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Outsourcing of Building Information Modeling (BIM) Among General Contractors in the United States

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By

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Abstract

Building Information Modeling (BIM) is a process used by AEC industry members that simulates a construction project in a multidimensional digital model and provides multitudes of project benefits from inception to occupancy. However, a variety of barriers impede a holistic BIM implementation. Because of these barriers, some general contractors are choosing to outsource the creation and/or utilization of BIM models to specialized Information Technology (IT) firms instead of performing these processes in-house. Since little literature currently exists for BIM outsourcing, this online survey-based study aimed to identify BIM outsourcing patterns among the general contractors across the US and the perceived impacts it has on construction projects. Analysis of 252 complete responses from general contracting firms determined 45% of them have outsourced BIM, signifying that outsourcing has become an important aspect of modern BIM usage. Data was also collected on company demographics, BIM outsourcing locations, strategic reasons for outsourcing, and various other BIM outsourcing aspects. It was found that contractors perceived BIM outsourcing as having a less effective impact than in-house BIM overall. However, its continued widespread utilization displays the adaptability of the industry in meeting challenges and embracing new technology through alternative methods despite the potential risks.

Key Words: Building Information Modeling, BIM, Outsourcing, General Contractor

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I would like to express my appreciation and thanks to my thesis adviser, Dr. Sandeep Langar, for his guidance and assistance with this research. It would not be nearly what it is now without all the work and the expertise he put into it.

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Introduction

The US is one of the biggest consumers and producers of Building Information Modeling (BIM) products and solutions (Wong et al., 2009). The rapid adoption of BIM services and products is attributed to the benefits it offers to the adopting companies. Some of the primary benefits perceived by project stakeholders include enhanced efficiency, collaboration between project stakeholders, improved visualization (Campbell, 2007; Staub-French & Khanzode, 2007; Glick & Angela, 2009; Langar & Pearce, 2014), improved project sustainability (Ku & Mills, 2010), integration of building systems, conflict resolution (Khanzode et al., 2008), and others. BIM adoption can also result in a positive return on the BIM investment for the project stakeholders through savings from reduced project costs (McGraw-Hill Construction, 2009; Azhar, 2011; Bryde et al., 2013). The multitude of benefits offered by BIM to a potential adopter comee from the numerous functions it provides to assist designers, contractors, and other project stakeholders. For these reasons, many federal and state agencies are mandating BIM adoption on some federal construction projects. However, BIM adoption has its own set of complexities that include a lack of software interoperability (Ma & Zhao, 2008; McGraw-Hill Construction, 2009; Ku & Taiebat, 2011), additional costs, and lowered productivity at the beginning stages of adoption. These obstacles are hindering accelerated and holistic BIM adoption throughout the entire construction industry.

Given the mix of advantages and challenges associated with holistic BIM adoption, different BIM utilization strategies have been explored by companies to address the particular needs of individual BIM adopters. One such strategy that some stakeholders are turning to is the outsourcing of the BIM process to specialized

Information Technology (IT) firms instead of utilizing in-house BIM personnel for the creation and application of BIM models (Ku & Taiebat, 2011). The multiple strategic reasons to outsource IT processes such as BIM include such possible benefits as cost reduction and improving business performance (DiRomualdo & Gurbaxani, 1998). However, because outsourcing adds a new dynamic to the traditional BIM process, it may affect how BIM is utilized and the recognized impacts BIM usage has on projects. A 2008 McGraw-Hill Construction study (Building Information Modeling: Transforming Design and Construction to Achieve Greater Industry Productivity) identified general contractors as more likely to outsource BIM functions than other project stakeholders such as Architects or Engineers, but less likely to outsource than Project Owners. It also found that only 7% of the contractors outsourced BIM in 2008, but expected the number of contractors associated with the practice to increase considerably over the years.

Since the little available literature on BIM outsourcing indicates its usage is increasing (McGraw-Hill Construction, 2008; McGraw-Hill Construction, 2009; Ku & Taiebat, 2011), the goal of this study is to determine BIM outsourcing patterns among general contractors in the United States and see how significant a role BIM outsourcing plays in modern BIM usage. This study also identified the reasons for outsourcing, the perceived value generated by the process of outsourcing, and the geographic locations to which such tasks were outsourced. Data on company demographics, outsourcing practices, BIM functions commonly implemented by contractors, and the functions commonly outsourced was analyzed to determine if correlations existed. Finally, this study tested the following hypotheses:

- The only reason contractors outsource BIM is to ease the transition into developing and utilizing in-house BIM capabilities.
- In-house BIM is perceived as having a more positive project impact than outsourcing BIM.
- A positive correlation exists between company size and BIM outsourcing.

Literature Review

Definitions of Building Information Modeling (BIM) and BIM Outsourcing

BIM can be adopted and implemented in multiple ways (AGC, 2007; Azhar et al., 2008), but at its root it is a software-facilitated process utilized by architects, engineers, and contractors in the construction industry (AGC, 2007). Although BIM is a single process, designers and contractors can derive many functions from BIM implementation on construction projects. Ku & Taiebat (2011) identified seventeen different BIM functions, and Langar & Pearce (2014) identified sixteen different BIM functions that contractors and designers could utilize respectively to assist in the completion of a project. Of these identified functions, nearly 50% did not overlap and were determined as specific to either the architecture or the construction industry. Therefore, even though all stakeholders in a project can use BIM functions such as visualization, constructability, and others, there also exist certain functions that are very specific to the individual stakeholder.

At a generalized level, McGraw-Hill Construction (2009) defines BIM as "*The process of creating and using digital models for design, construction, and/ or operations of projects*." The digital BIM model is meant to "*simulate the construction project in a virtual environment*" (Azhar, 2011). With regard to general contractors, BIM functions have the capability to integrate components of construction including 3D modeling, scheduling, resource allocation, estimating, code analysis, clash detection, lifecycle management, and others into building objects in a virtual structure in order to compile all project information in a single location (Bazjanac, 2004). Holistic adoption of these

capabilities by a potential stakeholder such as a general contractor can often create a domino effect for other stakeholders in a project, leading to increased collaboration and higher efficiency. Similarly, Succar (2009) defined BIM as "*a set of interacting policies, processes, and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle*." Even though BIM can be perceived as an all-encompassing process, on a singular level it can be identified as a 3-dimensional, data rich, object-oriented, and parametric model of a project that consolidates all incorporated project information pertaining to various phases of the project, so that stakeholders can extract and analyze required project information to incorporate decisions that conform to owner project requirements and efficient delivery of the project. Thus, this study focusses on digital BIM models as a software tool that can be used to collect project information in a way that will assist in collaboration and increase efficiency in the design and construction of a project.

