Assessing the Need for All-Inclusive Project Management Information Systems in the Construction Industry

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Abstract

This capstone report features an assessment of the need for an all-inclusive project management information system (PMIS) software program for the construction industry. The number of project management application service providers (PM-ASPs) available to the construction industry has increased over the past decade. While it was believed a decade ago that companies would begin integrating and reducing the number of programs in use, the number of programs in use has instead risen. The rise in programs in use by a company has been shown to lead to difficulty integrating programs, a loss in productivity, and fragmentation within the internal company. PM-ASPs have begun changing their model from focusing on one feature, i.e., scheduling or document control, to integrating multiple features. These all-inclusive programs focused on the construction industry have been shown to improve productivity, enhance efficiency, reduce costs, improve collaboration with project stakeholders, and spur business growth. The study also features an analysis of the views of the subjects and their companies on their perceived importance of integration, their limitations concerning implementation of a PMIS, what features should be in an all-inclusive program, and how the productivity of a PMIS affects a company and the subject's views. Lastly, open-ended comments about the current industry's trends with PMIS software are analyzed.

Keywords: construction, project management, project management information System (PMIS), software integration, all-inclusive PMIS software

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Historically, construction is an industry that has had well documented fragmentation problems, and it occurs in two ways: fragmentation of construction processes, and fragmentation of the project parties (Alashwal & Abdul-Rahman, 2011; Mohd Nawi, Baluch, & Ahmad, 2014; Sarkar & Jadhav, 2016). Project management information systems (PMISs) have helped solve some of the major problems of fragmentation in construction that has hindered the industry by streamlining communication and work-flow between project stakeholders (Forbes & Ahmed, 2011; Sarkar & Jadhav, 2016). The systems also have had significant positive impacts on the productivity of project managers and the overall success of the project (Raymond & Bergeron, 2008).

A project management information system (PMIS) is defined by the *PMBOK- Project Manager Body of Knowledge,* 5th edition, as "a system consisting of the tools and techniques used to gather, integrate, and disseminate the outputs of project management processes" (Project Management Institute [PMI], 2013, p. 580). Today's project management information systems have many types of features, such as drafting, accounting, spreadsheets/document creating, pre-construction, sales, scheduling, project control, RFIs (requests for information), change orders, and more. The marketplace has become congested over the years with PMIS being developed by project management application service providers (PM-ASP's) that focus on one feature within the construction process, i.e., AutoCAD with drafting, Dropbox with document storage and control, and Oracle with scheduling (Nitithamyong & Skibniewski, 2004). It is estimated in a 2017 report that over 1,000 start-ups are currently working on bringing new construction technologies to the industry (Tracy, 2017).

Scholarly research has shown that a resultant problem of the singularly focused PMIS has been that construction companies are choosing the best software that satisfies a functional need, such as scheduling or estimating, without regard to process workflow and system integration amongst all programs used internally within the company (Lotffy & Parth, 2015). Having to use many different types of PMISs to completely satisfy company needs is well documented by the industry (Armstrong & Gilge, 2016; JBKnowledge, Inc., 2017). The average number of programs in use by companies has grown steadily over the past decade. In 2008, less than 40% of companies used more than one PMIS. By 2012, over 85% used more than one PMIS; and by 2017, 60% of construction companies admitted to using at least three programs and sometimes six or more. (Armstrong & Gilge, 2016; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017; Raymond & Bergeron, 2008).

Frustrations are commonplace where different project management information systems do not communicate or integrate well with each other (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017). A PMIS was meant to solve the problem of fragmentation between stakeholders in construction. Conversely, it has added another layer of fragmentation at the company's internal level that organizations must now work to overcome. The solution for most companies is to create a system of double data entry by using comma separated values (CSV) or custom built macro-enabled spreadsheets to force the integration and communication. The functions of a company most dependent on spreadsheets was found to be estimating (71%), Accounting (59%), and Project Management (46%) (JBKnowledge, Inc., 2017). However, this 'solution' results in lost data, lost methodology and insight within the construction process, lost communication, and lost productivity of essential team members (Lotffy & Parth, 2015). This is because employees spend as much time manipulating data between PMIS programs as they do

analyzing the data, and they end up doing it primarily through external means rather than within the program itself.

Over the years, PMIS programs have begun to evolve to include many different types of features in one integrated package (Braglia & Frosolini, 2014; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). These all-inclusive PMIS programs, sometimes referred to as Construction Enterprise Information Systems (CEIS), "are aimed at achieving seamless integration of all processes and information flowing through a [construction] firm" (Tatari & Skibniewski, 2011, p. 347). Today's PM-ASPs are developing all-inclusive and integrated PMIS software programs for the construction industry, but scholarly research to date has not researched the needs of an all-inclusive PMIS by the construction industry, only the benefits of use. Scholarly research to date has concluded that integration of software is an important factor in PMIS success, but it has not looked at the trends of companies using PMIS programs currently within the industry and whether integration is still an issue (Braglia & Frosolini, 2014; Raymond & Bergeron, 2008; Tatari & Skibniewski, 2011).

In this paper, the results of a survey and scholarly article review are presented, which were used to gather information about the construction industry on their current PMIS usage and trends concerning project management information systems. This was done by surveying alumni from the Milwaukee School of Engineering CAECM (Civil/Architectural Engineering & Construction Management) program and construction professionals from recruiting companies at the MSOE career fair who leave behind their contact information. Respondents are primarily from the Midwest and are currently working within the industry at companies varying widely in revenue, size, company type, and job position.

The goal of the study was to investigate what an all-inclusive construction PMIS is and to determine if there is a need for it within the construction industry. This was done by analyzing background information and scholarly articles about PMIS programs to find knowledge gaps in existing literature. The survey was both qualitative and quantitative in nature and asked about the company's current usage of PMIS, the subject's own current satisfaction, what type of PMIS software programs they are using, and what features they are using PMIS software for. Lastly, the survey asked participants if they see a need for an all-inclusive PMIS in the construction industry and what that hypothetical program should include as far as features and capabilities. The research concluded with analysis of open-ended questions and general comments about PMIS usage in the construction industry. The goal of this capstone project was to close knowledge gaps or add to the background knowledge of PMIS programs in the construction industry by assessing the need for an integrated all-inclusive PMIS.

Background

Fragmentation in Construction

In recent years, construction overall has seen very little increase in productivity (Sveikauskas, Rowe, Mildernberger, Price, & Young, 2018). In the year 2000, upwards of 30% of construction costs were due to poor quality, mistakes/reworks, and delays caused by miscommunication (Forbes & Ahmed, 2011). Forbes and Ahmed (2011), claim this is caused by a few critical factors that revolve around communication and lean principles. Lotffy and Parth (2015) found the following:

> Companies risk $135 million for every $1 billion spent on a project, and new research indicated that $75 million of that $135 million (56%) is put at risk by ineffective

> communications, indicating a critical need for organizations to address communications deficiencies at the enterprise level. (p.1)

Construction is an industry with a long history of fragmentation and it occurs in two ways: fragmentation of construction processes, and fragmentation of the project parties (Alashwal & Abdul-Rahman, 2011; Mohd Nawi, Baluch, & Ahmad, 2014; Sarkar & Jadhav, 2016). The typical contractual guidelines of design-bid-build, design-build, design-CM, and Engineer-procure-construct puts project stakeholders (i.e., Architect/Engineer, Owner, Contractor, and Subcontractor) in adversarial roles (Forbes & Ahmed, 2011). This adversarial role directly contributes to a lack of sharing information, miscommunication, and poor information processing between parties and is often seen as one of the major contributors to low productivity in construction (Nitithamyong & Skibniewski, 2004; Lotffy & Parth, 2015; Sarkar & Jadhav, 2016). To overcome deep fragmentation in construction, project stakeholders have had to implement an integrated and lean approach in the design and construction process (Forbes & Ahmed, 2011; Mohd Nawi, Baluch, & Ahmad, 2014; Project Management Institute [PMI], 2013).

One solution that the construction industry has used to help overcome the barriers of communication and fragmentation is by using project management information systems to communicate and share project information freely with other project stakeholders (Braglia & Frosolini, 2014; Forbes & Ahmed, 2011; Sarkar & Jadhav, 2016). Project management information systems (PMISs) are defined by the PMBOK- Project Manager Body of Knowledge, 5th edition, as “an information system consisting of the tools and techniques used to gather, integrate, and disseminate the outputs of project management processes” (Project Management Institute [PMI], 2013, p. 580). These PMIS tools have greatly increased the efficiency of project

managers and design professionals (Braglia & Frosolini, 2014; Forbes & Ahmed, 2011; Shan, Zhai, Goodrum, Haas, & Caldas, 2016).

A core competency of today's project manager is to ensure that the proper information is flowing through to other project stakeholders in the most effective and efficient way possible (Lotffy & Parth, 2015; Project Management Institute [PMI], 2013). Project managers and other project stakeholders in construction utilize PMIS tools and software to help plan, execute, and monitor their projects from conception to completion, and include both manual and automated processes (Braglia & Frosolini, 2014; Lotffy & Parth, 2015). PMISs have been found to have a profound impact on project success by improving efficiency in managerial tasks, such as planning, scheduling, monitoring, and controlling (Project Management Institute [PMI], 2013; Raymond & Bergeron, 2008). While not sufficient enough to guarantee that a project is successful, a PMIS is still a necessity to effectively manage a construction project (Lee & Yu, 2012). PMISs were introduced to improve efficiency and information process workflow because executing those tasks and information manually reduces efficiency and can have negative impacts on the project management operations and construction project (Sarkar & Jadhav, 2016).

The Birth of Project Management Information Systems

Project Management Information Systems (PMISs) have been used in the management of business processes since the late 1980s. The earliest PMIS was developed by Gatco Inc. in the United Kingdom as a way of managing clinical trial data (Brackett & Isbell, 1989). The system was utilized to alleviate some of the issues of disbursing hard copies by distributing and communicating information across users and different levels of management via computers. This database was connected via the early days of the Internet and allowed companies in the United States to log onto a computer and readily access project information from Great Britain. This

greatly streamlined the time it took to communicate project specific information, reducing it from weeks to minutes. Unfortunately, the first PMIS developed was very project specific and was not translatable to the construction industry. The concepts of web-enabled communication and PMIS software, however, were just on the horizon.

New companies would come to emerge in the 1980s and early 1990s that developed PMISs that were more construction specific. A high percentage of PMIS solutions and features today focus on specific tasks, such as project planning, estimating, design, etc. (Alshawi & Ingirige, 2003). Companies that specialize in programming PMIS software, like Oracle, Microsoft, and AutoCAD, have been market share juggernauts for almost 30 years in their focused PMIS function fields of scheduling, document control, and drafting, respectively (Braglia & Frosolini, 2014; JBKnowledge, Inc., 2017). In recent years, the marketplace has become congested with hundreds of different types of PMISs that are used in different industries and for different features. As construction businesses and projects become more and more complex, companies are starting to use more and more software applications for different features (JBKnowledge, Inc., 2017).

PMIS Fragmentation

The number of choices in the marketplace presents a problem when choosing a software solution for contractors as many companies seriously underestimate the importance of program integration (JBKnowledge, Inc., 2017). A construction technology survey found that 70% of respondents reported having to use three or more different construction programs because none completely satisfied all their PMIS needs (JBKnowledge, Inc., 2017). Numerous surveys and technology reports for the construction industry have concluded that about 20% of companies are having to use as many as six different specialized programs to meet their company's needs

(Armstrong & Gilge, 2016; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017). In all these surveys, fewer than 20% attest to using a fully-integrated PMIS across their entire enterprise (Armstrong & Gilge, 2016; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017). Most recently, it was discovered in a survey that 30% of applicants said that none of its PMIS software currently in use integrate with each other (JBKnowledge, Inc., 2017).

According to Tatari and Skibniewski (2011), companies typically exercise four different methods when building or linking PMISs together:

1. Legacy System – an information system previously designed specifically for the firm's needs.
2. Enterprise Resource Planning – Off-the-shelf, commercially available enterprise information systems.
3. Best-of-breed – Collection of stand-alone application connected to one another.
4. Stand-alone – Collection of individual applications not connected to one another.

Scholarly articles indicate that a PMIS is often integrated into a company piece by piece; otherwise, the users would suffer from an information overload and companies would not have enough control of the implementation process (Braglia & Frosolini, 2014; Nitithamyong & Skibniewski, 2004; Tatari & Skibniewski, 2011). Most recently, it was discovered that many construction companies also report that PMIS solutions are adopted at the departmental level, without consideration to how their PMIS's information synchronizes and communicates with other departments (JBKnowledge, Inc., 2017). Because of these two factors, Information Technology (IT) managers and company executives are integrating one function, i.e. scheduling and estimating, of their company's processes into one PMIS program at a time. The short term,

and seemingly logical, decision for most companies is to choose the best program that performs at that function. As a result, most businesses are using disconnected instruments that are not designed for managing complex projects, but rather complex functions within a project (Braglia & Frosolini, 2014; Tatari & Skibniewski, 2011). This best-of-breed strategy is meant to get the maximum benefit of individual programs and create a custom way of integrating the information (Tatari & Skibniewski, 2011). The actual results are often fragmentation amongst internal job stakeholders because of a lack of communication between the programs, different features, and different positions of the internal company that use them (Lotffy & Parth, 2015; Tatari & Skibniewski, 2011).

System quality has a profound impact on a PMIS's success (Lee & Yu, 2012). System quality measures the extent to which a PMIS is technically sound by analyzing whether there are bugs in the system, consistency of the user interface, ease of use, quality of documentation, and sometimes quality/maintainability of the information and coding (Lee & Yu, 2012). The attributes for system quality are connectivity and usability, both of which are centered around the PMIS's compatibility with other software and its ease of use (Lee & Yu, 2012). The ability to process large amounts of information in an integrated and meaningful way in a PMIS is crucial to the overall success of the PMIS (Braglia & Frosolini, 2014; Froese, 2010; Lotffy & Parth, 2015; Nitithamyong & Skibniewski, 2004).

Using multiple PMIS solutions that do not easily integrate requires that companies transfer data using double data-entry either manually, via spreadsheets/comma separated values (CSV's), or custom-built integration using macro-based enabled worksheets (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017; Tatari & Skibniewski, 2011). This contributes to problems with software workflow, shortcomings in customization amongst

the different programs themselves, and poor integration with accounting software (Armstrong & Gilge, 2016; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). The approach makes it difficult and very time consuming to process information, taking up most of the user's time entering data rather than monitoring, screening, and interpreting the data (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). The process itself opens the opportunity for error and causes companies countless hours in lost productivity due to the reverting to spreadsheets and manual entry to connect data seamlessly between software (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; JBKnowledge, Inc., 2017). If PMIS tools are manual, standalone, or segregated; transparency, human errors, and communication with project stakeholders will inevitably suffer (Armstrong & Gilge, 2016).

The solution to having to use multiple PMISs for many companies is to use a company server to store and connect to each individual PMIS via the Internet (Nitithamyong & Skibniewski, 2004). The databases of information still do not connect with each other in a completely integrated way and it is challenging to look at individual programs or a folder holding all files and see the bigger picture of a construction project (Braglia & Frosolini, 2014). The important information gets lost amongst all the other small bits. Even more recently, in lieu of company servers, companies are beginning to outsource their data storage to web-enabled third-party programs, which has reduced the necessity of transferring information via hard copy or e-mail specifically and has increased communication amongst project stakeholders (Braglia & Frosolini, 2014; Bilal, et al., 2016; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; Sarkar & Jadhav, 2016). It also relieves the company of data control expenses and is often cheaper than their off-line counterparts (Alshawi & Ingirige, 2003; Bilal, et al., 2016; Braglia & Frosolini, 2014; Sarkar & Jadhav, 2016).

Only 36% of engineering and construction firms in a survey said that they were able to utilize PMIS solutions for advanced data analytics, in addition to cost or scheduling analytics; of that number, only 25% of owners and contractors responded yes when asked if they could "push one button" to obtain fully integrated, real time product data (Armstrong & Gilge, 2016). The low number is not surprising, considering that most firms are manually monitoring multiple PMISs (Armstrong & Gilge, 2016).

Data mining involves the automatic or semi-automatic exploration and analysis of large volumes of data to discover patterns or opportunities (Bilal, et al., 2016). The majority of PMIS solutions today can filter and data mine for aggregate data in a company's server. This has led to the construction team being able to easily pin-point and find the information they need quickly, if it can be easily found using the data mining capabilities of the program. How that information is presented or found poses a problem in today's PMISs. Organizations rarely have a systematic and pre-defined process for the way information is stored within a PMIS (Lotffy & Parth, 2015). A recent survey brought light to this problem when respondents were asked whether their company had a process/procedures manual that dictated how their day-to-day operations and information inflow was to be controlled. Thirty-seven percent said yes, 46% said yes for some process and others no, and 17% said that they had no process or procedure manual at all (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017).

It is the author's experience that finding and connecting information in a PMIS, especially when it is spread amongst different programs, can be very difficult when the information is not input, organized, or integrated in a meaningful way. A lack of a standard leaves the information updating up to the individual user, resulting in a lack of consistency and improper placement into the PMISs across the company, as well as variability from project to

project. It also leaves the way the information is presented up to the project manager, who selectively presents the information in such a way that may not accurately show schedule overruns or cost slippages (Lotffy & Parth, 2015).

All-Inclusive Construction PMIS Solutions

In 2004, Nitithamyong and Skibniewski proposed that there was a trend emerging in the construction industry. The trend indicated that the number of PM-ASPs would decrease, a standard of features would be established, and PMISs would be easier to use and more integrated with other systems than they were then (Nitithamyong & Skibniewski, 2004). One decade later, construction PM-ASPs have begun developing from singularly focused programs to complex systems that tackle many different functions within a company (Braglia & Frosolini, 2014; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; Tatari & Skibniewski, 2011). Emerging and existing PM-ASP companies have begun to add more and more features to their software to create an integrated approach to construction that is becoming increasingly more complex, but more easily data-minable (Zambare & Dhawale, 2017). However, parts of Nitithamyong and Skibniewski's theory were disproved as the number of ASPs has increased and integration is getting more difficult due to different coding (Tracy, 2017).

As it stands, companies admit to using many programs for many different features within construction, but not necessarily in the most efficient or productive way (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). It is the author's hypothesis that many construction companies do not take advantage of existing platforms when it comes to fully utilizing all advantages and many are only using a PMIS 'skin-deep' or for one of its features. For instance, a hypothetical company uses a PMIS for estimating, project management, scheduling, and cost control, but is ultimately using six PMIS programs to do it effectively. In an earlier study, Christianson et al.

(2017) defined the number of PMISs in use by a company versus the number of features or functions a PMIS is used for as the CW factor (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). By this measure, the hypothetical company has a CW factor of 0.67 (i.e., it performs four functions with six PMISs, or 4/6). It is a way to determine the productivity of PMIS usage within a company. Sixty percent of respondents said that they used more programs than they did features, which means they score below a 1.0 on the C-W Scale (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017).

Open-ended questions in the survey conducted by Christianson et al. discovered that numerous participants are feeling the frustrations of having to use many programs to capture all their day-to-day processes (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). At least five respondents from the initial survey expressed anger in open-ended questions that there wasn't a program that had an all-in-one solution to the construction process. When asked what type of PMIS functions should be included, at least 25% said they would like to see all construction functions as features under one all-inclusive program, revealing at least some need for an all-inclusive PMIS in the construction industry (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). The extent of that need has not been determined as it is only the ideas of a few subjects and perhaps not indicative of the general construction industry. Very powerful programs are being used in the construction industry currently, but not enough attention has been given in the past to the integration of programs by the software providers or the construction companies themselves (Tatari & Skibniewski, 2011).

A paradigm shift has begun that requires construction project managers and the construction companies themselves to change the way they practice project management by seeking a more unified approach with a PMIS solution to fully exploit its full capabilities

(Froese, 2010). As such, streamlining and integrating company functions within fewer PMIS programs is where the true value now lies in a company's software choices (Armstrong & Gilge, 2016; Braglia & Frosolini, 2014). The number of software applications in use by companies has declined overall since 2012, which suggests a trend among construction professionals that they are integrating more work processes into fewer programs (JBKnowledge, Inc., 2017). These statements were echoed in the open-ended comments of a recent survey where respondents said their goals were to integrate and reduce the number of PMISs in use (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017).

It is difficult to determine what survey respondents mean when they want an all-inclusive software, because it has not yet been defined in literature. When looking at any PMIS, it is important to note that project management has some very universal elements or functions that should be included: Scope, resource allocation, time, deliverables, assignments, risk management, monitoring, quality control, and customer relationship management (Braglia & Frosolini, 2014; Project Management Institute [PMI], 2013). To define an all-inclusive PMIS, it is possible to look to the definition of construction enterprise information systems (CEIS), which are defined "as a computer-based business management system that integrates all processes and data of the business, including engineering/design, planning, procurement, construction, and maintenance/operations" (Tatari & Skibniewski, 2011, p. 347).

For this study, an all-inclusive construction PMIS is defined as a project management information system software that synchronizes and integrates all the major types of PMIS functions needed to run every aspect of a construction project or company (i.e., sales, estimating, pre-construction, project management, client relationship management, accounting, jobsite reporting, scheduling, cloud storage, etc.). CEIS or all-inclusive PMIS programs are not as

difficult to implement as the industry makes them out to be, especially in an existing company (Tatari & Skibniewski, 2011). It only requires a paradigm shift from the existing company's processes and PMISs that they have grown accustomed to (Christianson, 2018). An all-inclusive PMIS requires a company initiative to implement an entire company's processes into one or two individual software solutions, but companies can hasten this process by doing more within one system and encouraging their employees to actively use it (Bor & Kiptum, 2017; Tatari & Skibniewski, 2011). "An integrated and comprehensive project management information system improves the project's information flow and accuracy to eliminate redundant files and poor data and consequently reduces time and effort being spent to obtain timely and accurate status" (Lotffy & Parth, 2015, p. 5).

Benefits of an All-Inclusive PMIS

Shortcomings of non-all-inclusive PMISs include lack of integration with other systems, a lack of standardization in the way data are entered, lack of compatibility with building information modeling systems, inadequate customization options, and lack of support for open source applications (Ilyas, Hassan, & Ilyas, 2013). An example by Lotffy and Parth (2015) of how a lack of integration plagues a company is how most project team members use e-mail to receive updates on pertinent construction information, such as RFIs, procurement logs, submittals, and construction coordination in the field. If information is stored in the individual e-mails, replies and communications down the chain are not always seen by all team members and communication discretion is left solely upon the manager of the information. Sharing of information will replace the individual data held by individual team members with a centralized system meant to streamline the most up-to-date information to all proper parties (Lotffy & Parth, 2015).

A case study of one small sitework general contracting company documents the process of switching from an offline server utilizing spreadsheets to a web-enabled all-inclusive PMIS solution (Christianson, 2018). The company, in general, had limited experience with PMISs. Issues with the existing systems were lost data, poor version control, poor communication and control internally, and inability to access information in the field. The utilization of a web-enabled all-inclusive PMIS greatly enhanced sales, increased managerial productivity, and contributed to an unprecedented documentation of daily work efforts. The company claims that the use of one system made training and implementation of the PMIS an easy and continuous process for those in the office and the field, even for an older work force with an average age above 40 years old. The productivity and cost savings from moving to an all-inclusive PMIS was a huge competitive advantage in the company's local industry due to its many benefits in communication and analysis of project information. The case study resulted in many of the same findings as those of Braglia and Frosolini (2014) and Tatari and Skibniewski (2011), in their use of a web-enabled all-inclusive PMIS. The use of an integrated all-inclusive PMIS led to a reduction of errors and reworks, time saving in real-time control of activities, improvement of communications, enhancement in the planning and execution of projects, and helped build a collaborative environment where all stakeholders could perform on-line interactions (Braglia & Frosolini, 2014; Christianson, 2018; Tatari & Skibniewski, 2011).

The objective of an integrated all-inclusive PMIS is to have an effective communication process by providing a cohesive project information management system that is accessible by all stakeholders, at any time (Lotffy & Parth, 2015; Tatari & Skibniewski, 2011). Two of the largest limiting factors to implementation are training and program functionality, something that companies need to be keen on when implementing a PMIS solution in general (Christianson,

Wilson, Hanke, Alhnaity, & Woo, 2017; Tatari & Skibniewski, 2011; Lee & Yu, 2012; Lotffy & Parth, 2015). Ultimately, the author has found through personal experience and scholarly research that if an all-inclusive PMIS is integrated properly, the result is a comprehensive solution with far reaching benefits to productivity and project success, similar in its overall structure, yet individualistic to each company (Bor & Kiptum, 2017; Tatari & Skibniewski, 2011).

