# QUESTIONNAIRE FOR OWNERS TO EVALUATE

# CONTRACTORS' PROFICIENCY IN BIM

A Thesis

by

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**ABSTRACT**


The use of Building Information Modeling (BIM) has been burgeoning in the construction industry because of its various advantages, which include the reduction of cost and duration, enhanced facilities management, and positive Return on Investment (ROI). Seeing the benefits from using BIM, building owners have started requesting contractors to submit the building information models integrated with necessary information, which can be used later for facilities management. As construction is presently growing complex and is in need of many specialized skills, contractor's proficiency is getting more important than before. Selecting a qualified contractor is one of crucial and basic requirement to the success of a BIM project, because the probability of project failure is greatly related to contractor's competency. However, it has been challenging for owners to select the right contractors who understand BIM, especially since not all owners know how to figure out which contractor is proficient in BIM. Although several contracting evaluation models have been introduced, it may have some challenges to be used by owners for client-contractor interviews. It is because some tools requires enough knowledge and experience about BIM, and some of them are self-grading systems for improving contractor's weaknesses in terms of using BIM. A questionnaire that can be easily used for evaluating contractors' proficiency in BIM is what owners may need.

The goals of this research are (1) to develop an effective questionnaire that can be used by owners when selecting contractors, and (2) to investigate the usability of the

questionnaire by using in-depth interviews with Subject Matter Experts (SMEs). This study explores various BIM manuals to determine their user-friendliness and practicality in evaluating a contractor's level of BIM proficiency. Moreover, the requirements for the BIM projects are investigated through BIM guidelines to create a prototype questionnaire, which would ideally provide deeper and more informative responses from contractors when interviewed. The questionnaire is then investigated to figure out the usability of the questionnaire and get feedback for future development. This thesis details the steps for questionnaire development, the outcomes of interviews, and the suggestions and feedback for questionnaire improvement.

# ACKNOWLEDGEMENTS

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**CHAPTER I**

**INTRODUCTION**

**1.1 Background**

Construction has evolved through the adoption of new methods, the maturity of management skills, and especially through the development of new technologies. In particular, Building Information Modeling (BIM) is the most effective technology that further develops and enhances the construction process (Azhar 2011; Eastman et al. 2011). Cost, schedule, productivity, and facility management (FM) are the major areas that have direct correlation to the use of BIM technology. Such advantages are seen through the increase of building performance, the reduction of the financial risk and project schedules, the attainment of reliable and accurate cost estimates, the assurance of program compliance, and the optimization of facility management and maintenance (Eastman et al. 2011; McGraw-Hill 2009). Since there are many benefits of BIM usage from the pre-construction through the post-construction phase, its usage has increased exponentially throughout the construction industry (Azhar 2011). According to McGraw-Hill Construction Company (2012), the level of BIM adoption in North America was 28% in 2007, increasing to 49% in 2009 and to 71% in 2012. Clearly, the adoption of BIM has expanded dramatically between 2007 and 2012. Several top companies, as well as mid-size companies, have now adopted BIM for their construction projects. According to the BIM handbook, owners reap benefits in project quality, cost,

and operation of the facility (Eastman et al. 2011). BIM-based process phases increase the value of project information, which in turn improves the collaboration and efficiency of the project team (McGraw-Hill 2009), thus overall project productivity is increased, and cost and time are saved to reduce the need for re-work (Eastman et al. 2011). Moreover, owners can better comprehend designs due to BIM visualization, problems from incomplete documents are less frequent during construction, and the project allows for better-constructed and well-reasoned designs (McGraw-Hill 2014). Owners can find optimized facilities management techniques by exporting relevant BIM data to start the system and maintain them over the lifecycle of the facilities (Eastman et al. 2011). BIM improves the processes of projects as owners receive a greater return in their investments. For the aforementioned benefits, a growing number of companies and owners are interested in investing in BIM (Mayo et al. 2012; McGraw-Hill 2009). However, the challenge lies in selecting competent contractors for owners because owners may not have enough contextual understanding of BIM.

**1.2 Research Problem**

Construction is presently growing complex and is in need of many specialized skill-sets (Eastman et al. 2011). To find a qualified contractor is very important and is a basic requirement to the success of a project (Alarcón and Mourgues 2002; Fong and Choi 2000; Holt 1998). Most current projects select contractors based on a low tender bid rather than qualification (Eastman et al. 2011; Fong and Choi 2000; Singh and Tiong

2005; Wong et al. 2001). Unfortunately, projects have a high probability of failure when the contractors are selected on the basis of low tender price rather than their qualifications (Singh and Tiong 2005). From the point of view of the owner, these cases would result in project failures since incompetence is a major cause of failure in the construction business (Russell 1991). As a result, it is crucial for owners to select a general contractor that has a high level of proficiency in construction in order for the project to be a success (Fong and Choi 2000; Singh and Tiong 2006).