BIM outsourcing is a field that is still developing and therefore has little research available on the topic. However, one study defines the outsourcing of architectural services by architects as, "*separating their core operational processes from their non-core support and production processes, instead utilizing third parties to perform those processes for them* (Fernandez, 2007)." This definition is similar in practice to BIM outsourcing by general contractors and provides a basis for this study's definition. This study defines BIM outsourcing as "*the contracting out creation and/or utilization of a BIM model by an organization to a third-party information technology firm that specializes in the BIM process*." The outsourcing of BIM functions is not limited by location and can occur between organizations that are geographically close or far. In

addition, BIM can be outsourced by any stakeholder (general contractor, owner, architect, and others) associated with a construction project. However, the scope of this study is limited to identifying BIM outsourcing among general contractors geographically located within the US.

BIM Background & Purpose

Researchers have discussed the concept of BIM since the CAD software that digitally drafts construction drawings was first developed in the 1980's. However, at that time the extent of the concept was a three-dimensional building model that was enriched with additional graphical information (Migilinskas et al., 2013). Over the years, BIM has transformed, and the modern day BIM has surpassed concepts discussed a few decades back. The current BIM tools are based on parametric models with user-defined rules that update automatically with any input changes down to the fabrication level (Eastman et al., 2008). Multiple software suites developed by software companies offer specialized solutions that can potentially capture all required project information (Smith & Tardif, 2009).

The broad scope of modern potential BIM usage encompasses data management from initial design all the way throughout a building's life-cycle (Penttilä, 2006), with the goal of project completion, providing the owners with an as-built model, and helping the owners/facility managers with operations and maintenance during occupancy. Given the complexities associated with project and stakeholder requirements related to the projects, tools available in the BIM software suites have been developed for many different

functional areas of construction, design, and life-cycle management. However, based on their specific needs and strategic plans, many companies determine specific areas they want to focus their efforts instead of attempting to utilize an all-encompassing BIM implementation. This trend has been observed by multiple studies that aimed to identify BIM adoption and implementation trends (McGraw-Hill Construction, 2008, 2009; Luthra, 2010; Ku & Taiebat, 2011; Langar & Pearce, 2016). One of the reasons that can be attributed to this observation is that each BIM function implemented within an organization requires a significant amount of investment, experience, and knowledge. Thus, to strategically implement BIM, certain general contractors might be inclined to focus more on some BIM functions than others.

BIM provides stakeholders with a unique ability to virtually execute the project in a virtual and controlled environment that was not possible a few decades back. These benefits have been documented in academics and by many organizations who have used or studied the process, but they are not always apparent in individual projects. Some of the areas where more positive impacts were reported than negative over a wide variety of projects include coordination improvement, scope clarification, project duration, quality, cost reduction or control, organization, communication, and risk management (Bryde et al., 2013). However, BIM positives and negatives are contextual due to numerous factors such as variability of project types, attributes of the adopting organization, and many others.

Because of the lack of literature on the outsourcing of BIM, how specifically it affects the impacts of BIM on individual projects is currently unclear. In a study of the outsourcing of architectural services by architects, a practice similar in some ways to

BIM outsourcing by contractors, it was noted that some limitations, tradeoffs, and constraints occur when choosing to outsource. The firm "*surrenders some level of control on their project*" by outsourcing, but gains a "*meaningful support team* (Fernandez, 2007)." However, the objective of increasing the overall efficiency of a project in outsourcing BIM is still the same as the objective of traditional in-house BIM.

Barriers to BIM Adoption

Even though there is little consensus on the exact population of BIM adopting/implementing firms within the US construction industry, there is a consensus among researchers and industry professionals that the number of firms adopting/implementing BIM is consistently increasing. Studies conducted by McGraw-Hill Construction (2009 and 2012) identify that BIM usage among general contractors grew from 50% to 74%. The trend shows to be the same for the rest of the AEC industry across all sizes of firms as well. In addition to increased adoption over time, it also increases with firm size. Large firms report 91% adoption while small firms report only 49% in 2012 (McGraw-Hill Construction, 2012).

Despite the fact that the trend in the industry seems to be strongly in favor of BIM adoption (especially for larger organizations), there are a wide variety of significant obstacles for potential adopters. Barriers to BIM implementation and use of the latest BIM technology include increased training required to use the software, high upfront costs, and the lack of support from senior leadership who want to take a more conservative approach (Migilinskas et al., 2013). Significant resources (time and money)

must be invested into an in-house BIM implementation to maximize its effectiveness, and some organizations are wary of the risk of a low or negative return on investment. Another obstacle to BIM adoption/implementation is software interoperability between project participants. The numerous programs developed to facilitate BIM do not have a universal file format so one party's software might not be able to work with the models another party created or is currently using unless they have invested training time and money into the same program (Migilinskas et al., 2013).

Contractual risks and problems also affect the parties involved in BIM usage. Because BIM is a new technology, many laws are not in place to protect those who utilize it. One problem lies in the complexities associated with model ownership after project completion. An owner might feel entitled to the model since they paid for it; however, the organization that created and utilized it could have included proprietary information that would need to be protected (Azhar, 2011). In addition, since a BIM model is meant to be a collaborative tool for all parties, determining accuracy and liability of data entry when creating, revising, or updating the model can be difficult. Furthermore, due to the nature of the process, the stakeholder utilizing resources to maintain the BIM model might not realize the project efficiency gains that offset the BIM costs. Also, because mistakes do invariably occur, determining liability and reparations may prove difficult since models are continually built upon by multiple parties (Azhar, 2011). These, in addition to other issues, such as lack of current and up-to-date BIM implementation standards, contract obligations, and unified documentation regions might pose as barriers for BIM implementation (Migilinskas et al., 2013).

Despite these barriers, project stakeholders are increasingly choosing to adopt BIM, and some owners require its utilization on their projects. Therefore, general contractors are challenged with how best to pursue their BIM implementation. They are continually analyzing whether it is worth it to complete the BIM models in-house, or whether outsourcing offers a better way to utilize the benefits of BIM adoption while transferring the risks and some of the barriers to a separate entity.

Reasons for the Outsourcing of BIM

The outsourcing of information technology activities in certain industries, not specifically construction, is not a new phenomenon and has roots back to the 60's and 70's (McLellan & Marcolin, 1994). Many reasons exist why companies would decide to outsource certain tasks as well as strategies to make the outsourcing more effective. The traditional rationale for outsourcing is based on economies of scale and scope for the immediate financial benefit to the company having tasks outsourced. In particular, for small- and medium-sized enterprises, some IT business processes may be cheaper and more effective performed by other specialized and larger IT firms than to be performed in-house (Rohde, 2004). However, even larger firms in which the economies of scale rationale is not as evident choose to outsource certain BIM tasks for the strategic benefit (McGraw-Hill Construction, 2009). One such strategy these companies could be demonstrating is commercial exploitation where partnerships between the company and the outsourcing firm exist to minimize the risk and share the reward (DiRomualdo & Gurbaxani, 1998). These are less the buyer-seller relationships of economies of scale, and

more the alliances which focus on strategic initiatives together (McLellan & Marcolin, 1994).

