

Exploring the Future Use of BIM in Construction Project Management in Canada

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This study explores the future use of BIM in Canada by analyzing its implications relative to five project management-specific issues. Major findings include: general contractors and their subcontractors have the greatest likelihood of collaborating using BIM in construction project management to assess the cost and time efficiency of construction methods; and Canadian architects are most likely to collaborate with other construction professionals using BIM processes. In addition, having established industry-wide rules and protocols governing accessing and updating of building information models appears to be a potential best practice associated with using BIM in project management. A potential barrier to the future use of BIM in project management is resistance to culture change from project participants. Lastly, methods of measurement promoted by the Canadian Institute of Quantity Surveyors (CIQS) will need to be revamped to facilitate the use of BIM in cost estimating. The major implication of these findings is that the Canadian construction industry must undergo a cultural transformation and a series of structural changes. These structural changes include government intervention in mandating a greater use of BIM in construction, developing industry-accepted BIM standards and best practices, revising standard contract documents to establish the legality of ownership and responsibility for information embedded in the building information model, increased emphasis on BIM training in post-secondary settings and the way in which Canadian construction professionals are trained in construction cost and project management practices. This paper ends by proposing three potential areas for future research studies that will facilitate the use of BIM in project management.

Keywords: BIM, Canada, Exploratory, Future Use, Project Management

Introduction

As is the case of many developed construction markets, the Canadian construction industry is currently in the midst of a change in the way building design and construction documents are produced and communicated among project stakeholders. Driving this change is a shift towards the use of Building Information Modeling (BIM) technologies and processes for visualization and communication purposes (Forgues et al. 2014). BIM is a "shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle" (National BIM Project Standard Committee 2014). In its simplest form, BIM is the use of visualization technologies to provide a digital representation of a facility's physical and functional characteristics. In its most advanced form, BIM is the use of digital technologies to not only visualize the facility being constructed, but it also entails augmenting a facility's digital model with information that is required for the efficient implementation and management of construction, sharing this information with project participants during construction, and subsequently, utilizing the as-built building model for facility management. While there are many theoretical studies on the development of BIM digital technologies and frameworks (e.g. Singh et al. 2011; Porwal & Hewage 2013; Jung & Joo 2011), there appears to be a dearth of understanding of how the use of BIM in construction will unfold in the future, especially as it pertains to construction cost and project management. McGraw-Hill Construction (2014) analyzed the business value of BIM for construction while Autodesk (2011) has provided best practices that will allow Mechanical, Electrical and Plumbing (MEP) firms to transition to the use of BIM technologies. Qian (2012) investigated the general benefits and the return on investment (ROI) of BIM for multidisciplinary construction project management in Singapore and Hergunsel (2011) has identified the benefits of BIM for construction managers and BIM-based scheduling. These studies have helped to promote the evolution and adoption of BIM, but it is still unclear what type of issues may affect the future use of BIM, more so, the future use of BIM in project management practices in the context of the Canadian construction industry. The use of BIM in construction project management refers to utilizing visualization and various integrative digital technologies applicable to virtual construction, as well as

streamlined project management processes and workflows to update, analyze and share project management information stored in the building information model among project participants during construction. When BIM is used in project management "project managers work with automated data, being able to see relationships; and use that to manage process and hence make better decisions based on more reliable information, and at an earlier stage" (NBS 2015). According to NBS (2015) the use of BIM in construction project management practices will lead to improvements in scheduling and budget control.

The goal of this exploratory research study is to obtain feedback from Canadian-based BIM practitioners on various issues that may potentially affect the future use of BIM in construction project management in Canada. As such, this exploratory study seeks to provide insight with respect to five issues, which when considered collectively, will provide a good appreciation of how the use of BIM in construction project management will be affected. These five issues are: 1) ways in which Canadian construction professionals are likely to collaborate with each other using BIM in construction project management, 2) likelihood of Canadian construction professionals collaborating with each other using BIM in construction cost and project management practices, 3) potential best practices associated with using BIM in construction cost and project management, 4) potential barriers and challenges to Canadian construction professionals collaborating with each other using BIM in construction cost and project management, and 5) Canadian construction cost management practices that may require adjustment to facilitate the use of BIM in cost management. Based on the discoveries concomitant with the five aforementioned issues, a series of potential research studies are proposed that will help to facilitate the use of BIM in construction project management in Canada. It is expected that the findings of this exploratory research study will be useful to both academics and construction industry policy-makers as these stakeholders will be provided with information that will help in crafting strategies to facilitate the sustained use of BIM in construction project management practices.