**1.3 Motivation**

Projects would be successfully carried out if a contractor managed them competently (CIC Research Group 2012). This need has given rise to research studies (Mahdi et al. 2002; San Cristóbal 2011; Wong et al. 2001) about selecting a competent general contractor. Many studies have been conducted about the standards for selecting a general contractor; however, there is little research done about the questions that the owner should ask the contractors to evaluate their capabilities, especially regarding BIM. For example, during an interview with contractors who are competing for a project, the owner may ask, "Are you experienced or knowledgeable about BIM?" and questioned contractors may respond with a simple and even inaccurate affirmation that they are. This potentially gives the owners an inaccurate response and confuses them. Companies may exaggerate their level of proficiency to win a project (CIC Research Group 2012). Nevertheless, owners who are not proficient in BIM must make the final decision

regarding the hiring of a contractor. Since the contractor's BIM expertise may be fallacious or unreliable, problems will arise in the BIM-based project since project team selection is crucial to the success of a project (CIC Research Group 2012). In McGraw-Hill's report (2012), "BIM capability is beginning to exert a greater influence on the process of evaluating companies for project teams. A significant 81% take it into account at some level when making project team selections." However, even in BIM guidelines, there is not enough information about evaluating the contractor's proficiency in BIM. The BIM guideline is the manual that explains most part of BIM process, and there have been many publications on the BIM guidelines from universities, institutes, and states; however, BIM guidelines tend to focus on the way to use BIM in construction and the benefits of using BIM without taking into account the owner's needs. Owners make decisions for their projects but the information in selecting a competent contractor is insufficient. If a questionnaire to evaluate a contractor was suggested in a tangible way, it would be very helpful in the hiring process.

## 1.4 Research Objective

The objectives of this research are three-fold: (1) to develop a questionnaire that can be used for owners to evaluate the contractors' level of proficiency in BIM; (2) to investigate the practicality and feasibility of the questionnaire; and (3) to figure out additional items to be included or dropped from the questionnaire. The following tasks were needed to achieve the objective of this research:

- Development of a questionnaire to evaluate the contractors' proficiency in BIM

- Validation of the questionnaire using an usability assessment method

## 1.5 Research Scope

The scope of this research is to develop a first prototype questionnaire that assists owners to select competent contractors. After completion of the questionnaire development, the draft has been evaluated by the industry professionals. The collected responses that can be applied to the questionnaire are analyzed for improving upon in the next draft. This is a constant reiterating process to improvise the questionnaire according to the responses gathered from the previous feedback of the questionnaire. Thus, this thesis provides only one time process for developing a questionnaire and achieving feedback from experts for future questionnaires.

## 1.6 Thesis Summary

The first chapter covers the background of the current construction industry, including the growth of BIM adoption to projects, the increase in owners' demands of using BIM, and the problems with selecting competent contractors. Also, the motivation and objectives of this research were stated in chapter one.

The second chapter introduces several existing contractor evaluation models such as CIC Research group's Scoring Matrix, bimSCORE, Vico's Scorecard, and Indiana

University's BIM Proficiency Matrix (BPM). The features and composition of these tools are stated as a part of this chapter.

The third chapter contains the research methodology that has been applied to achieve the research objectives. Content analysis method for developing the questionnaire for owners to choose competent contractors and usability assessment method for investigating the usability of the questionnaire are explained in this chapter.

The fourth chapter details the steps for developing a questionnaire. This chapter also covers the analysis of various BIM guidelines to figure out the significance of requirements for performing a BIM project.

The fifth chapter states the data collection for interviews in usability assessment method to investigate the validation of the questionnaire suggested in chapter 4.

The sixth chapter contains the outcome from the interviews with Subject Matter Experts (SMEs) about the usability of the questionnaire. Feasibility and applicability of the questionnaire, suitability of the contents in the questionnaire, and suggestions for questionnaire development are identified based on the SMEs' opinions and suggestions.

The seventh chapter discusses the conclusions made from the results of the interviews. A research summary and suggestions for future research are mentioned in this chapter.