It is unclear what strategies are used by general contractors and why they are used because of the current lack of existing research on the topic, but it is evident that BIM outsourcing is occurring in the AEC industry (Fernandez, 2007). Possible benefits of BIM outsourcing include overcoming some of the primary barriers towards BIM adoption. The contractors do not have to invest as heavily in the hardware, software, training, and other upfront costs associated with BIM because they do not necessarily have to maintain full in-house capabilities to utilize BIM. However, the implementations of BIM outsourcing can vary from contractor to contractor. Some might outsource every functional area of BIM, some might outsource specific areas and perform others in-house, and some might perform BIM tasks completely in-house on some projects and outsource them on others. BIM outsourcing implementations are company specific based on the strategy chosen and what the company believes will best allow it to meet its goals.

Current literature indicates BIM outsourcing is happening among contractors and other members involved in the AEC, but not much else about the process. Therefore, this study's goal was to begin understanding the topic by determining the BIM outsourcing patterns among general contractors in the US construction industry, and identify whether BIM outsourcing plays a significant role in overall BIM implementation. The study identified the reasons for outsourcing, the value generated by the process of outsourcing, and the geographic locations to which such tasks were outsourced. It also analyzed company demographics, outsourcing practices, BIM functions commonly implemented

by contractors, and the functions commonly outsourced to see if any correlations existed and why. The following three hypotheses were tested:

- The only reason contractors outsource BIM is to ease the transition into developing and utilizing in-house BIM capabilities.
- In-house BIM is perceived as having a more positive project impact than outsourcing BIM.
- A positive correlation exists between company size and BIM outsourcing.

Methodology

An online survey method was used to collect the data for this study. The population of the study was general contractors geographically located within the US. An online survey method was selected because of the ability to generate prompt responses, no cost associated with the survey creation, and most of the general population has access to the internet (Sheehan & Hoy, 1997).

The survey was developed using an online tool (Qualtrics.com) and had four broad categories: company demographics, BIM usage, BIM outsourcing, perceptions about BIM outsourcing. The survey was designed so that respondents could complete it within ten minutes. Once developed, the survey tool was pilot tested by three experienced general contractors and over fifteen graduate students. Upon completion of the pilot testing, respondent recommendations helped to improve the survey, make it more comprehensible, and eliminate errors. The finalized survey tool is located in Appendix A.

After finalization of the survey, the BIM outsourcing survey was activated in 2016. An invitation to complete the survey was distributed via email to representatives from over 1,800 general contractors across the US through a partnership with a construction information technology firm. Three reminders to complete the survey were sent by email, roughly one week apart, until the study period ended. The invitation to participate in the study was also emailed to member institute representatives of the Associated Schools of Construction (ASC) listserv with the request to forward the email to the general contractors on the schools' Industry Advisory Boards (IAB). The survey was kept open for four weeks.

At the time of survey deactivation, 460 total responses were collected (response rate of 25.5%). All compiled data was downloaded, and the following statistical analyses were conducted:

1. Descriptive statistical analysis
2. Chi-Square method
3. Logistic regression

These forms of statistical analyses were used to identify any patterns among the BIM outsourcing implementations as well as determine if any found correlations were significant.

Results

Survey Demographics

Upon deactivation of the survey, approximately 460 general contractors had responded, indicating a response rate of 25.5%. However, it was found that only 302 of the 460 responses were complete. Since only one response was accepted from each firm and the incomplete responses were deleted, the effective response rate was reduced to 252 (14%) general contracting firms. Sheehan (2001) indicates that it is difficult to obtain high response rates due to multiple factors such as: information overload, a greater number of online surveys generated in recent years, and others. Therefore, the effective response rate of 14% was accepted for this study. Figures 1-4 depict the demographic breakdown of the survey respondents by company experience (years), average annual revenue, geographic location, and type of projects performed. Responses were collected from contractors in all demographic ranges, but the most represented demographics were those with 20-40 years of experience, located in the Southern US, and with $100 - $499 Million in average annual revenue.

