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Project Controls and Management Systems: Current Practice and How It Has Changed over the Past Decade

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Project Controls and Management Systems: Current Practice and How It Has Changed over the Past Decade

by

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Abstract

Project Controls and Management Systems: Current Practice and How It Has Changed over the Past Decade

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Project Controls and Management System (PCMS) refers to an ecosystem of processes, tools and personnel required for the proper planning and execution of capital projects throughout the different phases of design, procurement, construction and startup. This can be divided into different focus areas (functions) that would include Estimating, Planning, Scheduling, Cost Control, Change Management, Progressing, and Forecasting. Various trends such as globalization, contractor specialization and information technology developments have impacted the way PCMS are implemented and made it the subject of extensive research over the past years to investigate how to best utilize those trends.

Replicating the research methodology used in a 2011 report published by the Construction Research Institute (CII), this work aims to investigate the current status of PCMS implementation and how it has changed over the past decade. It was concluded that while the original PCMS principles are still valid, adoption has drastically changed in terms of efficiency for the majority of the functions. The research also identifies areas of potential concerns and provides recommendations for further improvement.

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Chapter 1: Introduction

1.1. Background and Need

A proper Project Controls and Management System (PCMS) is vital to the success of a construction project. A Project Controls and Management System (PCMS) includes all the necessary resources, tools and techniques required for the planning and execution of a project and should address all related processes including, but not limited to, planning, scheduling, cost and schedule control, forecasting, and change management. While project controls first emerged in the late 1950s (O'Brien 2006), and despite all developments that have taken place since, a survey conducted in 1992 showed that most of construction projects are behind their original schedule (Cooper, 1994). Such delays incur severe damages, either through delay damages and increased overhead for contractors, or missed revenues and opportunities for owners. Furthermore, Singh and Lakanathan (1992) and Navon (1994) have found that construction companies often fail due to a lack of liquidity to support their business activities.

Nowadays, construction projects have increased in complexity. One dimension of that complexity is the increased number of stakeholders as well as the interdependencies between said groups. This includes, but is not limited to, engineers, architects, lawyers, financial institutions, contractors, and government authorities (Clough et. al. 2008). Another dimension is the increase in demand for construction projects; according to the United Nations, world's population is expected to increase by 30% by 2050, 75% of the population will live in cities (Merrill and Gray 2012).

In 2006, The Construction Industry Institute (CII) engaged the Global Project Controls and Management System (PCMS) to review and update the PCMS knowledge under the perception that PCMS practices and systems have changed due to the global changes mentioned discussed above. The end result was that while the main principles are still valid, the means of applications have been affected by various global trends such as speed of execution, project complexity, globalization, outsourcing, and others (CII 2011).

1.2. Purpose, Objectives, and Limitations

Using the aforementioned CII research report (2011), more commonly known as RT244 and referred to in this paper as The Report, as a reference point, the purpose of this report is to document the changes that happened to the adoption and application of PCMS over the past decade and provide a more contemporary guideline to construction companies to follow should they adopt those practices nowadays. Essentially, the main questions answered by this report are: 1) what is the current state of PCMS practice within CII member companies, 2) how have they changed over the past years, and 3) what changes are required to a) accommodate the current industry needs and capabilities, and b) further encourage the construction companies to adopt PCMS practices. Some specific objectives include:

- Document the current state of PCMS practices as implemented by CII member companies and identify trends and changes that took place over the past decade.
- Evaluate past and existing CII research and implementation related to PCMS and make recommendations for their disposition.

This work follows the same limitations originally set by The Report in terms of the targeted population, focusing on CII member companies. Unlike The Report, information technology developments were part of the hypothesis development process based on the available literature.

But what was tested was not the mere availability of such developments but whether they were being adopted within the construction industry.

Chapter 2: Literature Review

Project management can be defined as the process of controlling the achievement of the project objectives (e.g. Kerzner 1989). While Control is calculating variances between actual and targeted progress to determine if operations are being performed as intended (Carr 1993). With that in mind, one can say that PCMS practices have been applied in some way, shape or form since the beginning of time. The chances are major projects such as the Pyramids of Giza, Taj Mahal, the Buckingham palace, and the white house have featured some aspect of construction management.

One can say that modern day construction management was born in the 1910s with the introduction of the Gantt chart. Then it took a major leap forward in the 1950s, when CPM (by DuPont) and PERT (by the US Navy) were developed (O'Brien 2006). Moving forward, the PCMS trend also viral worldwide; the International Project Management Association (IPMA) was formed in Europe in 1965 under the name INTERNET, and North America's Project Management Institute (PMI) was formed in 1969, both promoting proper use of project management and control principles. The construction Industry Institute was founded in 1983 and began to study PCMS functions as a coherent system.

Nowadays, PCMS includes the planning, change management, estimating, scheduling, cost control, progressing, and forecasting functions. Going function by function, the following sections aim to provide some context regarding each of those functions in terms of definition and status (according to The Report), as well as current trends that have affected said functions over the past years.

2.1. Planning

Planning is defined in The Report as "The process devoted to clearly identifying, defining, and determining the execution means and methods necessary to achieve project goals and objectives before execution of means and methods (CII 2011)". This means that planning ultimately determines how the work will be scheduled, organized and controlled (Babu and Suresh 1996; Haugan 2002). Therefore, planning demands the undivided attention of competent project personnel (Kerzner 2009) and the earlier it is executed, the larger the impact it has on the project outcomes (Gibson et al. 1995; Laufer 1987). Early planning also makes the contractor more proactive than reactive towards any problems that might arise; a proactive contractor sets the pace of the project while a reactive contractor merely "firefights" project problems as they occur (Plumbing-Heating-Cooling Contractors (PHCC) National Association 2002).

Project planning has been a prime focus of research over the past three to four decades (e.g. Dumont et al. 1997; Gibson et al. 2006; Laufer 1987,1990; Laufer et. al. 1993; Menches et al 2008; Thomas and Elis 2007). The Report views planning as a function that is being implemented more by the contractors than the owners but with average efficiency overall. Only 40% of the owner companies reported the presence of Information Technology (IT) systems that support the function while 57% reported the presence of any training programs compared to 77% and 70% of the contractors, respectively. The Report also mentions how increased project complexity and speed of execution is making matters worse as planning phases are not getting the attention they deserve.

Issues that affecting planning throughout the past years have been the declining workforce due to retirements as well as globalization. Planning relies heavily on experience as opposed to other functions such as cost control which can be automated. Hence, retirements and the absence of proper replacements, especially for owners due to the lack of proper training programs as mentioned earlier, would adversely affect how well the function is adopted and performed. Similarly, globalization allow for the integration of multiple perspectives and viewpoints to better plan projects, as well as overcome the lack of project personnel at a certain location. And while Comu et. al. (2015) argues that construction companies are now dissolving the drawbacks of globalization by working more towards the integration of its global/virtual team members and stakeholder entities, for this to happen standardized communication methods and integrated IT systems have to be set in place otherwise the project environment becomes a communication jungle which hinders the decision-making process. An issue which has been referred to by the CII as lack of alignment across the project team (CII 2015a)

2.2. Change Management

The Report defines change management as “The process of effectively identifying, evaluating, and making decisions on new or revised scopes of work and monitoring implementation, all in an expeditious and systematic fashion (CII 2011).”. Bordat et al. (2004) stated that different US Departments of Transportations face difficulties keeping their projects within planned budgets and schedules because of change orders. Such change orders amount for an average of 9-13% of project cost overruns in different states (Shafaat et al. 2016). While Ogunlana et al. (1996) ranked change orders as the number one cause of project delays. Hence, changes are of great concern in the construction industry as they often lead to increase in project cost and duration. And for a change management process to be effective, both causes and effects (direct and indirect) of said changes must be properly understood (Stasis et al. 2013).