# CHAPTER II

## CONTRACTOR EVALUATION MODELS

This chapter includes reviews of several tools for evaluating a contractor's competency on BIM. BIM competence should be required as the basic capability to implement a BIM project and generate a BIM deliverable product (Succar 2010). Many studies about gauging the contractors' capabilities have been conducted by institutes and universities; as a result, several evaluation methods are available for assessing a contractor's BIM proficiency. Among several tools, the following four evaluation systems and tools are analyzed: CIC Research Group's Scoring Matrix, bimSCORE, Vico's BIM scorecard, and Indiana University's BIM Proficiency Matrix.

## 2.1 Scoring Matrix

Computer Integrated Construction (CIC) Research Group at Pennsylvania State University (2012) introduced Scoring Matrix through the guideline named "BIM planning Guide for Facility Owners". To ensure the success of a BIM project, project team members are required to possess adequate skills about BIM and owners should select proper contractors who have proficiency in BIM (CIC Research Group 2012). The Request for Qualifications (RFQ) allows owners to understand the contractor's BIM experiences and abilities. Through the RFQ, owners should be able to determine a contractor's competence to implement BIM projects, abilities for collaboration with

other firms, compliance with minimum BIM requirements, and experience in BIM Project Execution Planning. Scoring Matrix is a tool to help owners determine the contractors' level of BIM capabilities and skills when it is difficult to evaluate them. This matrix assists the owners to organize the submitted contractor's RFQ with a quantifiable score that can be ranked quickly and easily (CIC Research Group 2012). It contains two kinds of scoring matrices: BIM Qualifications Scoring Matrix (see fig. 1) and Proposal Scoring Matrix (see fig. 2).

| Category | Description | Level of Maturity | | | | | | Score | Possible |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | 0 | 1 | 2 | 3 | 4 | 5 | | |
| BIM Project Execution Planning Experience | Experience the team has with planning for BIM on projects | Team has no experience with BIM planning on a project | Team has completed discrete BIM Uses but has not composed a BIM plan | Team has assisted in BIM Planning with other teams | Team has led BIM planning on projects | Team has integrated BIM planning into standard operating procedures | Team has developed a standard BIM Execution Plan to use on projects | 1 | 5 |
| Collaboration Experience | Willingness of the team to collaborate with others and their experience collaborating | Team has not collaborated with other teams and does not encourage collaboration | Team has collaborated on previous projects, but is not willing to share model/information fluidly | Team has experience and is willing to share information with other team members | Team leads collaboration efforts and encourages information sharing among parties | Team is willing to co-locate for a project | Team encourages co-location on all projects | 2 | 5 |
| BIM Tools | Competence of the project team in implimenting various BIM tools | Team has not implimented BIM and is not willing to do so | Team has not implimented BIM, but is willing to | Team has implimented BIM to a limited extent | Team has implimented BIM on many projects if required by the owner | Team implements BIM tools on all projects | Team encourages all parties to impliment BIM tools on all project | 2 | 5 |
| Technical Capabilities | Ablities of the organization to preform BIM | Team does not impliment BIM or any other electronic technology | Team does not impliment BIM but utilizes limited electronic communication tools | Team does not impliment BIM but extensively uses electronic communication tools | Team Uses BiM to a limited extent and electronic communication tools | Team impliments cutting edge technologies on projects | Team is innovative in developing new technologies and BIM uses | 1 | 5 |
| TOTAL | | | | | | | | 6 | 20 |

**Fig. 1.** BIM Qualifications Scoring Matrix

BIM Qualifications Scoring Matrix helps owners filter out a contractor's exaggeration of their BIM expertise. It contains four main categories in the Matrix: BIM project execution planning experience, collaboration experience, BIM tools, and Technical Capabilities. Owners can evaluate the contractors' competence through checking the RFQs submitted by contractors with the contents in the matrix. Using this

tool, the owners can have proof of a contractor's qualification by asking how much experience on BIM projects they have, how well they collaborate with others, how competent they are in using various BIM tools, and their abilities to perform BIM (CIC Research Group 2012).