The ideal usage of an all-inclusive PMIS improves internal communication and reduces double data entry to solve the problems of fragmentation in construction PMISs currently caused by singularly focused PMISs that are split into separate 'data silos' (Tatari & Skibniewski, 2011). The reduction in the amount of applications used and the integration within the value chain of construction itself is engrained in lean principles (Forbes & Ahmed, 2011). Lean construction is an initiative entailing constant process improvement meant to reduce the waste in the construction process. It involves the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream, and pursuing perfection in the execution of a constructed project" (Forbes & Ahmed, 2011). The benefits of applying a lean methodology by switching to an all-inclusive PMIS solution have been confirmed in three separate studies spread out over a decade. The results of Braglia and Frosolini (2014), Christianson et al. (2017), and Tatari and Skibniewki (2011) have shown that the benefits include:

- Project management is looked at from an integrated approach and integration of silos of information enhances productivity in quality and production.
- Information availability, timeliness, and accuracy improves decision making, managerial benefits, and minimizes errors.

- A single source of data allows for easier integration of operations and business functions.
- Project stakeholders communicate in real-time on a system that is logged and tracked, greatly enhancing the speed of information.
- Tasks and To-Do's can be created, updated, and tracked in real time.
- Stakeholders have direct and real-time access to updated drawings.
- Documents are updated, and only last approved releases go to stakeholders.
- Tasks are timely updated and schedule changes immediately inform stakeholders.
- Workers can report their progress and updates from the field.

Initial scholarly research has shown that a few individuals in the construction industry are currently feeling the pains of having to use multiple programs that don't integrate well. While the number of programs in use by a company was expected to reduce over this decade, some evidence has shown that it continues to rise, while other evidence indicates that it is falling. Scholarly research has shown that system quality and integration is important to success, but it is not known if the construction industry feels that same way. It also is not known if the construction industry is currently struggling with program integration and would prefer to use an all-inclusive PMIS solution. A few knowledge gaps remain as to whether the construction industry is currently struggling with program integration, whether the industry would like to use an all-inclusive PMIS solution instead of multiple systems, whether the productivity of PMIS usage is related to PMIS success, integration, or user satisfaction, and what an all-inclusive PMIS program should include as far as features. The goals of this project were to close knowledge gaps and add to the background knowledge of PMIS usage in the construction industry by assessing the need for an integrated all-inclusive PMIS in the construction industry.

Methods

Research Questions

There are a significant number of scholarly articles in academia that show integrated PMIS solutions have profound benefits above stand-alone PMIS implementations. There is still a growing trend within the industry to use best-in-class programs and to force integration by other means, rather than to use an all-inclusive PMIS (Braglia & Frosolini, 2014; JBKnowledge, Inc., 2017; Tatari & Skibniewski, 2011). Doing this can have a significant negative impact on the project if the programs are stand-alone and do not integrate well with other programs used internally. This study features the analysis of the limitations of, or the reluctance to implement an all-inclusive PMIS among construction professionals and companies.

Employees in different job positions in a company use different PMIS programs for different features in their day-to-day activities. In the case of companies using many different programs, personnel in different job positions within the companies may be using programs that do not integrate with each other. A non-integrated system results in a fragmentation of the internal company information and contributes to lost productivity in the form of miscommunication, lost information, and lost productivity because of time spent to analyze the information from different ‘data silos’ (Tatari & Skibniewski, 2011). Are professionals in the construction industry currently frustrated with the way their PMIS systems in their company operate due these issues?

One of the purposes of this study was to gather information about the construction industry’s current usage and trends as they pertain to project management information systems in order to attempt to understand if people have better success using an all-inclusive PMIS solution versus trying to use best-in-class programs and forcing them to integrate. Numerous qualitative studies have already been conducted that show that integrated PMIS solutions, and PMIS

implementations in general, have significant impacts on project success and project manager productivity, as shown in the scholarly article review. As such, there is no significant knowledge gap in proving that these systems have an impact on project success. A few knowledge gaps remain: Are some companies integrating their programs better than others and having more success? Does the productivity of PMIS usage, which entails the analysis of the number of features a company is using versus the number of PMISs in use (i.e., the CW factor), have an impact on PMIS success in a company? Why aren't companies moving toward an all-inclusive PMIS instead of using multiple PMISs?

Research Goals

There are four research goals for this study. The first is to assess the industry's views on PMIS integration and if it is currently something that is hindering the industry. Questions were designed to assess the survey subjects' current satisfaction with their existing software, how well it integrates, and the perceived importance of integration. The second goal of the study was to come to a determination as to whether there is a need for an all-inclusive PMIS solution among construction professions. The purpose of that goal was two pronged, with the first being to research subjects in the construction industry to define what an all-inclusive PMIS is, what features it includes, how important it is to the industry, and if the construction industry is moving towards that model. The second purpose of the goal was to show PM-ASPs what features are most desired by the construction industry and to suggest improvements to be made to existing programs that are limiting construction companies' abilities to implement all-inclusive PMIS software. The third goal was to analyze if the efficiency of software usage in a company, also known as the CW factor, has a positive linear relationship with PMIS satisfaction among users, integration, and the importance of an all-inclusive solution. The final goal was to analyze the

construction industry's views, opinions, and trends with PMISs via their open-ended comments to identify similarities in limitations and successes among different subjects and their companies.

Methods

A knowledge gap exists in the understanding of individual beliefs of those in the construction industry when it comes to the use of all-inclusive PMIS solutions. This study focuses on qualitative and quantitative information from construction professionals to find common trends and issues within the industry, as they pertain to all-inclusive PMIS solutions. The study featured the use of electronically distributed surveys targeted toward those currently working in the construction industry to ask questions about their current PMIS usage and satisfaction. The survey was conducted through Qualtrics, a third-party cloud-based survey distribution website.

The survey was sent to alumni from the Milwaukee School of Engineering CAECM (Civil/Architectural Engineering & Construction Management) program and professionals from construction companies recruiting at the MSOE career fair who left behind their contact information. E-mail lists and contacts were provided by one of this project committee's advisors. The original e-mail list featured 739 e-mails. Of that list, 100 were e-mail addresses that were bounced back due to bad e-mail addresses or because the subject no longer worked at the company.

The original e-mail served as a cover letter providing information about the study, how many questions it featured, how long it would take to complete, the advisor committee overseeing the study, and the overall research goals of the study. Three questions where used to qualify applicants and to exclude respondents who did not give consent to information, did not currently work in the construction industry, or had no previous experience in the use of PMIS

solutions in construction. One hundred and seventy people opened and started the survey. Twenty-eight respondents failed to complete the survey and eleven respondents had their survey eliminated from the data set because they did not satisfy the survey respondent criteria, resulting in an exclusion of 22.5% of responses. This resulted in a total of 134 finished survey responses for an approximate 21% response rate.

This capstone project study was approved by the Milwaukee School of Engineering Institutional Review Board (IRB) for Human Study in January 2018 and was conducted from February 2018 to April 2018.

> The IRB is an administrative body established to protect the rights and well-being of human subjects recruited to participate in research studies. MSOE complies with requirements set forth in Title 45, part 46 of the code of Federal Regulations, known as the "Common Rule", as well as Wisconsin State laws and MSOE policies. The purpose of the IRB is to ensure the adequacy of the research plan, to minimize risks, and to maximize the benefits for human subjects who participate in research. (Institutional Review Board (IRB: Guidelines, 2018)

Survey Design, Procedure and Analysis Plan

A survey was developed consisting of 25 questions that were geared toward enabling the analysis of whether or not the PMIS trend for the construction industry is moving toward all-inclusive PMIS solutions. The survey was also structured in such a way as to provide data on whether or not PMISs are having a positive or negative impact on the industry and why. Questions featured multiple formats, including demographic questions, multiple-selection questions, Likert-scale questions, and open-ended opinion questions and testimonies. Every response had an 'other' option as well as an option to give 'no response'. 'No responses' were

not excluded from the study but could be excluded in individual questions. This was partly a qualitative study, so most questions were asked in such a way as to get the participants' thoughts and opinions on all-inclusive PMIS solutions or PMIS implementations in general. To make sure that users understood the scale for Likert-type questions, numbers were accompanied with a coding, such as 'average' or 'below average', to keep answers and opinions close in comparison to other subjects to limit variance and error. Some other examples of coding include: 'no importance at all', 'some importance', 'average importance', 'very important', or 'extreme importance'.

The survey started with an informed consent statement requesting agreement on the part of participant and informed them of their rights. In compliance with the MSOE Institutional Review Board (IRB), participants in a study must give informed consent before beginning the study. Respondents were given informed consent in the original e-mail cover letter and once more before beginning the study. Respondents who did not consent to having their survey information included in the study were excluded from the results. It was made clear that no personal or identifiable information would be made or attached to the responses of a company. Respondents were then asked if they currently work in the construction industry. This question, and the informed consent, were asked to exclude those not currently working in the construction industry, such as educators, students, or analysts. Eleven respondents were excluded because they either did not consent or did not currently work in the construction industry. The survey in its entirety is available in Appendix A.

The first seven questions were demographic questions meant to be filtered to investigate similar trends experienced by companies of the same type, size, or revenue, in addition to differences in opinion felt by people in different job positions. These questions were used as

independent variables and were analyzed against the Likert-scale questions asked later in the survey, which served as dependent variables. Respondents were asked, in order:

1. Do you currently work in the construction industry?
2. What construction industry do you primarily work in?
3. How would you classify your company type? (i.e. Contractor, Subcontractor, Engineer, Owner, etc.)
4. What is your job position within your respective company? (Executive/Owner, Project Manager, Superintendent, etc.)
5. What area of the United States do you operate within? (NW, SW, NE, etc.)
6. What is the size of your company? (i.e., 1-20, 20-99, 1000+ employees)
7. What is your annual sales volume? (<$1M, $5-$50M, $500M+)

The next nine questions were to get an understanding of the user's processes and the processes of their company to look for similarities in trends and use within the construction industry. The final questions were meant to get a gauge of the efficiency of programs currently in usage within the respondent's companies. This was used to calculate the CW factor, a concept originated in a study conducted by Christianson et al. (2017). Use of the factor looks at the ratio of how many programs are in use within a company versus how many features they are using the programs for. This factor was used to see if there is a correlation between companies with different CW factors and their user's overall satisfaction with their company's PMIS implementation. Hypothetically, companies with a low CW factor may be dealing with issues stemming from a lack of integration. The CW factor was tied to the Likert-scale and opinion-based questions to determine if there is a correlation. Questions were asked in the following order:

8. How many projects does a respondent typically work on, or manage, at one time?
9. How long does a typical project take?
10. What are methods of communication for project information and documents within and outside the organization?
11. How is information currently collected and interpreted on the jobsite? (Daily Logs, Production Times, QA/QC)
12. Has the respondent's company ever used any type of project management information system? (e.g., Microsoft Office, Procore, Bluebeam, Personal Server)
13. What functions, as defined by the Construction Management Association of America [CMAA], does the respondent's company use a PMIS for? (Project Management, Cost Management, Time Management, Quality Management, Contract Administration, and Safety Management)
14. What phases of construction is project management information software used for? (e.g., Pre-design, design, procurement)
15. What type of project management information software does the respondent's company use? (e.g., field data collection, sales, estimating, project management)
16. How many types of PMIS software providers does the respondent's company use?

The final nine questions are strictly based on the opinions of the survey respondents. These questions consist of open-ended questions giving the respondent an opportunity to talk about their experience with a PMIS. Responses were expected to vary greatly. Coding was created for each response to discover similarities or problems experienced by multiple respondents. Users were first asked if a PMIS improved their business and how or how not. Then, respondents were asked Likert-scale questions meant to gauge their overall satisfaction

with their companies' PMIS usage. These Likert-scale questions were asked on a 1-10 scale, with some numbers being denoted with a label, such as 'very important' or 'slightly important', to give respondents an explanation of what each number represents and to reduce error caused by the user's opinions. These questions were asked in the following order:

17. Has a PMIS improved the respondent's business? How or how not?
18. On a scale of 1-10, how well has a PMIS improved collaboration with other project stakeholders? (Architects, Engineers, Owners, Subcontractor)
19. For the PMIS a respondent has used, what were its limitation?
20. On a scale of 1-10, if the respondent uses more than one PMIS, how well do these programs integrate and communicate with each other?
21. On a scale of 1-10, how important is it to the respondent that different PMIS solutions integrate their software for ease of transferring data between programs or functions?

Questions one through five of the previous set of questions were set up for the final four questions of the survey. They were meant to get the respondent in a state of mind to decide how important it is that a PMIS is all-inclusive and what it should have as far as features. The questions conditioned respondents with the working definition of an all-inclusive PMIS and asked about its importance to the industry. A final open-ended question was asked to give the respondent an opportunity to give any further comments or testimony about the use of PMIS software in general in the construction industry. Questions were asked in the following order:

22. All-inclusive construction PMIS is defined as a project management information system software that synchronizes and integrates all of the major types of PMIS functions needed to run every aspect of a construction project and company. On a

scale of 1-10, how important is it to the respondent that a construction PMIS is all-inclusive?

23. Would the respondent's company benefit from using one all-inclusive PMIS instead of multiple PMIS?
24. What capabilities or types of PMIS does the respondent envision an all-inclusive PMIS program to have?
25. Does the respondent have any comments/testimony about the use of project management information software in the construction industry?

The discussion and analysis sections in this report are focused on answering the goals of this research study, which are shown in Table 1: (1) to assess the current construction industry's trends, (2) to assess the current need for an all-inclusive PMIS in the construction industry, (3) to analyze if the CW factor has a linear relationship with PMIS success, user satisfaction, and program integration, and (4) to inform PM-ASP providers about the features construction professionals would most like to see rolled into one all-inclusive PMIS. These goals were achieved by analyzing the following elements:

a. Importance of PMIS Integration
b. PMIS Limitations
c. Importance of All-Inclusive PMIS
d. Efficiency of PMIS Usage (CW factor)
e. Analysis of Open Ended Comments
f. Features of an All-Inclusive PMIS
g. Construction PMIS trends and usage
h. Stakeholder Collaboration in PMIS

Table 1

Research Questions and Goals

Research Question	Research Goal	Questions & Elements Analyzed
Assess current construction industry's uses, views, opinions, and trends about PMIS.	- Understand construction professional's views on PMIS and if it is currently hindering the industry. - Analyze open comments for similarities in limitations and successes.	8-14, 18, and 25 A, B, C, E, G, H
Does the productivity of PMIS usage have an impact on success of the company and user satisfaction?	- Show CW Factor has a linear relationship with PMIS success, user satisfaction, and program integration.	15-21 A, B, C, D
Understand limitations or reluctance of implementing an all-inclusive PMIS.	- Assess need for all-inclusive PMIS software. - Analyze limitations to implementation of all-inclusive PMIS.	17, 19-25 A, B, C, E, G
Discover features most requested by construction professionals for PM-ASPs.	- Define what an all-inclusive PMIS software is and what features it should have. - Show PM-ASPs which programs are most desirable.	15, 16, 24 D, F,

Demographics

Figure 1 shows the number of respondents for each type of construction company. Of the 134 respondents, the largest percentage of company types represented were commercial general contracting with 77 total respondents. The next largest company type is mechanical, electrical,

and plumbing (MEP) systems (34 respondents), followed by engineering (7 respondents), industrial (5 respondents), and transportation (2 respondents). The other respondents came from companies with specific specialties such as structural erection, concrete/masonry, interior finishes, and consulting.

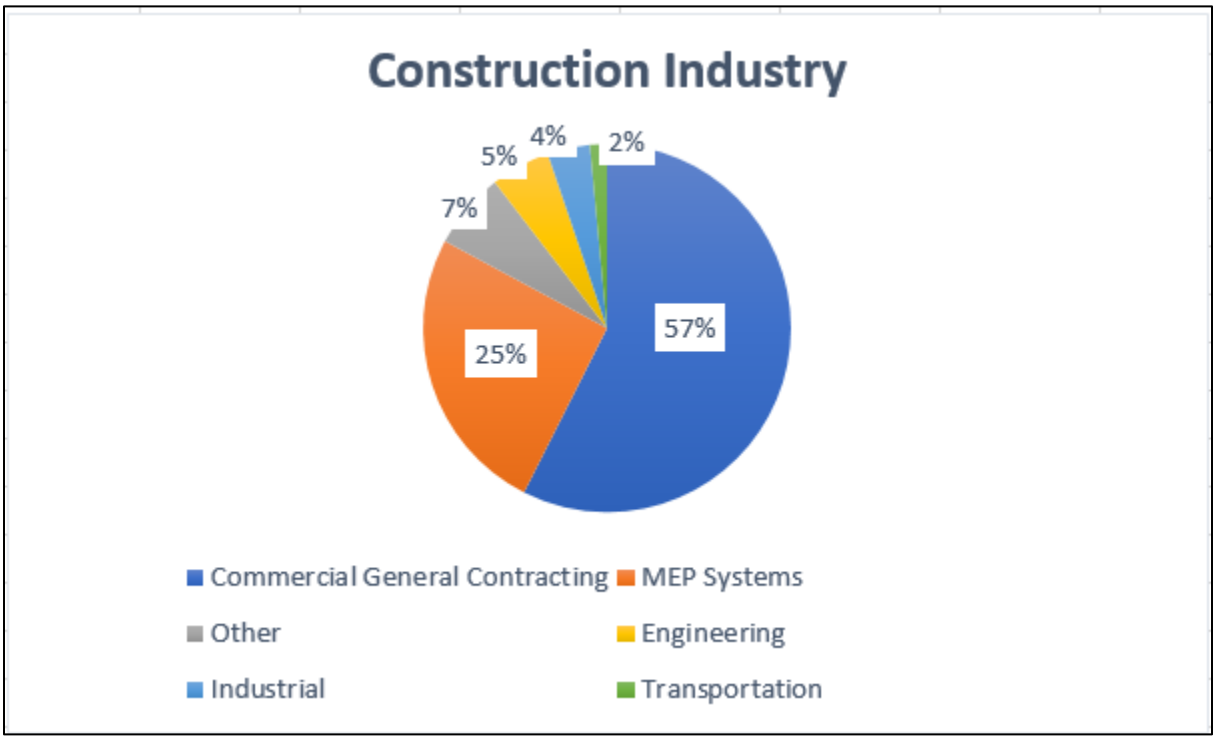

Figure 1. Percentage for each construction company type.

Table 2 shows the number of respondents for each company type, such as general contracting, sub-contracting, engineering, professional construction manager, owner representative, etc. About 45% of respondents came from general contractors (60), another 16.5% from subcontractors (22), 13.5% from design-build contractors (18), 9% from architectural/engineering design firms (12), 7.46% from professional construction managers (10), and 11 others consisting of owner builders, IT companies, consulting firms, and real estate developers.

Table 2

Construction Company Type

Answer	Count	%
General Contractor	60	44.8%
Subcontractor	21	15.7%
Design-Build Contractor	18	13.4%
Architectural/Engineering/Design Firm	12	9.0%
Other (please specify)	11	8.2%
Professional Construction Manager	10	7.5%
Owner-Builder	1	0.7%
Real Estate Developer	1	0.7%
Total	134	100%

The study features a diverse range of company sizes and revenue for the general contracting, subcontractor, engineering and architectural, and design-build company types. Respondents operate primarily in the Midwest. This is mostly attributed to the source of the contacts for the respondents used in the survey. The Milwaukee School of Engineering is in Wisconsin and the respondents were predominantly MSOE alumni or representatives of companies recruiting MSOE students. The largest sample of company size and annual sales volume came from the 1,000+ and $500+ million-dollar revenue range with 33% (51) and 29% (44) respondents, respectively. The number of responses from each size and revenue range are shown in Figure 2 and Figure 3.

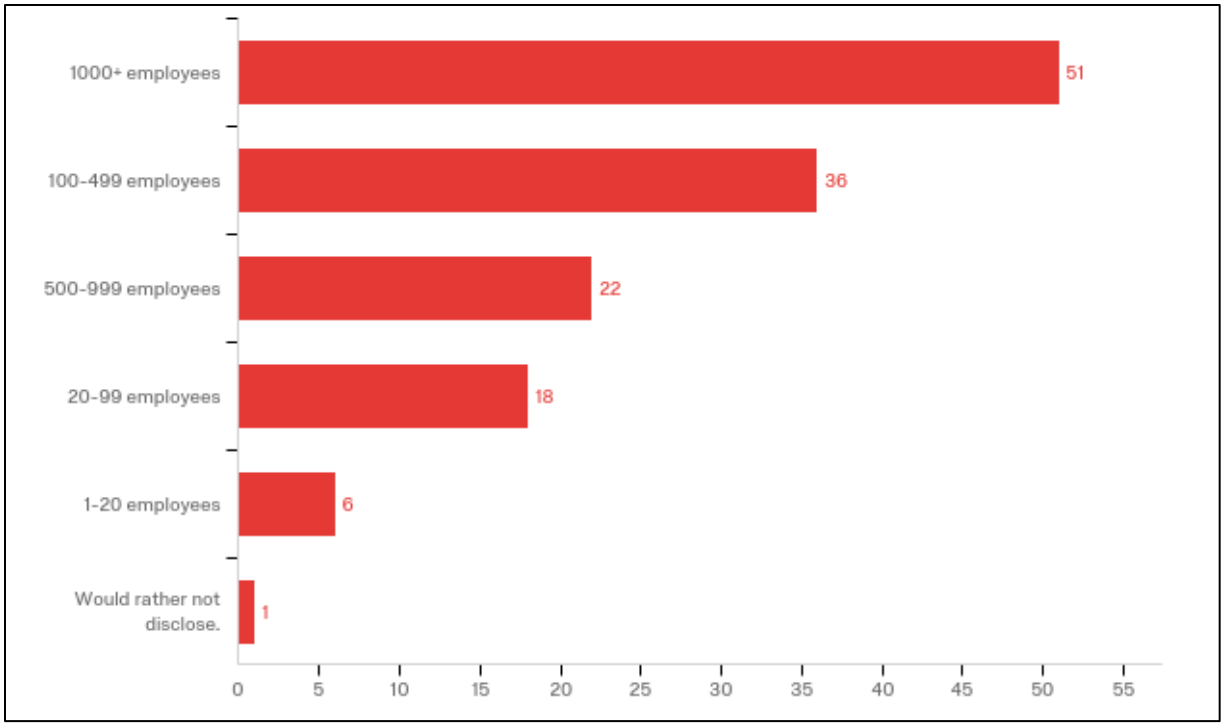

Figure 2. Number of employees as a representative of size.

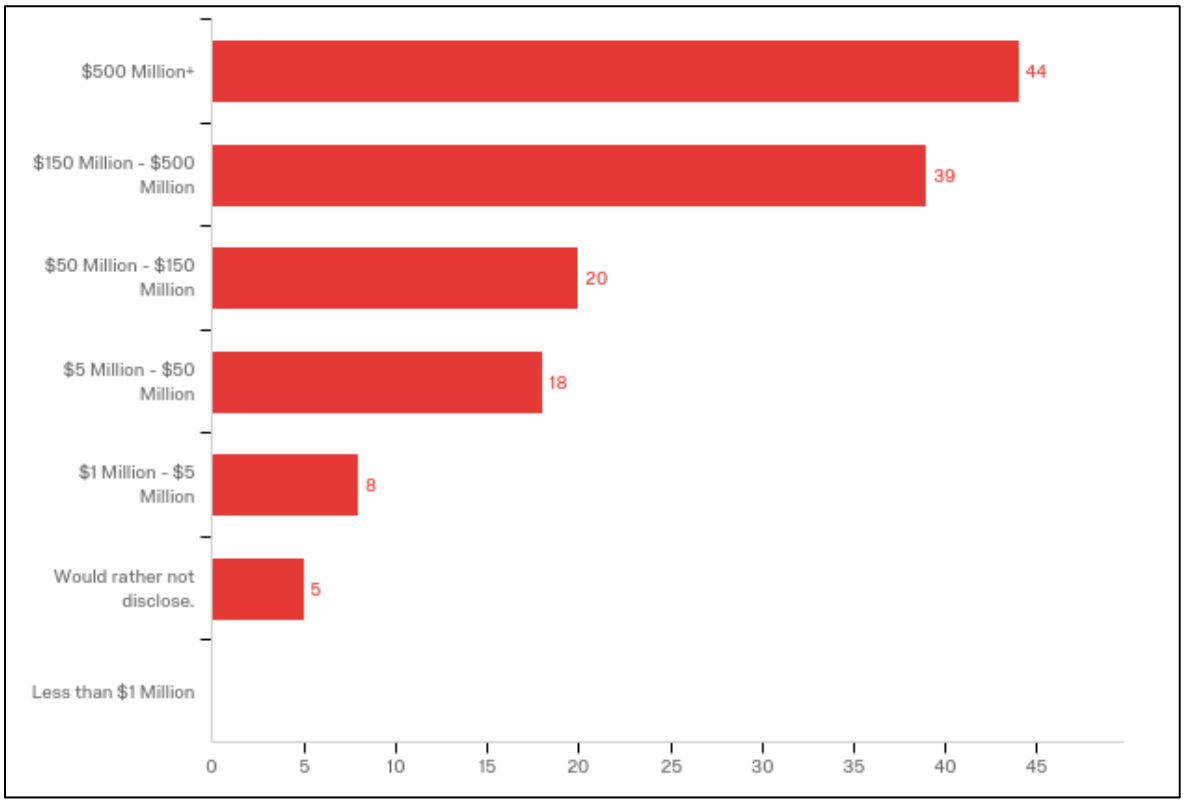

Figure 3. Revenue range of respondents.