Hence, multiple change management frameworks and toolkits have been developed since the start of the century. Such frameworks include Ibbs et al. (2001), Motawa (2005) and Arain and Pheng (2007) process oriented systems and models, Isaac and Navon (2009) object oriented model, the change management toolkit developed by Sun et al. (2006), and the systems dynamics model developed by Motawa et al. (2007) which allows for change prediction and dynamic planning. The frameworks agree on main phases and steps such as change identification, evaluation, implementation as well as post-change analysis and learning.

The Report mentions that contractors have strong change management processes while the owners have weak tools and training modules (only 50% reported the presence of change management training modules, while 40% reported the presence of IT modules). 69% of the contractors have training modules set in place but their effectiveness is below average. The Report also features change recognition as an upcoming industry trend, this has been supported by the frameworks referred to earlier as well as the IT systems developments that lead to more change detection through relying on Building Information Modeling (BIM) (Liu et al. 2014) as well as Discrete Event Simulation (DES) (Du et. al. 2016) as part of the change management frameworks. Karimidorabati et al. (2016) has classified the history of change management into three generations, mentioning that we are now part of the third generation (GEN3) which adopts the internet, the cloud-based applications, and the state-of-the-art database management and document management systems.

2.3. Estimating

The Report simply defines estimating as “The art and science of predicting the cost, time, and resources to deliver a scope (CII 2011).”. Hence, the concept of estimating is considered to be one of the oldest and main cores of PCMS functions.

The two opposite ends of the spectrum regarding cost estimates are conceptual/parametric estimates, which take place at the very beginning of the project using limited information, and detailed estimates, which take place after all designs, specs and relevant information are developed and made available to the estimators. Needless to say, this makes conceptual estimates less labor intensive, yet less accurate, than their detailed counterparts.

Ellsworth (1998) argued that the simplest method for determining a reasonable estimate of a project cost is to compare it to similar previously executed projects. Since then, multiple scholars have used different techniques trying to develop ways to “systemize” conceptual estimates and reduce its dependency on personal judgements. Soutos and Lowe (2005) developed a parametric cost model that depends on multiple regression of various cost data, while Cheng et al. (2008) resorted to more complex techniques such as genetic algorithms, fuzzy logic, and neural networks. Ji et al. (2010) developed a cost model using statistical methods such as normalization and correlation analysis, calling it the statistically preprocessed data–based parametric (SPBP) cost model.

Detailed estimates are much more straightforward, a cost estimator identifies the required material quantities and specs based on project documents and then collects prices for said materials, either through the company’s database for inhouse materials or soliciting quotations from subcontractors and external suppliers. The estimation related advances in CAD and BIM fields mainly aim to assist in the quantity take off process by making it less time consuming and more accurate (Karshenas 2005).

The Report describes the state of estimation as being an area of strength both for owners and contractors with the exception of the contractors’ processes during procurement phase. It is important to mention that estimation is one of the few functions, along with scheduling, that has off-the-shelf IT software available. Furthermore, while the owners reported the effectiveness of their estimating IT software and training modules, that response came only from the portion of the owner companies who have that in place to begin with, which are less than half of them. The remaining justify the absence by saying they rely on the contractor's processes and tools to do the job for them.

The argument for whether estimating has improved or not over the past few years can go both ways. On one side, the further developments in CAD and BIM and their integration with industry databases (Castro-Lacouture and Wasmi 2016; McCuen 2015) calls for an improvement. However, the workforce skills as well as the market fluctuations render those databases irrelevant. Which means that matters are getting worse, especially for conceptual estimates because the only source of information other than older data is personal judgement.

2.4. Scheduling

The report defines scheduling as "The art and science that results in a time-phased plan of activities that indicates what is to be done, when, by whom, and with what resources (CII 2011).". Hence, one can argue that the origins of scheduling methods date back to the introduction of bar charts. Starting with the Gantt Chart (GC), originally introduced in the 1910s (O'Brien 2006), the mid 1900 witnessed the birth of the Critical Path Method (CPM), the Program Evaluation and Review Technique (PERT), and the line of Balance (LOB) which was developed to manage projects with linear and/or repetitive activities. Other scheduling techniques emerged in the early 2000s such as the Last Planner System (LPS), and the Critical Chain Project Management (CCPM). which builds up on traditional CPM approaches by utilizing buffer management and theory of constraints for the sake of resource management and leveling and overcome the inherent CPM assumption of unlimited constraints (Leach 2014). Making the method, along with LPS, able to serve not only as scheduling techniques, but also as holistic project planning and control approaches (Al-Nasseri et. al. 2016).

Much like estimating discussed above, and for the same reasons, The Report views scheduling as an area of strength for the contractors but an area of weakness for the owners. The presence of off-the-shelf IT systems make the contractors' jobs easier in creating the schedule and the owners' count on that and they don't develop one themselves (48% and 42% of owner companies reported an absence of IT tools and training modules, respectively). And just like planning, globalization and virtual teams are making matters worse for the owners due to lack of proper alignment within the project team (CII 2015a) as well as the absence of a good communication foundation. And while one might think that modern scheduling techniques like LPS and CCCM would have led to an improvement in scheduling, the fact is the industry is still relying on CPM and its traditional counterparts due to their relative simplicity.

2.5. Cost Control

The Report defines Cost Control as "The process to catalog and analyze budgeted and actual expenditures of activities for purposes of timely identification of cost trends, problems and opportunities during the course of the project (CII 2011).". This is of great importance as it allows for the early detection of any cost overruns, allowing time to take any corrective actions needed. Examples where actual costs varied significantly from their respective budgets include the Olympic Complex in Montreal, Canada intended to host the 1976 Summer Olympics, and the Big Dig in Boston, Massachusetts. According to Singh and Lakanthan (1992) and Navon (1994), a prime reason for failure of construction companies is lack of finances to support their ongoing operations.

For a cost control system to be effective, it should highlight problem areas in a level of detail and reliability that is adequate for decision making processes. In other words, the system should indicate the reasons behind the project's superior or subpar performance (e.g. a trade(s) is working below standards). Furthermore, effective cost control systems should provide sufficient data for cost estimation of future projects as well as support building up new rates for upcoming variations (Al-Jibouri 2003; Bennet 2003).

The Report views cost control as an area of strength for both owners and contractors. This is not a surprise as cost control is ultimately what gets people paid. And while The Report looks at the trend of increased oversight as something that might be worse for proper cost control due to multiple reporting, this is counterbalanced by the IT improvements as well as the direction the industry is taking regarding cost and schedule control integration (e.g. Cho et al. 2013; Wang et al. 2016), making the reporting process easier.

2.6. Progressing

A more generic term than cost control, The Report defines progressing as "Determining the status of project completion using a consistent method, which should include earned value (CII 2011).". Progress management determines the state of the project performance by comparing actual cost and schedule data to the planned budgets and plans. Hence the establishment of those plans and budgets are essential for progress management to work. First, the progress of activities and work packages is measured separately then aggregated to determine the overall progress of the project.

