

Developing a Framework of Metrics to Assess Collaboration in Integrated Project Delivery

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Integrated Project Delivery is an emerging delivery system in which participants' success is dependent on collaboration among key parties. Developing and maintaining such a collaborative environment is not easy and requires continuous team assessment and improvement. Although much research highlighted that collaboration is a critical requirement in IPD, only few research has focused on collaboration assessment and improvement. A proactive and real-time collaboration assessment helps to make sure a project is healthy from the standpoint of collaboration and also reflect bottlenecks and required actions to improve collaboration. To fill this gap in research, this paper comprehensively reviews the literature in construction and non-construction research to collect indicators, and develop a framework of metrics for assessing collaboration within IPD. This study investigates traits of collaboration within IPD and links them with respective metrics to shape the framework. Development of this framework is the first step for more comprehensive research on aspects of proactive collaboration assessment within IPD. It can also be used in professional practice to interpret collaboration level and effectiveness in IPD projects.

Key Words: IPD, collaboration assessment, metrics, team approach

Introduction

Organizations usually make transition to teamwork due to the lack of potentials to perform multifunctional tasks efficiently by few individuals (Weiss and Molinaro, 2010). Most works have a multidisciplinary nature, which necessitates coordination and collaboration on various expertise. Therefore, teams of different people with diverse backgrounds and characteristics must be built to promote performance (Lencioni, 2002).

Currently, one of the most significant discussions in construction industry and research is the transition towards new collaborative project delivery systems. According to the literature, collaboration usually improves project performance and efficiency within construction industry (Baiden and Price, 2011; El Asmar, Hanna, and Loh, 2013). Based on this fact, American Institute of Architects (AIA) defined Integrated Project Delivery (IPD) as a project delivery method in which individual's success is dependent on collaboration and teamwork among all project participants (AIA California Council, 2007). Ertel, Weiss, and Visoni (2001) confirmed the importance of collaboration in multi-party agreements by stating that poor collaboration is the most important reason of failure in project alliances (as cited in Gerschman and Schauder, 2006). However, such collaborative environment is not easy to adopt and maintain. Cleves and Dal Gallo (2012) stated that an IPD contract itself does not assure successful delivery of the project. Participants' ability to collaborate, and engaging key personnel of different parties are necessary to implement IPD as it is intended (Thomsen, 2009). Standard types of IPD agreements such as ConsensusDOCS 300 explicitly bind project participants to collaborate; however, they do not provide measures to assess such a requirement (ConsensusDOCS, 2007). A collaborative team needs performance assessment and continuous improvement to remain effective (Stamatis, 2011).

So far, much research highlighted that collaboration among participants is a critical requirement in IPD projects (e.g. Ashcraft, 2011; Brennan, 2011; Cleves and Dal Gallo, 2012; Franz and Leicht, 2012; O'Connor, 2009). However, previous studies of IPD have not adequately dealt with collaboration performance assessment and there is a need to investigate how collaboration performance can be measured within IPD. Few researchers have worked on collaboration performance in IPD projects. For example, El Asmar et al. (2013) investigated communication performance in IPD projects by using metrics to assess numbers and processing time of Requests for Information (RFIs), resubmittals, and rework. Franz and Leicht (2012) also used information on RFIs to assess team efforts.

Nevertheless, they only tend to examine collaboration outcomes rather than proactive performance assessment to improve collaboration. Although measuring outcomes of collaboration is necessary to compare project results to targets, assessing collaboration itself during processes is also important. A proactive collaboration assessment helps to make sure a project is healthy from the standpoint of collaboration. It can also reflect what actions are required to make improvements. To fill this gap in research, the main purpose of this study is to develop a framework of metrics for measuring collaboration performance in IPD projects.