Based on Figures 2 and 3, it is possible that the companies with 1000+ employees consist mostly of companies that generate $500 million+ in revenue. This was not always the case. Approximately one third of the respondents who said their company had 1000+ employees fell within the $150-$500 million revenue range. The other one third of the respondents in the $500+ million range consisted of companies with 100-499 employees or 500-999 employees. Figure 4 shows the diversity of company types and sizes.

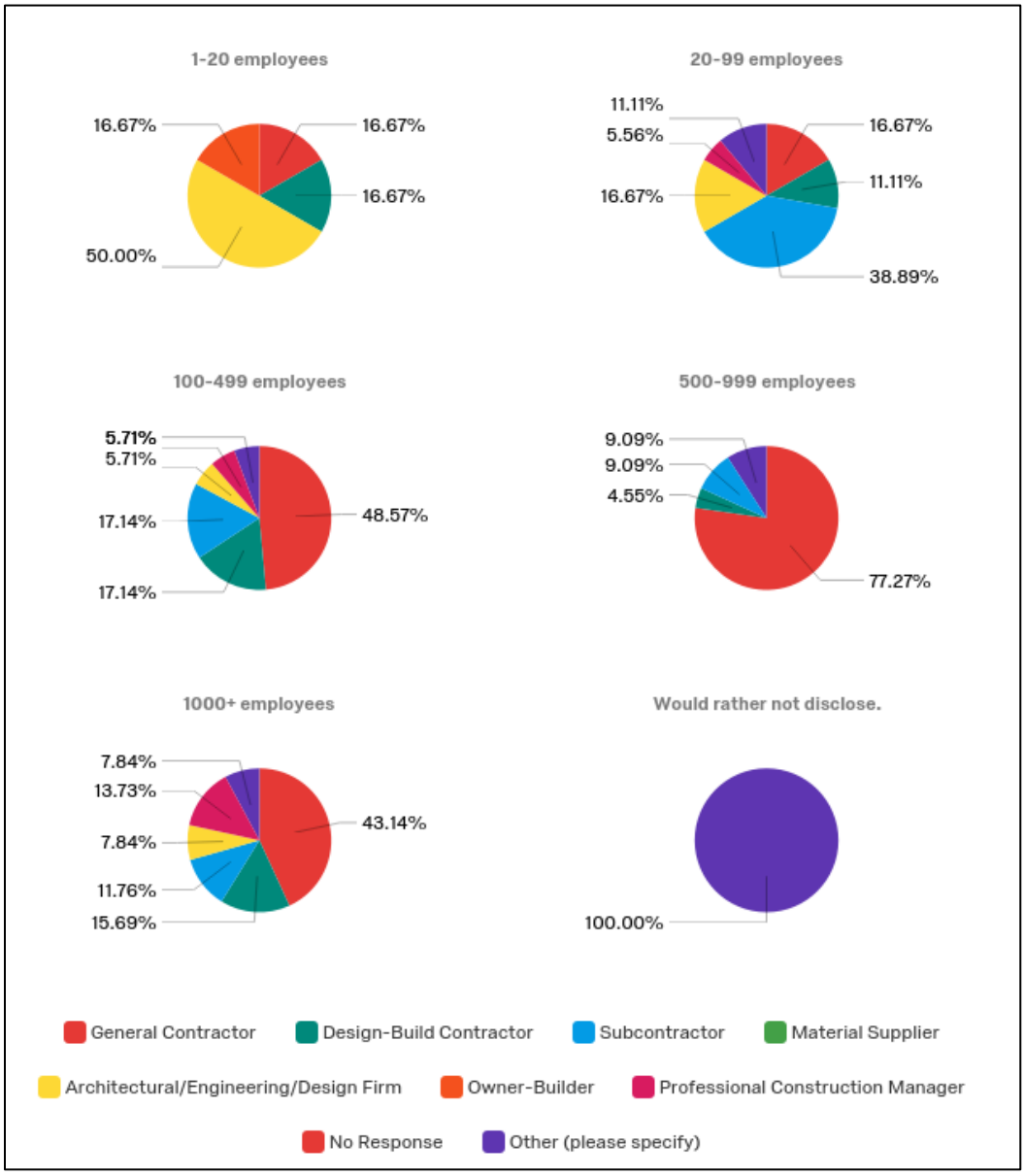

Figure 4. Diversity of company types and sizes.

Table 3 shows the percentage of respondents for each different type of job position. Approximately 33% of the subjects were project managers and 25% consisted of executive managers or owners. Most respondents stated that the typical time to complete a project was 1-3 years or 4-12 months with a percentage of 51% and 35.5%, respectively. Forty-four percent of respondents said that they typically work on or manage fewer than five projects at a time.

Table 3

Percentage of Respondents for Each Job Position

Answer	Count	%
Project Manager	44	32.84%
Executive/Owner (i.e. CEO, CIO, CFO, VP)	33	24.63%
Other (please specify)	17	12.69%
General Manager	13	9.70%
Engineer/Architect	10	7.46%
Superintendent	7	5.22%
Estimator	6	4.48%
IT Staff	2	1.49%
Office Manager / Administrator	2	1.49%
Totals	134	100.00%

Results

Importance of PMIS Integration

Figure 5 shows the results from the question on how well a subject's current PMIS implementation in use at their company integrates with other PMIS solutions. A score of 1 was labeled (not well at all), 3 (slightly well), 5 (average), 6 (moderately well), 8 (very well) and 10 (extremely well). Table 4 shows the descriptive statistics for the question, including minimum, maximum, mean, standard deviation, variance, and the number of responses.

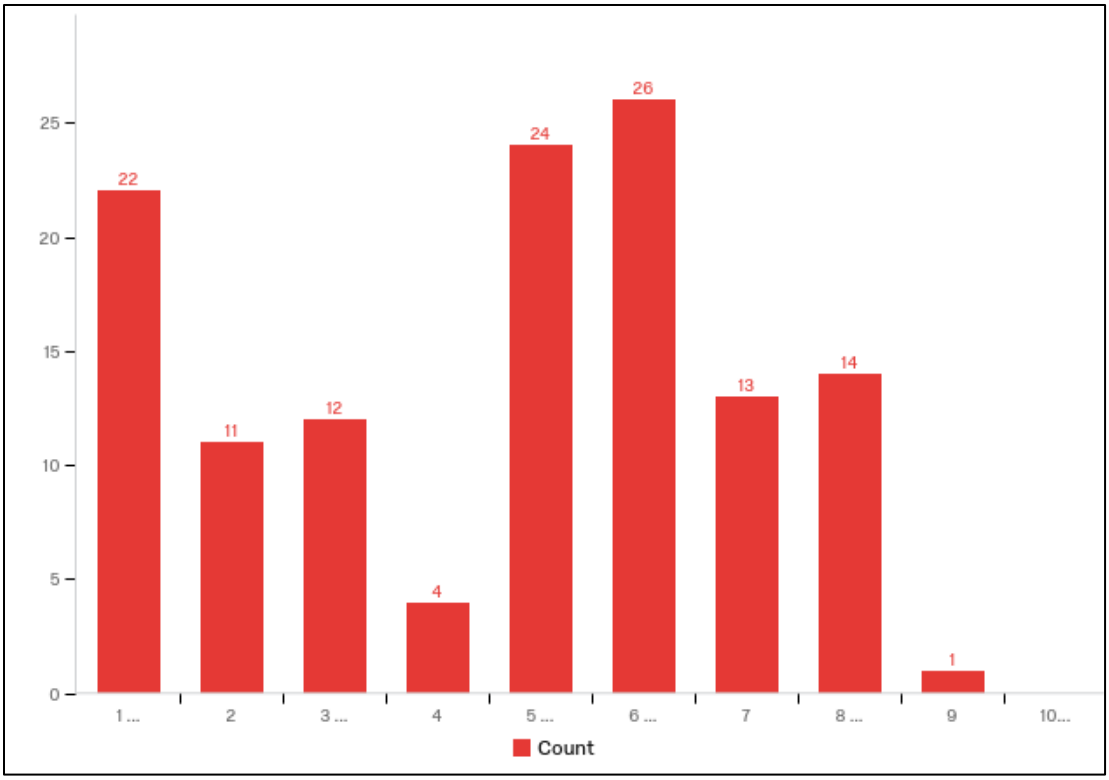

Figure 5. How well subjects' current PMIS software in use integrates with other PMIS software.

Tables 4 and 5 shows the descriptive statistics for how well programs integrate if using more than one and how they differ based on different company types. The mean score is below the score denoted as average (5). There is a large variance in scores, but an alarming 20% of respondents said that their programs do not currently integrate at all.

Table 4

Descriptive Statistics for How Well Programs Integrate and Communicate

Question	Min	Max	Mean	Std. Dev.	Variance	Count
On a scale of 1-10, if you use more than one PMIS program, how well do these programs integrate and communicate with each other?	1	9	4.6	2.35	5.53	127

Table 5

How Well Programs Integrate and Communicate With Each Other if Using More Than One for Each Company Type

Answer	Min	Max	Mean	Std. Dev.	Variance	Count
Design-Build Contractor	1	9	4.88	2.37	5.63	17
Other (please specify)	1	8	4.73	2.83	8.02	11
General Contractor	1	8	4.72	2.13	4.53	54
Architectural, Engineering, or Design Firm	1	8	4.2	2.44	5.96	10
Professional Construction Manager	1	7	4.1	2.43	5.89	10
Subcontractors	1	8	3.79	2.35	5.53	19

The next question asked was what the subject's perceived importance was that a PMIS integrates and communicates with other PMIS solutions easily and in a functional way. Figure 6 shows the individual number of responses for each Likert-scale score. Scores were labeled with 'no importance at all' for a 1, 3 ('some importance'), 5 ('average importance'), 8 ('very important'), and 10 ('extremely important'). Table 6 shows the descriptive statistics concerning the same question for the importance to each subject that different PMIS solutions integrate with other PMIS software for ease of transferring data.

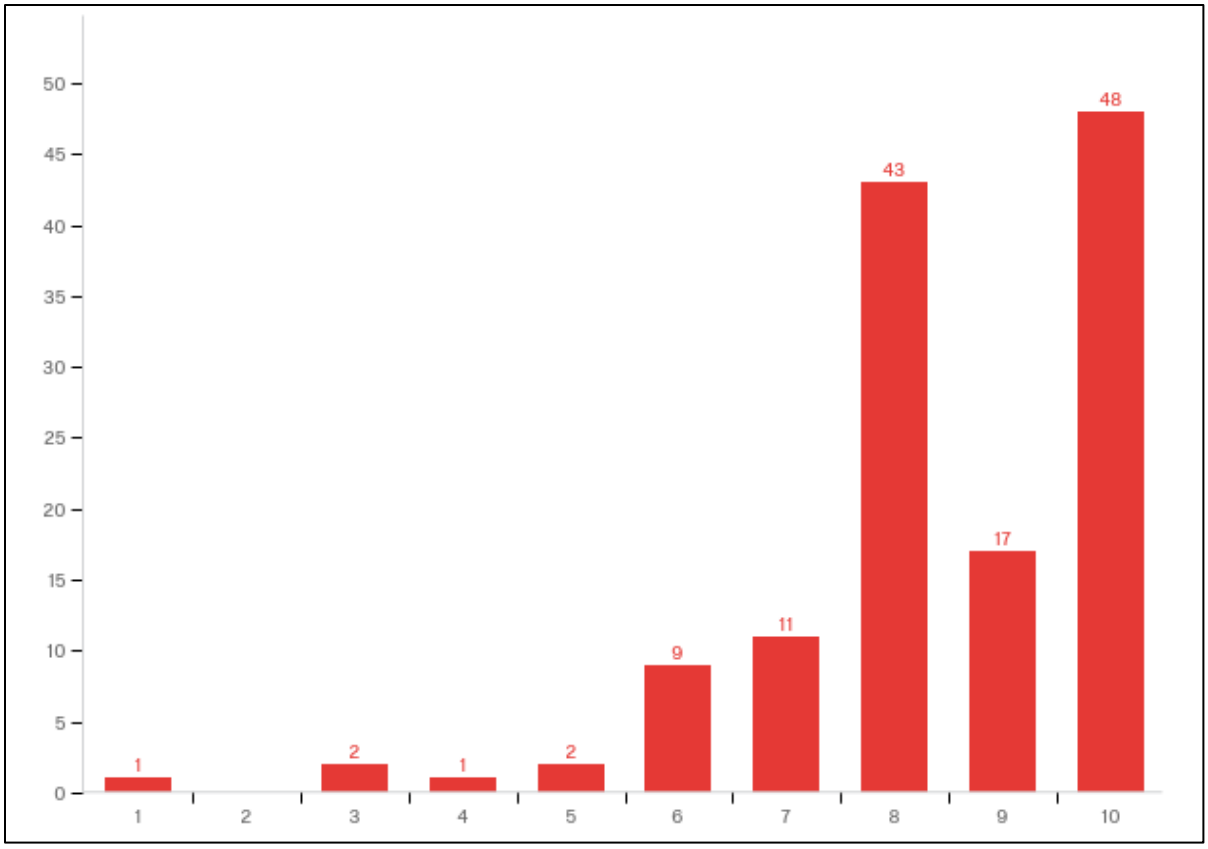

Figure 6. Importance that PMIS software integrates with other PMIS software.

Table 6

Importance to Subject That PMIS Software Integrates with Other Software

Question	Min	Max	Mean	Std. Dev.	Variance	Count
On a scale of 1-10, how important is it to you that different project management information softwares integrate their information for ease of transferring data between programs or functions?	1	10	8.43	1.65	2.72	134

Limitations to Implementation

Tables 7 and 8 show the response totals for each common barrier to implementation for the individual subject responses. Response totals were split up into different company types for Table 7, and different company job positions for Table 8. The highlighted numbers are for the percentages that were exactly 50% or over. This was to point out the figures where more

respondents within a set responded with the answer than not. One could reasonably assume that these results show that there is at least some issue in implementation or need in features amongst the majority. These denote the most common limitations for each subject's company type or job position.

Table 7

Limitations to PMIS Implementation for Different Company Types

Answer	General Contractor		Design-Build Contractor		Subcontractor		Architectural, Engineering, or Design Firm		Professional Construction Manager		Other (please specify)		Totals
Training	56%	33	65%	12	38%	8	67%	8	40%	4	64%	7	64
Lacks a Unified Vision or Not All-in-One Solution	46%	26	71%	12	62%	13	50%	6	30%	3	73%	9	63
Technological Barriers for Employees	53%	33	59%	11	38%	8	25%	3	30%	3	64%	7	62
Functionality / System Not Flexible	54%	31	53%	9	48%	10	67%	8	50%	5	46%	6	61
Cost	40%	23	18%	3	33%	7	42%	5	0%	0	27%	4	37
Wrong Team Implementing	12%	7	12%	3	10%	2	8%	1	0%	0	18%	2	14
Other / Why?	11%	6	0%	0	0%	0	0%	0	0%	0	18%	2	8
No Limitations	2%	1	0%	0	10%	2	0%	0	10%	1	9%	1	5
N/A	2%	1	0%	0	5%	1	0%	0	20%	2	0%	1	5
Responses	Total	60	Total	18	Total	21	Total	12	Total	10	Total	13	134

Table 8

Limitations to Implementation for Different Company Job Positions

Question	Executive / Owner		General Manager		Superintendent		Project Manager		Estimator		Engineer or Architect		Other (please specify)		Total
Training	55%	18	46%	6	71%	5	57%	25	50%	3	50%	5	47%	10	72
Lacks a Unified Vision or Not All-in-One Solution	48%	16	46%	6	29%	2	64%	28	33%	2	30%	3	71%	12	69
Functionality / System Not Flexible	48%	16	54%	7	43%	3	70%	31	17%	1	50%	5	35%	6	69
Technological Barriers for Employees	39%	13	54%	7	71%	5	50%	22	33%	2	40%	4	47%	12	65
Cost	27%	9	0%	0	57%	4	43%	19	33%	2	10%	1	41%	7	42
Wrong Team Implementing	9%	3	15%	2	14%	1	9%	4	17%	1	0%	0	18%	4	15
Other / Why?	6%	2	0%	0	0%	0	5%	2	17%	1	10%	1	12%	2	8
N/A	3%	1	0%	0	0%	0	5%	2	0%	0	10%	1	6%	1	5
No Limitations	6%	2	8%	1	0%	0	0%	0	17%	1	0%	0	6%	1	5
Totals	Total	33	Total	13	Total	7	Total	44	Total	6	Total	10	Total	21	134

Importance of an All-Inclusive PMIS

Figure 7 shows the percentage of subjects who were asked on a scale of 1 to 10 whether their company would benefit from the use of an all-inclusive PMIS. Responses allowed were ‘yes’, ‘no’, ‘no response’, or ‘we currently only use one PMIS’. Figure 8 shows the importance to a subject that a PMIS is all-inclusive. The same Likert scale used in Figure 6 was also used in Figure 8. Table 9 shows the descriptive statistics for Figure 8. Figure 9 indicates how different job positions view an all-inclusive PMIS.

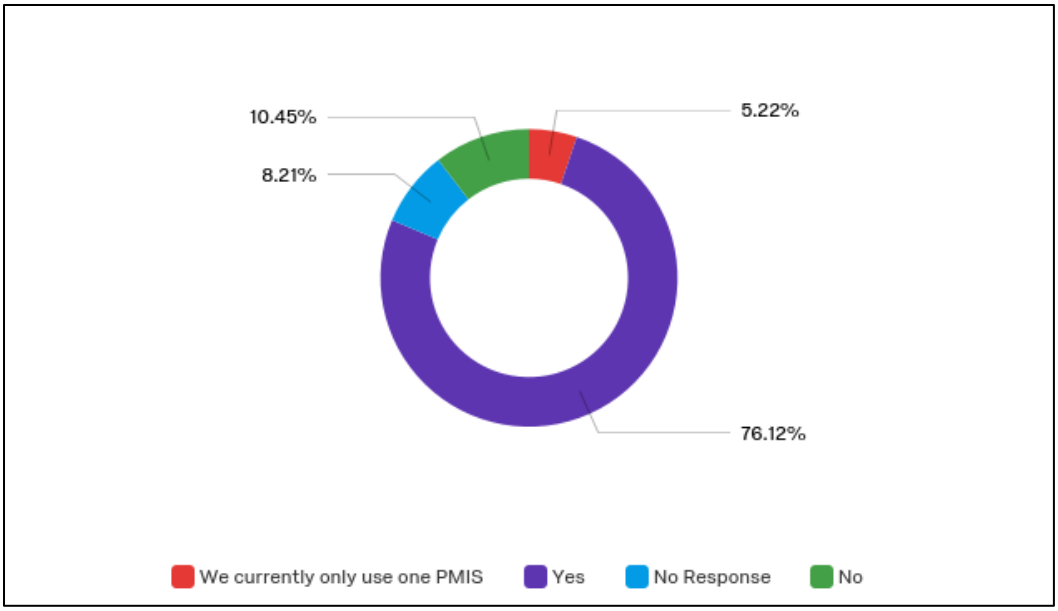

Figure 7. Perception that company would benefit from an all-inclusive PMIS.

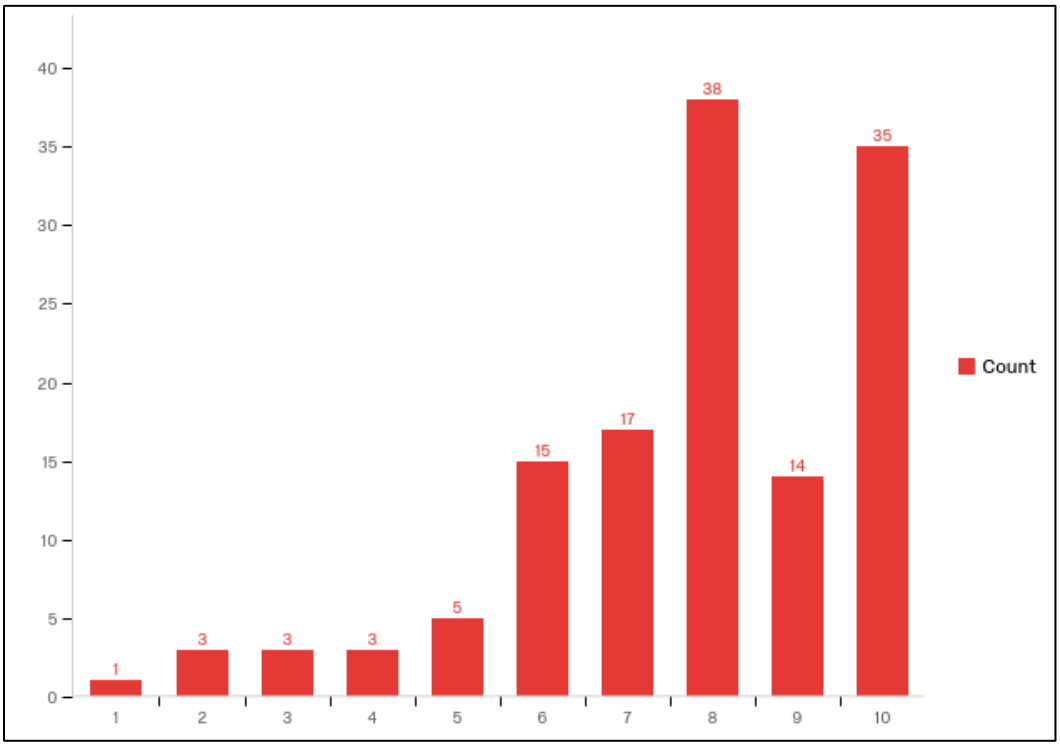

Figure 8. Importance of all-inclusive PMIS software – Likert-scale count.

Table 9.