The main bottleneck regarding progress management lies in monitoring and collection of field data. The traditional and manual methods have proven to be time and cost consuming as well as too slow to allow for timely corrective actions (Navon 2007). Research efforts for the past 30 years have focused on ways to automate the measurement process using techniques such as Radio Frequency Identification (RFID) (e.g. Jaleskis et al. 1995), laser scanning and photogrammetry (e.g. El-Omari and Moselhi 2011; Saidi et al. 2003), the use of computer vision and augmented reality (e.g. Golparvar-Fard et al. 2009; Ibrahim et al. 2009), integrating BIM models into cloud computing frameworks and mobile applications (Garcia-Lopez and Fischer 2014), and using predictive data analytics to develop proactive management systems (Lin and Golparvar-Fard 2017). Navon and Goldschmidt (2003) investigated the possibility of measuring indirect parameters, such as location and duration, and converting them into labor productivity or inputs. The hypothesis was that knowing the location of the worker at a given time as well as the time spent at that location, when combined with additional schedule and building physical information, can provide information about what activity is being performed along with the productivity of said activity.

Despite all those efforts, progressing is viewed by The Report as an area of average efficiency with the owners being slightly worse than the contractors. And while the bottleneck of data collection has been resolved by the research work presented earlier, other downfalls such as inconsistency of metrics and their inability to measure the "true" performance of the project (CII 2016) is setting the function back. This issue is further exacerbated by other global trends such as increased project complexity, outsourcing, and contractor specialization. In summary, the industry is now able to collect more data, yet there is no consensus on what is the correct data to collect.

2.7. Forecasting

The Report defines forecasting as "The process of continuously predicting the final outcome of cost, time, and resources required to complete a scope (CII 2011).". This is of extreme importance because large resource variances can affect the viability of the project and can even jeopardize its completion in case the estimated resources could not be provided. According to Teicholz (1993), a good forecasting system should be simple in nature as well as in its data requirements. In addition, the generated forecasts should be accurate, timely, unbiased (neither consistently overestimating nor underestimating) and stable (Teicholz 1993).

What all forecasting methods have in common is their reliance is what is known as the performance factor (PF) as an assumption for productivity. Most common assumptions for productivity are either that it is as planned (PF=1) or that it is equal to the calculated performance index. This index can either be the cost performance index, the schedule performance index, or a weighted average between the two. Batselier and Vanhoucke (2015) conducted a case study where they created time and cost forecasts using different PF values. They concluded that the most accurate forecasts were the one obtained with PF=1 as this takes into account the corrective actions taken by the project team inspired by the unsatisfactory progress measurements. More recent techniques have developed later on such as Lipke (2011) who integrated the effect of rework in ESM forecasts, Elshaer (2013) who incorporated the activity sensitivity (e.g. criticality) into ESM forecasts, Khamooshi and Golafshani (2014) who developed a way to calculate schedule performance thorough EDM principles but using time units instead of cost units, Batsalier and Vanhoucke (2017) who combined EVM metrics with exponential smoothing techniques to account for experience-driven performance improvement and/or corrective management actions, and Wauters and Vanhoucke (2016) who studied the use of artificial intelligence for duration forecasting.

Despite all those research breakthroughs, The Report sees progressing as an area of weakness for both owners and contractors. The fact that progressing is not getting any better also implies that forecasting is not either, since one cannot do much without the correct data to work with.

Chapter 3: Hypothesis and Research Approach

3.1. Hypothesis

In general, one might think that PCMS in general have been improved due to IT advances as well as contract provision and implementation guides such as the American Institute of Architects (AIA) BIM Protocol (2013). Yet guided by the literature review expressed in the previous section, the authors' hypothesis has been further tailored on a function by function basis. A tabular view of the hypothesis developed by the authors for each function, based on The Report's comments as well as observations from the literature review and the industry, combined with the state of function as per The Report is presented in table 1.

Table 1: A Tabular View of the Hypothesis Developed by The Authors

<table>
<tr><th>Function</th><th>RT244 status (Owners)</th><th>RT244 status (Contractors)</th><th>Trends</th><th>Effect</th><th>Conclusion/Overall Hypothesis</th></tr>
<tr>
<td>Estimating</td>
<td>Strong Processes, Strong IT systems, strong Training program
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.15</td><td>6</td></tr>
<tr><td>IT</td><td>2.25</td><td>4</td></tr>
<tr><td>training</td><td>2.28</td><td>4</td></tr>
</table></td>
<td>Weak Processes in procurement phase, Strong IT systems
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.05</td><td>76%</td></tr>
<tr><td>IT</td><td>2.25</td><td>69%</td></tr>
<tr><td>training</td><td>2</td><td>55%</td></tr>
</table></td>
<td>Integration of BIM and CAD (Castro-Lacouture and Wasmi 2016; McCuen 2015).

Workforce Skills, price shocks, declining productivity</td>
<td>Better

worse</td>
<td>Worse overall, lack of predictability and relevance of prior projects databases hinders the quality of BIM and CAD outputs. Also due to worse planning</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Weak Processes
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.03</td><td>71%</td></tr>
<tr><td>IT</td><td>2.18</td><td>49%</td></tr>
<tr><td>training</td><td>2.23</td><td>54%</td></tr>
</table></td>
<td>Strong Processes, strong IT systems
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.18</td><td>84%</td></tr>
<tr><td>IT</td><td>2.4</td><td>79%</td></tr>
<tr><td>training</td><td>2.03</td><td>77%</td></tr>
</table></td>
<td>No perceived trends in literature

Globalization and virtual teams (CII 2012; Comu et al. 2015)

lack of team integration/alignment (CII 2015a)</td>
<td>Same

Better for contractors

Worse</td>
<td>Better for contractors only due to the presence of a good foundation. Globalization will make planning for owners worse due to the lack of effective processes to gather everyone's input</td>
</tr>
<tr>
<td>Planning</td>
<td>Average
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.08</td><td>71%</td></tr>
<tr><td>IT</td><td>2.15</td><td>40%</td></tr>
<tr><td>training</td><td>2.18</td><td>54%</td></tr>
</table></td>
<td>Average
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.13</td><td>81%</td></tr>
<tr><td>IT</td><td>2.2</td><td>69%</td></tr>
<tr><td>training</td><td>1.98</td><td>67%</td></tr>
</table></td>
<td>Retirements – less experience
Shorter project schedules; inconsistent</td>
<td>Worse/ same

Worse</td>
<td>Worse overall, planning cannot be automated so it is highly affected by the declining workforce</td>
</tr>
</table>

Table 1 (continued)

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>Project complexity and increased execution speed
Globalization and global integration (CII 2012; Comu et al. 2015)

lack of team integration/alignment (CII 2015a)</td>
<td>Better

Worse</td>
<td></td>
</tr>
<tr>
<td>Cost Control</td>
<td>Strong Processes, Strong IT systems, strong Training program
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.18</td><td>71%</td></tr>
<tr><td>IT</td><td>2.35</td><td>48%</td></tr>
<tr><td>training</td><td>2.25</td><td>48%</td></tr>
</table>
</td>
<td>Strong Processes
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.1</td><td>73%</td></tr>
<tr><td>IT</td><td>2.08</td><td>76%</td></tr>
<tr><td>training</td><td>1.83</td><td>67%</td></tr>
</table>
</td>
<td>IT developments and Integration into schedule control (e.g. Cho et al. 2013; Wang et al. 2016)
Increased oversight (CII 2011)</td>
<td>Same/Better