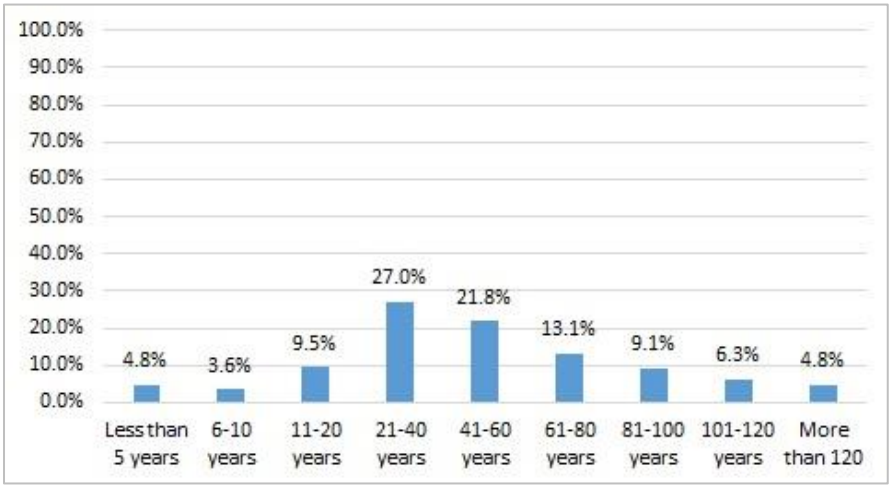

Figure 1: Company Construction Experience

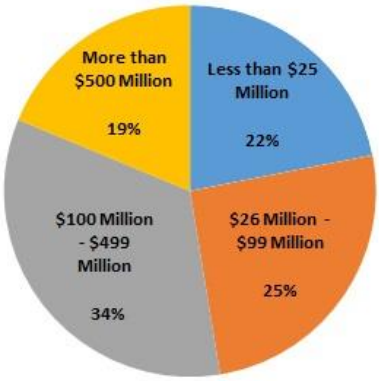

Figure 2: Company Annual Revenue

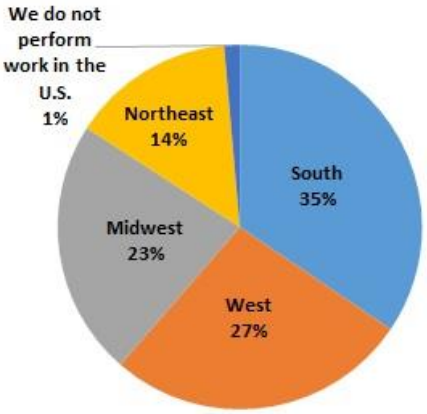

Figure 3: Company Regional Location

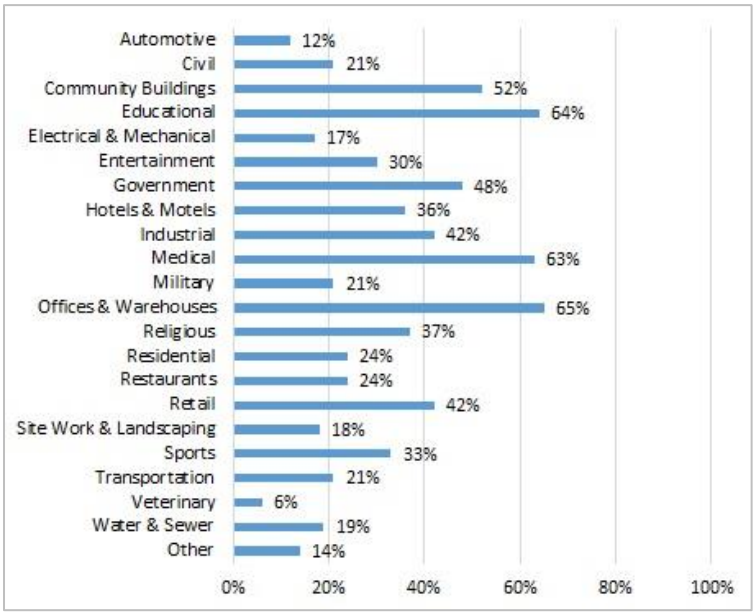

Figure 4: Company Project Types

BIM Outsourcing Trends

72% of the responding contractors reported BIM utilization within the past ten years. This percentage is similar to the 74% identified by a McGraw-Hill Construction (2012) survey and provides an indication that the results discussed in the subsequent section of this report are indicative of the BIM usage among contractors in the industry as a whole, which supports the argument for generalizability of the study. Of the companies who reported BIM utilization in the last ten years, 62% reported having outsourced some aspect of the BIM process to a specialized Information Technology firm. In reference to all respondents (252 general contracting firms), 45% of all responding general contractors reported outsourcing BIM to some degree.

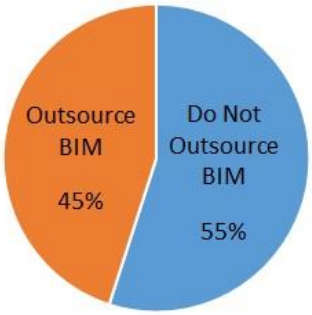

Figure 5: Outsourcing of BIM by Contractors

BIM is outsourced primarily to companies geographically located within the US and India with 68.8% and 16.2% of all outsourcing respectively. China and the Philippines were the next most outsourced to nations with only 2.6% of contractors outsourcing to each. Other main IT outsourcing hubs were also reported (Brazil, Mexico, Australia, Romania, Malaysia, Poland). However, they only account for up to 2% of the responses each. Figure 6 displays the outsourcing percentages reported as specific

instances of outsourcing, but a substantial portion of contractors indicated outsourcing to multiple countries. When looked at as a whole, 95% of all contractors selected outsourcing to the US and 22% selected outsourcing to India.

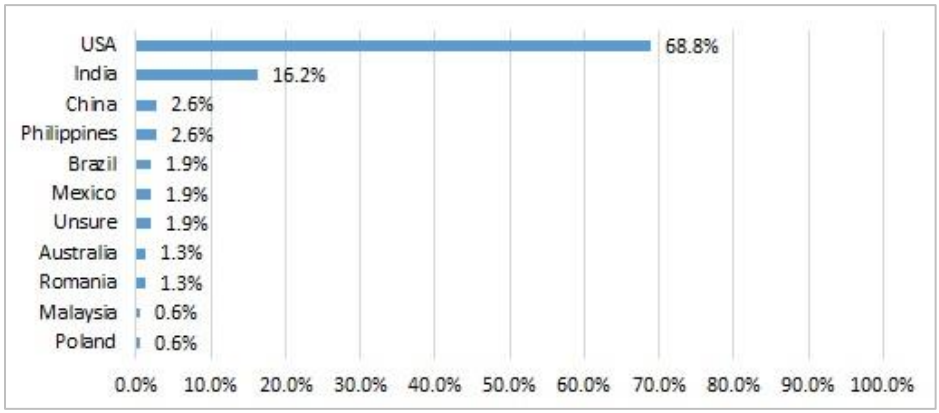

Figure 6: Main Nations to which BIM Tasks Are Outsourced

Approximately 13% of the respondents reported that they had not currently implemented BIM but were "likely" or "very likely" to implement BIM in the near future. When asked how they planned to implement BIM, 44% of those respondents reported that they would like to train in-house staff and create an "In-house" BIM department, 35% reported being unsure of the strategy that they would utilize to implement BIM, and 32% of the respondents reported outsourcing BIM to specialized IT firms would be a major part of their implementation. The percentages do not equal 100% because many contractors selected multiple possible BIM implementations.

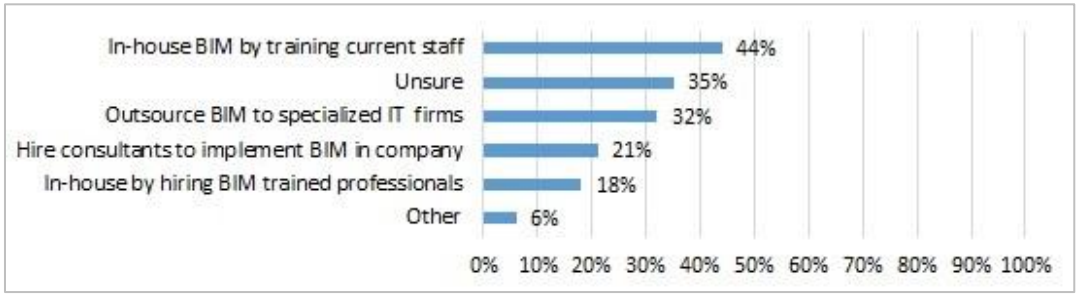

Figure 7: Likely BIM Implementations for Future Adopters

In a separate question, the contractors who currently utilized BIM, but do not outsource, were asked if they were likely to begin outsourcing. A clear trend emerged with 81% selecting they were either "Unlikely" or "Very Unlikely" to outsource BIM in the near future. Communication gap, lack of ability to manage projects, and poor quality were the three primary reasons identified by the respondents for not selecting to outsource as depicted in Table 1.

Table 1: Reasons Not to Outsource BIM

Ranking	**Reasons Not to Outsource BIM (1: most important, 5: least important)**
1	Communication gap
2	Lack of ability to manage project
3	Poor quality
4	Poor service
5	Poor contract management

How Contractors are Outsourcing BIM

Since BIM implementations vary, the contractors were asked what specific BIM functional areas they outsource. The three most commonly outsourced BIM functions are constructability [clash detection] (56%), visualization [3D modeling] (42%), and as-built and shop drawings (40%). The same three BIM functions were the most utilized in overall BIM usage (in-house and outsourced combined) as well. However, there is a substantial drop-off in the percentage of often the other areas are outsourced.