Literature Review

Traits of Collaboration & IPD

Brewer and Mendelson (2003) indicated that there are nine traits in an effective team that can result in collaboration, creativity and productivity. These traits include co-location, commitment, multidisciplinary work, decision authority, productive environment, training, accountability, immediate feedback and consensus leader selection. Moore, Manrodt, and Holcomb (2005) stated that collaboration has three characteristics, including “real time sharing of data, aligned people and organizations, and aligned processes and practices.” Brewer and Mendelson (2003) suggested that multidisciplinary teams should also have diversity for being effective. Horwitz and Horwitz (2007) claimed that diversity in “task-related” attributes such as skills, education, organizational role and position, can improve team performance. Brewer and Mendelson (2003) indicated that diversity should be in form of “compatible opposites,” which means compatible as a group and opposite in mentioned characteristics.

Collaboration in IPD is a requirement, not a choice. Within IPD, project participants have the obligation to coordinate and collaborate, in addition to their traditional responsibilities. Moreover, to enhance the team approach and collaborative project delivery, IPD agreements also include provisions to share “risk of non-performance” among all parties (AIA National and AIA California Council, 2007). In IPD, different parties share their insight and perspective early in the process. Values of this approach can be realized by gathering other parties’ knowledge and experience in design, solving design-related issues before construction, buying in ideas on construction means and methods, reducing documentation time and improving budget management and quality (AIA National and AIA California Council, 2007). Participants can also provide more reliable information on the market prices, fluctuations and risks which can affect both design and construction (Cleves and Dal Gallo, 2012). Collaboration of various parties during design phase and need for team buy-in, significantly increases the frequency of getting inputs and providing outputs (AIA National and AIA California Council, 2007). Building Information Modeling (BIM) also supports the IPD concept by providing the platform and tools for collaborative design and project management. AIA National and AIA California Council (2007) confirmed that “full potential benefits of both IPD and BIM are achieved only when they are used together.”

In an IPD approach, communications are managed by the collaborative IPD team (AIA National and AIA California Council, 2007). This approach intends to reduce the time and cost of sharing information among the owner, architect, engineer, contractor, and subcontractor. Furthermore, information remains value adding as it is shared timely (Cleves and Dal Gallo, 2012). Cleves and Dal Gallo (2012) described that the need for easy-flow communication and collaboration within the team, requires co-location of project participants, or face to face meetings, on a regular basis. In a case study, Thompson and Ozbek (2012) confirmed that co-location results in increased desire to discuss the project issues, increased number of meetings, decreased planning and scheduling efforts for arranging meetings. This approach is also encouraged by other scholars. Some other advantages of using the co-location concept can be “faster pace of the project, quicker identification of problems and solutions, the increased collaboration among team members, the positive social interaction, the face-to-face communication, more productive meetings and knowledge sharing” (Thompson and Ozbek, 2012, p. 6). Different characteristics, background and perceptions of participants can affect the pace of transition to a co-location environment. Therefore, collaboration in a co-location office may not be realized early in the project without preparation and team building approach (Thompson and Ozbek, 2012). A co-location workplace may not be realized in the projects in which human resources are shared among other projects of their organization.

Metrics and KPIs

According to the literature, if you want to control and manage something, you have to measure and monitor it (Garvin, 1993; Martin, Petty, and Wallace, 2009). Therefore, developing a measurement system to manage and improve collaboration is a must and could be a value adding tool. Before developing a performance measurement

system, it is necessary to define Critical Success Factors (CSFs), Key Result Indicators (KRIs), Key Performance Indicators (KPIs) and metrics together to gain a better understanding of their concepts. “A Key Performance Indicator (KPI) is a criterion by which an organization can determine whether the outcome associated with a capability exists or the degree to which it exists” (Project Management Institute, 2003, p. 15). A performance indicator may be either an ordinary metric or a KPI depending on its importance in a project, project stages and perspectives of stakeholders (Kerzner, 2012). According to Association for Project Management (2000), CSFs “are those factors that are most conducive to the achievement of a successful project.” According to Kerzner (2011), “CSFs measure end results; KPIs and metrics generally measure the quality of the processes, which are used to achieve the end results and accomplish the CSFs.” Metrics and KPIs measure intermediate factors, which can collectively affect CSFs (Constructing Excellence, 2006; Parmenter, 2010).