Worse</td>
<td>Better overall, the IT improvements makes it easier to report to the increased oversight entities</td>
</tr>
<tr>
<td>Change Management</td>
<td>Weak Tools (IT systems)
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.1</td><td>69%</td></tr>
<tr><td>IT</td><td>2.03</td><td>38%</td></tr>
<tr><td>training</td><td>2.18</td><td>46%</td></tr>
</table>
</td>
<td>Strong Processes, below average training
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.18</td><td>78%</td></tr>
<tr><td>IT</td><td>2.18</td><td>63%</td></tr>
<tr><td>training</td><td>1.83</td><td>67%</td></tr>
</table>
</td>
<td>IT systems development leads to More frequent change recognition (CII 2011; liu et al 2014, karimidorabati et al. 2016)</td>
<td>Better</td>
<td>Better overall</td>
</tr>
<tr>
<td>Progressing</td>
<td>Average
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.18</td><td>57%</td></tr>
<tr><td>IT</td><td>2.25</td><td>41%</td></tr>
<tr><td>training</td><td>2.08</td><td>45%</td></tr>
</table>
</td>
<td>Average
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.15</td><td>76%</td></tr>
<tr><td>IT</td><td>2.1</td><td>72%</td></tr>
<tr><td>training</td><td>1.9</td><td>62%</td></tr>
</table>
</td>
<td>Inconsistent metrics (CII 2016)

No guidance for improving metric reliability (CII 2016)</td>
<td>Same or Worse

Worse</td>
<td>Worse overall, the industry can collect data, yet there is no consensus what is the right data to collect</td>
</tr>
</table>

Table 1 (continued)

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>Current metrics unable to provide a “true” measure of project performance

Complexity, contractor specialization, outsourcing

Research in Predictive data analytics (Lin and Golparvar-Fard 2017)

BIM for on-site construction (Garcia-Lopez and Fischer 2014)

Material tracking</td>
<td>Worse

Worse

Potentially better, some case studies, lack of widespread adoption – same or worse may dominate</td>
<td></td>
</tr>
<tr>
<td>Forecasting</td>
<td>Weak
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.13</td><td>48%</td></tr>
<tr><td>IT</td><td>2.05</td><td>35%</td></tr>
<tr><td>training</td><td>2.1</td><td>43%</td></tr>
</table>
</td>
<td>Weak
<table>
<tr><td></td><td>Eff.</td><td>%</td></tr>
<tr><td>Processes</td><td>2.05</td><td>76%</td></tr>
<tr><td>IT</td><td>2.1</td><td>69%</td></tr>
<tr><td>training</td><td>1.7</td><td>65%</td></tr>
</table>
</td>
<td>Limited resources for forecasting

More forecasting techniques (el shaer 2013, khamooshi and golafshani 2014, lipke 2011)</td>
<td>(Affected by poor progressing) -likely same or worse

May see limited pockets of better using</td>
<td>Likely same or worse overall due to poor progressing (you can’t do much if you don’t have enough correct data to work with) Also project complexity makes it harder to forecast performance</td>
</tr>
</table>

Table 1 (continued)

			Implementation of artificial intelligence (Wauters and Vanhouke 2016) Project complexity	data analytics Worse	

IT improvements have led to the hypothesis that cost control and change management have improved due to the ease of timely reporting. Unfortunately, the same could not be said about progressing because the counterargument of the absence of reliable and consistent metrics (CII 2016) outweighs the potential improvements coming from technological advances (e.g. Garcia-Lopez and Fischer 2014, Lin and Golparvar-Fard 2017) since metrics are more fundamental and are more exploited by other trends such as project complexity, globalization and outsourcing. Also, as mentioned by Yang et. al. (2015), there is still a gap between research output and industrial application. In other words, such technological advances, which constitutes the main bulk of the improvement hypothesis, might not have been widely adopted yet. The hypothesis that progressing is getting worse, as well as the premises on which it is built, leads to the hypothesis that forecasting is getting wore as well (or at least not getting better) simply because there are less plausible progressing data that can be fed into the forecasting tools and techniques. Improvements might have taken place in isolated pockets but it is not enough to be generalized. An argument can be made that forecasting can now do more with the same data it has than it used to, thus justifying an improvement hypothesis, but the increased project complexity makes it harder to do so.

The hypothesis for planning is that it is getting worse due to the increased project complexity and execution speed that give the planning phase less attention than it deserves. This issue is exacerbated by the change in workforce demographics in terms of experience level; people with experience are retiring and their replacements do not possess as much experience. This is a major issue in planning because planning cannot be automated. This is slightly compensated for by globalization initiatives and the attempts of construction companies to build integrated global teams to benefit from the different perspectives (Comu et. al. 2014) but this solution is not powerful enough to tip the scales to its favor. Estimating is also getting worse for similar reasons; the technological advances and the integration of CAD and BIM (Castro-Lacouture and Wasmi 2016; McCuen 2015) is hindered by the workforce skills and, most importantly, the market instability which ultimately renders the software cost databases irrelevant. Scheduling, on the other hand, is getting better for contractors only since they have a good reference point to build up on and reap the rewards of trends such as globalization. Yet owners will suffer from the difficulty of gathering everyone's input as they lack the proper tools and techniques to do so and, consequently, they will end up in a worse shape as far as scheduling is concerned.

3.2. Methodology/Research Approach

Similar to The Report, the hypothesis developed by the authors aimed to answer two questions; a) what is the state of project controls implementation? And b) what has changed over the past decade? Currently the hypothesis answers both questions by saying that Scheduling, Cost Control and Change Management have gone better, while the other functions have gone worse.

To confidently answer those questions, the research approach on which this paper is based is divided into two main phases. The first phase includes an extensive review of The Report to determine the state of PCMS ten years ago, the trends observed that would affect the industry, and the recommendations provided by the research team to further develop PCMS implementation and adoption. This established the baseline to which modern practices are compared. It also includes reviewing academic papers and other CII publications that were published over the past decade to explore how each of the PCMS functions have changed over time. The results of this phase have aided in formulating the hypothesis mentioned above as well as partially moderating the qualitative research phase by asking the discussion groups what they think of the conclusions derived from said literature.

The second phase is about testing the hypothesis established earlier as a conclusion of phase one. This is done using both qualitative and quantitative approaches. On the quantitative side, surveys were used as they were deemed by Rossi et al. (1983) as a powerful way to obtain information from individuals about a social unit they are involved with. To maintain data consistency and solve the problem addressed by De Vaus (2001) regarding this type of survey design (Cross-sectional design) which is the lack of a time dimension, the survey used by The Report research team and distributed during the 2006 CII Board of Advisors (BOA) meeting was reused and addressed to the same population (CII member companies). The surveys were manually delivered to the member companies in person during one of the CII meetings and virtually via email. The survey simply asks the companies to assess the state of their PCMS in terms of the existence and efficiency, through a 3-point scale, of formal procedures and processes, IT tools and techniques that support said processes, and training modules for each PCMS function. In essence, the survey is intended to know the status of a given company regarding how PCMS are being implemented. Hence, the recipients of the survey were allowed to take the survey back to their companies and consult with their personnel about what could best describe the current status of their company. A copy of the administered survey is available in Appendix A.

