funding for a statistics student as well for all of the analysis research tasks.

**Next Steps**

Beyond the CIFE Seed project duration, the research team will obtain continuation funding from industry member companies affiliated during the proposal period or new companies to further validate DPMM impacts to theory and practice.

**References**


T. Hartmann, A Grassroots model of decision support system implementations by construction project teams, Ph.D. Dissertation Department of Civil and Environmental Engineering, Stanford University, Stanford, 2008.