Importance to the Construction Industry that PMIS Software is All-Inclusive

	Count	Min	Max	Mean	Std. Dev.	Variance
On a Scale of 1-10, how important is it to you that construction project management software is all inclusive.	134	1	10	7.78	2.02	4.1

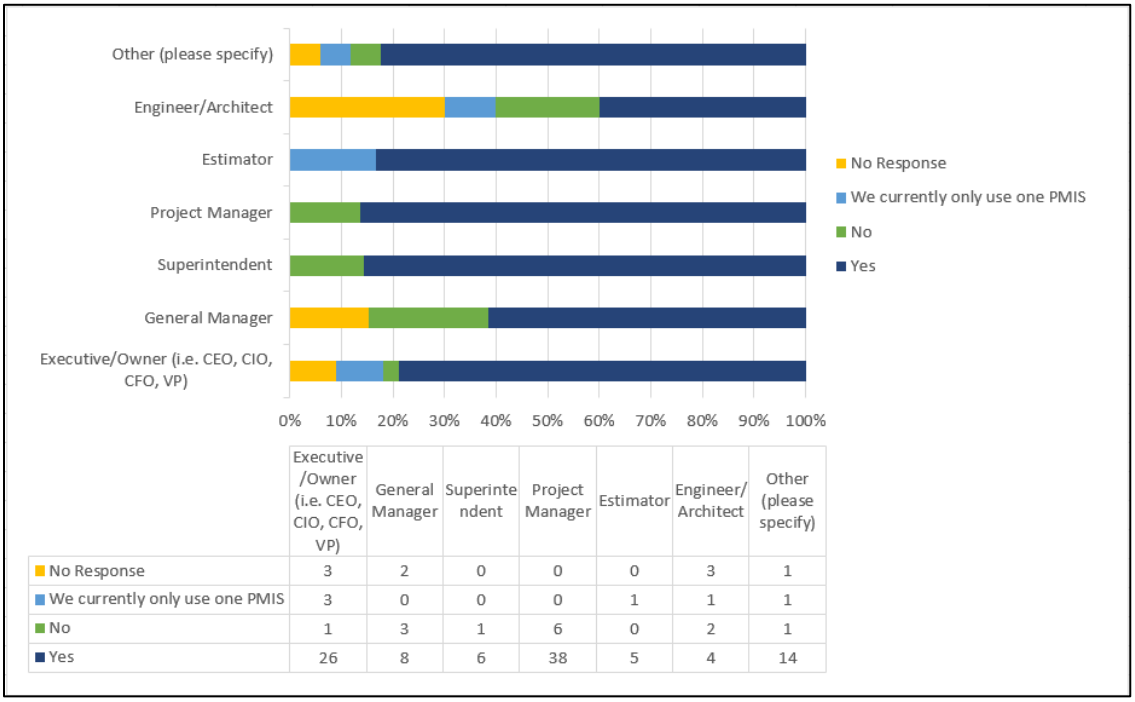

Figure 9. Subjects opinions on whether an all-inclusive PMIS would be better for their company than using multiple programs.

Features of an All-Inclusive PMIS Solution

Table 10 shows the most requested features from each different job position. The scores that are highlighted are those that are exactly at or above 50%.

Table 10

Most Requested Features for an All-Inclusive PMIS for Each Company Type

Question	General Contractor		Design-Build Contractor		Subcontractor		Architectural, Engineering, or Design Firm		Professional Construction Manager		Other (please specify)		All Totals	All %
Project Management (Pricing Quotes, Submittals, & RFI's)	98%	59	100%	18	95%	20	92%	11	100%	10	92%	12	130	97%
Field Data Collection (Daily Reporting and photos)	95%	57	100%	18	95%	20	83%	10	80%	8	92%	12	125	93%
Change Orders & PCO's	95%	57	94%	17	90%	19	58%	7	100%	10	92%	12	122	91%
Document Storage & Plan Management	85%	51	89%	16	76%	16	92%	11	100%	10	85%	11	115	86%
Project Scheduling	80%	48	89%	16	81%	17	100%	12	90%	9	77%	10	112	84%
Performance Tracking	82%	49	89%	16	76%	16	58%	7	80%	8	85%	11	107	80%
Estimating, Mark-ups & Takeoffs	85%	51	83%	15	76%	16	50%	6	80%	8	69%	9	105	78%
Accounting	78%	47	72%	13	67%	14	50%	6	90%	9	69%	9	98	73%
Proposal & Contract Generation	73%	44	78%	14	62%	13	75%	9	60%	6	69%	9	95	71%
Word processor, Sheets (Excel), & Presentations	50%	30	67%	12	57%	12	75%	9	80%	8	54%	7	78	58%
AutoCAD, BIM, & Design	57%	34	56%	10	57%	12	67%	8	60%	6	54%	7	77	57%
Invitation to Bid & Plans Room	58%	35	56%	10	33%	7	33%	4	60%	6	46%	6	68	51%
Sales & Lead Tracking	52%	31	72%	13	48%	10	42%	5	20%	2	46%	6	67	50%
Client Relationship Management (CRM)	45%	27	72%	13	38%	8	50%	6	10%	1	54%	7	62	46%
Time Clock	48%	29	39%	7	62%	13	33%	4	40%	4	31%	4	61	46%
Prequalification	55%	33	56%	10	24%	5	17%	2	60%	6	31%	4	60	45%
Other, choose any missing.	7%	4	0%	0	5%	1	0%	0	0%	0	15%	2	7	5%
Totals	Total	60	Total	18	Total	21	Total	12	Total	10	Total	13	134	

Efficiency of PMIS Usage: The CW Factor

Table 11 shows the number of programs in use for each subject's company and descriptive statistics. Figure 10 shows the CW scores for each individual subject. This was found

by dividing the number of features by the number of PMIS software systems in use. Each dot denotes a single response. Dark colored dots denote multiple responses of the same value.

Table 11

Number of Programs in Use by Each Company

# of Programs in Use	Count	%
1-5	28	20.9%
6-10	78	58.2%
11-15	27	20.1%
15+	1	0.7%
Totals	134	100.0%

Descriptive Statistics	
Mean	7.835
Standard Error	0.264
Median	8
Mode	9
Standard Deviation	3.054
Sample Variance	9.326
Count	134

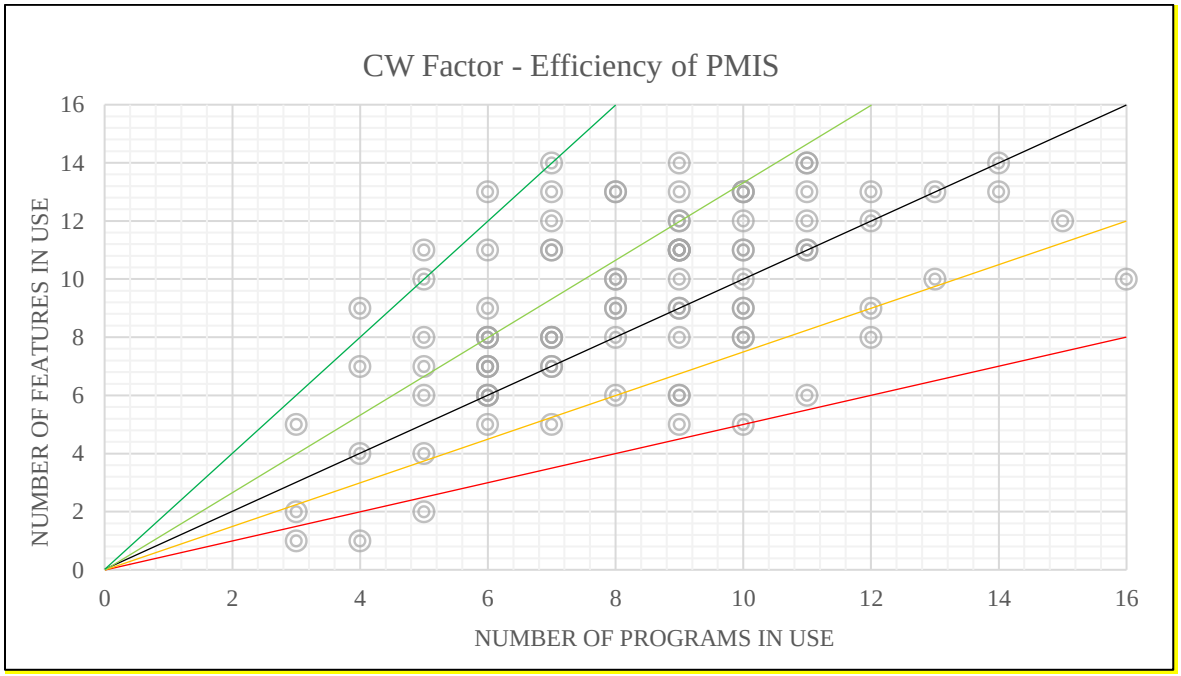

Figure 10. CW Ratios of survey subjects.

Table 12 shows the number of subjects that scored within a certain CW factor range. Scores include poor efficiency (0.0-0.49), below average (0.5-0.99), above average (1.0-1.5), good efficiency (1.5-1.99), and superior efficiency (2.0+). The descriptive statistics in Table 12 show the average score of all responses, along with the minimum, maximum, standard deviation, and variance.

Table 12

CW Ratio and Scores of Subjects

CW Ratio	Count	%	CW Score
0-0.49	8	6.0%	Poor Efficiency
0.5-0.99	41	30.6%	Below Average Efficiency
1.0-1.49	57	42.5%	Above Average Efficiency
1.5-1.99	15	11.2%	Good Efficiency
2.0+	13	9.7%	Superior Efficiency
Totals	134	100.0%	

Descriptive Statistics	
Mean	1.241
Standard Error	0.084
Median	1.04
Mode	1
Standard Deviation	0.968
Sample Variance	0.937
Range	8.9
Minimum	0.1
Maximum	9
Count	134

Figures 11, 12, 13, and 14 are Likert-scale questions used as dependent variables to be compared to the CW factor, which is the independent variable, to look for a positive linear relationship (R=1.0). Figure 11 features the CW factor with respect to how well PMIS usage has improved collaboration. Figure 12 features the CW factor with respect to how well currently

used PMIS software integrates with other PMIS implementation. Figure 13 features the CW factor with respect to the importance to the subject that PMIS software integrates with other PMIS software, and Figure 14 features the CW factor with respect to the subject's opinion on the importance that a PMIS is all-inclusive.

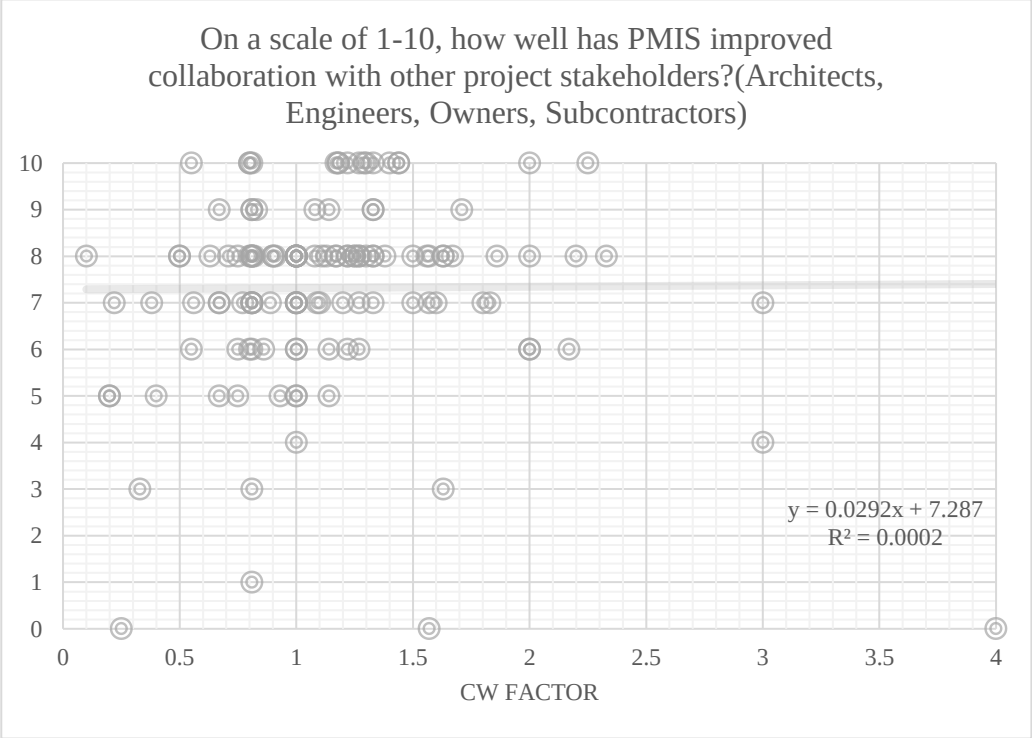

Figure 11. CW Factor vs. how well PMIS software has improved collaboration.

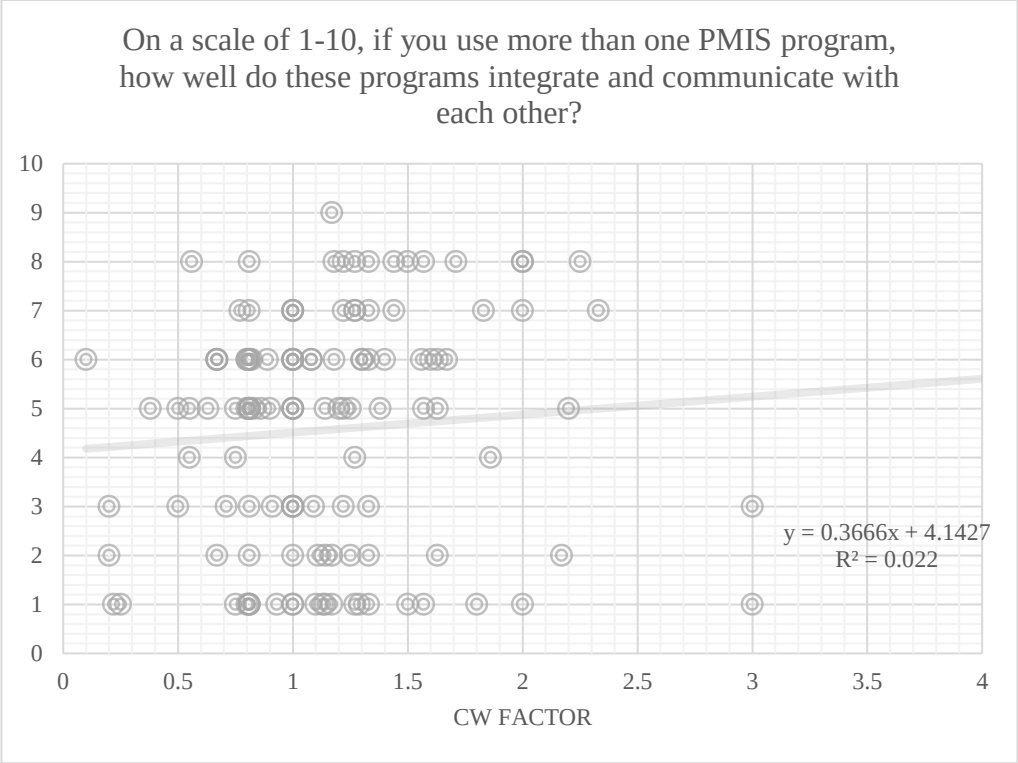

Figure 12. CW Factor vs. how well currently used PMIS software integrates with other PMIS software.

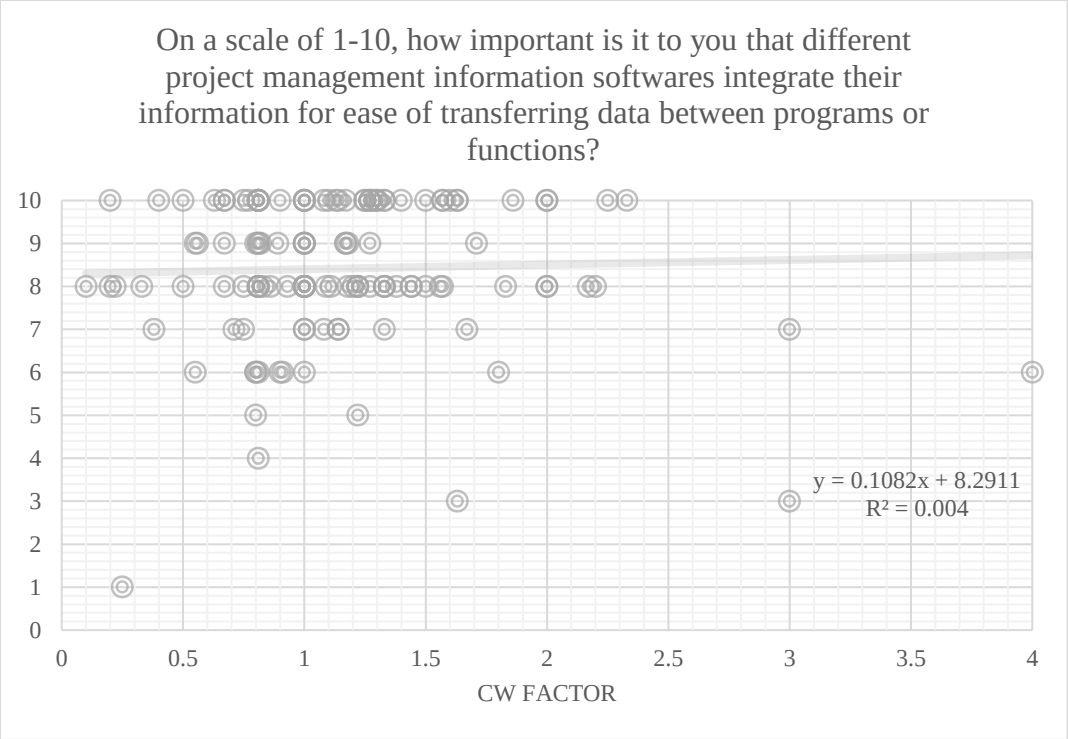

Figure 13. CW Factor vs. importance to subject that PMIS software integrates with other PMIS software.

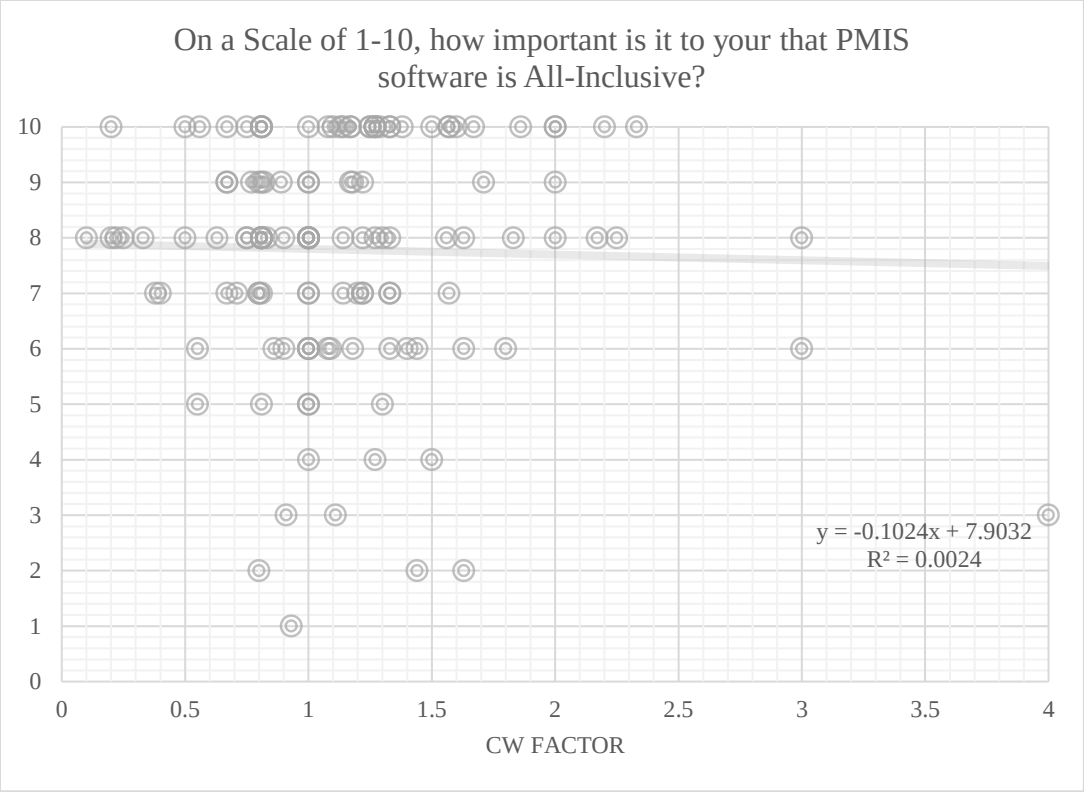

Figure 14. CW Factor vs. importance to subject that PMIS software is all-inclusive.

Open-Ended Questions: How PMISs Affect the Construction Industry

Open-ended questions to subjects on their opinions on how PMIS usage has or has not improved their company or general comments about PMIS usage were coded with phrases that fit the overall theme of the comment. All responses can be viewed in Appendix B, along with their respective coding.

Positive effects of PMISs on construction companies. Table 13 shows the coding for the subjects' opinions on how PMIS usage has improved their businesses. The total number of responses was 134 and the percentage shows the number of responses as a percentage of all responses.

Table 13

How PMIS software has or has not Improved Subject's Business (Positive)

Answer	%	Count
Yes	93.28%	125
Increased Efficiency	39.55%	53
Collaborate & Share Info.	37.31%	50
Organize Information	33.58%	45
Information Storage	29.85%	40
Process Consistency	25.37%	34
Better Job Tracking	18.66%	25
Increased Speed of Communication	18.66%	25
Better Decision Making	13.43%	18
Real Time Availability	11.94%	16
All-Inclusive Software	11.19%	15
Use of Historical Data	5.97%	8
Software Integration	5.22%	7
Improved Accounting	4.48%	6
Increased Accountability	3.73%	5
Better Estimating	2.99%	4
Total		134

Negative effects of PMISs on the construction industry. Table 14 shows the coding for each individual subject's response that had to do with a negative experience with PMIS usage. Of the 21 subjects that said PMIS usage had some negative impact, 15 said that there were at least some positive impacts as well. Coding for individual comments can be found in Appendix B.

Table 14

How PMIS software has or has not Improved Subject's Business (Negative)

Answer	%	Count
No	15.67%	21
Yes	11.19%	15
Using Multiple Software	8.96%	12
Poor Software Integration	8.21%	11
Difficulty Implementing	5.97%	8
Difficulty Datamining Information	3.73%	5
Organize Information	3.73%	5
All-Inclusive Software	2.99%	4
Double Data-Entry Required	2.24%	3
Personal Contact More Important	1.49%	2
Need More Capabilities	0.75%	1
Resist Change - No Usage	0.75%	1
Total		134

General comments about PMISs. Subjects were given the option to make general comments about PMIS usage at the end of the survey. This was also after they had been asked questions about an all-inclusive PMIS. Table 15 shows the coding and overall themes for these responses, all of which can be found in Appendix B.

Table 15

General Subject Comments About PMIS Software After Being Asked About Importance of All-Inclusive Software

Answer	%	Count
Program Integration is Important	29.73%	22
Skeptical of All-Inclusive Software	28.38%	21
Limitations to Implementation	25.68%	19
PMIS Flexible to Company Processes	24.32%	18
Must use Multiple Programs	22.97%	17
PMIS Structure Not Adaptable	18.92%	14
Best-in-Class Usage	17.57%	13
Customization is Important	14.86%	11
Need All-Inclusive Software	14.86%	11
All-Inclusive Software Success	14.86%	11
Cost/Time to Train is Extreme	13.51%	10
Adapt to other's PMIS	10.81%	8
Programs Not Designed for Construction	10.81%	8
Complicated Programs	8.11%	6
Speed of Technology Change Issue	6.76%	5
Problems Changing/Adjusting to Software	6.76%	5
Total	100%	74

Construction Trends

Figure 15 shows the results of one question that asked how subjects communicate project information within and outside of the organization. The number on the right side of the bar shows the number of responses out of the 134 individual responses. Figure 16 shows how respondents currently collect and interpret information on the jobsite.

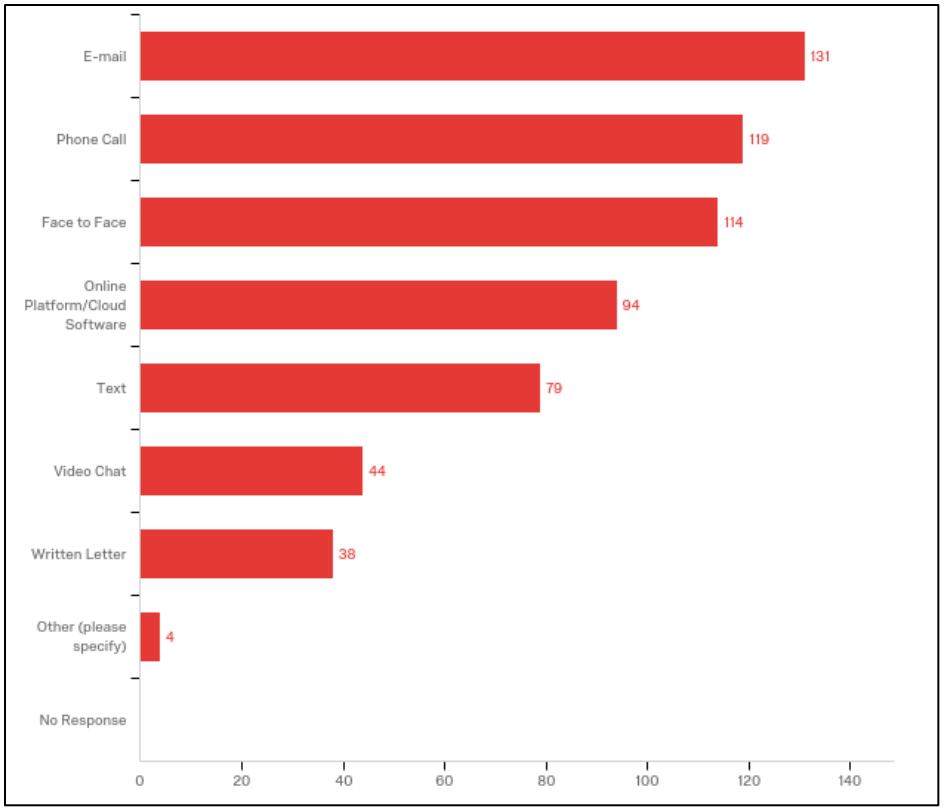

Figure 15. Methods of communicating project information and documents within and outside of the organization.