KPIs can also signal undesirable progress in a project that might result in poor project outcome (Kerzner, 2011). They are measured regularly throughout the project to show required actions and responsibilities of the project team members (Constructing Excellence, 2006; Parmenter, 2010). Parmenter (2010) highlighted the differences between KPIs and KRIs. A KRI is a result of more than one performance criteria and directly summarizes and reflects the performance regarding a CSF. KPIs can show what the required action involves, but KRIs do not show where team members should focus. KPIs reflect responsibilities of teams and team members, but KRIs reflect management responsibilities (Parmenter, 2010). It is important to note that using KPIs should not be limited to tangible and easy to measure criteria; KPIs can also be used to measure intangibles within a project (Kerzner, 2011). Project Management Institute (2003) indicated that KPIs can be evaluated quantitatively or qualitatively, by measurement or expert judgement.

According to Parmenter (2010), another important aspect of KPIs is their ability to reflect “past, current and future performance measures.” Lag indicators measure results and “do not have predictive power for future.” Lead indicators measure progress of processes and can be used to predict future progress and performance (Barrett, 2013). It is important to have a measurement system to cover both leading and lagging outcomes (Kaplan, 2010; Kaplan and Norton, 2001). Hansen, Mowen, and Guan (2009) indicated that a metric can also be an indicator of both past and future performance and must be interpreted correctly.

Metrics and KPIs in Multi-Party Contracts

IPD is distinguished by multi-party contracting approach. Three forms of multi-party agreement can be used for IPD, including project alliancing, relational contracts, and single purpose entities. UK and Australian construction industry have extensively adopted project alliancing model, but this contracting method is new in the U.S. (AIA National and AIA California Council, 2007). In Australian Project Alliancing model, it is required that project participants discuss KRIs and KPIs in their alliancing agreement negotiations (Department of Treasury and Finance, 2006). Galloway (2013) described that using KPIs in the project alliancing model is not limited to the cost and time performance. In some contracts, alliance members are accountable for developing KPIs, especially for non-cost performance measurement. These KPIs can be developed in different areas, including human-resource management, change management, stakeholder management and innovation (Galloway, 2013; Reed and Loosemore, 2012; Transport Infrastructure Development Corporation, 2008). In contrast, the obligation to define metrics and KPIs in IPD standard forms of agreement is not such explicit, and its focus is mostly on time and cost. For example, as stated in AIA Document C195 (AIA, 2008), “Project Management Team shall be responsible for monitoring and stimulating the progress of the Project and for developing periodic cost projections, benchmarks, metrics, and standards for evaluating the performance of all Members and Non-Members in the achievement of timely and cost effective services and construction on the Project” (as cited O’Connor, 2009).

Reviewing the literature on the project alliancing model shows that most of non-cost KPIs are defined in a way to measure project results directly (lag indicators). For example, Jensen (2005) introduced community and stakeholders, traffic, quality, and environment as non-cost KPIs in road construction projects. Cooper, Jones, and Spencer (2009) presented timing, safety, deliverables, health of relationship and overall satisfaction (qualitative) as non-cost KPIs in a plant construction project. In a plant upgrading project, participants used operation costs and nutrient discharges to the environment as the non-cost KPIs (McFaul, Walpole, Purcell, and Hartley, 2002). Ross (2003) indicated that developing non-cost KPIs is for linking the actual performance to a “shared pain/gain” model and its target.

Although it is reasonable to link KPIs to project targets, it cannot reflect the problematic areas. For example, cost or schedule overrun can be measured easily, but they cannot demonstrate sources of problems without more in-depth performance assessment. Therefore, there is a need to define metrics and performance indicators at the process level to reflect required actions (lead indicators). According to Barrett (2013), level of collaboration can be considered as a lead indicator, because it reflects inputs and progress, and an expectation of future.