Method and Data Collection

This exploratory research study was implemented using a basic method of analysis on data collected by administering a detailed questionnaire survey to seven Canadian-based construction professionals with expertise in the implementation of BIM in Canada. The authors believe that this approach is suitable for this type of exploratory study. The questionnaire survey was used to collect data for a study of a much larger scope and consisted of 43 close- and open-ended questions. Of these 43 questions, responses from seven of them were used as the base dataset for analysis in this research study. These seven questions elicited information that addressed the study's main objectives, and, when considered together, provide a good appreciation of how various issues may affect the use of BIM in construction project management in Canada. In completing the questionnaire, participants answered questions and ranked issues and practices by considering the likelihood of how these issues and practices would affect the use of BIM in construction project management. As an example, a question asked the experts to consider the ranking of the ways in which construction professionals are likely to collaborate with each other using BIM in construction cost and project management. For this ranking, the study's participants were provided with a list of ways in which construction professionals are likely to collaborate with each other using BIM in construction cost and project management. Each participant then used his/her knowledge of the industry as well as their experiences using BIM to determine the relative likelihood of collaboration using BIM in construction cost and project management. Although this study was implemented without the use of advance quantitative methods of analysis, its basic method of analysis is appropriate since the aim of this research study is to provide a basis for the implementation of more direct and conclusive future research studies.

It is important to note that initially it was planned that the study would utilize input from at least 2 experts from each of Canada's nine provinces. However, during the course of the study it was revealed that BIM was not actively utilized in all Canadian provinces and that the provinces of Ontario, Alberta and British Columbia were the provinces where BIM was experiencing a relatively greater uptake. Based on this, it was decided that the research study would be based on input from respondents in these three provinces in order to prevent the study from being based on unrealistic and inaccurate input. Information on the seven Canadian-based construction professionals who completed the questionnaire survey is provided in table 1. These construction professionals have expertise in the implementation of BIM in four of Canada's nine provinces. It should be noted that three of these provinces (Alberta, Ontario and British Columbia) are perceived to have the most activity in building construction in Canada, as well as in the implementation of BIM in design and construction practices. In addition, these seven experts, by virtue of their differing professional role in the Canadian construction industry, provide unique perspectives on how various issues and practices may affect and shape the use of BIM in construction project management. This, along with expertise by Canadian geographic region, provides a suitable underpinning for this exploratory research study.

Table 1: Information on Canadian construction professionals with expertise in BIM that participated in this study

Expert No.	Provincial Construction Industry	Involvement in Industry	Organizational Title	Years of Experience in the Industry (Approximate)
1	Alberta	Academic	Department Chair	22
2	British Columbia	General Contractor	BIM Manager	10
3	British Columbia	Architect	BIM & quality control manager	15
4	Manitoba	Construction Manager	Manager of estimating	14
5	Ontario	General Contractor	Director of virtual construction services	23
6	Ontario	General Contractor	BIM Manager	7
7	Ontario	General Contractor	BIM Manager	10

Results and Discussion

The results from the analysis of survey data of the aforementioned five issues investigated in this study are presented and discussed in the following sections.

Ways in which Canadian Construction Professionals are likely to collaborate with each other using BIM in Construction project management

Results indicate that in Canada, the greatest likelihood of construction professionals collaborating with each other using BIM in construction project management is by general contractors and their subcontractors collaborating via inputting and extracting data from the building information model to assess the cost and time efficiency of construction methods and processes. In addition, there is a significant likelihood that owners' project management representatives, architects, and general contractors will collaborate via making adjustments to the building information model to assess changes and their impacts on project schedules and cost. These findings are highlighted in figure 1, which also shows that there is a low likelihood of collaboration between architects or quantity surveyors and general contractors' project managers and/or estimators via inputting and extracting data from the building model to assess progress payment claims. In addition, the results indicate that it is less likely that there will be collaboration between the general contractor's project manager and project site supervisors via the building information model to monitor and control project costs during project execution.