Qualitatively, a semi structured discussion was held with members of the CII Project Controls Community of Practice (COP), later on referred to as “The Experts”. The discussion consisted of two main parts. First, the conclusions, trends, and recommendations of The Report were presented, and The Experts were asked to evaluate them in terms of how relevant these comments are nowadays and if there are any new parameters and/or incidents that should be taken into consideration. Next, going function by function, The Experts were asked to comment on the state of each PCMS function mentioning any improvements, or lack thereof, that took place over the past decade. For each function, the discussion started with a blank page with only the function's name to maintain objectivity of The Experts' opinions (i.e. for them not to be led by the conclusions previously developed from the literature review) as well as to see what the impulse response is, then comments collected by the authors through the literature review process as well as the developed hypothesis were presented to determine their validity, thoroughness, and comprehensiveness. A work flow of the full research approach is shown in figure 1.

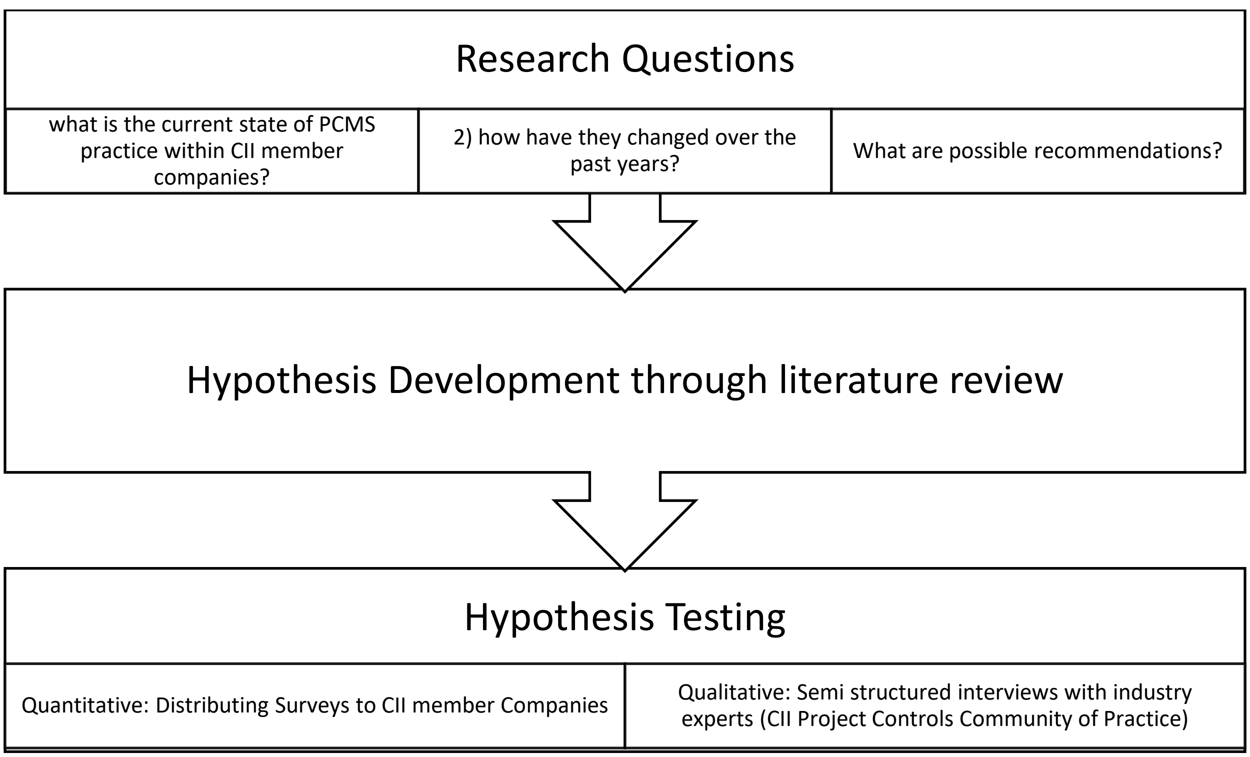

Figure 1: Workflow Describing the Full Research Approach

Chapter 4: Results and Discussion

4.1. Insights from COP Discussions

Overall, The Report's comments are still valid today the same way they were valid ten years ago regarding the validity of PCMS principles as well as the increase in project complexity, contractor specialization and difficulty in finding experienced personnel. Increased management layers pose a problem regarding the validity of project data as they might become invalid by the time they reach the decision makers. Especially with the increased speed of project execution that we are now witnessing the shift from "fast-track" to "flash-track". This has made various researchers such as Austin et al. (2016) work on identifying best practices to successfully deliver projects under such tight time constraints. There is an increased reliance on IT up to the point where the focus has shifted from data analysis to mere data entry and automatically believing in whatever outcome the software provides. Moreover, the benefits coming from IT usage are still not felt by the small size projects because of their budget limitations.

Estimating is getting worse as experts are still unable to bill their own experience and companies are still failing to correlate between the estimates and the time these estimates were created. A potential area of growth is analyzing estimates from a risk perspective in a level of detail that allows to identify what risks a project has, especially for small and medium size projects. Owners are getting better in control rather than estimating as they still rely on contractors to do the estimates. While this approach has been argued for by Winch and Leiringer (2016) introducing the concept of the "strong owner". This means that the quality of the estimate is a function of the contractor creating it, which is a problem within small projects where contractors do not put much rigor into the estimates. Regarding contractors, they tend to be "over-optimistic" with their estimates for the sake of being competitive, even if this means that the estimate is not realistic enough. A view supported by the fact that formal analytical risk analysis models and contingency theories are not implemented in practice (Laryea and Hughes 2011). And unless there is some sort of a partnering agreement between the owner and the contractor where negotiations take place to reach more realistic estimates, this issue would incur losses on both parties. BIM integration helps with the process, but it is only up to the level supported by the project budget. However, as with all software usage, there is a problem of over-reliance on the software output, treating it as a "black box" without understanding the basic concepts of how it operates and why the results are the way they are. Market fluctuations poses a huge threat to the quality of the estimates provided, often exacerbated by the fact that some contractors use wrong rates (e.g. wrong area code) to build up their estimates. This deems all the BIM potential described by various researchers such as Castro-Lacouture and Wasmi (2016) as well as McCuen (2015) impotent since database integration is useless if it is the wrong database that is being used.

There is not much progress felt regarding scheduling as it is still performed using the traditional methods (e.g. CPM) despite the emergence of more modern techniques that overcome the pitfalls of their traditional counterparts and allow for better resource planning. Companies are not resorting to such more modern methods primarily because of their resistance to change. Using lean construction as an example, Marhani et al. (2013) refers to seven different categories of barriers to implementation: Managerial commitment, technical difficulties, human attitude, implementation process, training and education, and market fluctuations and lack of financial incentives. Most owners still rely on their contractors to develop schedules, but they play a role through audits and performing due diligence. This also falls under the "strong owner" concept advocated for by Winch and Leiringer (2016). But this means that there is a huge variance in schedule quality and level of detail as it is a function of the contractor doing it. Alignment and integration among project stakeholders is key for a proper scheduling but it is often the owner's responsibility to enforce such integrative culture rather than it being an industry standard. Globalization has not impacted planning that much from a procedural standpoint. It only impacts inputs and outputs. The project personnel have more aspects to consider but they are doing so using the same tools and procedures regardless whether the project is domestic or international.