Adopting Metrics from Literature

Brennan (2011) demonstrated that collaboration of project team, effective communication, trust and respect are among most important CSFs within an IPD approach. Rowlinson and Cheung (2005) listed continuous communication, training for improving knowledge on delivery approach, regular team building activities and tight involvement of key players as other CSFs in project alliancing. Actually, increasing collaboration and building high-performing teams are among key goals of industry transition to the IPD approach (Raisbeck, Millie, and Maher, 2010). Developing “collaboration metrics or KPIs” alongside “regular encouragement” helps many organizations to foster a collaborative culture (Gerschman and Schauder, 2006). IPD intends to incorporate approaches that can make significant improvements within the industry; innovative contractual relationship, new collaborative team approach, using BIM approach and technologies are blended together. Due to this change within the industry, conventional performance metrics might not be sufficient to adequately assess collaboration performance. Therefore, investigating literature in other industries such as manufacturing, IT, and management industry is essential to identify and collect a comprehensive framework.

In construction-related literature, several KPIs have been introduced to cover team performance, communication, stakeholder, and human-resource management. UK construction industry has adopted social KPIs for people management within the projects (Constructing Excellence, 2006). El Asmar (2012) introduced several areas other than cost, time and quality to compare performance in IPD vs. non-IPD projects. Project changes, communication, and labor performance metrics are among these areas. To assess change performance, El Asmar (2012) used “(1) total percent of change in the project (the absolute value of the total percentage of change), (2) reason of changes (project additions and/or design-related change), and (3) average processing time for change orders.” He suggested that “Communication performance refers to direct means of communication as well as process inefficiencies and work that needed to be redone.” Performance metrics to evaluate communication and collaboration in projects, include “(1) the number of RFIs, (2) the RFI processing time, (3) the extent of rework, and (4) the number of resubmittals.” To assess labor performance, he suggested to measure three KPIs. First, a KPI measures the extent to which additional labor is used, in terms of overtime, shift work, and over-manning. Second KPI analyses the trend of Percent Plan Complete (PPC), or the measure of workflow reliability, which is calculated by dividing the number of actual task completions by the number of planned tasks. Third KPI assesses the labor factor, measured as a ratio of the total cost of self-performed work divided by the labor cost of the work.” Chelson (2010) also indicated “the number of RFIs on a project is indicative of the clarity and completeness of the plans.” Numerous RFIs reduce team performance because processing RFIs is both costly and time consuming (Chelson, 2010). The number of change orders also shows the quality of planning and decision making in a team. “The more change orders, the less efficient the operation is” (Chelson, 2010). Franz and Leicht (2012) introduced some “Pass/Fail” criteria for collaboration in IPD; for example, implementing a co-location office. Raisbeck et al. (2010) indicated that co-location is one of the most important differences between the IPD and the Australian Project Alliancing, and can result in significant improvements. Kerzner (2012) introduced some proactive metrics, which can reflect shortcomings in collaborative processes. He suggested to monitor “quality of assigned resources” as an indicator of probable poor work. Measuring “assigned versus planned resources” is also important because inappropriate resource planning and allocating signals future impact on duration and quality of work. “Number of baseline revisions is usually an indication that the requirements were not fully developed or understood.” Number of open action items and their lifetime can reflect poor collaboration and inappropriate resource assignment. Later in a project, these interim results can show their impact on cost and schedule (Kerzner, 2012).

From non-construction related literature, several metrics could be adopted. Lee, Jung, Kim, and Jung (2011) developed some collaborative KPIs (cKPIs) in manufacturing industry. They introduced cycle time of design changes, number of change requests, number of change approvals and loss cost of design changes as cKPIs. Natter, Ockerman, and Baumgart (2010) stated that two aspects of collaboration can be assessed; technical aspect and human aspect. For assessing the technical aspect of collaboration they suggested to “(1) analyze the inter-connectivity of team members to information sources, meaning the ability to get required information via communication channels, and (2) inter-connectivity of team members to each other.” They suggested simple metrics

to assess human aspects of collaboration, including “(1) how much time is spent collaborating, (2) how often various modes of communication are used to collaborate, and (3) the frequency of collaboration.” In the case of communication and collaboration in a social network, analyzing “Who talks to whom” can be a metric, which measures availability of communication channels and frequency of communications (Freeman, Weil, and Hess, 2006). Zhang, He, and Zhou (2012) also adopted this criterion to measure tacit knowledge sharing in an IPD project. As stated by Brewer and Mendelson (2003), some traits of collaboration directly relate to behavioral attributes and human characteristics. Although focusing on human behaviors is not within the scope this research, few metrics about individuals’ involvement within collaboration should be considered. For example, staff turnover and absence rate are metrics for assessing participation in team work (Constructing Excellence, 2006; University of Westminster, 2012). Individual skills should also be taken into account for team building (Kerzner, 2012; Wu, 2009).