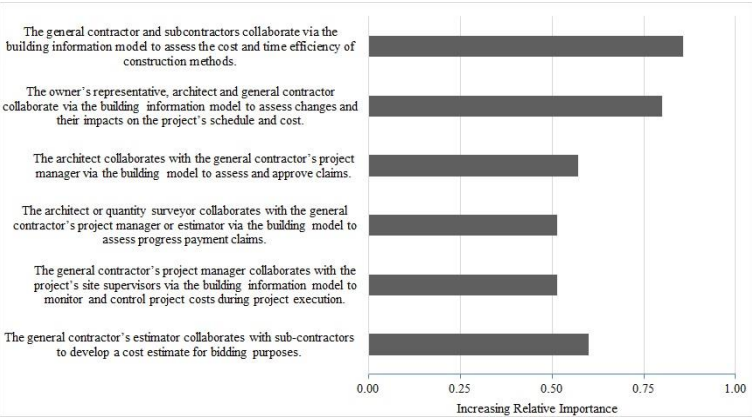

Figure 1: A ranking of the ways in which Canadian construction professionals are likely to collaborate with each using BIM in construction project management

These findings imply that the use of BIM in construction project management in Canada will likely result in Canadian construction professionals collaborating with each other using BIM technologies and processes to simulate changes on projects and assess their impacts on the primary project objectives: *cost* and *time*. It is apparent from the

analysis of the survey data that Canadian construction professionals will be less likely to collaborate with each other using BIM in cost control and analysis during project execution. This is evident by the practice of the general contractor's project manager collaborating with the project's site supervisor via data extracted from the building information model to monitor and control project costs ranking relatively low in likelihood of collaboration in comparison to the other BIM-collaborative construction project management practices. It is believed that the reason for this may be related to the unwillingness and inability of a significant number of Canadian site-level construction professionals to actively collaborate using BIM in construction project management.

Likelihood of Canadian Construction Professionals Collaborating with each other using BIM in Construction project management

A deeper analysis of this issue based on the study data reveals that Canadian construction professionals that are most likely to collaborate with each other using BIM in construction project management practices include architects and general contractors' estimators. Canadian construction professionals that are least likely to collaborate using BIM in construction project management include site foremen, superintendents, and commissioning agents. These findings are illustrated in figure 2 which highlights the likelihood of Canadian construction professionals collaborating with each other using BIM in construction project management. It is important to note that collaboration in this regard refers to working with each other and engaging in frequent information exchange through the use of a building information modeling platform.

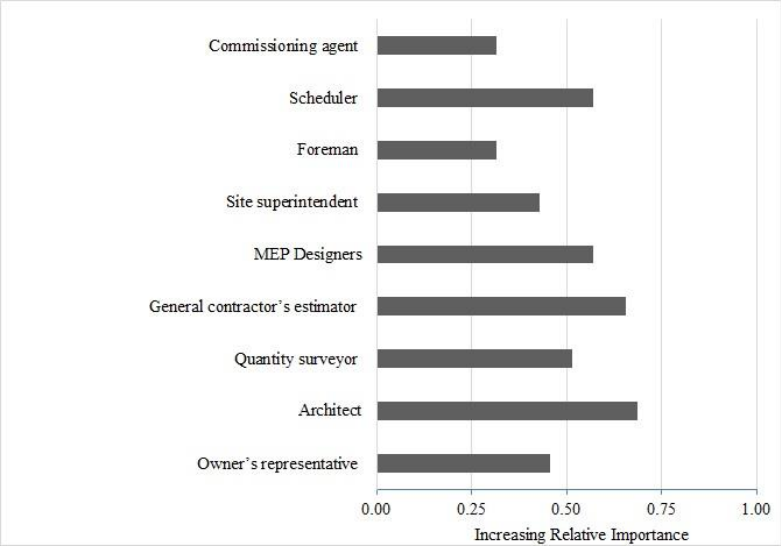

Figure 2: Likelihood of Canadian construction professionals collaborating with each other using BIM in construction project management

Based on opinions gathered from the study's participants, it appears that one possible reason for differences in likelihood of collaboration among Canadian construction professionals using BIM in construction project management is that site-level supervisory construction professionals may lack the necessary skills and abilities as well as the onsite BIM infrastructure with respect to BIM technology and collaboration processes, thus preventing them from collaborating with each other and with management-level construction professionals. In fact, it appears that site-level supervisory construction professionals are more resistant to transition to using BIM in construction project management by insisting on 2D paper-based data exchange. This may very well be a symptom of the way in which Canada trains and educates its site-level construction professionals, and is of concern since for a construction project to achieve greater efficiency in terms of cost and time, there needs to be greater and faster exchanges of construction project management information, especially between site-level and management-level project staff as well as the design professionals. Feedback from the study's group of experts reveals that other Canadian construction professionals and project participants who are beginning to actively collaborate with other project team members using BIM in construction project management include mechanical, electrical, and plumbing subtrades. It should be noted that collaboration of these construction professionals using BIM in construction project management is relatively low. A potential implication of these findings is that in order for the use of BIM in

construction project management in Canada to be sustainable and have an impact on the productivity of the Canadian construction industry, there must be greater effort to train all project participants to collaborate using BIM in construction project management. These findings also indicate that the increased push for the use of BIM in construction project management without investing in the requisite training and collaborative culture may alienate site-level construction professionals in the management of projects and impact negatively on the performance of the construction industry.