While planning serves as the main component to develop a project baseline, it is considered to be more rigid than scheduling since it mainly focuses on what is the best way to perform the project and establish the baseline while scheduling tries to incorporate as many real-life scenarios as possible to see how they can impact that baseline. The practice has not changed over the past decade (it is still done the same way it was done before) while the quality of the deliverable has degraded due to the increased uncertainties, increased stakeholders, and the push from sponsors for faster execution. This often means that there is not enough time to do proper planning, leaving the project management personnel with no option but rather "drive" the project and predict the future on the go instead. The contractor's input is still not often utilized during planning and there is not a common/standard planning approach available so far. Such non-standardization can go as far as who is invited to the planning meetings. As an approach for standardization, Kähkönen et al. (2013) called for the formation of core project teams to guide the project throughout its life cycle, defining a team to be the "central organizational unit for projects and their management". Listing possible core teams depending on the stakeholders of a given project, one of those teams would include the contractor personnel for being the "implementation experts". On the bright side, there is a potential for improvement as companies tend to share ideas through industry forums in additions to the planning tools developed over the past few years for small projects to protect them from "flying under the planning radar" (e.g. CII 2015b). Similar to scheduling, globalization has not impacted planning that much from a procedural standpoint. It only impacts inputs and outputs. The project personnel have more aspects to consider but they are doing so using the same tools and procedures regardless whether the project is domestic or international.

While the increased project complexity makes the implementation harder, cost control has improved due to the improvement in IT systems, 3D model integration, as well as the push from owners to standardize the contractors' deliverable to allow for a more detailed analysis. It still relies heavily on personnel expertise as poor software implementation and setup might lead to incorrect outputs and consequently more work. A case study by Zhao and Wang (2014) has reached the same conclusions, there are barriers to proper BIM implementation and wide adoption for cost control purposes, yet practitioners should train themselves to fully reap its potential rewards. Smith (2016) mentions that one of the reasons is the fact that the model objects lack the data required by project cost managers. The main bottleneck is the task-oriented approach adopted by project managers in managing their projects without necessarily tying those tasks to cost accounts through linking their work breakdown structure to a cost breakdown structure and a resource breakdown structure. As mentioned earlier during the literature review, integrating cost and schedule control to overcome that issue has been the subject of many research efforts (e.g. Cho et al. 2013; Wang et al. 2016).

Change management has gone better and is significantly promoted across projects. Especially with the various technological development that allow for more timely change detection (e.g. Du et al. 2016; Liu et al. 2014) The main bottleneck is the culture because the managers have to report their performance trends, and some might not acknowledge the fact that their projects are failing until it is proven to them. Regarding change factors, the industry is getting better with acknowledging and solving internal factors (e.g. resource shuffling and distribution). Jayatilleke and Lai (2018) have reviewed causes and models of requirement change management following both the traditional and the agile management approaches, as well as methods to predict those changes. The external factors (e.g. market prices), however, fluctuate so rapidly that they are causing more stress on the projects.

There is no observable change in how progressing and reporting are done. While technology is supposed to help with the timeliness of data collection, modeling, and visualization, the use of such tools is still not a reality because the task is so difficult, complex and effort driven that it is much easier and simpler to do traditional reporting. There is a failure in measuring what is important for project assessment as well as the clarity of a roll up matrix and aggregating various reports. These observations are similar to the ones obtained by the authors through the literature review. The works of Orgut et al. (2016) can be considered to be a step in the right direction regarding what metrics actually contribute to project performance and are worth measuring compared to what metrics are perceived to be important. The ultimate goal is to develop a list of "must-have" metrics for project performance and then a list of other "nice to have" ones where a business unit can choose from the list what can best benefit its objectives. Currently, each business unit elects what metrics to measure and track based on what they are looking for. For example, an owner who wishes to track the contractor's performance may elect to track the number of revisions a document has gone through after being approved (the lower the better, zero being ideal) and use that as a performance indicator.

Forecasting is getting better as it allows the managers to be more proactive regarding the changes happening to their projects. There is a lot of value added in terms of showcasing real calculations and trends and comparing them with what the management personnel believe. This sometimes turns the forecasting function into more of a negotiation activity because it is frowned upon to show such high forecasts even though that was true. Especially with the fact that management and sponsors tend to be more fixated towards a number as opposed to a range or a confidence level. It heavily relies on the timeliness of the data and the way progressing is measured (e.g. earned value). The techniques and software are there but they are implemented on a few projects. Also, project complexity poses some forecasting challenges. One can get better and more direct forecasts if the function was the responsibility of a different line of command as opposed of having it part of the project manager's responsibility. Timeliness of data is a major issue, typically owners would push for no more than a one-week lag between data collection and reporting. But depending on the size of the project that lag can grow up to a month because of the responsibility matrices the data has to go through for validation and approval prior to being presented. This makes the data not so helpful for future forecasting because by the time it gets out the project is already "living the future".

Limited resources regarding data collection for forecasting purposes, which is often the contractor's responsibility, does not pose a major threat to the quality of forecasting since it is not an industry trend but it is targeted towards the smaller projects that do not require those resources and consequently an intricate level of forecasting. The complexity of forecasting is a function of ow big the project is. While project complexity does not directly impact the complexity of forecasting, but it affects the method of forecasting and the way it is reported. Less complex projects might not need a formal report, while more complex projects warrant the need of using methods such as earned value techniques or line of credit to validate the actual work. Multi-disciplinary projects would need to be broken into smaller pieces (e.g. work packages) where the performance of each piece is evaluated separately before they can be aggregated and before trends and indices can be developed and properly used.

Table 2 relates the trends attained from the literature review to the ones observed by The Experts, summarizing the above paragraphs, in a point-counter-point fashion. With only the function and, later on, its observed trends being presented, The Experts reached their conclusions freely and without guidance from the project team. The authors only interfered when a trend was not being addressed as part of the discussion. Later on those comments were later on analyzed to see which trend a comment is addressing. Some of the comments did not correlate to any of the observations found in the literature. Hence they were listed under “Newly Introduced Points”.

Table 2: Point-Counter-Point Comparison for the trends attained from literature vs. the ones observed by the COP meeting group

Function	Observed Trend	Expert Comments	Newly Introduced Points	Expert Conclusion
estimation	Integration of BIM and CAD (Castro-Lacouture and Wasmi 2016; McCuen 2015).	BIM is being implemented but up to the level supported by the project budget, so smaller projects are unable to reap full benefits. The software usage is very standardized and common up to the point where some estimators run the software without necessarily understanding what it does	Owners still rely on contractors for estimation. Hence, they are not getting better in estimating but they are getting better in controls.	Worse overall
	Workforce Skills, price shocks, declining productivity	This is true, one more thing is that contractors often base their estimates on the wrong rates. Some contractors tend to be over-optimistic with their estimates for the sake of being competitive which sometimes make the numbers unrealistic. Professionals are still unable to bill their own experience		
Scheduling	Globalization and virtual teams (CII 2012, Comu et al. 2015)	Globalization affects the inputs and outputs, but not the process. The same tools are still used for both domestic and international projects.	Owners rely heavily on contractors to develop schedules while playing a role through audits and due diligence	No change
	lack of team integration/alignment (CII 2015a)	Alignment and Integration is key and it is often the owner's responsibility.		