| Category | Description | Level of Maturity | | | | | | Score | Possible |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | | |
| Price | What is the total price for the listed services | Price is significantly different from the estimated price | Price is significantly higher than estimated price | - | Price is close to estimated price | - | Price is lower than estimated price but still within acceptable range | 1 | 5 |
| Additional BIM Uses | What additional BIM services are proposed | Many Required BIM Uses are not included in the proposed | A few required BIM Uses are not included in the proposal | - | All required BIM Uses are included in the proposal | - | Required and additional BIM Uses (with added value described) are included | 3 | 5 |
| Project Team Qualification | How much experience and success has the proposed project team had | None | Team has had minimum success with BIM projects | Team has limited experience and success with BIM projects | Team has adequate experience with BIM projects | Team has significant experience with BIM projects | Team has expert experience with BIM projects | 1 | 5 |
| Collaboration Procedure | What collaboration procedure is included in the proposal | No collaboration procedure described | Team proposes a basic collaboration procedure | Team has developed a BIM Execution plan detailing collaboration | - | A detailed BIM Execution plan including a collaboration procedure is proposed | A detailed BIM Execution Plan including a collaboration procedure is proposed for every team member including onsite collaboration | 2 | 5 |
| Deliverables | What are the deliverables proposed | Minimum deliverables are not met | Some of the minimum deliverables are met | Most of the minimum deliverables are met | All of the minimum deliverables are met | All of the minimum deliverables are met and additional ones are proposed | All of the minimum deliverables are met and additional ones are proposed with a value added description | 3 | 5 |
| Total | | | | | | | | 10 | 25 |

**Fig. 2.** Proposal Scoring Matrix

The other matrix is the Proposal Scoring Matrix. The Request for Proposal (RFP) requests a price for proposed service, contains a description of the proposed BIM implementation, and requests a description of a contractor's BIM qualification. To help owners rank the qualifications of contractors, the Proposal Scoring Matrix provides five categories: Price, Additional BIM Uses, Project Team Qualification, Collaboration Procedure, and Deliverables. For accurate scoring of the applicants' proposals, the owners should request a detailed description of the services and requirements that they

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are expecting on their projects. The applicants may be asked, "What BIM uses in regards to proposed services, collaboration procedures, and deliverables do you have for the projects?", "Who will manage the project?", "How much experience of implementing BIM projects does your BIM manager have?", "How much is the total cost for the proposed service?", etc. (CIC Research Group 2012).

Through analysis of the applicants' RFQs and RFPs with those two scoring matrices, the owner can not only filter the contractors who are not competent for their projects, but also determine the contractors' level of proficiency in BIM.

## 2.2 BimSCORE

BimSCORE (2014) is a web-based evaluation system for contractors to measure their proficiency in BIM. BimSCORE can assess the applicants' understanding of BIM maturity and their decision-making process regarding four areas: planning, adoption, technology, and performance. Each area has ten specific divisions to evaluate the applicants with multiple factors. In the system, confidence level is illustrated to clarify the assessment's context and inputs. According to the bimSCORE website, "The confidence level reflects multiple factors, including the number measures, the BIM/VDC role and stakeholder organization of the user providing inputs, and the frequency of scorecard use" (bimSCORE 2014).
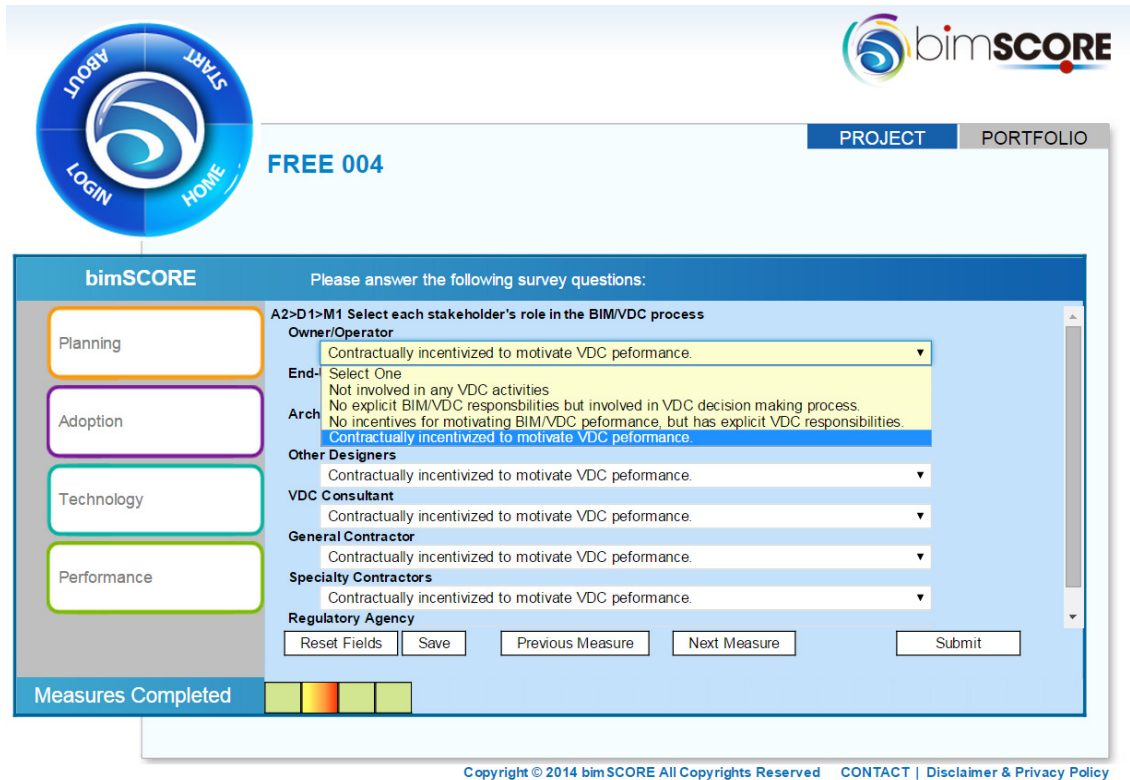
**Fig. 3.** The Sample Questions of BimSCORE