Potential Best Practices Associated with using BIM in Construction project management

Analysis of the survey data indicates that the frequency and extent to which Canadian construction professionals will collaborate with each other using BIM in construction project management is directly related to developing best practices associated with implementing BIM in construction project management processes. Some of these potential best practices and their relative importance is highlighted in figure 3. Practices that were identified as being highly important to facilitating the use of BIM in construction project management are "*clear and consistent rules and protocols when assessing and updating the building model*", "*assigning ownership and responsibility for the accuracy of various types of building information*", *"contracts should clearly indicate the frequency and time periods at which the building information model will be updated"* and *"establish protocols with respect to dealing with conflicts in construction project management information derived from the building information model"*. These four practices, according to the study's participants, will have the effect of removing doubt and uncertainty from the use of BIM in construction project management processes and will likely lead to greater frequencies of information exchange, as well as a wider variety of construction project management data being exchanged. Practices that were deemed to be potentially low in importance with respect to facilitating the use of BIM in construction project management processes are *"establish liabilities and penalties for inputting incorrect and inaccurate data into the building model"* and "*contracts should include clauses dealing with penalties and liabilities for incorrectly updating the building information model"*. These findings imply that the use of BIM in construction project management in Canada will depend on implementing consistent and acceptable rules and protocols that will streamline how the building information model is developed and manipulated, as well as how construction project management processes and workflows are adjusted to facilitate the use of BIM.

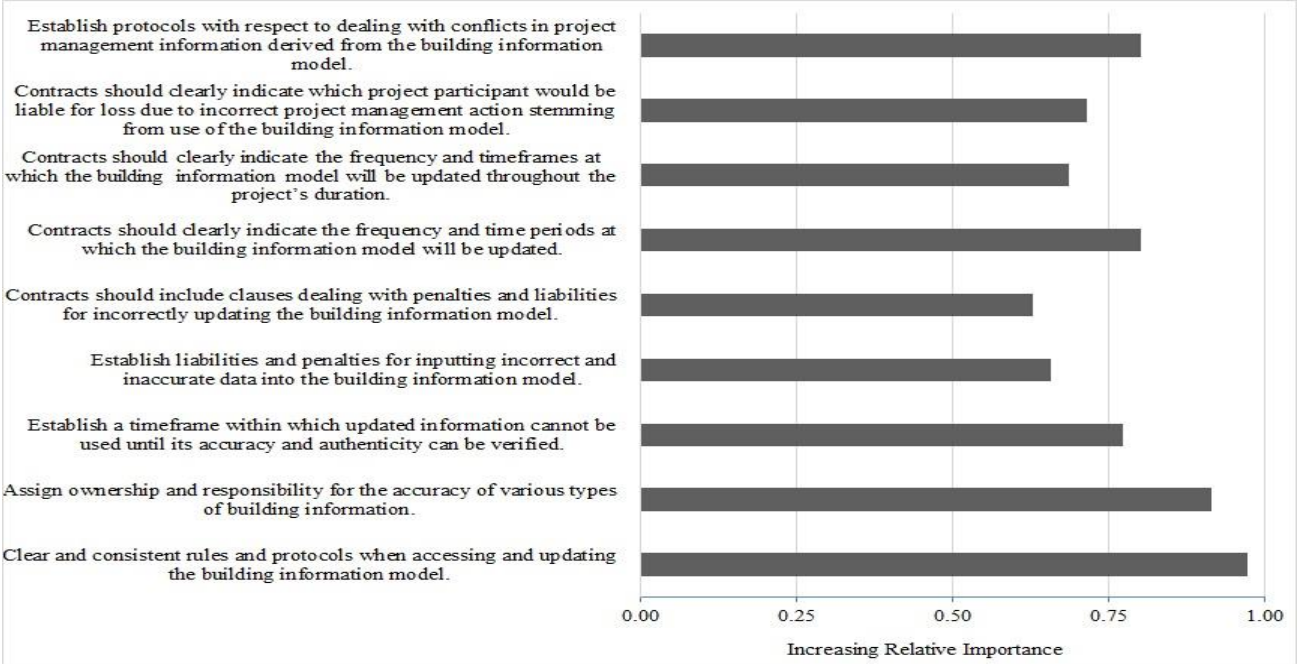

Figure 3: Canadian best practices associated with using BIM in project management