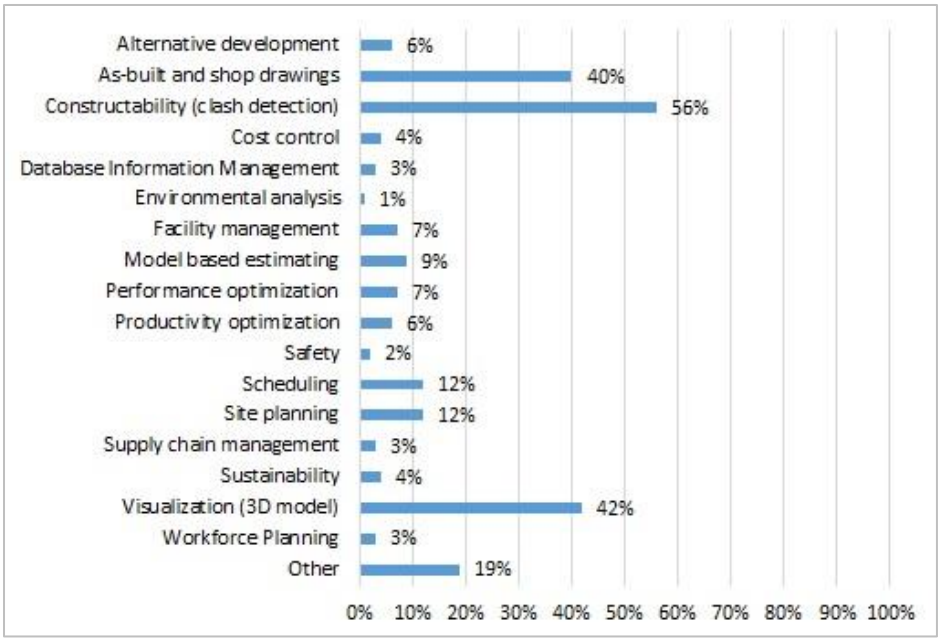

Figure 8: Outsourced BIM Functional Areas

Another important aspect of BIM outsourcing is the duration for which an outsourcing firm's services are engaged per project. The majority of the respondents (36%) indicated that the duration varies considerably from project to project. Given the variety of responses (shown in Figure 9) for the time spent on each project, it can be determined that the length of an outsourced project varies from contractor to contractor, possibly depending on their chosen outsourcing strategy. Some of the reasons for these different strategies and different outsourcing durations may be attributed to project size, project scope to be outsourced, current BIM workload, and others.

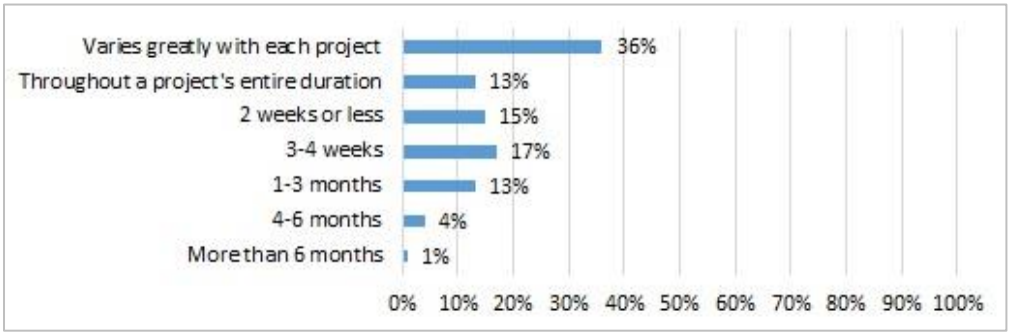

Figure 9: Time Spent Outsourcing for Each Project

The contractors who have previously outsourced BIM were asked how they currently implement BIM (results in figure 10). 41% of contractors choose to outsource even though they have in-house capabilities as well, and a combined 54% of contractors choose to either solely outsource, or outsource only what they do not have the capabilities for. This finding, along with how contractors ranked the importance of specific motives to outsource (shown in Table 2), indicates that there are two primary strategic uses for BIM outsourcing currently among general contractors:

- BIM outsourcing gives the ability to utilize BIM only when needed. This ability allows outsourcing to be used as a relief outlet to take the burden from in-house BIM resources.
- BIM outsourcing is temporarily used by contractors to ease the transition from non-BIM usage or limited BIM usage into the utilization of BIM functional areas that they do not have the in-house capabilities to perform.

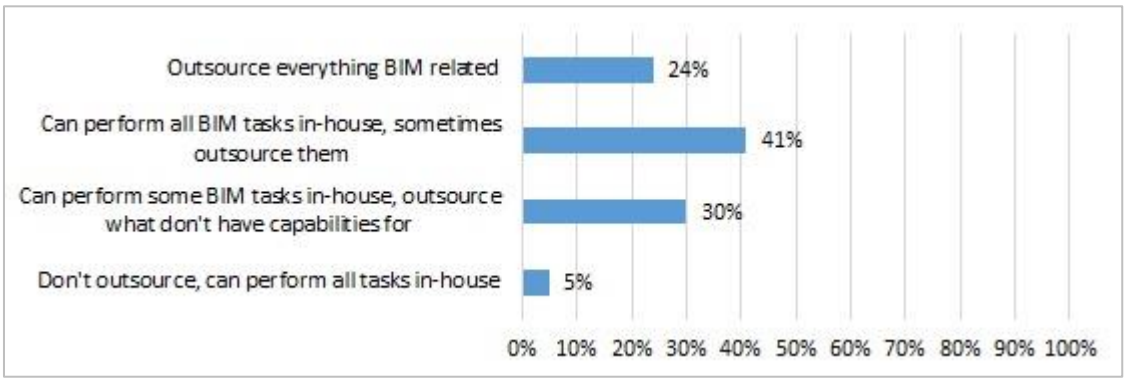

Figure 10: BIM Implementation among Outsourcing Contractors

Table 2: Importance of the Motives to Outsource BIM

Ranking	Motives to Outsource BIM (1: most important, 5: least important)
1	Ability to use BIM services only when needed
2 (tied)	Lack of in-house employees with BIM experience
2 (tied)	Outsourcing firms provide high-quality services
4	Lower costs
5	Lack of BIM professionals seeking employment

Perceived Impacts of BIM Outsourcing on Projects

Contractors who have utilized BIM were asked about their perceptions on "In-house BIM" versus "BIM Outsourcing." The perceptions of contractors who have worked with BIM were used as a metric of project impacts because applicable data for how in-house and outsourcing BIM usage affects projects in comparison to traditional non-BIM practices can be difficult to obtain. The majority of the contractors viewed in-house BIM as having an overall more positive impact on projects than BIM outsourcing with 24% more contractors selecting "Very Positive" or "Positive" in the category of money, 12% in the category of time, 42% in the category of quality, and 43% in the category of value. Therefore, it seems to be the opinion of most contractors that in-house BIM utilization is superior to outsourcing in every measured category. However, all perceptions of both in-house and outsourcing BIM's project impacts were still more positive than negative (shown in Figure 11).