Table 2 (continued)

Planning	Retirements – less experience Shorter project schedules; inconsistent	There is a lessons-learnt culture within the industry by sharing ideas through industry forums. But there is no common planning approach at this point.	Planning is still done using the same conventional methods	No Change in practice, but less quality of the outcome
	Project complexity and increased execution speed	Stakeholders and sponsors want faster execution without necessarily allocating enough time for planning. So projects end up being "driven" with poor planning and more scheduling is done on the go. Many small projects used to go under the radar, but this is becoming less and less due to the planning developed being developed over the past 3-5 years.		
	Globalization and global integration (CII 2012; Comu et al. 2015)	Globalization affects the inputs and outputs, but not the process. The same tools are still used for both domestic and international projects.		
	lack of team integration/alignment (CII 2015a)	The contractor input is still not utilized in planning efforts, but this is starting to change		
Cost control	IT developments and Integration into schedule control (e.g. Cho et al. 2013; Wang et al. 2016)	There are software packages available now that would make the task easier, but it largely depends on how the software is set up. Poor implementation doesn't give the right answer and leads to more work.	Timeliness and validity of Data Lack of connection between cost control line items and WBS.	Better but not easier to implement due to complexity

table 2 (continued)

	Increased oversight (CII 2011)	There is an owner trend to standardize what contractors need to provide for them to assess the costs in more detail.		
Change Management	IT systems development leads to More frequent change recognition (CII 2011; liu et al 2014; karimidorabati et al. 2016)	The IT implementation can give you the trends, but ultimately it is up to the managers to report such changes. This makes it more of a culture issue than a software issue		Better, but projects are becoming mores stressed because of external change factors (e.g. price fluctuations)
Progressing	Inconsistent metrics (CII 2016)	There is a failure in measuring what is "really important" Beyond what is commonly known as key metrics to measure performance (e.g. schedule, cost, etc.), each business unit can elect what metrics they would want to focus on based on what they are looking for.	Progressing and data collection is primarily the contractor responsibility. Owners focus on analyzing the reports and data they receive.	No changes observed
	No guidance for improving metric reliability (CII 2016)			
	Current metrics unable to provide a "true" measure of project performance			
	Complexity, contractor specialization, outsourcing	Project complexity call for different methods of progress measurement and reporting (e.g. earned value management) Having multiple contractors/disciplines means that each scope of work is forecasted independently before trends and performance indices can be evaluated		

Table 2 (continued)

	Research in Predictive data analytics (Lin and Golparvar-Fard 2017)	The plan is that technology would allow for capturing real-time data to be integrated into the developed models. But that is still not a reality. The task is currently so complex and effort driven that it is better to do traditional reporting.		
	BIM for on-site construction and Material Tracking (Garcia-Lopez and Fischer 2014)			
Forecasting	Limited resources for forecasting	Limiting resources is intentional because it only takes place in small projects which don't warrant that much of attention	Sometimes forecasting the final project cost becomes a negotiation rather than relying on actual data A better answer for how well the project is going can be obtained if the function was taken from the construction team and assigned to a different line of command Management tend to get attached to the forecasted number rather than the range or the confidence level	Getting better overall
	More forecasting techniques (el shaer 2013, khamooshi and golafshani 2014, lipke 2011)	There is a lot of added value in comparing expectations with actual calculations and trends.		
	Implementation of artificial intelligence (Wauters and Vanhouke 2016)	Data visualization in front of management allow them to be more proactive and shows them which direction the project is actually headed to despite their personal beliefs that goals can be accomplished in a certain way		
	Project complexity	Complex projects can be brought down to smaller parts (e.g. work packages) for easier forecasting. Hence, forecasting complexity depends more on the project size than complexity level.		

4.2. Initial Screening of the Survey Results

Table 3 compares the results from the recently administered survey to their Report counterparts. It is important to mention that these results are not final as they are pending further data points to be statically significant. This is also the reason why there is no detailed breakdown of the current results. For the sake of fair comparison, the results for owners and contractors were recombined through weighted averages based on the number of responses (see Equation 1) to yield collective results. The objective of the comparison is not to reach a decisive conclusion, but to establish a trend for what could be expected from a bigger dataset and to establish a sense of urgency and need within the CII community to provide a bigger dataset.

Equation 1:Calculation Of The Collective Weighted Average Score Between The Owners And The Contractors Based On The Number Of Responses Received (Total Responses Received By The Report Authors Were 28 Owner Responses And 25 Contractor Responses)

$$The\ Report\ (collective) = \frac{The\ Report\ (Owners) * 28 + The\ Report\ (Contractors) * 25}{28 + 25}$$

Table 3: Comparison between the Results Obtained Through Initial Screening of the Recently Administered Survey to Those Produced from the Report

Function		The Report (Owners)		The Report (Contractors)		The Report (Collective)		Current Status (Collective)	
		Eff.	%	Eff.	%	Eff.	%	Eff.	%
Estimating	Processes	2.15	66%	2.05	76%	2.10	71%	1.7	75%
	IT	2.25	44%	2.25	69%	2.25	56%	2.68	60%
	Training	2.28	45%	2	55%	2.15	50%	1.88	45%
Scheduling	Processes	2.03	71%	2.18	84%	2.10	77%	1.93	70%
	IT	2.18	49%	2.4	79%	2.28	63%	2.3	75%
	Training	2.23	54%	2.03	77%	2.14	65%	1.63	45%
Planning	Processes	2.08	71%	2.13	81%	2.10	76%	1.95	75%
	IT	2.15	40%	2.2	69%	2.17	54%	2.25	20%
	Training	2.18	54%	1.98	67%	2.09	60%	1.58	40%
Cost Control	Processes	2.18	71%	2.1	73%	2.14	72%	2.2	90%
	IT	2.35	48%	2.08	76%	2.22	61%	2.63	65%
	Training	2.25	48%	1.83	67%	2.05	57%	1.73	45%
Change Management	Processes	2.1	69%	2.18	78%	2.14	73%	2.08	70%
	IT	2.03	38%	2.18	63%	2.10	50%	2	20%

Table 3 (continued)

	Training	2.18	46%	1.83	67%	2.01	56%	1.63	35%
Progressing	Processes	2.18	57%	2.15	76%	2.17	66%	1.58	60%
	IT	2.25	41%	2.1	72%	2.18	56%	2	20%
	Training	2.08	45%	1.9	62%	2.00	53%	1.5	30%
Forecasting	Processes	2.13	48%	2.05	76%	2.09	61%	2.03	65%
	IT	2.05	35%	2.1	69%	2.07	51%	2.23	55%
	Training	2.1	43%	1.7	65%	1.91	53%	1.75	35%

All functions have reported a decline in the availability of training modules as well as the efficiency of those modules. On the other hand, IT has witnessed an overall improvement in terms of presence (with the exception of change management and progressing) as well as efficiency (with the exception of change management, progressing, and planning). This comes as a surprise since both the literature review and the COP discussion indicated otherwise; that the tools are becoming more available, yet the problem is with utilization to deliver the "right" outputs. Cost control was the one of only three functions (along with forecasting and estimating) that has an increased adoption of formalized processes, yet it was the only function where the efficiency of said processes has increased.

This goes back to one of the main conclusions of the COP discussion. Which was the fact that there is a state of overreliance on IT software to the point that the only piece of knowledge required is how to run the software. Training is more focused on data entry than on understanding the core principles of the functions.

Among the seven functions, change management and progressing where the only two that have gone worse on all three parameters. This raises concerns especially taking into account the fact that these two functions were the ones with the direst needs for improvements due to the ongoing industrial trends on increased stakeholders, speed and uncertainties. Such declines have made these two functions the two weakest and least utilized functions of the modern era of the construction industry

The improved efficiency of planning IT is promising since planning was one of the functions that relies primarily on personal experience rather than rigid procedures. Hopefully this opens up the opportunity for better collaboration and sharing of said experiences. The improved efficiency in IT for the other functions, however, is expected due to the prior high dependency of those functions on IT and the availability of off-the-shelf software packages for them. Hence the only step that was missing is periodic upgrades and integration packages.