After completion of the evaluation, the BIM expert provides the applicant's level of maturity, some suggestions for a project, benchmarking projects in comparison with best practices in order to identify their status in using BIM and improve their BIM abilities. The system is a self-grading evaluation system for improving the companies' BIM weaknesses (bimSCORE 2014).
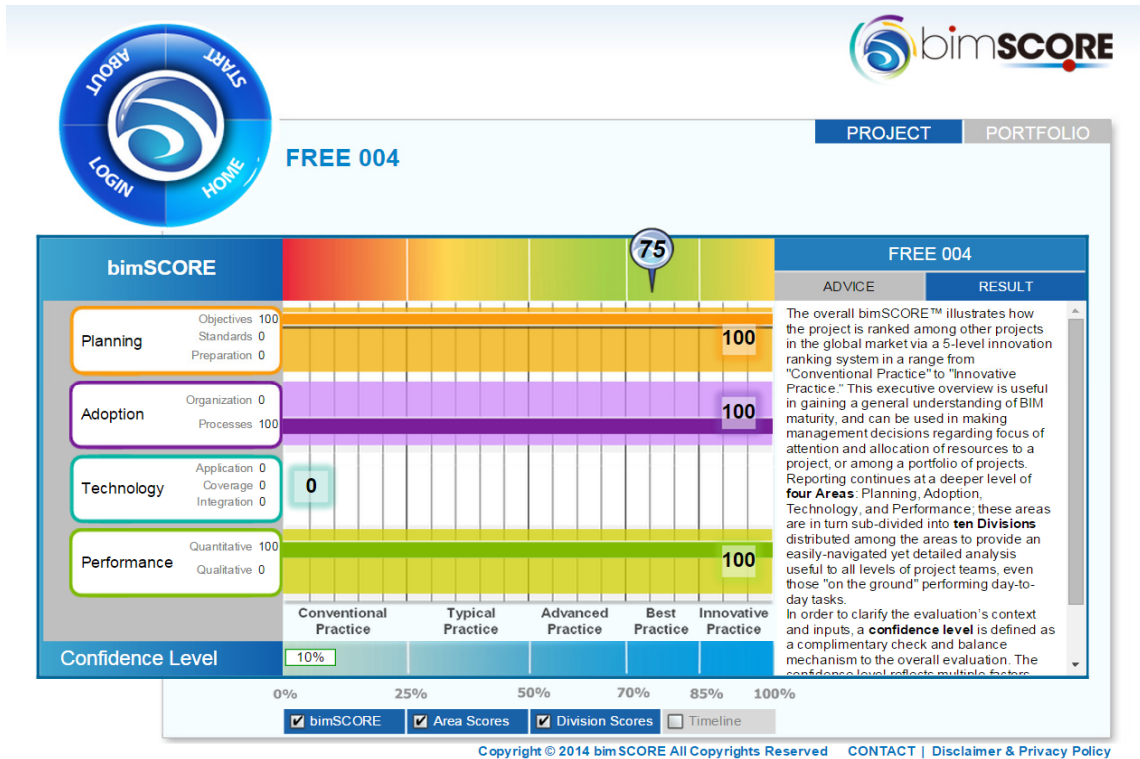
**Fig. 4.** The Sample Result of BimSCORE