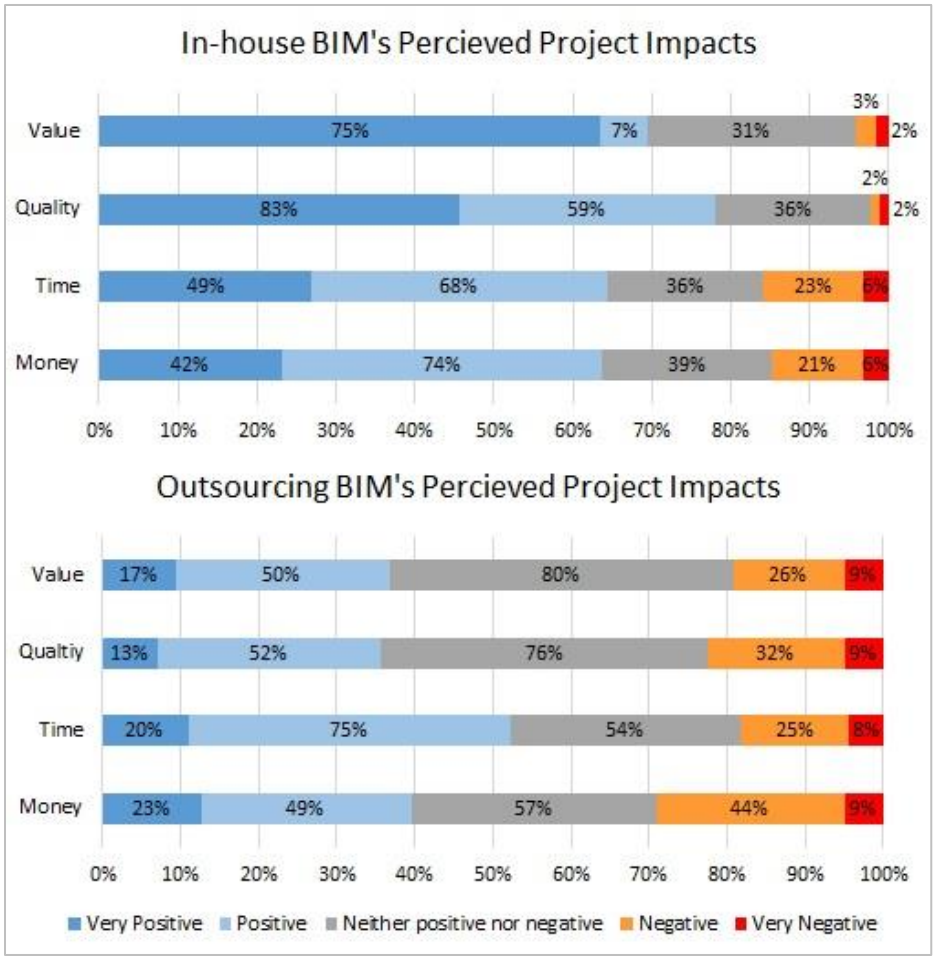

Figure 11: BIM In-house vs. Outsourcing Project Impacts

BIM Outsourcing Demographic Correlations

Previous research shows company size (average annual revenue) plays a major role in the adoption of BIM with larger companies being more likely to adopt than smaller (McGraw-Hill Construction, 2012; Langar & Pearce, 2014). From the results of the survey, 71% of contractors with an annual revenue of $500 million or more and 48% of contractors with a revenue of less than $25 Million outsourced BIM tasks (Figure 14). However, a chi-square analysis of the correlation between BIM outsourcing and annual revenue produces a p-value of .29 (< .05 is significant). Therefore, there is no significant

correlation between company size and BIM outsourcing. A chi-square analysis was also performed on the correlation between general BIM usage and company revenue producing a p-value of .00, indicating the correlation is very significant and reinforcing the previous research.

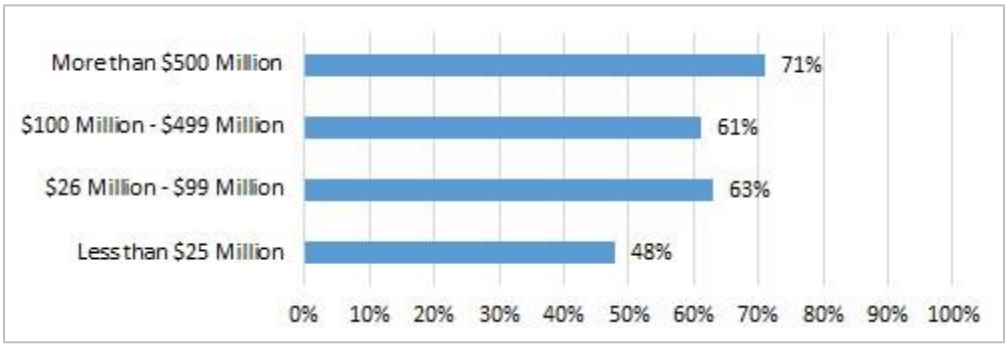

Figure 12: BIM Outsourcing by Company Size

The researchers also identified if any correlation existed between company experience with BIM and whether the company outsourced BIM. Using logistic regression with outsourcing as a binary dependent variable, it was found that for every one-year increase in the number of years a company has been utilizing BIM, the odds of outsourcing BIM decreases by 10%. This indicated that the more the experience companies had with BIM, the less likely they were to outsource.

Conclusion

After analyzing the responses from general contractors around the United States, it is evident that the outsourcing of Building Information Modeling (BIM) plays a significant role in the modern construction industry. With 45% of this representative sample reporting outsourcing BIM, the practice has become so widespread it cannot be ignored. A study, such as this one, specifically on the topic was necessary to serve as a launching point for future research and to inform those in the construction industry who need to make BIM-related strategic business decisions.

Using descriptive analysis of the survey data, current BIM outsourcing trends were determined. Contrary to how outsourcing is sometimes perceived as sending overseas, the vast majority of outsourcing US contractors chose to outsource BIM tasks to other companies who were also located in the US. In addition, among those contractors who had not utilized BIM previously, BIM outsourcing was a strategy that many (32%) reported to be interested and inclined to use, during BIM implementation. However, among those contractors who currently utilized BIM, but do not outsource, only 19% reported being likely to outsource in the foreseeable future. How contractors are choosing to outsource BIM was also analyzed. The three most utilized functional areas for in-house BIM, constructability (clash detection), visualization (3D modeling), and as-built and shop drawings, were determined to be the three most outsourced BIM functional areas as well. All other functional areas were outsourced significantly less.

The first hypothesis of this study, "The primary strategic motive to outsource BIM is to ease the transition into developing and utilizing in-house BIM capabilities" was

determined to be false. While easing the transition into in-house BIM capabilities was determined to be one of the primary strategic uses, 41% of contractors reported outsourcing even though they had in-house capabilities. Outsourcing gives those contractors who already have in-house capabilities the ability to utilize BIM only when needed and allows outsourcing to be used as a relief outlet to take the burden from in-house BIM resources. This provides for immediate scalability to accomplish large or numerous projects without having to invest in extensive BIM resources that will be left unused when the company's temporarily large scale of work decreases. Because of this, BIM outsourcing can be seen more than just a temporary practice, but as a solution that can be continually utilized when necessary.

The second hypothesis of this study, "In- house BIM is perceived as having a more positive project impact than outsourcing BIM" was determined to be true. Contractors on average rated in-house BIM as having a more positive project impact than outsourcing BIM in all four impact categories: Money (24%), Time (12%), Quality (42%), and Value (43%). Therefore, it seems to be the opinion of most contractors that in-house BIM is superior to outsourcing. However, the strategic uses outlined above and the number of contractors currently outsourcing show that BIM outsourcing has a place in the industry.