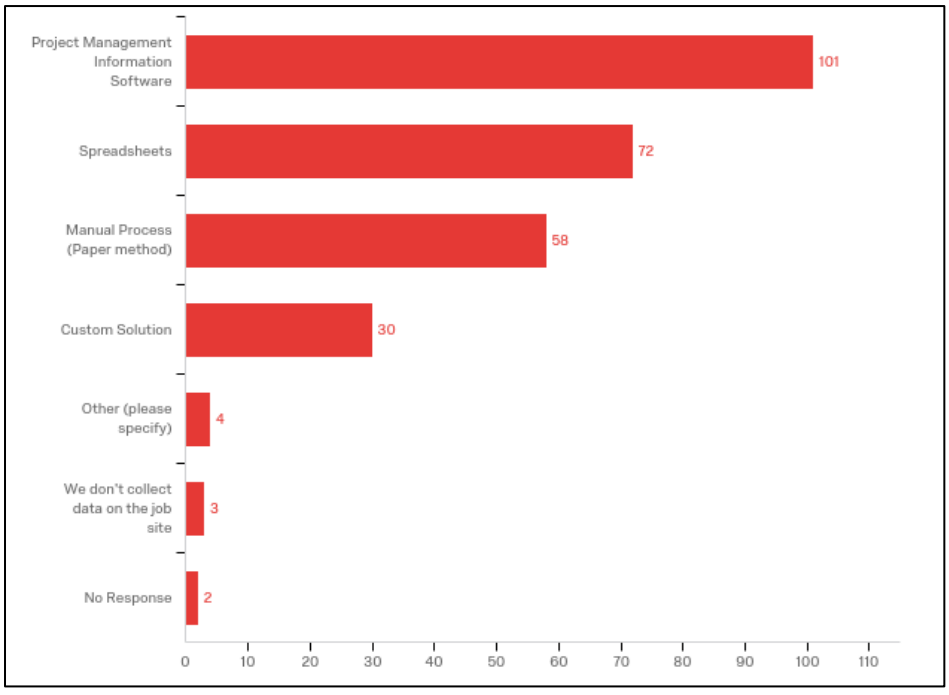

Figure 16. How respondents currently collect and interpret information on the jobsite.

Table 16 shows the total number of subjects that use PMIS software for the Construction Management Association of America (CMAA) defined functions of construction: project management, cost management, contract administration, quality management, and time management. Table 17 shows the phases of construction that PMIS software is used for. These include pre-design, design, procurement, construction, and post-construction.

Table 16

Functions that Construction Subjects Use PMIS Software for per the Construction Management Association of America's (CMAA) Definitions

Answer	Count	%
Project Management	117	87.31%
Cost Management	107	79.85%
Contract Administration	98	73.13%
Quality Management	87	64.93%
Time Management	81	60.45%
Safety management	77	57.46%

Table 17

Phases of Construction PMIS Software is Used For

Answer	Count	%
Construction	129	96.27%
Procurement	100	74.63%
Design	91	67.91%
Post-Construction	90	67.16%
Pre-Design	67	50.00%

Table 18 features the results of the survey and shows the answers to the research questions and goals shown in Table 1. PMIS usage has been shown to improve communication, increase efficiency, provide better job tracking, improve process consistency, and provide data storage. The negative aspects, however, are that it sometimes creates double data entry, is difficult implementing, features the need to use too many software programs, and is associated

with poor software integration. Seventy-nine percent of companies are using six or more programs, with the average number in use being eight. Forty percent of subjects' companies use more programs than they do features. The biggest limitations for PMIS usage are training, technological barriers, programs not being all-inclusive, and PMIS solutions not being flexible. Respondents on average perceive software integration and programs being all-inclusive to be very important. Eighty-two percent of the survey subjects would prefer to use an all-inclusive system. The most popular features that subjects would like to see in an all-inclusive system are project management, field data collection, change orders/PCO's, document storage and plan management, scheduling, performance tracking, estimating/take-offs, accounting, and proposal generation.

Table 18

Research Results

Research Question	Research Goal	Questions Analyzed	Results
Assess current construction industry's uses, views, opinions, and trends about PMIS.	- Understand construction professional's views on PMIS and if it is currently hindering the industry. - Analyze open comments for similarities in limitations and successes.	8-14, 18, and 25 A, B, C, E, G, H	Pros: PMIS in general increases efficiency, sharing of information, data storage, improves process consistency, and provides better job tracking. Cons: Must use multiple software, poor software integration, difficulty implementing, difficulty organizing and finding information, double data entry.

Research Question	Research Goal	Questions Analyzed	Results
Does the productivity of PMIS usage have an impact on success of the company and user satisfaction?	- Show CW Factor has a linear relationship with PMIS success, user satisfaction, and program integration.	15-21 A, B, C, D	79% of companies using 6 or more programs. Average number of PMIS in use is ~8 programs. 40% of subject's use more programs than features. CW Factor not found to impact PMIS success, user satisfaction, or program integration.
Understand limitations or reluctance of implementing an all-inclusive PMIS.	- Assess need for all-inclusive PMIS software. - Analyze limitations to implementation of all-inclusive PMIS.	17, 19-25 A, B, C, E, G	Limitations: Training, Not All-Inclusive PMIS, Technological Barriers, System not Flexible. Subjects on average found All-Inclusive PMIS and software integration very important. 82% of subjects would prefer to use one all-inclusive system.
Discover features most requested by construction professionals for PM-ASP's.	- Define what an all-inclusive PMIS software is and what features it should have. - Show PM-ASP's which programs are most desirable.	15, 16, 24 D, F,	Project Management, Field Data Collection, Change Orders and PCO's, Document Storage and Plan Management, Project Scheduling, Performance Tracking, Estimating and Take-offs, Accounting, Proposal Generation

Discussion

One hundred and thirty-four individual survey responses were included in the final data sample. Responding subjects operate predominantly in the Midwest (86%), are associated in some way with the Milwaukee School of Engineering, are currently working within the construction industry, and vary widely in revenue, size, company type, and job position. All 134 respondents consented to give information about their company through informed consent and all respondents' identities have been withheld to protect the respondents and their companies' processes.

Importance of PMIS Integration

One of the research questions of the study was to more clearly understand if people are having better success using an all-inclusive PMIS or multiple best-in-class programs, which are then forced to integrate. It was found in scholarly research that a non-integrated system results in a fragmentation of the internal company information and contributes to lost productivity and communication. It was not clear at the time of study whether companies have made it an initiative internally to solve the problems of fragmentation in construction by integrating or by using an all-inclusive PMIS. One of the goals of the study was to analyze whether system quality and integration is a significant factor that is hampering the industry and to look at the limitations of the PMIS currently in use.

Table 4 shows the descriptive statistics for the question that asked respondents how well the programs currently in use in their company integrate. One-hundred and twenty-seven respondents answered the question with a mean score of 4.6 and a standard deviation of 2.35. This result denotes a score that is below the 'average', score which was a 5. Figure 5 shows that 40% of subjects feel that the integration between their PMIS programs currently in use works in

an average manner (5) or moderately well (6). The third largest number of responses came from 17% of respondents saying that their current programs do not integrate well at all (1). Almost 40% of respondents said that integration within all their programs currently in use is below average while 43% said that integration was above average. This left about 19% of respondents who said that their PMIS implementation just worked in an average manner. It is clear from these numbers that subjects, and their businesses, are evenly split as far as integration that performs in an above or below average manner. This fact, coupled with the large variance in scores among subjects, gives weight to the theory that there are the haves and have nots when it comes to companies being successful with PMIS integration.

Table 5 shows the descriptive statistics for the same question as Table 4, but is split into company types. On average, subcontractors scored lower than other company types and perceived that their current PMIS integration was below a 4, which was labeled ‘slightly well’. On average, design-build contractors, general contractors, and those placed in the ‘other’ group had higher scores than design firms, construction managers, and subcontractors. This could be because PMIS implementations are typically designed with general contractors or project managers in mind, rather than subcontractors and tradespeople.

Figure 6 shows the number of responses for each Likert score for the question asking subjects how important it is that their PMIS software integrates with other PMIS programs or features. All subjects participated in this question, with approximately 81% of subjects saying that transferring of data between programs and functions between their PMIS was very important to extremely important. Table 6 shows the average score was 8.43 with a standard deviation of 1.65. The highest number of responses were for a Likert scale of 10 and 8, which is a score of extremely important and very important. Thus, it is possible to determine that much of the

construction industry believes it is very important to extremely important that PMIS programs integrate with each other.

PMIS Limitations

When subjects were asked what their biggest limitation to implementation was for PMIS, Table 7 shows that at least 50% of subjects perceived that some of the largest barriers to implementation of a PMIS were training, technological barriers for employees, functionality of the system, or PMIS lacking a unified vision or not being an all-in-one solution. It can be seen in Tables 7 and 8 that different company types and different job positions have different barriers when it comes to implementation. For instance, general contractors most often had issues with implementation stemming from training, technological barriers, and systems not being flexible. However, 71% of design-build contractors strongly felt that current PMIS programs in use lack a unified vision or all-inclusive solution. Other company types and subcontractors also saw value in an all-inclusive system, more so than general contractors or engineers. About two thirds of subjects from design or architectural firms indicated that training and functionality was an issue. Only five subjects indicated that they had no limitations to implementation. There is a larger need for an all-inclusive PMIS among design-build contractors and subcontractors versus general contractors or CMs.

Table 8 shows that different job positions also are associated with a different idea about limitations to implementation. Superintendents, which typically rise from the trades to supervise and oversee projects, see training and technological barriers as two of the biggest limitations to implementation. This shows that superintendents may be struggling to adapt to programs due to the nature of having to use new technologies while receiving little training on a PMIS. Project managers, however, perceived that current PMIS implementations lack a unified vision or are not

all-inclusive and are also not flexible with respect to their needs. The ‘other’ group, which consists of site engineers, administrative personnel, real estate developers, IT, and other company staff, strongly perceived that PMIS solutions lack a unified vision.

Only about 10% of respondents perceived that PMIS solutions were being implemented by the wrong team or they perceived other reasons for limitations to PMIS usage. Some of these additional limitations include: data storage limitations, speed of the system, resistance to change, steep learning curve, clunky complex solutions, general bugs, or having to use workarounds. In conclusion, over 50% of subjects said that current PMIS in use is lacking a unified vision or is not an all-in-one solution.

On another note, functionality, or the system not being flexible, are other important factors that were often mentioned and that are linked with system quality of a PMIS being an important factor. Training and technological barriers are some things that companies can control only internally. Companies need to properly train their employees on using a PMIS properly and to company standards and to make sure that the method and means are user-friendly. One of the biggest factors is understanding where information is supposed to be stored in ever expanding ‘data silos’. Scholarly research has shown that companies sometimes have a standard for internal processes for some things but not others. Entering data and information correctly into a PMIS software system is a key in making the data easily accessible and easy to find later.

Training and a company process manual for PMIS usage ensures that employees understand where to input information so that it can be referenced again later. Scholarly research has shown that reducing the number of PMISs in use via integration makes it easier to train an employee, as it is necessary only to teach them a fewer number of programs. It is the author’s experience that companies using multiple PMISs do not have adequate time to teach employees

how to use all relevant PMIS implementations for their job. As such, the employee must be self-taught or will only end up using the PMIS at its limited potential. This is evidenced by many companies using their PMIS in a 'skin-deep' fashion.

The general open-ended comments were another opportunity for subjects to identify frustrations about limitations to implementation. One respondent said:

> Existing systems seem to frequently be designed with the construction industry as an afterthought. They are often migrated from software development or written by developers who do not actually manage construction projects. Those systems that are designed for construction itself are many times rigid in implementation, forcing you to adapt your workflow to them rather than cleanly complementing the existing workflow.

One thing that was alluded to in Table 5 was that subcontractors had a lower average score when it came to perceiving how well their PMIS integrates and communicates with other PMIS programs. A big reason for this, as some open comments reveal, is that subcontractors are frustrated with having to use whichever PMIS program the general contractor is using. Often their programs do not easily synchronize with their own internal programs. A disconnect thus occurs between the project manager and his subcontractors:

> As a subcontractor, it's frustrating to have to use the various software that each GC uses (Procore, Oracle, Expedition, Stratusvue, etc.) while none of them integrate with our systems so it creates double entry for every project and a learning curve on software that changes faster than it can be learned.

Another subcontractor said, "As a subcontractor, you are tasked with using various systems based on the platforms utilized by specific general contractors or construction managers and that alone can be burdensome when you are operating on 4-5 platforms at any time."

Many of the limitations to implementation could be fixed by either using better PMIS integration or coordination between stakeholders' PMIS programs in use. Another one of the biggest limitations to implementation comes in the system quality itself via issues with functionality, flexibility, or not being an all-in-one solution. PM-ASPs need to make their software adaptable through customization to allow for companies to inject their own standard operating procedures. Integration between other popular external systems that a large percentage of companies use, such as AutoCAD, Oracle, Bluebeam, or Microsoft would also make programs more valuable due to their integration with existing programs.

It has been determined in a review of scholarly articles that using fewer programs will make it easier for companies to properly train their employees and overcome technological barriers among their employees. Analysis of scholarly articles reveals that a clear majority of companies have standard operating procedures for some things and not for other things. Standard operating procedures for PMIS usage will help to train employees and help to ensure that the systems are used as intended.

Importance of an All-Inclusive PMIS

Project management information systems in general have been associated with a drastic improvement on project manager productivity and project success. Scholarly research to date has shown that this productivity is compounded and improved through the use of all-inclusive systems or by integrating PMISs wisely. Companies that are exercising a stand-alone or partial stand-alone/best-in-breed PMIS strategy without regard to integration with existing PMISs used in the firm may be having problems and frustrations with having to use multiple PMISs that are not integrated. These issues have been shown to contribute to a false sense of security, lost productivity, poor communication, and less effective job tracking in construction. Recent

scholarly research published around the same time of this study shows that there is a growing need within the construction industry for an all-inclusive PMIS system.

The second research goal of the study was to come to a determination as to whether there is or is not a need for an all-inclusive PMIS software solution among construction professionals. The subjects' overall perceived importance of integration, the subjects' perceptions about how their current PMIS integrates, and the subjects' perceived limitations to implementation all point to a need for an all-inclusive PMIS system. While Table 8 shows that at least 50% of subjects indicated that a limitation was that their PMIS is not all-inclusive, it was not known if the entire construction industry maintains the same perception and would rather use an integrated all-inclusive PMIS system instead of multiple PMIS solutions.

There has been an increase in the number of PM-ASPs focused on the construction industry in the past few years. A search on Capterra.com, a website used to search for business software and PMIS solutions, currently features a list of over 350 PM-ASPs. The speed of change in technology was a comment that came up in some open-ended comments, which is a concern that by the time technology is implemented, it may already be obsolete. The speed of change makes it difficult to invest too much into one program as it may not be the front runner or it may get bought out within a few years.

While some subjects expressed skepticism concerning an all-inclusive system, Figure 7 shows that 76% of subjects said their companies would benefit from the use of one all-inclusive PMIS, rather than using multiple PMISs. Approximately 10% of subjects decided not to respond to the question, while only 8% of subjects perceived that they would not benefit. Five percent said that they currently only use one PMIS. It is clear that a large percentage of the subjects believe that they would benefit from an all-inclusive PMIS.

Analysis of Question 22 results, concerning the perceived importance regarding an all-inclusive PMIS, also suggests that companies would prefer an all-inclusive PMIS model. Figure 8 shows the scores on a scale of 1 (‘no importance at all’) to t10 (‘extremely important’). The figure shows that 89% of respondents believe that an all-inclusive PMIS is at least moderately important. The Likert-scale numbers with the highest number of responses came are 8 (‘very important’) and 10 (‘extremely important’), with 29% and 26%, respectively. The descriptive statistics for the question in Table 7 show that the average score was a 7.78, which is very close to an 8 (‘very important’).

Subjects were first asked about the perceived importance of a PMIS before being asked if their company would benefit from one. Subjects that said ‘Yes’ had a mean score and standard deviation of 8.08 and 1.82 for 102 respondents. There were 11 ‘No responses’ with a mean score of 5.64 and 2.23, and 14 responses for ‘No’ with a mean score of 6.79 and standard deviation of 2.24. Seven subjects that claim to be using only one all-inclusive PMIS had an average score of 8.71 with a standard deviation of 0.88. The lower scores among those who indicated ‘no’ or had ‘no response’ was lower on average than those that indicated ‘yes’ or only used one PMIS.

Figure 9 shows the subject’s opinions, broken out by each job position, on whether their company would benefit from an all-inclusive PMIS. At least 82% of subjects who were in the project managers, superintendents, or the ‘other’ category perceived that their company would benefit from an all-inclusive PMIS. Eighty-eight percent of executives or owners of companies indicated that they would benefit from, or were already using, an all-inclusive PMIS solution. Only one subject who identified as an executive/owner indicated that their company would not benefit from an all-inclusive PMIS while three subjects gave no response.

The results show that the engineers, architects, and general managers who completed the survey do not appear to have as strong of a perception about an all-inclusive PMIS than the perception of superintendents, executives/owners, project managers, or those classified as 'others'. Thus, it can be determined that the subjects who perceive that an all-inclusive PMIS would benefit their company also strongly believe that an all-inclusive PMIS is very important.

Features of an All-Inclusive PMIS

The second part of the second goal was to provide PM-ASPs with the most desired PMIS features on the part of the construction industry. A fact that points to a need for an all-inclusive PMIS is that most subjects requested on average more than twelve features to be included in one PMIS that integrated and functioned together. Table 10 shows that the most requested features amongst all responses to be included in an all-inclusive PMIS were project management (97%), field data collection (93%), change orders and PCOs (91%), document and plan storage (86%), project scheduling (84%), performance tracking (80%), estimating, mark-ups, and takeoffs (78%), accounting (73%), and proposal and contract generation (71%).

One of the most interesting results was that different company types have different opinions about what should or should not be included in an all-inclusive PMIS. Table 9 also shows a breakdown of the subjects' responses for each company type and what features they would like to see included in an all-inclusive PMIS. The statistics reveal that general contractors and design-build contractors clearly want more with their PMIS. Outside of the time clock system, at least 50% of subjects in those company types requested all listed features. Others that were suggested by contractors were equipment management, quality management, and safety management.

Subcontractors, on the other hand, expressed a higher perceived importance concerning the inclusion of a time clock system. Subjects within that company type were the only type where at least 50% of subjects requested a time clock system. Subcontractors also valued the project management features, field data collection, change order and PCOs, scheduling, performance tracking, and estimating and takeoffs. At least two thirds of subjects who identified as architects or engineers, which the study shows were less convinced of the idea of an all-inclusive system, requested that project scheduling, project management, field data collection, document and plan storage, proposal/contract generation, word processors/excel sheets, and CAD drafting be included in one system, which still indicates at least some need within their company type. The 'other' group, which consisted of office admin, site engineers, assistant project managers, real estate developers, and multi-functional types, unanimously requested that project management, field and data collection, change orders and PCOs, document storage and planning, project scheduling, estimating, proposal/contract generation, and accounting be included.

Efficiency of PMIS Usage (CW Factor)

One of the goals of the survey was to analyze if the productivity of software usage within a company affected a user's views on their current PMIS software integration and their perceived importance of integration and all-inclusiveness in a PMIS. It is clear from the questions about integration and an all-inclusive PMIS that the construction industry highly values integration with a PMIS. Figure 7 and Figure 8 show that a good majority of the construction industry highly values integration, with over 79% of subjects in the study wanting to see an all-inclusive PMIS program. Subjects on average requested at least 12 features to be included in an all-inclusive program. Even though much of the construction industry would like to use an all-inclusive

PMIS, it is not known if companies are moving to this type of system. Likert-scale scores and averages in Table 6 and Table 9 show that on average, subjects valued integration slightly more than they did an all-inclusive PMIS.

Companies exercise four different strategies when selecting and implementing a PMIS: (1) a Legacy System, (2) an Enterprise Resource Planning (ERP) strategy (commercially available enterprise information systems), (3) a Best-of-Breed strategy (collection of stand-alone application connected to one another), or (4) a Stand-Alone strategy (collection of stand-alone applications not connected to one another). It is the belief of the author that many companies in today's construction industry are using either a best-of-breed or stand-alone system, rather than an ERP or legacy system. This appears to be the case because the average number of programs in use by each company is seven, with many companies using ten or more programs. This approach may have been sound in the past when the average number of programs in use were less than three and there were fewer PM-ASPs. Now, with most companies using either a best-of-breed or stand-alone system, there are the haves and the have-nots. Frustrations are commonplace in the industry with PMIS users frustrated that they must move between potentially three or more programs to complete a task. The companies that perceived an improvement are the ones that are simultaneously focusing on integration with their existing systems and working to reduce the number of PMIS programs in use. This finding is additionally supported in the open-ended comments section of the report.

Scholarly research to date indicates that PMIS software has improved the productivity of project managers and helped to streamline communication with stakeholders. Research also indicates that in the last decade, companies have begun to use integrated all-inclusive PMIS software made for the construction industry. However, in the past decade, most companies were

only using one or two PMIS software providers, but that number continues to grow as more technology companies and PM-ASPs enter the marketplace. Recent technology reports suggest that most companies are using upwards of six or more programs (Armstrong & Gilge, 2016). However, technology reports for the construction industry feature conflicting views on whether this number is decreasing or increasing (Armstrong & Gilge, 2016; JBKnowledge, Inc., 2017). A clear majority of these programs are focused on only a few features with some type of niche as a selling point.

Recently published technology reports distributed during the time of this study feature differing opinions about how many programs companies were using, with one stating that the number of programs in use is going down as companies begin to value integration more. Table 11 shows the number of PMIS programs in use for each subject's company. It was found that almost 60% of companies were using anywhere from six to ten PM-ASPs. Seventy-nine percent of companies indicated that they use more than six PM-ASPs, while only 20.9% said that they used fewer than five. The descriptive statistics in Table 11 show that the average number of PM-ASPs in use by a company is 7.835. It is important to keep in mind that PM-ASPs may provide more than one software in their package, e.g., AutoCAD with its Revit and Civil package, or Microsoft with its word processor, Excel sheets, storage, and project software. The most PM-ASPs in use by a respondent was 16, but when considering how many separate programs that are provided by a PM-ASP, like Microsoft or AutoCAD's many programs, the company could be using as many as 15 to 20 different programs.

Previous research shows that many users only use programs skin deep (Alashwal & Abdul-Rahman, 2011; Alshawi & Ingirige, 2003; Braglia & Frosolini, 2014; Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017; Lotffy & Parth, 2015). Theoretically, having to learn 20

different programs and how they integrate could be very difficult for the average employee. This is especially true if one considers that two of the biggest limitations to implementing PMISs found in this study are training and technological barriers. The entire goal of a PMIS is to improve collaboration, most importantly amongst the project team. Having too many programs leads to disaggregated 'data silos'. An even larger problem in the author's experience is that employees may only end up using half of the companies' programs and may not have a fundamental understanding of how their programs integrate with some of the companies' other programs.