Using BIM as a new collaborative approach and technology, might necessitate specific metrics to assess its performance. Although most of BIM performance metrics within the literature are lag indicators, some lead indicators can be found among them. Chelson (2010) suggested that impact of Building Information modeling on productivity at construction stage can be measured by some aforementioned KPIs, including idle time, re-work, RFIs, and change orders. Keavney, Mitchell, and Munn (2013) presented six KPIs to measure results of using BIM, including “man-hours, the number of requests for information, rework, material measurement accuracy, using more prefabricated elements and on-time completions.” Coates et al. (2010) also extracted some KPIs from a case study, focusing on business impact of BIM and different from conventional metrics; for example, “speed of development, improvement in skills and knowledge, reduction of costs, travel, printing, document shipping, and better architecture and deliverables.” Barlish (2011) listed “Future BIM Tracking Metrics” including some metric that can be measured during the process. “RFI quantities in 2D versus 3D,” and “offsite prefabrication man-hours” are among these metrics. Manzione, Wyse, Sacks, Van Berlo, and Melhado (2011) developed KPIs measure modeling process and information flow within BIM. These KPIs can be directly monitored by using data within BIM servers. Measuring actions of a BIM user over time (rate of information transfer), rates of improving the level of details, an amount of information in each transmission, speed of information transmission through a team to find bottlenecks, and monitoring rework on models are indicators of performance within BIM processes (Manzione et al., 2011).

After collecting metrics, a framework of metrics can be developed by linking metrics with respective collaboration traits. The framework is presented in *Table 6*. To interpret measurements meaningfully, some of the leading KPIs should be monitored periodically (e.g. monthly). As Kerzner (2012) presented, for some KPIs, not only a measurement itself can be meaningful, but also trends of its change over time should be interpreted. Some metrics should be interpreted both quantitatively and qualitatively to reflect intangible status of collaboration.

Discussions and Conclusions

Transition to IPD is one of the most significant current discussions in the industry. In an IPD approach, individual and team’s success depends on collaboration of key project participants. Therefore, developing and maintaining the collaboration is a must, and requires continuous collaboration assessment. Trends of research on performance assessment in construction industry show that most of the performance indicators are being used as lag indicators and application of non-cost and non-time indicators are very limited. Furthermore, no research has adequately dealt with a proactive collaboration assessment to monitor collaboration within a project. Therefore, this paper, based on a comprehensive literature review on traits of collaboration, collaboration within IPD, and metrics for assessing collaboration, developed a framework of metrics and combination of lead, lag, and coincident indicators for assessing traits of collaboration in a project (*Table 6*). The framework explicitly shows that many factors must be considered for a comprehensive collaboration assessment, including but not limited to personal and team characteristics, trainings, human-human and human-computer interactions, communication channels, and even physical locations of team members. It also demonstrates that how non-construction related literature can be adopted to improve performance management systems within the industry.

This research, makes several noteworthy contributions to the understanding of collaboration assessment within IPD. This study demonstrates some limitations of the conventional performance measurement approaches to assess collaboration within construction industry. Furthermore, in order to fill the gap in the knowledge, this research reviews non-construction related literature to find out how other fields used indicators and metrics to assess team collaboration. For the first time, this research deals with proactive collaboration assessment and investigates metrics, which can reflect ongoing status of collaboration traits within a construction project. This framework can be used as

a tool in IPD projects to monitor different traits of collaboration among project participants. Development of the framework opens a new area for future research on IPD. Many of the adopted metrics in the framework are extracted from non-construction related literature; it should be investigated that if these metrics reflect collaboration effectively and could be measured efficiently within IPD projects or not. To develop KPIs from the metrics, research can be conducted on validating and prioritizing metrics within the framework to evaluate their importance and contribution to collaboration assessment. Linking measures of these metrics (as lead indicators) to project performance indicators (lag indicators) can also demonstrate KPIs of collaboration.