The last hypothesis, "A positive correlation exists between company size and BIM outsourcing" was determined to be inconclusive. Previous studies show that larger companies utilize BIM more often (McGraw-Hill Construction, 2012; Langar & Pearce, 2014), and in this study that was true for companies under $25 Million in revenue a year and companies over $500 Million, but not for the companies in between. A chi-square

analysis of the data proved that any correlation was insignificant, but perhaps with a larger sample size, a correlation could be determined.

The current state of BIM outsourcing among general contractors is a testament to the adaptability of the industry to meet challenges and embrace new technology through alternative methods despite the potential risks. Even though outsourcing can be perceived by some as a somewhat inferior trade-off to in-house, it is still being used effectively to take advantage of an industry advancement in circumstances where utilization might have been otherwise impossible or the immediate return on investment would have been uncertain. Because of this, as BIM utilization expands in the future, it is likely that BIM outsourcing will continue to have an expanding role alongside it.

Future Research

Since relatively little research has occurred on the topic of BIM outsourcing there are many unexplored opportunities for more in-depth future study. Many of the same methods used to study in-house BIM could be mirrored except with organizations that outsource the process. Case studies could be performed on projects where BIM was outsourced and then compared to case studies on similar projects where it was performed in-house so the differences could be analyzed. Also, the other members of the AEC industry that outsource BIM other than general contractors (architects, engineers, subcontractors, owners, etc.) as well as the specialized BIM outsourcing firms themselves could be studied. There are many ways to expand upon this research since it is now clear that BIM outsourcing is a significant feature in the construction industry.

Underlying Challenges for this Study

Considerable challenges exist with a survey-based research method that attempts to portray an accurate cross-sectional representation of the entire population such as in this study. The sample size may not be large enough, the validity of the survey tool, the inherent bias among the respondents towards a certain trait, or accuracy of the responses provided by the respondents. However, these issues have been addressed to the best of the researchers' abilities. The sample contained over 250 unique and complete responses from which the demographics were evenly distributed and lined up with previous research. Only a single response was kept from firms that responded multiple times to prevent bias towards a firm that had multiple responses. Also, the survey tool was reviewed and pilot tested by over 15 members of academia familiar with survey method and many industry professionals for errors or possible misunderstandings that might arise while taking it. No issues are anticipated regarding the accuracy of these results.

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Appendices

Appendix A – BIM Outsourcing Survey Questions

*Question display logic in blue

Q0 The information collected from this survey will not be attributed to an individual company in any way. To prevent multiple responses from a company, we are asking you to provide a company name, but all identities will remain private and only aggregate data will be used for analysis.

Q1 Upon the completion of this study, if you or another representative from your company would like to receive a comprehensive report of the findings please enter the email address for it to be sent to below. If not interested, please leave this form blank.

Email:

Q2 Please enter your company's name:

Q3 How long has your company operated within the construction industry? (In years)

Q4 In what region(s) of the United States does your company perform the majority of its work? (Please select all that may apply.)

- ❑ South
- ❑ West
- ❑ Midwest
- ❑ Northeast
- ❑ We do not perform work in the United States

Q5 What are the primary project types that your company performs? (Please select all that apply) If unsure about a certain category, you may hover your mouse over it to see examples.

- ❑ Automotive
- ❑ Civil
- ❑ Community Buildings
- ❑ Educational
- ❑ Electrical & Mechanical
- ❑ Entertainment
- ❑ Government
- ❑ Hotels & Motels
- ❑ Industrial
- ❑ Medical
- ❑ Military

- ❑ Offices & Warehouses
- ❑ Religious
- ❑ Residential
- ❑ Restaurants
- ❑ Retail
- ❑ Site Work & Landscaping
- ❑ Sports
- ❑ Transportation
- ❑ Veterinary
- ❑ Water & Sewer
- ❑ Other (22) _____
- ❑ Other (23) _____

Q6 Please select the range that best represents your company's gross annual revenue.

- ❍ Less than $25 Million
- ❍ $26 Million - $99 Million
- ❍ $100 Million - $499 Million
- ❍ More than $500 Million

Q7 Has your company utilized Building Information Modeling (BIM) in the last 10 years? *BIM Definition: A 3-dimensional, data rich, object-oriented, and parametric model of a facility that consolidates all incorporated project information pertaining to various phases of the project, so that stakeholders can extract and analyze required project information to incorporate decisions that conform to owner project requirements and efficient delivery of the project*.

- ❍ Yes
- ❍ No

Answer If For Q7 'Yes' Is Selected

Q8 Approximately what percentage of projects performed by your company utilized BIM in the last 5 years?

_____ Percentage of projects

Answer If For Q7 'Yes' Is Selected

Q9 For approximately how many years has your company been utilizing BIM?

Answer If For Q7 ‘Yes’ Is Selected

Q10 Please select the areas for which your company utilizes BIM, even if the tasks are outsourced to a specialized information technology company. (Select all that apply)

- ❑ Scheduling
- ❑ Alternative development
- ❑ As-built and shop drawings
- ❑ Constructability (clash detection)
- ❑ Cost control
- ❑ Database information management
- ❑ Environmental analysis
- ❑ Facility management
- ❑ Model-based estimating
- ❑ Performance optimization
- ❑ Productivity optimization
- ❑ Safety
- ❑ Site planning
- ❑ Supply chain management
- ❑ Sustainability
- ❑ Visualization (3D model)
- ❑ Workforce planning
- ❑ Other _____
- ❑ Other _____
- ❑ Other _____

Answer If For Q7 ‘Yes’ Is Selected

Q11 If applicable, please identify the number of employees within your company that are experienced in BIM.

- ❍ Approximate number of employees: _____
- ❍ Our company does not have professionals experienced in BIM.
- ❍ Unsure

Answer If For Q7 ‘Yes’ Is Selected

Q12 Has your company lost employees experienced in BIM to competing companies?

- ❍ Yes
- ❍ No
- ❍ Unsure

Answer If For Q7 'Yes' Is Selected

Q14 Has your company ever outsourced any aspect of BIM implementation to a specialized information technology firm?

- ❍ Yes
- ❍ No

Answer If For Q7 'No' Is Selected

Q15 How likely is it that your company will adopt BIM in the next 5 years?

	Very Unlikely	Unlikely	Likely	Very Likely
Likelihood of BIM adoption	❍	❍	❍	❍

Answer If For 'Very Likely' Is Selected Or If For Q15 'Likely' Is Selected

Q16 How would your company plan to implement BIM? (Please select all that may apply)

- ❑ Develop in-house capabilities by hiring people trained in BIM
- ❑ Develop in-house capabilities by training current staff in BIM
- ❑ Outsource all or parts of the model creation to an outside information technology firm
- ❑ Hire an outside consultant to implement BIM within the company
- ❑ Unsure
- ❑ Other _____

Answer If For Q14 'No' Is Selected

Q17 In the next 5 years, what is the likelihood that your company will outsource any part of BIM or BIM implementation to a specialized information technology firm?