Questions 15 and 16 in the survey were designed to discover the number of software providers in use by a company and how many features that they used those programs for. Features are the different functions of a construction company, such as sales, project management, scheduling, estimating, document storage, and computer aided drafting (CAD). These questions were asked to determine a subject's CW ratio. The CW ratio is a way of gauging the productivity of a company's usage of PMIS (Christianson, Wilson, Hanke, Alhnaity, & Woo, 2017). For instance, a company that uses five programs for ten features would receive a score of 2.0. A company that had ten programs for only five features would score a 0.5. These numbers are then used as an independent variable to measure against other dependent variables, such as Questions 18 through 22 of the survey, which asked about the perceived importance of integration or the perceived importance of an all-inclusive PMIS.

Figure 10 shows the number of features in use versus the number of programs in use for each subject's company. Each dot is a single subject's response and the lines on the graphs denote the levels of CW productivity for a PMIS. Dots that are darker than others have more than one response of the same value. These levels are also denoted in Table 12 as poor efficiency,

below average efficiency, above average efficiency, good efficiency, and superior efficiency. Subjects' companies that have a score below a 1.0 are using more PM-ASPs than features. Companies that score above a 1.0 are using more features than programs and are actively using their programs for more than one feature or slightly better than one feature per program.

Table 11 shows that as many as 36% of subjects' companies have below average or poor productivity with their PMIS usage. The largest group of subjects are associated with above average productivity, with 42.5% of companies indicating that they are using as many or more features than they are PM-ASPs. The CW factor was analyzed against other Likert-scale questions asked in the survey, to try to find a linear relationship with a subject's satisfaction or beliefs. The idea behind this analysis was to look at the productivity of each subject's company and compare their ratio to dependent variables to look for a linear correlation. Theoretically, the higher a CW factor, the more satisfied the subject should be with their PMIS implementation and how it integrates, as some studies have suggested.

Figures 11, 12, 13, and 14 show each subject's CW ratio versus their answer for each dependent Likert-scale question. It was found that there is no R^2 linear relationship between the CW factor and the beliefs of a subject's concerning importance of PMIS integration, how well a PMIS has improved collaboration, how well a PMIS integrates, or the perceived importance that a PMIS needs to be all-inclusive. The straight trendline and gaps between Likert-scale responses may imply that some are having more PMIS success or problems than others.

On average, those with a CW ratio lower than a 1.0 scored on average about a half point lower on all the Likert-scale questions than those with a CW ratio above a 1.0. This result may suggest evidence that the CW ratio has at least some impact on those factors, but it is not conclusive. This conclusion and the difference in average scores between Table 6 and Table 9

points to the fact that integration is a more important factor with respect to PMIS success, instead of use of the strategy entailing the reduction of the number of PMIS implementations just to be productive. While an all-inclusive PMIS focuses on integration of features, there was a lot of skepticism concerning these types of programs by subjects at the time of this study. The reasons for skepticism are pointed out in the general open-ended comments.

Analysis of Open-Ended Comments

The final goal of the study was to conduct analysis on the views, opinions, and trends of PMIS usage by subjects through their responses to open-ended questions. This was done by looking at their opinions on how PMIS usage has or has not improved their company. All general comments about PMIS usage were coded with phrases that fit the overall theme of the comment. The subjects' responses within each question set were analyzed for general themes that were similar. There was no limit to the number of codes that could be assigned to a subject's response. The author's intent was to limit the number of themes to be used for all responses, while still capturing the overall themes of each individual response. All responses, along with their respective coding, can be viewed in Appendix B.

Positive effects of PMISs on construction companies. The first open-ended question asked subjects how PMIS usage has or has not improved their business. Every subject answered this question, which was asked prior to subjects being presented the definition of an all-inclusive PMIS and whether they would benefit from it. Each individual response was coded and can be referenced in Appendix B, Question 17. Table 13 shows the positive responses for how a PMIS improved the subject's business. Ninety-three percent of respondents said that PMIS in some way improved their business. The most popular improvements included increased efficiency, improved collaboration and sharing of information, better organization and storage of

project information, more internal company process consistency, more accurate job tracking and better decision making, and increased speed of communication between stakeholders.

Increased efficiency was associated with the highest response total with almost 40% of responses. One respondent said, "[PMIS] has streamlined the daily activities allowing the project management team to focus our time on cost control, construct-ability, and quality control in lieu of just processing paperwork." Another said, "[PMIS] has created consistency of information collection and storage across our organization. It has also allowed our field crews out of the office to work more efficiently with project managers and back office project coordinators." The consensus amongst subjects that alluded to increased efficiency was based around the streamlining of activities and efficiencies gained from increasing collaboration with project stakeholders.

Improved collaboration and sharing information is a well-documented positive effect that comes from the proper implementation of a PMIS. One respondent said, "Yes, it allows the entire design, construction, and project management team to view critical data all at once saving valuable time." Another respondent, alluding to multiple improvements that came from the use of a PMIS, stated that "it has supported the implementation of more formally developed processes and work flows. Increases both speed and efficiency in information sharing and collaborating. Supports higher quality and faster decision making."

The fact that a PMIS has supported the implementation of more formally developed processes is an interesting and positive PMIS effect that was alluded to by at least 25% of subjects. One subject had virtually the same idea: "a centralized location of project information; [has] standardized businesses protocols and processes for scalable deployment company wide." Some subjects' companies are even using a PMIS to ensure a level of compliance and provide

accountability to project managers. One respondent said, “I believe the software has its uses and can help make sure your company is consistent across the board with communication and documentation. We mainly use the software to keep people on track with our company SOP.” Another subject admitted to using a fully integrated ERP system by using ‘SAP’ software, which is a PM-ASP company. The success provided process consistency for the company and all its separate projects, divisions, and regions:

> Our SAP driven fully integrated and interconnected project management system has revolutionized our construction, engineering, planning and tracking systems. As a corporation we now are more transparent, and individuals can move from project to project and region to region within the corporation seamlessly using the same integrated systems.

Beyond the productivity and efficiency benefits, an integrated system or all-inclusive system was mentioned by at least 5% and 11% of respondents, respectively. More respondents either alluded to wishing there was a program that could capture all their companies’ daily activities or confessed to actively integrating and reducing the number of PMISs in use by their company. As previously mentioned, many companies are using a best-in-breed method for implementing a PMIS. For instance, one respondent said:

> Document Control using Newforma is a dream and makes managing/tracking of documents almost fool proof. Sage Timberline allows us to create our project estimates using Estimated Extended, change orders using Project Management, serves as the company time clock, and a whole slew of other accounting tasks. Plan Swift is used in lieu of On-Screen Takeoff. They are the same thing once you figure out the hot keys. Document creation using Microsoft Office Suite and Bluebeam Extreme.

One of the most important parts of exercising a best-in-breed strategy is that integration between the different ‘data silos’ is required.

Earlier analysis showed that companies find integration very important. One subject’s comments allude to that:

> Our company has centralized all operations around digital solutions for all facets of the project and company management to streamline and integrate all ‘silos’ of our business and provide better availability of the information. It all produces data to analyze, trend, etc. to improve business operations.

Twice as many respondents alluded to the use of or desire to move towards an all-inclusive system as compared to those who only view software integration as the greatest importance. One respondent said, “Over the past 5 years we have implemented CMiC which is an ERP system. It has streamlined several processes within the company, brought everything into one platform so that certain systems talk and share information.” Another respondent alluded to the same positive effects of using an all-inclusive system:

> We have recently made a switch from a less integrated to a more integrated system which has helped our company immensely. When everything is more integrated, there's less ‘data silos’ and more analysis possible within the project. It also makes things so much easier to track when there's only one or two systems being used opposed to many more.

Multiple companies also alluded to integrating their PMIS with accounting, job tracking, and productivity to create one system and one program with all project information. The subjects’ comments have implied that the overall integration has helped to streamline subcontractor change order processes and to keep accounting and project management on the same page.

Negative effects of PMISs on the construction industry. Table 14 shows some of the problems that subjects are having with today's PMIS solutions. About 16% of subjects in total said that a PMIS had not improved their business in some way. Approximately 11% of respondents that said that a PMIS had improved their business also mentioned that it had negatively impacted them in some way as well.

In general, some of the subjects' biggest complaints revolve around having to use multiple software programs, having poor software integration, and/or wishing there was some type of all-inclusive PMIS software they could use. Some subjects' companies are dealing with software that doesn't integrate, while others have actively combatted this problem by reducing the amount of software in use and by focusing on integration between the remaining programs. Other problems that subjects had were difficulty implementing the program, difficulty datamining information, double data entry requirements, and resistance to change. Many of these other problems often are directly related to having to use multiple software programs and having poor software integration. One respondent said, "Our software is very good and helps us to manage our projects. But, sometimes it means multiple reports that would be better coming from just one software program." Some subjects feel that they can't find the right solution, because they do not think it is out there. One subject said, "The issue is that there is not a single software integration of each individual solution." Another respondent said, "It helps to keep everything in one place, however, we have not found one all-inclusive system that integrates all aspects."

Other complaints and problems with PMIS implementations had to do with datamining and finding information or having problems when different stakeholders' internal systems do not align. Datamining information becomes a big problem when systems are not aligned. One

subject said, “It gives information a place to live. But with multiple systems not integrated it becomes clunky most of the time whereas the tools are made to save time.” Another subject said:

> Project Management Software makes for more efficient work flows along with easily communicating among mass quantities of people, and it also helps with document control at the end of a project. The down side of PM software is when internal systems, and owner systems do not align, and you end up with double entry of data across multiple platforms.

Some respondents believe that there have been few improvements with PMIS. One subject said, “Often information is saved / recorded, but it is hard to get usable data / reports. Often data must be exported to a spreadsheet and then manipulated.” Another respondent felt that there were no gains at all to be made with a PMIS: “In many ways technology has made things worse. Massive amounts of unfiltered information and non-intuitive data input has increased waste. The time to accomplish very simple process tasks has skyrocketed. Clear communication and relationship development has plummeted.” Instances like these lead to thousands of hours in productivity loss due to a PMIS not integrating or not being flexible enough for each company’s different standards of operation. It is the author’s experience, and a review of scholarly articles tends to confirm, that the popular choice is employing the use of spreadsheets and pulling the information to force integration. This was echoed in many comments by different subjects.

General comments about a PMIS. Subjects were given the option at the end of the survey to add any additional general comments about the use of a PMIS in the construction industry. Table 15 shows the coding for each subject response after subjects answered questions about software integration and an all-inclusive PMIS. Many subjects alluded to either program integration being important or they were skeptical about all-inclusive software. While at least

28% of respondents expressed skepticism, indicating that an all-inclusive software was a longshot, that isn't to say that they wouldn't still like to see one produced or have their companies use one. At least 15% of subjects who took the survey indicated a need for an all-inclusive PMIS to use in their company. Other comments alluded to issues that subjects, and their companies, were having, such as limitations in implementation, the PMIS structure not being adaptable to or flexible with company processes, or not being an all-inclusive solution.

Subjects who are skeptical of an all-inclusive PMIS have many different reasons for their viewpoint. For one, most respondents indicated that there is not an all-inclusive PMIS available in the market or even available for purchase. Another problem is that there are a few large software companies, such as Microsoft, Bluebeam, or AutoCAD, whose products have been deemed irreplaceable and difficult to replicate. One respondent alluded to this issue: "There are many good programs, but often one program does one thing much better and is used for that. Another program does something better and then is used for that function. Often "all-in-one" programs do many things poorly."

Another issue indicated by some is that existing platforms are not designed with the construction industry in mind. Some subjects revealed the belief that the problem with a PMIS is that software is either accounting based and has added PM, or it is PM software that has added accounting functionality. As such, the all-inclusive programs in existence are inflexible and require many workarounds from company to company. The existence of PMIS solutions that are inflexible was alluded to by 19% of subjects, while 25% said that existing PMIS offerings must make their systems more flexible and adaptable from company to company and project to project. Otherwise, companies are required to go with a best-of-breed solution because the integration within an all-inclusive is not effective.

One respondent said:

> We have elected to go with Best-in-Class for individual solutions and plan on a data warehouse for overall metric tracking. Procore / Vista do a solid job on PM collaboration, accounting, and job costing but neither has good scheduling solutions. We use P6 for CPM development and Pull scheduling. CRM / Business Development tracking remains separate from PMIS as does estimating and VDC solutions. Changes are happening at an exponentially rate with respect to technology solutions in the industry and ensuring each solution can share data to avoid duplicated tasks is the major challenge. The option to go with a fully developed ERP solution (one stop shopping) is impractical with the speed of change resulting in average solutions from that approach in our experience.

Many subjects believe that their companies are also incapable of change when it comes to moving to a different platform. Many respondents alluded to issues of implementation, such as: the time it would take to implement, advancements of technology causing a PMIS to be outdated in a few years, or differences in procedures from job to job or owner to owner. One respondent said:

> The reality is that we've all been using some version or mix of different platforms. From experience, transferring platforms can be a very painful process, incurring significant costs and data loss. I don't think a solution which integrates everything listed in the previous questions will be feasible due to licensing issues let alone costs.

Another respondent said:

> If a firm manages many varieties of projects, a one-stop-shop solution isn't always practical nor is always an efficient solution. When mixing and matching [programs], a

> step might be lost through intercommunication, but is regained through picking the best solution on a per need and practicality basis.

Lastly, one respondent alluded to the time it would take to implement an all-inclusive PMIS system as being a large problem:

> Depending on the system I see limitations being the time of implementation. Our system took years to develop, customize, train, then go live. This effort and cost was extreme. If that system is now limited or does not keep up the pace of development in the industry it could be a lengthy process. Remember that that true cost is not just the software but maintenance and staff to manage the process.

Companies that alluded to needing an all-inclusive solution were quick to mention that they believe they have found it in programs like Procore, Buildertrend, or Vista Viewpoint. Multiple respondents said that they perceived that a PMIS does a good job of connecting the team and reaching out to multiple features. Subjects said a PMIS is also a great place to store all important information, and that it easily synchronizes and integrates with their other programs in use.

Construction Trends

The Construction Management Association of America (CMAA) states there are six functions of construction management: project management, cost management, contract administration, quality management, time management, and safety management. Subjects were asked what phases and functions of construction management their company used a PMIS for. The most popular choices were project management and the construction phase of construction, with over 87% and 96% of respondents. Cost management and contract administration were other popular functions that a PMIS is used for. The least popular functions that companies used

a PMIS for were quality management, time management, and safety management. That isn't to suggest that companies who use a PMIS for those functions are better than those who are not. It could be possible, however, that the level of documentation is a step above and easier to analyze. Pre-design, post-construction, and design are the phases that subjects are using less than procurement or construction. The reason for this trend could be that many companies or job positions are not directly involved in those portions of the work or they do not understand how a PMIS is used in those phases of construction.

The most popular form of communication was e-mail, followed by a phone call, face-to-face contact, online platform/PMIS, text, video, and lastly, a written letter. An interesting statistic to take from this result is that 70% of respondents are using a PMIS to communicate with other project stakeholders and that number is starting to get close to other more popular forms of contact, such as e-mail and face-to-face communication.

Figure 16 shows how subjects currently collect and interpret information on the jobsite. A PMIS is the most popular form of data collection and interpretation, with 75% of subjects saying it is commonly used. The next closest are spreadsheets and a paper method. Of the 101 subjects that are using a PMIS to interpret information on the jobsite, approximately 55% and 44% are using spreadsheets or manual processes, respectively, in conjunction with a PMIS. As previously mentioned, this result suggests that many companies are losing productivity, having to manipulate their information to fit within a PMIS.

This statistic also may indicate that a PMIS may still be limited in its ability to take in information from the field without being manipulated. In the author's experience, this could be as simple as a subject's company not liking the way a PM-ASP lays out a fill-in document that is rigid in its form. As such, the company uses a custom-built company spreadsheet and attaches

the information, as they would in an e-mail. This procedure in theory is good, because the information is in the cloud and available for stakeholders, but on the other hand, the information does not integrate with the system, requiring further manipulation, and the data cannot intuitively be tied back into other parts of the system as the 'rigid' system intends. As such, it is a glorified storage database in the cloud. It is the author's experience that a good way to overcome this type of limitation is to ensure that the company chooses a PM-ASP that has a system that is customizable. On the other hand, companies must also be willing to adapt to the systems to utilize their full capabilities. This would ensure that they are not using the PMIS 'skin deep', at a basic user level, because many of the features do not work for their company style. Perhaps the company style or standard operating procedure needs to be slightly manipulated.

Limitations of Research Study

Empirical research indicates that as the integration of PMIS systems increases, so does the user's satisfaction. As a system becomes more integrated with stand-alone systems, user satisfaction also increases. The CW factor was designed to analyze the productivity of program usage within a construction company. The results of the CW factor analysis in this study were inconclusive and did not point to the same results as in past research. There may be a few reasons for this result. Research in this project indicates that often different job positions or company divisions may be using different programs within a company and may not be aware of the full extent of PMIS usage within the remainder of the company, nor do the positions and divisions have a fundamental understanding of everything that the PMIS is used for. This result was confirmed when analyzing the CW factor scores for subjects with the same company e-mail address. There was a very large variance in the CW factors in one situation due to the PMIS providers and features chosen by the user. Some employees entered scores as low as 0.5, some as

high as 3.0, and many around the 1.0 score. Therefore, how the CW factor is currently determined is considered to not be effective. Future research should first verify internal company PMIS usage and what features the PMIS is used for to set the CW factor for the company, which can then be analyzed against the user's satisfaction and the system's productivity benefits. Also, the type of PMIS integration strategy in use by a company, such as best-in-breed, stand-alone, or enterprise systems, was not asked by the survey. A future survey should include this question, so that the responses can be compared to the company's CW factor and its user's satisfaction to understand which strategy fosters the highest user satisfaction, integration, and productivity.

Other limitations include the sample size and location of the respondents. Respondents were primarily from the Midwest in the United States and associated with the Milwaukee School of Engineering. Survey research assumes that respondents are unbiased. A possibility exists that subjects may have been biased towards an all-inclusive PMIS before taking the survey. While the demographics show that subjects are very diverse in their company type, size, and job position, the small sample size made it difficult to analyze certain populations. In the future, a larger and more diverse demographic group could validate this study's findings, or offer different results.

Conclusion

The number of PM-ASPs available to the construction industry has drastically increased in the past decade. Correspondingly, the number of programs in use by a construction company has continued to increase over the years. Approximately 80% of companies surveyed in this project are using more than six PM-ASPs, with some companies using as many as ten or more. Companies that are exercising a best-in-breed or stand-alone PMIS strategy are starting to have issues with integration between their programs and are suffering from productivity losses because of the need to manipulate information. Some PM-ASPs for the construction industry

have begun deploying an all-inclusive model that connects the major features of construction together in an integrated and meaningful away. Scholarly research to date had not assessed the need by the construction industry for these all-inclusive systems. A few knowledge gaps remain as to whether the construction industry is currently struggling with program integration, whether the industry would like to use all-inclusive PMISs instead of multiple PMISs, whether the productivity of PMIS usage is related to PMIS success, integration, or user satisfaction, and what an all-inclusive PMIS program should include as far as features. This capstone project sought to close these knowledge gaps by assessing the need for an integrated all-inclusive PMIS in the construction industry.

It was found by surveying the construction industry that some companies are experiencing frustration trying to integrate their PMIS implementations together. The average score for how well programs integrated with others amongst all subjects was slightly below average, with 17.3% saying that their programs do not integrate well at all. On average, subjects perceived that program integration was very important, with at least 36% of subjects saying it was extremely important. Major limitations to the implementation of a PMIS perceived by at least 50% of subjects were training, technological barriers, poor functionality/flexibility of the system, and the lack of an all-inclusive solution. These results show that there are issues with program integration in the construction industry, flexibility of systems, and a general limitation caused by programs not being all-inclusive.

When the construction industry was asked whether they perceived that an all-inclusive PMIS was important to the industry, the average score was a 7.78, which was extremely close to a score of ‘very important’. Approximately 65% of subjects indicated that it was very important or extremely important. When all subjects were asked if their company would benefit from using

an all-inclusive system instead of multiple PMIS programs, over 75% of subjects indicated ‘yes’, with 5% indicating that they currently only use one PMIS. Approximately 20% either indicated that their companies would not benefit or provided no response. Some of the skepticism about an all-inclusive PMIS is that those that are currently available in the industry do not provide a platform that is easily usable and performs better than a best-in-breed program that solely focuses on one feature. Other limitations are the time and training required to implement an all-inclusive platform and the speed of change that occurs with PMIS technology, rendering some implementations obsolete in a short time period. As a result, many companies have still not begun moving towards an all-inclusive model, even though the results show many subjects would like to move to that model.

The average number of features selected by subjects to be included in an all-inclusive PMIS was 12. The most popular features selected were project management, field data collection, change orders and PCOs, document and plan storage, project scheduling, performance tracking, estimating/take-offs, accounting, proposal and contract generation, word processor/Excel sheets, AutoCAD, and an invitation to plan room. PM-ASPs looking to move towards an all-inclusive model should be sure to include these features in their offering and look to ensure that integration and communication is streamlined between activities in a meaningful way.

Lastly, use of the CW factor analyzed the productivity of a company’s internal PMIS usage. Less than 10% of subjects had a CW score greater than 2, which meant they were not using on average one program for at least two features. Approximately 36% are using more programs than they are using features. This means that companies are having to use one program per feature or they are using multiple programs for one feature. The remainder of the subjects

finished with a score of 1.0 to 1.99, which means they are moving in the right direction for above-average PMIS productivity. There were limitations to the scoring found for each subject due to the user's potential bias, and as such, it could not be confirmed if increasing the productivity of a PMIS within a company has an impact on the success and productivity of a PMIS or the subject's satisfaction with a PMIS.

The results of this capstone project confirm that there is a need on the part of the construction industry for an all-inclusive PMIS program. A review of scholarly research has shown that these programs, while not confirmed through the survey study, have improved integration, increased productivity, increased the level of user satisfaction, and reduced double data entry. In the results of this capstone study, participants expressed widespread skepticism about an all-inclusive PMIS and its use in the construction industry. This is likely because existing programs claiming to be all-inclusive are less functional and more difficult to implement. PM-ASPs should look to integrate more of a PMIS's features together in an integrated and intellectual way while still allowing for the customization that each different company in the industry requires. The problem of not being able to use an all-inclusive PMIS requires a change by the service providers to have a better functioning platform and a change by the construction industry in general to be adaptable to these implementations to take full advantage.

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Appendix A: Survey

English (US)

SURVEY INSTRUCTION

Intro.

Welcome to the All-Inclusive PMIS research study!

This survey is for a master's thesis research conducted by Gage Christianson of the Milwaukee School of Engineering. The thesis adviser's are Milwaukee School of Engineering professors: Dr. Jera Sullivan, Dr. Jeong Woo, & Dr. Blake Wentz. The purpose of this survey is to analyze the construction industry's usage of PMIS software's within their own respective company. The objective of the study is to assess the need and usage of all-inclusive PMIS in construction. All-Inclusive Construction PMIS is defined as a project management information system software that syncs and integrates all the major types of PMIS functions needed to run every aspect of a construction project and company. (i.e. Sales, Estimating, Pre-construction, project management, Client Relationship Management (CRM), accounting, daily logs, to-do's, calendars, word processors, cloud storage, etc.)

The survey is 25 questions and will take approximately 10-15 minutes. Questions consist of open answer, Likert scale, and multiple-choice answers. The survey opens with some simple demographics about your company size and your job position. The survey will then ask participants about their current usage of PMIS within their company and ask about your satisfaction. The survey will ask what PMIS software your company is using, for what functions of construction, and what types of PM (Project management) software. Finally, we will ask participants if they see a need for an all-inclusive PMIS in the construction industry and define what capabilities or project management functions it should include.

The objective of this thesis is to determine if there is a need among construction professionals for an all-inclusive project management information system (PMIS) software in the construction industry. This information, if confirmed, could be used by PMIS service providers to begin adding more functions and integration into their programs to better service the needs and wants of construction professionals. It also will encourage construction companies to integrate more of its functions into all-inclusive

PMIS to take advantage of the enhanced productivity that comes from it. This could also encourage construction professionals to see the benefit in integrating more of its companies processes into all-inclusive PMIS.

Please direct any questions about the survey or thesis study to Gage Christianson at christiansong@msoe.edu.

Informed Consent & Qualifying Question

Informed Consent.