Table 6: A framework of metrics for measuring collaboration within IPD

Traits of Collaboration	Criteria / Measures / Metrics
Co-location (Brewer and Mendelson, 2003) (Thompson and Ozbek, 2012)	Co-location as defined by project team(Pass/Fail) (Franz and Leicht, 2012)
Diversity, multidisciplinary work (Horwitz and Horwitz, 2007)	Team diversity in Skills, Education, Organizational Role and Position. “Compatible opposites” (Pass/Fail)
Team Productivity (Brewer and Mendelson, 2003)	Number of baseline revisions (Kerzner, 2012) Number of open action items (Kerzner, 2012) Number of scope changes approved, denied and pending (Kerzner, 2012; Lee et al., 2011) Number of change orders initiated by each different source. Number of resubmittals (El Asmar, 2012) Number of RFIs (El Asmar, 2012) Percent Plan Complete (PPC) trend (El Asmar, 2012)
Cost impact of collaboration	Loss cost of design change- The absolute value of the total percentage of change - Extent of rework (El Asmar, 2012; Lee et al., 2011)
Training (Brewer and Mendelson, 2003) (Thompson and Ozbek, 2012)	Team building and co-location training (Thompson and Ozbek, 2012) Training on project delivery method (Rowlinson and Cheung, 2005) Achievement rate of training (Wu, 2009) Average individual training per employee (University of Westminster, 2012)
Immediate Feedback (Brewer and Mendelson, 2003)	Average change order processing time (El Asmar, 2012) RFI processing time measured in weeks (El Asmar, 2012) Timely Reviews (Franz and Leicht, 2012) Lost time accounting (wait for information) (Cox, Issa, and Ahrens, 2003)
Real Time Sharing of Data (Moore et al., 2005)	Interconnectivity of team members to information sources (the ability to obtain required information via communication channels) (El Asmar, 2012) Interconnectivity of team members to each other (Natter et al., 2010)
Methods of Communication (Thompson and Ozbek, 2012)	How often various modes of communication are used to collaborate (e.g. face to face or virtual) (Natter et al., 2010)
Degree of Interaction (Pocock, Hyun, Liu, and Kim, 1996) Knowledge Sharing (Thompson and Ozbek, 2012)	Number of persons in interaction (Pocock et al., 1996) Frequency of interaction types (planned vs. unplanned) (Pocock et al., 1996) “Who talks to whom” (Freeman et al., 2006) Frequency of communication between nodes (Freeman et al., 2006) How much time is spent collaborating (Natter et al., 2010)
Individual Human Aspects	All staff turnover (University of Westminster, 2012) Voluntary staff turnover (University of Westminster, 2012) Human-resource absence rate (Constructing Excellence, 2006) Variety of jobs that take advantage of each person’s skills (Wu, 2009) Quality of assigned human resources (Kerzner, 2012)

Table 6: A framework of metrics for measuring collaboration within IPD (cont)

Traits of Collaboration	Criteria / Measures / Metrics
BIM (AIA National and AIA California Council, 2007)	Number of requests for information on model (Keavney et al., 2013) Material measurement accuracy (Keavney et al., 2013) Options to use more prefabricated elements (Keavney et al., 2013) Speed of development (Coates et al., 2010) Improvement in skills and knowledge (Coates et al., 2010) Reduction of costs, travel, printing, document shipping (Coates et al., 2010) Better deliverables (Coates et al., 2010) RFI quantities in 2D versus 3D (Barlish, 2011) Offsite prefabrication man-hours (Barlish, 2011) Measuring actions of a BIM user over time (Manziona et al., 2011) Rates of improving level of details (Manziona et al., 2011) Amount of information in each transmission (Manziona et al., 2011) Speed of information transmission through a team (Manziona et al., 2011) Monitoring reworks on models (Manziona et al., 2011)

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