Potential Barriers and Challenges to Canadian Construction Professionals Collaborating with Each Other using BIM in Construction Project Management

The findings of a more in-depth investigation into potential challenges that will be faced by construction professionals with respect to collaborating with each other using BIM in construction project management is displayed in figure 4. Challenges that are likely to be most critical as identified in this study include: *resistance for culture change from project participants, lack of enforceable BIM standards and protocols, lack of willingness of parties to participate in BIM-enabled collaboration, lack of adequate training in BIM processes, and 2-D is still the dominant construction project management practice*. Challenges that are likely to be the least critical include: *costs associated with BIM-enabled collaboration platforms, lack of suitable high speed connectivity and data storage and retrieval accessible at a jobsite,* and *incompatibility of software.* The latter is expected given the wider variety of software that is becoming available and reduced costs associated with collaboration platforms. Based on this finding, it is speculated that in order for there to be an uptake in the use of BIM in construction project management there must be a cultural shift in the attitudes and expectations of project participants. This finding is supported by similar arguments put forward by others, e.g. Bachman (2009) and FM World (2014) who allude to the need for cultural shifts in the way built environment projects are designed and constructed if BIM is to be properly implemented across the construction industry. In addition, the Canadian construction industry must begin to enact and follow industry-wide accepted and enforceable BIM standards and guidelines. Feedback obtained from the study's respondents indicates that the resistance to culture change from project participants could be overcome by a government mandate in much the same way as the UK's government mandate on BIM. It is however, not yet clear as to whether such an approach may be feasible in the Canadian construction industry given its differences in structure (greater degree of fragmentation) and operation when compared to the UK construction industry.

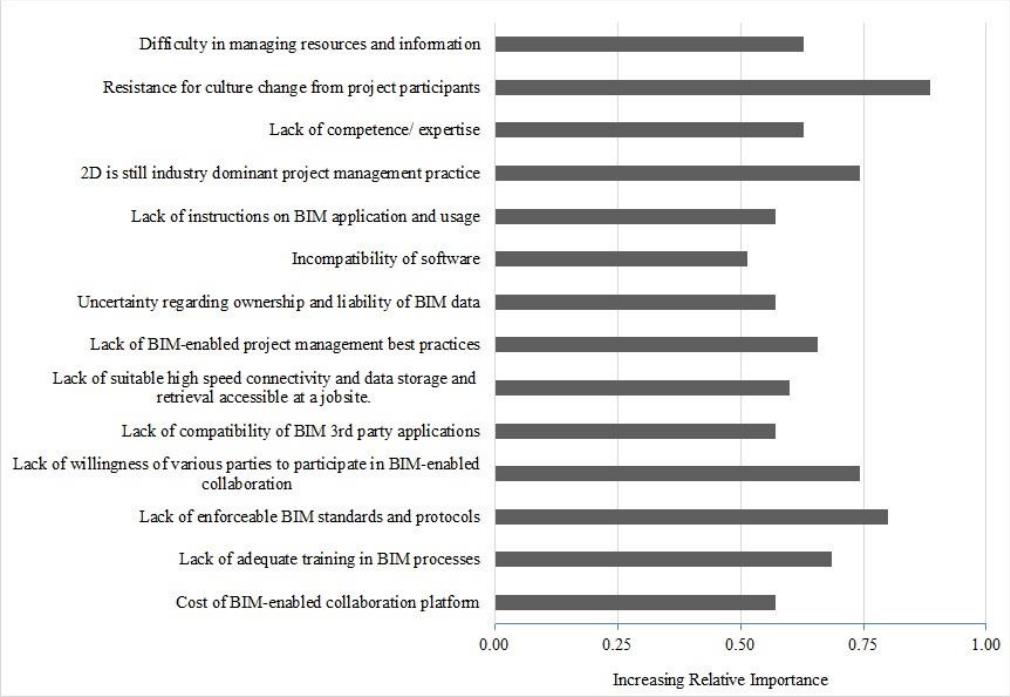

Figure 4: A ranking of some barriers and challenges to Canadian construction professionals collaborating with each other using BIM in construction project management