Informed Consent Statement

All individual participant survey results will be kept confidential. This survey is voluntary. Refusal to participate will involve in no penalty or loss of benefits to which the participant is otherwise entitled. At any time, participants may cease to continue, exit the survey, or skip answers by answering would rather not disclose or N/A. No e-mails or specifics identifiers will be asked that would disclose your company. Individual Participant results will not store private participant data that would otherwise identify the individual. Individual survey results will be protected by a password and stored on MSOE's Qualtrics's server. After completion of the master's thesis, individual results will be saved on a single USB Drive to be protected by the investigator. All survey information will be wiped from Qualtrics's server at that time.

By proceeding with this survey, you are giving consent to have your survey information included in the study. I appreciate you taking the time to participate in the survey. I hope that this survey will lead to further collaboration and productivity among construction professionals in the usage of PMIS.

- ○ I consent, begin the study
- ○ I do not consent, I do not wish to participate

Q1. Do you currently work in the Construction Industry? (Not an educator, student, or analyst.)

- ◯ Yes
- ◯ No

Main Survey

Q2. What construction industry do you primarily work in? Choose the main one that applies.

- ◯ Commercial General Contracting
- ◯ Residential General Contracting
- ◯ Transportation
- ◯ Industrial
- ◯ Waste/Waste-water/Solid Waste
- ◯ MEP Systems
- ◯ Engineering
- ◯ Structural
- ◯ Concrete/Masonry
- ◯ Finishes
- ◯ Landscaping
- ◯ Site-work/Earthworks
- ◯ Drywall/Interiors
- ◯ No Response
- ◯ Other (please specify)

Q3. How would you classify your company type? Pick one.

- ◯ General Contractor
- ◯ Design-Build Contractor
- ◯ Subcontractor
- ◯ Material Supplier
- ◯ Architectural/Engineering/Design Firm
- ◯ Owner-Builder

- ◯ Real Estate Developer
- ◯ Professional Construction Manager
- ◯ No Response
- ◯ Other (please specify)

Q4. What is your job position in your respective company? Pick one.

- ◯ Executive/Owner (i.e. CEO, CIO, CFO, VP)
- ◯ General Manager
- ◯ Superintendent
- ◯ Project Manager
- ◯ Estimator
- ◯ Sales
- ◯ IT Staff
- ◯ Office Manager / Administrator
- ◯ Engineer/Architect
- ◯ Misc. Office (i.e. Human Resources, Marketing, Intern)
- ◯ No Response
- ◯ Other (please specify)

Q5. What area of the United States do you operate in?

- ◯ Northwest
- ◯ Southwest
- ◯ Mid-west
- ◯ South-Central
- ◯ Northeast
- ◯ Southeast
- ◯ I do not operate within the United States
- ◯ Would rather not disclose.

Q6. What is the size of your company?

- ◯ 1-20 employees
- ◯ 20-99 employees
- ◯ 100-499 employees
- ◯ 500-999 employees
- ◯ 1000+ employees
- ◯ Would rather not disclose.

Q7. What is your annual sales volume?

- ◯ Less than $1 Million
- ◯ $1 Million - $5 Million
- ◯ $5 Million - $50 Million
- ◯ $50 Million - $150 Million
- ◯ $150 Million - $500 Million
- ◯ $500 Million+
- ◯ Would rather not disclose.

Q8. How many projects do you typically work on, or manage, at one time?

- ◯ 1-5
- ◯ 6-10
- ◯ 11-19
- ◯ 20+
- ◯ No Response

Q9. How long does your typical project take?

- ◯ < 1 month
- ◯ 1-3 months
- ◯ 4-12 months

- ◯ 1-3 years
- ◯ +3 years
- ◯ No Response

Q10.

What are your methods of communicating project information and documents within and outside the
organization? Choose all that apply.

- ☐ Face to Face
- ☐ Phone Call
- ☐ E-mail
- ☐ Text
- ☐ Video Chat
- ☐ Online Platform/Cloud Software
- ☐ Written Letter
- ☐ No Response
- ☐ Other (please specify)

Q11.

How do you currently collect and interpret information on the job site? (Daily Logs, Production Times,
QA/QC notes, etc.) Choose all that apply.

- ☐ Manual Process (Paper method)
- ☐ Spreadsheets
- ☐ Project Management Information Software
- ☐ Custom Solution
- ☐ We don't collect data on the job site
- ☐ No Response
- ☐ Other (please specify)

Q12.

Has your company ever used any type of project management information software? (i.e. Microsoft Office, Procore, Bluebeam, Personal Server)

- ○ Yes
- ○ No
- ○ No Response

Q13.

What functions of construction management does your company use PMIS for? (Definitions are taken from the CMAA Outline of CM Functions.) Choose all that apply.

- ☐ Project Management (Use of integrated systems and procedures by a team of professionals during project design and construction.)
- ☐ Cost Management (Managing, controlling and monitoring project costs.)
- ☐ Time Management (Most effective use of people, materials, equipment and funds. Proper planning, scheduling and coordination to achieve on-time completion within budget and at the level of quality expected.)
- ☐ Quality Management (Process of planning, organizing, implementing, monitoring and documenting a system of policies and procedures that coordinate and direct relevant project resources and activities in a manner that will achieve quality.)
- ☐ Contract Administration (Function of implementing the terms and conditions of a contract based upon established systems, policies and procedures.)
- ☐ Safety management (Establishing the methods and procedures for providing safety management services.)
- ☐ None
- ☐ N/A

Q14.

What phase of construction do you use project management information software for? Choose all that apply.

- ☐ Pre-Design
- ☐ Design
- ☐ Procurement

- [ ] Construction
- [ ] Post-Construction
- [ ] None
- [ ] N/A

Q15. What type of project management information software does your company use? Choose all that apply.

- [ ] Field Data Collection (Daily Reporting, Photos, & Performance Tracking)
- [ ] Project Management (Pricing Quotes, Submittals, RFI's, Change Orders, etc.)
- [ ] Estimating, Mark-ups & Takeoffs
- [ ] Sales & Lead Tracking
- [ ] Proposal & Contract Generation
- [ ] Word processor, Sheets (Excel), & Presentations
- [ ] Document Storage & Plan Management
- [ ] Accounting
- [ ] Autocad, BIM, & Design
- [ ] Prequalification
- [ ] Invitation to Bid / Plans Room
- [ ] Project Scheduling
- [ ] Time Clock
- [ ] Client Relationship Management (CRM)
- [ ] None
- [ ] Other(s) (please specify all others)

Q16. What PMIS software providers does your company use? Choose all that apply.

- [ ] Viewpoint
- [ ] Procore
- [ ] AutoCAD (Revit, Navisworks & Affiliates)
- [ ] Trimble (Sketch-up)
- [ ] BIM 360

- [ ] Co-Construct
- [ ] Oracle / Primavera (P6)
- [ ] Sage
- [ ] Quickbooks
- [ ] Dropbox
- [ ] Bluebeam
- [ ] On-Center / On-Screen Takeoff
- [ ] Multivista
- [ ] Newforma
- [ ] Timberline
- [ ] Microsoft Office (OneDrive, Word, Excel, Powerpoint, Outlook, MS Project)
- [ ] Prolog
- [ ] Personal Company Server (i.e. Citrix)
- [ ] Custom Solutions (Spreadsheets & Manual Processes)
- [ ] No Response
- [ ] Other(s) (please specify all)

Q17. Has project management information software improved your business? How or How not?

Q18.
On a scale of 1-10, how well has PMIS improved collaboration with other project stakeholders?
(Architects, Engineers, Owners, Subcontractors)

- ○ 10 (Extremely well)
- ○ 9
- ○ 8 (Very Well)

- ◯ 7
- ◯ 6 (Moderately Well)
- ◯ 5 (Average)
- ◯ 4
- ◯ 3 (Slightly Well)
- ◯ 2
- ◯ 1 (Not well at all)
- ◯ We do not collaborate through PMIS
- ◯ N/A

Q19. For the PMIS you have used, what were your limitations? Choose all that apply.

- ☐ Functionality / System Not Flexible
- ☐ Training
- ☐ Wrong Team Implementing
- ☐ Lacks a Unified Vision or Not All-in-One Solution
- ☐ Cost
- ☐ Technological Barriers for Employees
- ☐ No Limitations
- ☐ N/A
- ☐ Other / Why?

Q20.

On a scale of 1-10, if you use more than one PMIS program, how well do these programs integrate and
communicate with each other?

- ◯ 10 (Extremely well)
- ◯ 9
- ◯ 8 (Very Well)
- ◯ 7
- ◯ 6 (Moderately Well)
- ◯ 5 (Average)

- ◯ 4
- ◯ 3 (Slightly Well)
- ◯ 2
- ◯ 1 (Not well at all)
- ◯ N/A

Q21.

On a scale of 1-10, how important is it to you that different project management information software's
integrate their information for ease of transferring data between programs or functions?

- ◯ 10 (Extremely Important)
- ◯ 9
- ◯ 8 (Very Important)
- ◯ 7
- ◯ 6 (Moderately Important)
- ◯ 5 (Average Importance)
- ◯ 4
- ◯ 3 (Slightly Importance)
- ◯ 2
- ◯ 1 (No Importance At All)
- ◯ N/A

Q22.

All-Inclusive Construction PMIS is defined as a project management information system software that
syncs and integrates all of the major types of PMIS functions needed to run every aspect of a construction project and company. (i.e. Sales, Estimating, Pre-construction, project management, Client Relationship Management (CRM), accounting, daily report logs, to-do's, calendars, word processors, cloud storage, etc.)

On a Scale of 1-10, how important is it to you that construction project management software is all inclusive.

- ◯ 10 (Extremely Important)
- ◯ 9
- ◯ 8 (Very Important)
- ◯ 7
- ◯ 6 (Moderately Important)
- ◯ 5 (Average Importance)
- ◯ 4
- ◯ 3 (Slightly Importance)
- ◯ 2
- ◯ 1 (No Importance At All)
- ◯ N/A

Q23.

Would your company benefit from using one all-inclusive PMIS instead of multiple PMIS?

- ◯ Yes
- ◯ No
- ◯ We currently only use one PMIS
- ◯ No Response

Q24.

What capabilities or types of PMIS do you envision an all-inclusive PMIS program to have? Choose All
that Apply.

- ☐ Field Data Collection (Daily Reporting, Photos, &
- ☐ Performance Tracking)
- ☐ Project Management (Pricing Quotes, Submittals, RFI's,
- ☐ Change Orders, etc.)
- ☐ Estimating, Mark-ups & Takeoffs
- ☐ Sales & Lead Tracking
- ☐ Proposal & Contract Generation
- ☐ Word processor, Sheets (Excel), & Presentations

- [ ] Document Storage & Plan Management
- [ ] Accounting
- [ ] Autocad, BIM, & Design
- [ ] Prequalification
- [ ] Invitation to Bid / Plans Room
- [ ] Project Scheduling
- [ ] Time Clock
- [ ] Client Relationship Management (CRM)
- [ ] None
- [ ] Other, choose any missing.

Q25.

Do you have any comments/testimony about the use of project management information system
software in the construction industry?

Appendix B: Coded Open-Ended Questions

Question 17

Has Project Management Information Systems improved your business? How or How Not?

Answer	Coding
Helped organize the process	Yes,Organize Information,Process Consistency
It has helped create templates and an area to share data across the company but there are several options for project management information software which has also created some chaos.	Information Storage,Using Multiple Software,Process Consistency,Real Time Availability,No,Yes,Collaborate & Share Info.,Poor Software Integration,Organize Information
Yes, centralizes info and makes it shareable.	Collaborate & Share Info.,Information Storage,Yes,Organize Information
Yes allowed us to collectively communicate better and establish better efficient ways to manage projects. However only as good as the people using it....Garbage in/Garbage out.....must be self disciplined to be consistent with data entry.	Process Consistency,Increased Efficiency,No,Yes,Difficulty Datamining Information,Collaborate & Share Info.,Increased Speed of Communication,Better Job Tracking
It has added a level of complexity the firm as a whole isn't used to. However, the benefits have been great. As it moves forward it will help save time and cost.	Yes,Increased Efficiency,No,Difficulty Implementing
It would be almost impossible in todays environment to manage without a PM software.	Better Decision Making,Yes
Yes, it makes data easier to manage	Information Storage,Yes,Organize Information
Yes, it helps to keep everything in one place however we have not found one all inclusive system that integrates all aspects.	Information Storage,Using Multiple Software,No,Yes,Poor Software Integration,Organize Information,All-Inclusive Software
Has supported the implementation of more formally developed processes and work flows. Increases both speed and efficiency in information sharing and collaborating. Supports higher quality and faster decision making	Better Decision Making,Information Storage,Process Consistency,Increased Efficiency,Yes,Collaborate & Share Info.,Increased Speed of Communication,Organize Information
Havent used this system	No Response
Yes to help capture and aggregate all project information	Information Storage,Yes,Organize Information
Yes, gives information a place to live. But with multiple systems not integrated it becomes clunky most of the time where the tools are made to save time.	Information Storage,Using Multiple Software,No,Yes,Difficulty Datamining Information,Poor Software Integration

Answer	Coding
Yes - improves efficiency and accuracy of our project teams.	Information Storage,Increased Efficiency,Yes,Increased Accountability
Yes. We've recently implemented the use of Bluebeam in the field.	Information Storage,Increased Speed of Communication,Yes
Yes - centralized location of project information; standardized businesses protocols/processes for scalable deployment company wide.	Information Storage,Process Consistency,Yes,Collaborate & Share Info.,Increased Accountability,Organize Information
Still looking for the right solution	No,Using Multiple Software,Poor Software Integration
Yes, but it has limits. Often information is saved / recorded, but it hard to get usable date / reports. Often data has to be exported to a spreadsheet and then manipulated.	Yes,No,Difficulty Datamining Information,Double Data-Entry Required
Yes. Make tedious work much more efficient	Yes,Increased Efficiency
Speed of information sharing has increased	Collaborate & Share Info.,Information Storage,Increased Speed of Communication,Yes
Not used in estimating	No Response
Yes, makes people more efficient and uniformed.	Yes,Increased Efficiency,Process Consistency,Increased Accountability
Yes	Yes
Yes, makes it a solid foundation for people to check for anything they need through the team and/or our suppliers.	Information Storage,Real Time Availability,Yes,Collaborate & Share Info.,Organize Information
Made response times faster	Collaborate & Share Info.,Increased Speed of Communication,Yes
It makes all of our estimating processes much more efficient. We are able to track projects, customer interactions, update information for all parties working on the estimate, etc. It allows everyone in the company to have all the information.	Information Storage,Process Consistency,Better Estimating,Increased Efficiency,Yes,Collaborate & Share Info.,Organize Information,All-Inclusive Software,Better Job Tracking
Yes. Information is shared easily, quickly, and accurately.	Collaborate & Share Info.,Increased Efficiency,Increased Speed of Communication,Organize Information,Yes
yes. keep things organized and streamlines information flow.	Organize Information,Increased Efficiency,Collaborate & Share Info.,Increased Speed of Communication,Yes

Answer	Coding
Not necessarily. In many ways technology has made things worse. Massive amounts of unfiltered information and non-intuitive data input has increase waste. The time to accomplished very simple process task has skyrocketed. Clear communication and relationship development has plummeted.	Using Multiple Software,Personal Contact More Important,No,Difficulty Datamining Information,Double Data-Entry Required,Difficulty Implementing,Poor Software Integration
My company just started using procore and so far it's improved our ability to get updated plans to the guys out in the field	Better Decision Making,Increased Efficiency,Yes,Collaborate & Share Info.,Increased Speed of Communication
Absolutely. It allows us to accurately forecast trends and be able to make quick changes within the project before it's too late.	Better Decision Making,Increased Efficiency,Yes,Use of Historical Data,Better Job Tracking
Absolutely. Makes us more efficient and collaborative with various stakeholders on our projects.	Increased Efficiency,Collaborate & Share Info.,Yes
Yes. We have recently made a switch from a less integrated to more integrated system which has helped our company immensely. When everything is more integrated, there's less "data silos" and more analysis possible within the project. It also makes things so much easier to track when there's only one or two systems being used opposed to many more.	Better Decision Making,Using Multiple Software,Process Consistency,Increased Efficiency,No,Yes,Poor Software Integration,Use of Historical Data,Organize Information,All-Inclusive Software,Software Intregration,Better Job Tracking
Our company has centralized all operations around digital solutions for all facets of project and company management to streamline and integrate all silos of our business and provide better availability of the information. Finally, it all produces data to analyze, trend, etc to improve business operations.	Better Decision Making,Information Storage,Process Consistency,Increased Efficiency,Real Time Availability,Yes,Collaborate & Share Info.,Use of Historical Data,Organize Information,Software Intregration,Better Job Tracking
Of course, this isn't a great question.	Yes
Yes, it has streamlined the daily activities to allow the project management team to focus our time on cost control, construct-ability, and quality control in lieu of just processing paperwork.	Better Decision Making,Using Multiple Software,Process Consistency,Improved Accounting,Increased Efficiency,Yes,Organize Information,Better Job Tracking
Yes. Increase production.	Increased Efficiency,Yes
Time saving and more effective communication and tracking of open items	Increased Efficiency,Yes,Collaborate & Share Info.,Increased Speed of Communication,Organize Information,Better Job Tracking
In some was it has (by streamlining the process) and it some ways it hasn't (some sets of software over complicate things)	Process Consistency,Increased Efficiency,No,Yes,Difficulty

Answer	Coding
	Implementing,Poor Software Integration
Yes, it's created several efficiencies in workflow but there are still several efficiencies to be had.	Increased Efficiency,Yes
Yes, it has made us more efficient and allows us to effectively communicate throughout the company (and outside the company).	Information Storage,Increased Efficiency,Yes,Collaborate & Share Info.,Increased Speed of Communication
Yes, by expediting processes and flow of information	Process Consistency,Increased Efficiency,Yes,Collaborate & Share Info.,Organize Information
Yes, it makes tasks much more streamlined and clean. It saves time, keeps an outline of what information is needed for a specific process, and helps organize job files for easy access.	Information Storage,Process Consistency,Increased Efficiency,Real Time Availability,Yes,Collaborate & Share Info.,Organize Information
Yes, jobs that have many moving parts run smoother with all of the data being put into one central location that can then be organized/referenced.	Information Storage,Real Time Availability,Yes,Collaborate & Share Info.,Organize Information,All-Inclusive Software
Yes, previous electronics now being replaced with cloud based, more, better storage and retreival	Information Storage,Yes,Organize Information,Real Time Availability
Helps us save ,track, and learn from our project results.	Information Storage,Yes,Use of Historical Data,Organize Information,Better Job Tracking
They are tools, like any other tool	No
We've used various tools the entire time of my career. I can't imagine not using PMIS in construction. It makes us far more efficient.	Increased Efficiency,Yes,Using Multiple Software
Yes, the software we utilize makes our job tasks more efficient.	Increased Efficiency,Yes
We are old school. Some people in our company are trying to change the way we work but we continue to fight against change.	No,Resist Change - No Usage
Yes - we continue to expand the capabilities of Viewpoint and how it's used on a daily basis.	Yes,All-Inclusive Software,Process Consistency,Increased Efficiency
Yes, increases organization, efficiency, and communication.	Increased Efficiency,Collaborate & Share Info.,Yes,Organize Information

Answer	Coding
Absolutely - PMIS helps improve communication and streamline data collection activities. PMIS software solutions have had less benefit as they are generally forced by GCs, and we utilize the functions they demand. Custom solutions we've developed in house have been most beneficial. Not matter the solution, it needs to be tailored to the specific needs of our organization. Defining the requirements is half the battle. Off-the-shelf solutions generally don't integrate well with systems we've already developed in-house.	Information Storage,Using Multiple Software,Process Consistency,Increased Efficiency,No,Yes,Collaborate & Share Info.,Increased Speed of Communication,Difficulty Implementing,Poor Software Integration,Organize Information
Improves the speed, organization, uniformity of the documents	Information Storage,Process Consistency,Yes,Increased Speed of Communication,Organize Information
Yes. Integration of billing, production, construction management, contracts into one system creates one program for project information.	Information Storage,Improved Accounting,Yes,Collaborate & Share Info.,Organize Information,All-Inclusive Software,Software Intregration,Better Job Tracking
Has improved our business in that it's easier to share and distribute information to team members.	Collaborate & Share Info.,Information Storage,Increased Speed of Communication,Yes
YES, OUR JOB COSTING ONLY LEGS ON WEEK DUE TO PAY PERIODS. WE HAVE THE MOST ACCURATE JOB COSTING AND ACCOUNTING AVAILABLE TO US AND WE DO NOT OUTSOURCE ANY PROFESSIONAL SERVICES.	Better Job Tracking,Yes,Improved Accounting
Streamlined information and made it more organized.	Information Storage,Increased Speed of Communication,Yes,Organize Information
I believe the software has its uses and can help make sure your company is consistent across the board with communication and documentation. We mainly use the software to keep people on track with our company SOP.	Information Storage,Process Consistency,Yes,Collaborate & Share Info.,Organize Information,Better Job Tracking
It has made things more efficient and easier to find documents as they are all in one or more program. The fact that most software's also are able to be used within another software makes transferring and editing documents from to the other an easy and smooth process.	Information Storage,Using Multiple Software,Increased Efficiency,Yes,Organize Information,All-Inclusive Software,Software Intregration
'- Quick and efficient transfer of data. (Reports, Construction Docs, Time/Production) - Consolidation of Data within a few platforms provides limited locations for information - Online services provide easy access for Subcontractors and Field Personnel	Information Storage,Using Multiple Software,Increased Efficiency,Real Time Availability,Yes,Increased Speed of Communication,Organize Information

Answer	Coding
yes speed and efficiency	Yes,Increased Speed of Communication,Increased Efficiency
Yes, our SAP driven fully integrated and interconnected project management system has revolutionized our construction, engineering, planning and tracking systems. As a corporation we now are more transparent and individuals can more or less move from project to project and region to region within the corporation seamlessly using the same integrated systems.	Better Decision Making,Process Consistency,Yes,Collaborate & Share Info.,Increased Accountability,All-Inclusive Software,Software Intregration,Better Job Tracking
Yes. More efficient.	Yes,Increased Efficiency
Yes, things are more timely and accurate.	Yes,Collaborate & Share Info.,Increased Efficiency,Increased Speed of Communication
Project Management Software makes for more efficient work flows along with easily communicating among mass quantities of people, and it also helps with document control at the end of a project. The down side of PM software is when internal systems, and owner systems do not align, and you end up with double entry of data across multiple platforms.	Information Storage,Using Multiple Software,Process Consistency,Increased Efficiency,No,Yes,Double Data-Entry Required,Poor Software Integration,Organize Information
yes	Yes
Yes	Yes
Yes. Keeps accounting and project managers on same page, streamlines sub-contracts change orders, billings, and other daily activities.	Better Decision Making,Process Consistency,Improved Accounting,Increased Efficiency,Yes,Collaborate & Share Info.,All-Inclusive Software,Software Intregration
Yes. It has made the transfer of information much quicker and reliable.	Increased Efficiency,Collaborate & Share Info.,Increased Speed of Communication,Yes
Absolutely. Availability of to connect, store and retrieve data	Information Storage,Real Time Availability,Yes,Collaborate & Share Info.,Use of Historical Data,Organize Information
Yes. Over the past 5 years we have implemented CMiC which is an ERP system. It has streamlined a number of processes within the company, brought everything into one platform so that certain systems talk and share information. For personnel job duties have changed and new positions within the company have been created to manage the software and the information within it.	Information Storage,Process Consistency,Increased Efficiency,Yes,Collaborate & Share Info.,More IT Staff,Organize Information,All-Inclusive Software,Better Job Tracking