	Very Unlikely	Unlikely	Likely	Very Likely
Likelihood of BIM Outsourcing	❍	❍	❍	❍

Answer If For Q17 ‘Very Unlikely’ Is Selected Or If For Q17 ‘Unlikely’ Is Selected

Q18 Please rate the possible reasons that reflect why your company is not likely to outsource BIM to specialized information technology firms in the future. You may add additional barriers that are not listed in the "other" section and rate them as well.

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Communication gap	❍	❍	❍	❍	❍
Hidden costs	❍	❍	❍	❍	❍
Lack of ability to manage project	❍	❍	❍	❍	❍
Lack of protection for intellectual property rights	❍	❍	❍	❍	❍
Poor service	❍	❍	❍	❍	❍
Poor quality	❍	❍	❍	❍	❍
Poor contract management	❍	❍	❍	❍	❍
Lack of BIM specialized IT firms	❍	❍	❍	❍	❍
We were unaware of BIM specialized IT firms	❍	❍	❍	❍	❍
Other (8)	❍	❍	❍	❍	❍
Other (9)	❍	❍	❍	❍	❍
Other (10)	❍	❍	❍	❍	❍

Answer If For Q17 ‘Very Likely’ Is Selected Or If For Q17 ‘Likely’ Is Selected

Q19 Please rate the possible reasons that reflect why your company is likely to outsource BIM to specialized information technology firms in the future. You may add additional reasons that are not listed in the "other" section and rate them as well.

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Lack of trained in-house employees experienced with BIM	❍	❍	❍	❍	❍
Lack of qualified BIM professionals seeking employment	❍	❍	❍	❍	❍
Lower costs	❍	❍	❍	❍	❍
Specialized IT firms provide a high quality of service	❍	❍	❍	❍	❍
Ability to use BIM services only when needed	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍

Answer If For Q14 ‘Yes’ Is Selected

Q20 For approximately how many years has your company outsourced tasks associated with BIM?

_____ Years outsourcing BIM

Answer If For Q14 ‘Yes’ Is Selected

Q21 For approximately what time period does your company engage a BIM outsourcing firm's services for a typical project?

- ❍ 2 weeks or less
- ❍ 3-4 weeks
- ❍ 1-3 months
- ❍ 4-6 months
- ❍ More than 6 months
- ❍ Throughout a project's entire duration
- ❍ Varies greatly with each project

Answer If For Q14 ‘Yes’ Is Selected

Q22 Please select the statement that best reflects your company's current BIM implementation.

- ❍ We have the capability to perform all BIM tasks in-house, we do not outsource them.
- ❍ We have the capability to perform some, but not all, BIM tasks in-house. We only outsource the tasks we don't have the capability to perform.
- ❍ We have the capability to perform all used BIM tasks in-house, but we sometimes we choose to outsource them.
- ❍ We outsource everything BIM related.

Answer If For Q14 ‘Yes’ Is Selected

Q23 Please select the geographical location(s) of the specialized information technology (IT) firms to which your company is currently outsourcing BIM tasks to. (Please select all that apply) If the location of the IT firms are unidentified in our options, please select 'other" and insert the locations.

- ❑ United States
- ❑ Australia
- ❑ Brazil
- ❑ China
- ❑ India
- ❑ Malaysia
- ❑ Mexico
- ❑ Philippines
- ❑ Poland
- ❑ Romania
- ❑ Unsure
- ❑ Other _____

Answer If For Q14 ‘Yes’ Is Selected

Q24 Please specify the areas of BIM that your company outsources to a specialized information technology firm. (Please select all that apply)

- ❑ Scheduling
- ❑ Alternative development
- ❑ As-built and shop drawings
- ❑ Constructability (clash detection)
- ❑ Cost control
- ❑ Database Information Management
- ❑ Environmental analysis
- ❑ Facility management
- ❑ Model based estimating
- ❑ Performance optimization
- ❑ Productivity optimization
- ❑ Safety
- ❑ Site planning
- ❑ Supply chain management
- ❑ Sustainability
- ❑ Visualization (3D model)
- ❑ Workforce Planning
- ❑ Other _____
- ❑ Other _____
- ❑ Other _____

Answer If For Q14 ‘Yes’ Is Selected

Q25 Please rate how important the following reasons are to your company's decision to outsource BIM.

	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Lack of trained in-house employees experienced with BIM	❍	❍	❍	❍	❍
Lack of qualified BIM professionals seeking employment	❍	❍	❍	❍	❍
Lower Costs	❍	❍	❍	❍	❍
Specialized IT firms provide a high quality of service	❍	❍	❍	❍	❍
Ability to use BIM services only when needed	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍

Answer If For Q7 ‘Yes’ Is Selected

Q26 The following questions are based upon your personal experiences and opinions about BIM and BIM outsourcing, not about its implementation in your company.

Answer If For Q7 ‘Yes’ Is Selected

Q27 Which statement(s) best describe your current experience with BIM implementation? (Please select all that may apply)

- ❑ I have experience in an entirely in-house BIM implementation. (1)
- ❑ I have experience in an entirely outsourcing BIM implementation. (3)
- ❑ I have experience in a partially in-house and partially outsourcing BIM implementation (2)

Answer If For Q7 'Yes' Is Selected

Q28 Please select the statement that best represents your views about BIM outsourcing as a permanent practice vs a temporary solution.

- ❍ BIM outsourcing should be treated as a step towards developing fully in-house BIM capabilities. It is a temporary solution.
- ❍ BIM outsourcing should be treated as a possible permanent practice that offers benefits to a company equal to or greater than maintaining fully in-house BIM capabilities depending on the situation.
- ❍ BIM outsourcing should not be considered as a viable option when implementing BIM within a company.
- ❍ Other _____

Answer If For Q7 'Yes' Is Selected

Q29 Based on your experiences with BIM in general, please rate how you would perceive the effects of a primarily in-house BIM implementation on projects for the following categories.

	Very Positive	Positive	Neither positive nor negative	Negative	Very Negative
Money	❍	❍	❍	❍	❍
Time	❍	❍	❍	❍	❍
Quality	❍	❍	❍	❍	❍
Value	❍	❍	❍	❍	❍

Answer If For Q7 'Yes' Is Selected

Q30 Based on your experiences with BIM in general, please rate how you would perceive the effects of a primarily outsourcing BIM implementation on projects for the following categories.

	Very Positive	Positive	Neither positive nor negative	Negative	Very Negative
Money	❍	❍	❍	❍	❍
Time	❍	❍	❍	❍	❍
Quality	❍	❍	❍	❍	❍
Value	❍	❍	❍	❍	❍

Appendix B – IRB Approval Letter

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: CH16012906
PROJECT TITLE: Implementation Patterns of Building Information Modeling (BIM) Outsourcing among General Contractors in the United States
PROJECT TYPE: Change to a Previously Approved Project
RESEARCHER(S): James Fountain
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: School of Construction
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 02/04/2016 to 02/03/2017
Lawrence A. Hosman, Ph.D.
Institutional Review Board