Overall, the initial screening of the survey results show that project control functions have gone worse over the past decade in terms of efficiency as well as adoption rates.

Chapter 5: Conclusion and Recommendations

The objective of this thesis is to study the current state of Project Controls as well as how and why it has changed over the past ten years. This was done using the CII PCMS Research Report (2011), hereby referred to as The Report, as a reference point. The research consisted of a literature review portion to develop a hypothesis regarding the state of each project controls functions as well as the reasoning behind that state before testing the hypothesis quantitatively, through re-administering The Report's survey, and qualitatively, through discussions with industry experts. This thesis is still bound by the same limitations originally established by The Report in terms of focusing on the CII community. Other limitations are the potential subjectivity of The Experts involved as they are part of the same community as well as he low number of data points collected which made the results non-decisive because of the lack of statistical significance. What the study has succeeded to do is shed the light on the issue of PCMS implementation within the construction industry, establishing a trend and motivating the CII community to develop a more extensive study to describe the state of the industry more accurately.

One of the major findings is while PCMS principles are still valid to date, the problem lies with the way companies adopt and implement those principles. The surveys showed a more pessimistic view of the state of project controls than the COP discussions, but it was not surprising to the COP members when presented. There are various trends that have led to the downfall of PCMS adoption and efficiency. These trends include market fluctuations, lack of skilled personnel, increased project complexity and execution speed, contractor specialization which has led to increased number of stakeholders, and others. Owners still rely heavily on the contractors for estimating and scheduling, only taking part in the process through auditing, which makes the quality of the output a function of the contractor doing the job. The industry is currently lacking efficient training modules that teach the concepts of project controls not just how to run the software. There is a lack of collaboration structures set in place between owners and contractors which affect the timeliness and the accuracy of the data exchange. There is also a problem with consistency regarding planning frameworks and procedures as well as progress reporting and data collection. Finally, while the literature shows great development potential and technological breakthroughs, there is no industry-wide adoption of such developments.

Hence, the following are recommendations to help companies better adopt PCMS functions. The recommendations are listed in no particular order:

1. Develop proper training modules that focus on understanding the concepts and essence of how and why a given function is implemented in practice rather than focus on teaching the practitioners how to run the software.
2. Devote time to analyze and challenge the software outputs.
3. Develop a collaboration culture between the contractor and the owner, focusing on the fact that official documents are there to allow for collaboration and risk sharing efforts rather than reprimands.
4. Develop a consistent list of what metrics should be measured, what type of primary data to be collected for a given metric, and why should they be measured (how the correlate to the business performance indicators)
5. For owners: take part in the data collection/generation process instead of focusing on mere analysis through audits and due diligence.
6. Develop consistent project planning methodologies where the input of all project stakeholders is utilized.

7. Collaborate more with the academic community and consider further implementations of the tools and models developed by academic researchers.
8. Advocate for utilizing modern scheduling and planning methods and counter the existing resistance to change mentality.
9. Establish a framework that can reliably correlate between developed plans, estimates, and schedules and the time and location where they were created

Based on the initial results, this thesis identifies forecasting, progressing and change management as areas of potential improvement. It also highlights training modules in general as well as the startup phase as areas that require attention moving forward.

Appendix A: CII Project Controls and Management Systems Survey

All surveys will be kept in confidence per CII confidentiality rules. All data will be reported in aggregate form and no personal identifying information will be revealed.

DEFINITION: Project Control and Management Systems (PCMS) includes the people, processes and tools for the planning and execution of all phases of capital projects including, but not limited to, estimating, cost control, planning, scheduling, change management, work packaging, reporting, progress measurement, and forecasting.

PURPOSE: This survey asks you to quickly assess PCMS practices in your company across project phases and functions. The goal is to compare the findings on PCMS with a survey performed by RT-244 in 2007.

Section 1: Use of PCMS in Your Company

Instructions: This part of the survey seeks detailed assessment of practice across several PCMS functions. For each function, please indicate whether your company has 1) a Formal/Documented Process, 2) an IT System to Support Process, and 3) Core Competency Training. In addition, please indicate the effectiveness of your company's 1) Formal/Documented Process, 2) IT System to Support Process, and 3) Core Competency Training on a L-A-H scale.

Low **(L)** – Process/System/Training provides poor/minimal support for projects.

Average **(A)** – Process/System/Training provides adequate support (typical industry practice)

High **(H)** – Process/System/Training provides superior than typical support for projects

DESIGN

	Do you have…and how effective is…					
PCMS	**Formal/Documented Process**		**IT System to Support Process**		**Core Competency Training**	
	Yes /No	L/A/H	Yes/No	L/A/H	Yes /No	L/A/H
Estimating	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Scheduling	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Planning	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Cost control	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Change management	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Work packaging	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Progressing	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Forecasting	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Is the handover between **design** and **procurement** processes seamless?

Yes ☐ No ☐

Are the IT systems used in the **design** and **procurement** phases integrated?

Yes ☐ No ☐

PROCUREMENT

PCMS	**Do you have…and how effective is…** **Formal/Documented Process**		**IT System to Support Process**		**Core Competency Training**	
	Yes /No	L/A/H	Yes/No	L/A/H	Yes /No	L/A/H
Estimating	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Scheduling	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Planning	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Cost control	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Change management	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Work packaging	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Progressing	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Forecasting	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Is the handover between **procurement** and **construction** processes seamless?

Yes ☐ No ☐

Are the IT systems used in the **procurement** and **construction** phases integrated?

Yes ☐ No ☐

CONSTRUCTION

PCMS	Do you have…and how effective is… Formal/Documented Process Yes /No	L/A/H	IT System to Support Process Yes/No	L/A/H	Core Competency Training Yes /No	L/A/H
Estimating	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Scheduling	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Planning	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Cost control	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Change management	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Work packaging	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Progressing	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Forecasting	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Is the handover between **construction** and **start-up / validation** processes seamless?
Yes ☐ No ☐

Are the IT systems used in the **construction** and **start-up / validation** phases integrated?
Yes ☐ No ☐

START-UP / VALIDATION

PCMS	Do you have…and how effective is… Formal/Documented Process Yes /No	L/A/H	IT System to Support Process Yes/No	L/A/H	Core Competency Training Yes /No	L/A/H
Estimating	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Scheduling	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Planning	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Cost control	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Change management	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Work packaging	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐
Progressing	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Forecasting	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐	☐/☐	☐/☐/☐

Section 2: PCMS in Your Company

Your company's name: ____

Do you have a dedicated project controls group?___________________________

Is the function centralized / decentralized?_______________________________

Which of the following areas is your company investing in to improve PCMS capabilities? (Check all that apply)

PCMS Processes ☐ Technology ☐ Core Competency Training ☐

Your name (optional): ____

Your telephone (optional): ____

Your e-mail address (optional): _____________________________________

Would you like a copy of the survey results? (If yes please provide e-mail address)

Yes ☐ No ☐

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Thank you for participating in our survey. Please contact Dr. Bill O'Brien at wjob@mail.utexas.edu for question and comments.

At the Board of Advisors meeting, please return survey to the registration desk. If mailed, please return survey to **Dr. Bill O'Brien** at The University of Texas at Austin, Department of Civil, Architectural & Environmental Engineering, 300 East Dean Keeton, 1 University Station, C1752, Austin, Texas, 78712-0273, wjob@mail.utexas.edu.

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