Canadian Construction Cost Management Practices that may require adjustment to facilitate the use of BIM in Construction Cost Management

The study's participants identified three general construction cost management practices that may need to be adjusted to facilitate the use of BIM in cost management. Firstly, the practice of having estimators rely mainly on manual quantity takeoff and spreadsheets in the development of cost estimates may not be a suitable approach to the use of BIM in cost management. Using BIM in cost management, particularly in cost estimating, will require estimators to take a technology-based career path that will allow for the application of different forms of BIM technologies in the estimating process where quantity takeoff is automated. Secondly, in order for an accurate estimate to be developed using BIM technologies and BIM cost management processes, the general contractor must be integrated in the design team and provide input in the development of the building information model. If this is not possible, the building information model must be developed according to industry-accepted rules and guidelines that will allow the general contractor to manipulate it for estimating and other cost management purposes. Thirdly,

Canadian methods of measurement as developed by the Canadian Institute of Quantity Surveyors (CIQS) will have to be adjusted to facilitate the use of BIM technologies. The CIQS methods of measurement in its current form is geared towards a manual takeoff of work quantities. The takeoff and pricing of work quantities using BIM technologies will require units of measurement for certain trades to be revised, e.g. structural steel is currently estimated in tonnage, but with BIM technologies exact member sizes and lengths can be taken off and more accurate prices can be estimated based on exact attributes of the steel elements.

Conclusion

This exploratory study has provided some initial insight into five issues that are likely to affect the use of BIM in construction project management in Canada. From a general perspective, it appears that Canadian general contractors and their subcontractors are project participants that are most likely to collaborate with each other using BIM in construction project management to assess the cost and time efficiency of construction methods and processes. Also, it is expected that architects and general contractors' estimators will lead the way in collaborating with other project stakeholders using BIM in construction cost management. On the other hand, site personnel, such as site foremen and site superintendents are expected to be the least likely to collaborate with other construction professionals using BIM in construction project management. Some potential best practices associated with using BIM in construction project management include establishing clear and consistent rules and protocols and assigning ownership and responsibility for the accuracy of various types of building information. In terms of potential barriers and challenges that may obstruct Canadian construction professionals from collaborating with each other using BIM in construction project management, it appears that resistance to culture change from project participants will be the most significant factor. It should be noted that this finding does not seem to be in tune with mainstream opinion which is that contractual-related issues are a greater barrier, and as such requires further investigation. Lastly, it appears the methods of measurement will inevitably need to be adjusted to facilitate the use of BIM in cost management, in particular, the use of BIM in cost estimating. Some of the major implications associated with these findings include:

1. The culture of the Canadian construction industry must evolve in order for the development and uptake of BIM in construction cost and project management to progress. This evolution may be best initiated by more diverse and complete education and training in BIM and by government mandates at the provincial level.
2. Legal precedent must be established in order for rules and protocols associated with ownership and responsibility for information embedded in the building information model to be adopted, accepted and enforced. In other words, without legal precedent being established, it will be difficult for various rules and protocols to become accepted best practice in the Canadian construction industry.
3. Industry-accepted BIM standards and best practices must be developed to streamline collaboration among all project participants.
4. The training of Canadian construction professionals in cost estimating needs to be revolutionized in order to facilitate the complete adoption of the use of BIM in cost estimating.

Table 2 lists three potential areas for further research that can be developed in any construction jurisdiction and will help to facilitate the use of BIM in construction project management. These three example research studies are provided to stimulate ideas on ways of facilitating the use of BIM in construction project management practices.

Table 2: Potential research studies associated with the use of BIM in construction cost and project management

Title of Potential Research Study	Summary
Identifying barriers to general contractors collaborating with their subcontractors using BIM in construction project management	This study can be implemented either as an industry-wide survey or case study analysis. In addition to identifying barriers to collaboration, this study will elicit feedback on how to best overcome barriers to collaboration and provide information on the tools and skills that are necessary to facilitate collaboration between a general contractor and its subcontractors.
Testing the feasibility of site foremen and superintendents collaborating with other project participants using BIM in construction project management	This study will identify the potential benefits associated with both site foremen and superintendents being able to collaborate with other project participants using BIM. It will determine whether or not it is worthwhile to have site foremen and superintendents develop capabilities to use BIM in construction project management.
Establishing modeling guidelines that will enhance the use of BIM in construction project management	This study will establish a series of modeling guidelines that architects will follow in order to allow the building information model to be used for construction project management without the need to redevelop/reformat the architect's model.

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