Answer	Coding
Overall yes but not without it's inherent challenges. With all these various software and technology tools comes the higher expectations of capabilities; a torrent of information delivered quickly and routinely resulting in deluge of information which becomes extremely challenging to sift, sort, store, synthesize, synchronize and share.	Using Multiple Software,No,Yes,Difficulty Datamining Information,Increased Speed of Communication,Poor Software Integration,Need More Capabilities
It has created consistency of information collection and storage across our organization. It has also allowed our field crews out of the office to work much more efficiently with project managers and back office project coordinators.	Information Storage,Process Consistency,Increased Efficiency,Yes,Collaborate & Share Info.,Organize Information,Better Job Tracking
Yes allowing full access to all CA components of a project to entire project team via Procore. Allows tracking of commitments through automatic notifier (previously done in person with phone calls) and increases level of accountability. GC Pay helps us regulate payments based on project compliance and forces compliance to reciieve payments.	Improved Accounting,Increased Efficiency,Yes,Increased Speed of Communication,Increased Accountability,All-Inclusive Software,Better Job Tracking
Yes it has improved by providing consistence from project to project	Yes,Process Consistency
sure	Yes
yes	Yes
Yes, better tracking and organization of information.	Information Storage,Better Job Tracking,Yes,Organize Information
Yes - better efficiency for project team with on-line collaboration. Easier to share information.	Increased Efficiency,Collaborate & Share Info.,Increased Speed of Communication,Yes
Yes, it has streamlined the documentation process and document access process	Increased Efficiency,Yes
speed, accuracy, consistency	Increased Speed of Communication,Yes
Yes	Yes
Yes. Bluebeam, Microsoft Office products, and HCSS HeavyBid have been the most useful. Bluebeam is used to collaborate on development of quantity take-offs, communication with designers, and questions/comments within our estimating team. MS Excel is used to organize the quantity data and HCSS HeavyBid is used for the development of the detailed estimate.	Information Storage,Using Multiple Software,Better Estimating,Yes,Collaborate & Share Info.,Increased Speed of Communication,Organize Information
We have had ProCore for two years and frankly no one has mastered it; we use pieces of it, especially the paperwork side of it.	No,Difficulty Implementing

Answer	Coding
yes	Yes
It has improved business by helping to bring multiple users onto the same page, but it is difficult to convert users to the new systems when introducing them in an established company.	Collaborate & Share Info.,No,Difficulty Implementing
Provides a place to put information together and to store it.	Information Storage,Yes,Organize Information
Yes, Increases the speed of communication between the project teams, across different offices and between separate sub-consultants.	Collaborate & Share Info.,Increased Speed of Communication,Yes
The efficiencies provided by the use of these software solutions are incredibly valuable. The ability to instantly share information with a wide array of users while housed in a single interactive location really increases our efficiencies.	Increased Efficiency,Collaborate & Share Info.,All-Inclusive Software,Yes
Yes	Yes
Yes. Makes some processes more simple.	Yes,Process Consistency
Yes	Yes
Yes. More accessible on the go	Yes,Real Time Availability
It has improved our business by giving us a universal platform to manage the project controls on our jobs. It also helped us to be structured with our SOPâ€™s	Better Job Tracking,Yes,Process Consistency
Yes, increased productivity and the time that it takes to transmit information.	Increased Efficiency,Increased Speed of Communication,Yes
Document Control using Newforma is a dream and makes managing/tracking of documents almost fool proof. Sage Timberline allows us to create our project estimates using Estimated Extended, Change orders using Project Management, serves as the company time clock, and a whole slew of other accounting tasks. Plan Swift is used in lieu of On-Screen Takeoff. They are the same thing once you figure out the hot keys. Document creation using Microsoft Office Suite and Bluebeam Extreme.	Information Storage,Using Multiple Software,Improved Accounting,Yes,Organize Information,Software Intregration,Better Job Tracking
Each individual solution that we use at different phases of construction are useful and improve that phase specifically. The issue is that there is not a single software integration of each individual solution.	Using Multiple Software,No,Yes,Poor Software Integration,All-Inclusive Software
Yes. We have been using and improving software systems for decades to improve organization and information flow.	Information Storage,Using Multiple Software,Yes,Collaborate & Share Info.,Organize Information

Answer	Coding
Yes. Procore allows the company to share information in one location with the entire team involved. Architect, PM, Superintendent & Owner.	Collaborate & Share Info.,Information Storage,Yes
Yes & NoYes - new programs and features greatly increase efficiency of process flows and sharing of informationNo - every time we switch programs (scrap and move to new program) great amount of time and energy (and waste) goes into it.No - Need to keep focus on keeping personal (face-to-face) connections in business despite trending technology in the opposite direction	Using Multiple Software,Personal Contact More Important,Increased Efficiency,No,Yes,Collaborate & Share Info.,Difficulty Implementing
Yes, it allows us to standardize our procedures and links cost information into other project management functions.	Yes,Organize Information,Process Consistency,Better Estimating
Streamlined communication between the field and the office.	Collaborate & Share Info.,Yes
Yes. Complex projects require detailed project management which requires software to efficiently track the information.	Increased Efficiency,Yes,Organize Information
Yes and No, Our software is very good and helps us to manage our projects. But, sometimes it means multiple reports that would be better coming from just one software program.	Better Decision Making,Using Multiple Software,No,Yes,All-Inclusive Software
Yes. Clear lines of communication.	Collaborate & Share Info.,Yes
Yes - More productive & Effective	Increased Efficiency,Yes
Yes - it has helped to standardize what information is logged which allows for data analytics; increased productivity in the field through ease of access to information and input of information; trade partner communication flow, etc.	Better Decision Making,Process Consistency,Increased Efficiency,Real Time Availability,Yes,Collaborate & Share Info.,Use of Historical Data
Yes, it has increased the efficiency of information sharing with team members, clients, and contractors.	Increased Efficiency,Collaborate & Share Info.,Yes
Our custom applications in Google Drive have proven to be helpful, scheduling resources is still clumsy as our tasks and milestones change so much. Most of all we meet often and talk through issues and planning.	Yes,No,Difficulty Implementing
Yes - Procore has standardized the way our project teams collect and utilize data as well as how we interact with designers and trade partners. The familiarity and use of use has made our operations more efficient.	Process Consistency,Increased Efficiency,Yes,Collaborate & Share Info.,Organize Information,Better Job Tracking
Yes. It allows the entire design, construction and project management team to vir=ew cfrital dat all at one saving valuable time.	Increased Efficiency,Collaborate & Share Info.,Yes
It streamlines the process by making it consistent.	Yes,Process Consistency

Answer	Coding
It has helped create consistent processes throughout the organization and created a central hub to host all material	Collaborate & Share Info.,Yes,Organize Information,Process Consistency
Yes	Yes
Yes we continue to look for new products	Yes,Using Multiple Software
Yes, by improving real time information sharing	Information Storage,Yes,Real Time Availability
Yes, improvements to software management have created a more effective and efficient work place.	Increased Efficiency,Better Decision Making,Yes
PMIS plays a tremendous role in our day to day activities. Distribution, logging, reviewing and updating documents and files is are aspects that are company wide (Architecture, Design, Construction, Furniture and Field Staff). Estimating Software with built in Onscreen Take off is also relied on heavily here. These forms of PMIS improve communication & document control and also increase our accuracy and minimize mistakes in the field.	Better Decision Making,Information Storage,Better Estimating,Real Time Availability,Yes,Collaborate & Share Info.,Organize Information,Better Job Tracking
yes	Yes
not sure	No Response
Yes. Gives team members a template to work off of instead of creating the same sheet multiple times.	Yes,Process Consistency
Makes us leaner and meaner. Weâ€™re able to manage from anywhere on any device.	Better Decision Making,Increased Efficiency,Real Time Availability,Yes,Collaborate & Share Info.
Yes, significantly. The data retention and organization has allowed for intelligent data mining for all phases of a project. This in turn has led to informed decisions on project fee, personnel assignment, client contact and business development.	Better Decision Making,Information Storage,Real Time Availability,Yes,Organize Information,Better Job Tracking
Yes - the technology has helped in being more proficient	Increased Efficiency,Yes
yes	Yes
Early awareness of potential problems. More data aids in better decision making.	Better Decision Making,Real Time Availability,Yes,Use of Historical Data,Better Job Tracking
Yes, standardization	Yes,Process Consistency
Yes, real time data. Able to make project decisions based on analytical data instead of personal preferences, bias, or assumptions.	Better Decision Making,Real Time Availability,Yes,Use of Historical Data,Better Job Tracking
Yes. Creates standard process	Yes,Process Consistency
Yes	Yes
Collaboration has improved with stakeholders and accuracy of documentation has improved with one source of data	Yes,Collaborate & Share Info.,Organize Information,All-Inclusive Software,Better Job Tracking

Answer	Coding
Yes, creates efficiency and clarity	Increased Efficiency,Yes
Yes, has provided a consistent process across all jobs.	Yes,Process Consistency
Yes. Better communication of written information and better management of issues early in the project.	Collaborate & Share Info.,Better Job Tracking,Better Decision Making,Yes

Question 25

Do you have any general comments about the use of PMIS in the construction industry.

Answer	Coding
Incorporate projects, costs and employee tracking all in one	Program Integration is Important,Need All-Inclusive Software
All in one programs would be nice, however flexibility in the system is a must. Every project is different and has different needs and therefore may require different formats of reporting.	PMIS Flexible to Company Processes,Need All-Inclusive Software,Programs Not Designed for Construction,Problems Changing/Adjusting to Software
Its gotten a lot better and there are some systems that are making huge strides in the right direction. Procore does a great job and I can see them being one of the first to have an all inclusive PMIS.	Must use Multiple Programs,Programs Not Designed for Construction,All-Inclusive Software Success,Program Integration is Important,Limitations to Implementation
In todays world, it takes a least 3-4 separate programs to manage all aspects of construction.	Must use Multiple Programs,Programs Not Designed for Construction,Program Integration is Important,Need All-Inclusive Software,Best-in-Class Usage,Limitations to Implementation
N/A	No Comments
Given the challenges that the construction industry faces, having a defined platform for PMIS is critical both now and in the future	Need All-Inclusive Software,Program Integration is Important
Systems need to be flexible and able to adapt to individual projects	Limitations to Implementation,PMIS Flexible to Company Processes,PMIS Structure not Adaptable,Programs Not Designed for Construction
There are many good programs, but often one program does 1 thing much better and is used for that. Another program does something else better and then used for that function. Often "all in one" programs do many things poorly.	Skeptical of All-Inclusive Software,Must use Multiple Programs,Best-in-Class Usage

Answer	Coding
Generally, the most efficient integrated system ties estimating to accounting and eliminates the data entry aspects of the job. As a downside, it tends to give people a false sense of security that everything that needs to be done gets done and they stop checking.	Keep Balance Between PMIS & People,All-Inclusive Software Success,People More Important than Software,Skeptical of All-Inclusive Software,Program Integration is Important,Limitations to Implementation
Impossible to find one software package that does it all	Skeptical of All-Inclusive Software,Must use Multiple Programs,Need All-Inclusive Software
At the other two companies I worked at, there was no PMIS. Once I started here, I realized how important and how incredibly useful it was to have.	PMIS Success
It seems "all-inclusive" software is either accounting based that has added PM, or PM software that has added accounting. Neither is adequate for both. In my experience, IT is part of accounting, thus the firm uses accounting software that is not efficient for PM (this is our current case). There are too many work-arounds in the accounting software, creating added work and wast for the project managers.	Must use Multiple Programs,Problems Changing/Adjusting to Software,Programs Not Designed for Construction,Complicated Programs,Skeptical of All-Inclusive Software,Program Integration is Important,Customization is Important,PMIS Structure not Adaptable,Information not utilized,Limitations to Implementation
I think that use of this is really important just because it's constantly changing and the connect of communication between the field and the office is very important and so making sure that we have a system that both can use is one of the most important things to make sure that a job is done with the best quality	Program Integration is Important,PMIS Flexible to Company Processes,All-Inclusive Software Success,PMIS Success
Our company operates on an EPC basis (Engineer Procure Construct). We operate and think like a construction company, but also perform all engineering work within our project. Our "Operations Management" system that is currently being implemented has seen some "bugs" along the way, but we have been very adamant to fix these bugs. The biggest challenge is to relate the Engineering Ops Management world with the Construction Ops Management world. Engineering operates much differently from constructing work. It's been a challenge to relate the two and to have a combined PIMS that can be linked to both sides of the company.	Programs Not Designed for Construction,All-Inclusive Software Success,PMIS Flexible to Company Processes,PMIS Structure not Adaptable,Limitations to Implementation

Answer	Coding
It seems to keep getting better and we're flexible about which we use based on client desires and ease of use.	PMIS Flexible to Company Processes,All-Inclusive Software Success,Adapt to other's PMIS,Speed of Technology Change Issue
I would look into InEight. My company has been working on this integrated information system that ties, CRM to estimate to quantities controls linked to P6 which links to our cost management system which ties back to our estimating historical costs. Safety and quality tracking to trend all observations and incidents to deliver historical data and trends for better management.	Program Integration is Important,PMIS Flexible to Company Processes,All-Inclusive Software Success,PMIS Success
It is improving quickly. With that being said, the challenge for one software to check all of the boxes (efficiently and effectively) would be an extremely large challenge due to the complex nature of a company's daily activities.	Program Integration is Important,Skeptical of All-Inclusive Software,PMIS Flexible to Company Processes
In today's market, Procore has provided us the best solution however the cost exceeded our leadership's ability to see a benefit when comparing it to using multiple platforms.	Must use Multiple Programs,All-Inclusive Software Success,Cost/Time to Train is Extreme,Requires Buy-in for Company
Using the right software can either make or break any given scenario. The main concern always needs to be usability and flexibility.	Program Integration is Important,PMIS Flexible to Company Processes,Best-in-Class Usage
I've been exposed to several different platforms. The one my company currently uses does have several features that are best-in-class in the industry but the costs to renew / maintain the agreement is significantly higher now nearing the end of the contract term.	All-Inclusive Software Success,Best-in-Class Usage,Cost/Time to Train is Extreme
The key to any type of PMIS being effective is "buy-in" from the entire company. If there are folks that do not feel that the PMIS is necessary, they need to be educated as to how the PMIS will benefit the company (and them personally) so that they use it and use it correctly.	Cost/Time to Train is Extreme,Requires Buy-in for Company,PMIS Flexible to Company Processes,PMIS Structure not Adaptable

Answer	Coding
They are great tools, but unfortunately, I beleive all in one programs will never work as inteded due to competition of individual softwares and the disconnect of integration behind software code of different software manufacturers. All in one programs have very high cost most of the time and individual programs have more options to pick and choose what best suits a firm. Also Autodesk has a monopoly over the design BIM market and their more accounting/construction software does not compare at all with others at this time, if they have any.	Speed of Technology Change Issue,Cost/Time to Train is Extreme,Skeptical of All-Inclusive Software,Program Integration is Important,PMIS Flexible to Company Processes,Best-in-Class Usage,Limitations to Implementation
I believe that it has greatly improved the quality and provides a quicker path to reach the end product.	PMIS Success
When using multiple systems, data is possibly lost in translation or overlap	Program Integration is Important,Must use Multiple Programs,Best-in-Class Usage,Information not utilized
We have yet to find an all inclusive PMI system.	Need All-Inclusive Software
I think it's a great thing! I wish we would use it!	Need All-Inclusive Software
As a subcontractor, it's frustrating to have to use the various software that each GC uses (Procore, Oracle, Expedition, Stratusvue, etc) while none of them integrate with our systems so it creates double entry for every project and a learning curve on software that changes faster than it can be learned.	Must use Multiple Programs,Speed of Technology Change Issue,Problems Changing/Adjusting to Software,Cost/Time to Train is Extreme,Complicated Programs,Program Integration is Important,Adapt to other's PMIS,Limitations to Implementation
there are many systems out there - some are more robust than others.	Skeptical of All-Inclusive Software,No Comments

Answer	Coding
The goal of creating an all-inclusive PMIS is fabulous. The reality is that most established companies have a variety of tools at their disposal, and replacing them could be catastrophic. I believe a more beneficial focus would be to develop a means of enabling different software systems to collaborate and communicate more freely. This is a huge challenge in an open competitive marketplace where everyone is seeking to generate more market share for their own. For example, companies that are good with drawings would have a challenge getting into construction accounting. I would like to see AutoDesk incorporate scheduling, time tracking, and other detailed construction functions, but expanding that to also include accounting, contract management, CRM and other functions seems like a stretch. I would like to see another option besides AutoDesk for the construction industry.	Must use Multiple Programs,Cost/Time to Train is Extreme,Programs Not Designed for Construction,Skeptical of All-Inclusive Software,Program Integration is Important,Need All-Inclusive Software,PMIS Structure not Adaptable,Best-in-Class Usage,Limitations to Implementation
It's hard for the subcontractors becuase we not only have to know our Compnay's system, we have to learn whatever the GC's are implementing. Also, while PMIS are very flexible, someone at the COmpany has to have the time to set all of this up and get everyone trained. The software has sometimes "too much" functionality.	Cost/Time to Train is Extreme,PMIS has too many Functions already.,Requires Buy-in for Company,Skeptical of All-Inclusive Software,Adapt to other's PMIS,PMIS Flexible to Company Processes,Limitations to Implementation
Procore seems to be the most popular system at the present, while several design build firms still use private servers and FTP sites for document access. The PROCORE is a great access point for all the subs on the project to access each others submittal documents and approved shop drawings. This eliminates the "bottle neck" of rfi's or access to data to keep the project flowing smoothly. It is also a great way to track RFI's, CB's, ASI's, addendum, and schedules...	Program Integration is Important,All-Inclusive Software Success

Answer	Coding
I have had the opportunity to use a couple of systems over my years in the industry. The difficult aspect of all of them, is trying to get your team to understand the many functions that the systems can do. Not everyone works well with technology, and though technology is great, it does not trump experience. When you have someone that can build a building in their sleep, but doesn't know how to type their name, does that mean you leave them behind? I have learned over the years that my best employees are not actually great at computers, so we tend to still use paper and manual systems. I absolutely understand that technology and information systems are the future and they help streamline projects, I just think we need to find a way to balance it to keep the humans talking to each other and interacting. That is how we pass on experience. It is no different than doing a math problem long hand even though you can easily type it into a calculator, we should still want to know how the problem was solved.	Limitations to Implementation,Keep Balance Between PMIS & People
If a firm manages many varieties of projects, a one-stop-shop solution isn't always practical nor is always an efficient solution. When mixing and matching a step might be lost through intercommunication, but is regained through picking the best solution on a per need and practicality basis.	Must use Multiple Programs,Skeptical of All-Inclusive Software,Program Integration is Important,PMIS Flexible to Company Processes,Best-in-Class Usage,Limitations to Implementation
I believe an all inclusive PMIS system is a moon shot but noble. The more practical here and now successes I've seen is the establishment of a consistent data sharing platform between the various PMIS systems so the same information can be integrated and shared across a wide range of individual pieces of software.	Must use Multiple Programs,Skeptical of All-Inclusive Software,Program Integration is Important,Need All-Inclusive Software,PMIS Flexible to Company Processes,PMIS Structure not Adaptable
There probably never be the "magic bullet" that results in a complete and truly all-inclusive software solution.	Skeptical of All-Inclusive Software
Depending on the system I see limitations being the time of implementation. Our system took years to develop, customize, train, then go live. This effort and cost was extreme. If that system is now limited or does not keep up the pace of development in the industry it could be a lengthy process. Remember that that true cost is not just the software but maintenance and staff to manage the process.	Speed of Technology Change Issue,Cost/Time to Train is Extreme,Skeptical of All-Inclusive Software,Customization is Important,PMIS Structure not Adaptable,Limitations to Implementation
Creating an all inclusive syst m that serves the construction industry is difficult since every construction company had different needs. Even some of the best softwares need to be flexible to individual needs.	Skeptical of All-Inclusive Software,Customization is Important,PMIS Flexible to Company Processes,PMIS Structure not Adaptable,Limitations to Implementation

Answer	Coding
Yes all are very complicating to use a lot of information that is never used.	Customization is Important,Complicated Programs,Information not utilized
Ability to create reports with some degree of customization	Customization is Important
As a subcontractor, you are tasked with using various systems based on the platforms utilized by specific general contractors or construction managers and that alone can be burdensome when you are operating on 4-5 platforms at any particular time.	Must use Multiple Programs,Problems Changing/Adjusting to Software,Cost/Time to Train is Extreme,Program Integration is Important,Adapt to other's PMIS,Best-in-Class Usage,Limitations to Implementation
no, but I am not a "major" user	No Comments
Due to owners/clients all using different systems, delivery methods, software, and vast differences in the types/sizes/scopes of projects I don't believe there will ever be one perfect solution to make a perfect construction project. Experienced and knowledgeable construction and engineering professionals as well as quality craftsmen will ALWAYS be needed to build successful projects.	People More Important than Software,Skeptical of All-Inclusive Software,Adapt to other's PMIS,Customization is Important,PMIS Flexible to Company Processes,PMIS Structure not Adaptable
It seems as though there is no consensus and every few years a different GC wants us to use a PMIS that is different than what we were trying to implement team wide.	Limitations to Implementation,Must use Multiple Programs,Adapt to other's PMIS
Existing systems seem to frequently be designed with the construction industry as an after thought. They are often migrated from software development, or written by developers who do not actually manage construction projects. Those systems that are designed for construction itself are many times rigid in implementation, forcing you to adapt your workflow to them rather than cleanly complementing the existing workflow.	Programs Not Designed for Construction,Complicated Programs,Skeptical of All-Inclusive Software,Customization is Important,PMIS Flexible to Company Processes,PMIS Structure not Adaptable,Limitations to Implementation
As an engineering sub-consultant we need to be able to use whatever systems the lead design consultant or owner's project management team dictates.	Must use Multiple Programs,Adapt to other's PMIS
Need a single source but also have the ability to become specific to the company or project for which it is utilized.	PMIS Flexible to Company Processes,PMIS Structure not Adaptable,Customization is Important,Need All-Inclusive Software

Answer	Coding
We are primarily using CM14 but slowly transitioning to Procore for some of our projects because it does a better job of integrating the project team. We have looked at integrated systems but none that seem to give us the functionality that we need for our different operating divisions. It seems that either the Accounting or the Project Control side lack what we need for a total solution.	All-Inclusive Software Success,Program Integration is Important,Need All-Inclusive Software,Customization is Important,PMIS Flexible to Company Processes,PMIS Structure not Adaptable
Its ok if not ALL business functions are included in a single solution.	Skeptical of All-Inclusive Software
Here is the biggest problem. I think the intent of your research is to get everyone in the industry to standardize on one system. The problem is that one of the only things that differentiates one construction manager from the next is their systems. If they don't have different systems and processes there is no differentiation in the customers eyes. If there is a top-of-the-line PMIS system, one CM will try to differentiate themselves by advertising that they use something else. That means that all of that CM's subs need to use something else too.	Skeptical of All-Inclusive Software,People More Important than Software
We only recently made the upgrade to Procore.	All-Inclusive Software Success
We have found that trying to find one PMIS system is limiting. We prefer "best fit" of various systems and software for our business, and value integration/communication between each.	Program Integration is Important,Skeptical of All-Inclusive Software,Best-in-Class Usage
most follow very similar processes/ standards	PMIS Structure not Adaptable
Procore is good. Plangrid is good. Bluebeam is essential. CxAlloy is too cumbersome and annoying.	Must use Multiple Programs,Best-in-Class Usage,Complicated Programs
I like Procore. They are responsive and can customize the software to your liking.	Customization is Important
The idea of a unified platform does sound very appealing. However, the reality is that weâ€™ve all been using some version or mix of different platforms. From experience, transferring platforms can be a very painful process, incurring significant costs and data loss. I donâ€™t think a solution which integrates everything listed in the previous questions will be feasible due to licensing issues let alone costs.	Must use Multiple Programs,Problems Changing/Adjusting to Software,Cost/Time to Train is Extreme,Skeptical of All-Inclusive Software,Best-in-Class Usage

Answer	Coding
We have elected to go with Best in Class for individual solutions and plan on a data warehouse for overall metric tracking. Procore / Vista do a solid job on PM collboration / accounting and job costing. Neither has good scheduling solutions for which we use P6 for CPM development and Pull scheduing. CRM / Business Development tracking remains separate from PMIS as does estimating and VDC solutions. Changes are happening at an exponentially rate with respect technology solutions in the industry and ensuring each soltuion can share data to avoid duplicated tasks is the major challenge. The option to go with a fully developed ERP solution (one stop shopping) is impractical with the speed of change at this time resulting with average solutions resulting from that approach in our experience.	Must use Multiple Programs,Speed of Technology Change Issue,Skeptical of All-Inclusive Software,PMIS Structure not Adaptable,Best-in-Class Usage,Limitations to Implementation
Procore is like "crack" but without integration with other systems, it's another flashy, silo of data.	Program Integration is Important,Information not utilized
The software companies should speed up integration of the different software systems and make it very user friendly and intuitive.	Complicated Programs,Program Integration is Important,Adapt to other's PMIS,Customization is Important,Limitations to Implementation