## 2.3 VICO's Scorecard

VICO, Inc.(2014) found that many General Contractors (GCs) said they do BIM on projects but owners may have no idea about finding the differences between those GCs. To win the business with BIM, the GCs appeal to what level of competency on BIM they have and what capabilities they possess. Also, GCs must be competitive to win a project. VICO, Inc. developed their own evaluation system named "BIM scorecard" which can evaluate an individual company's BIM maturity and help companies compare their competence to others (VICO 2014). This system assesses a

company's current solutions in three aspects: capabilities, company's best practices, and enterprise integration. The solutions are mainly evaluated about clash detection, scheduling, and estimating areas in the system. Contractors are self-graded on their BIM capabilities and best practices by answering twenty seven questions. According to the Vico's website, the system asks the company to self-grade "the importance to the firm of the following construction management capabilities: Portfolio and Project Management, Cost Planning and Cost Control, Schedule Planning and Production Control, Coordination, and Design Tram Engagement" (Vico, 2014).

After answering the questions, the results are provided by a VICO consultant to point out the company's BIM weaknesses to help them improve their BIM skills (Vico, 2014). Vico Inc. claims to have "detailed benchmarking of Vico Office solution" and "guaranteed Customer Success Program," which means that they help firms who have low BIM scores improve their scores (Vico, 2014). However, this system is a self-grading system, so it is contractors (and not owners) who use this tool. Because of this tool's self-grading nature, contractors can exaggerate their BIM proficiency. Thus, owners may not want to use this tool for selecting their contractors.

**What's Your BIM Score?**

**VICO SOFTWARE** — Integrating Construction

BIM Score

**Vico BIM Scorecard**
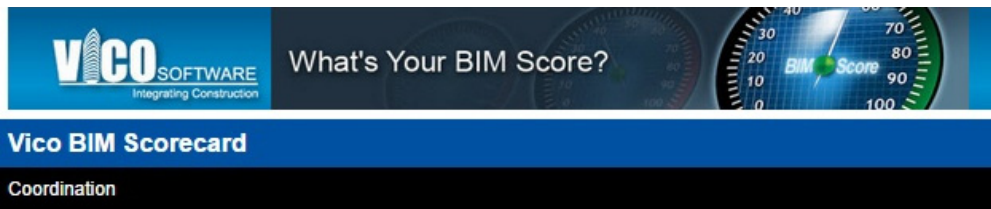
**Coordination**

The next set of questions dives into your clash detection and coordination process.

Do you have a system or systems to compare, store, and analyze/clash 2D drawings and 3D models?

A) Yes, we have a clash detection tool and a 2D comparison solution.

B) Yes, we have a clash detection tool and a 2D comparison and a document management solution.

C) Yes, we have a clash detection tool but we typically manually review the 2D drawings.

D) No, we manage coordination with 2D drawings in a team environment.

| | Answer A | Answer B | Answer C | Answer D |
|---|---|---|---|---|
| Choose one: | ○ | ○ | ○ | ○ |

Have you established a standard process for drawing/model coordination throughout the project?

A) Yes, we assign a skilled BIM Manager to each project who is responsible for coordination.

B) Yes, we have a standard protocol for coordination used by all our project managers/engineers.

C) No, 3D coordination is not standard on all projects, typically only if required by the owner.

D) No, our company does not use 3D technology at this moment; our company relies on the skills of engineers and field team to find and resolve potential issues.

| | Answer A | Answer B | Answer C | Answer D |
|---|---|---|---|---|
| Choose one: | ○ | ○ | ○ | ○ |

Do you use the coordinated model to update quantities/estimates and/or to connect to a Total Station for site layout?

A) No, we do not update the estimates but we do use the information from the model for use in a Total Station.

B) No, coordination typically happens in the field after the subcontractors have been hired.

C) No, we are not using 3D models on our projects, yet.

D) Yes, we use the coordinated model to feed our estimate and we also use a Total Station that reads points from our coordinated 3D model.

| | Answer A | Answer B | Answer C | Answer D |
|---|---|---|---|---|
| Choose one: | ○ | ○ | ○ | ○ |

**Fig. 5.** Sample Questions from Vico's BIM scorecard

## 2.4 IU's BIM Proficiency Matrix (BPM)

Indiana University (IU) (2012b) created their own evaluation matrix called "BIM Proficiency Matrix (BPM)" for measuring the expertise of a contractor in terms of using a BIM process on IU projects. BPM includes eight main categories: Physical Accuracy of Model, IPD Methodology, FM Data Richness, Construction Data, As-Build Modeling, Content Creation, Location Awareness, and Calculation Mentality. Each category is divided into four maturity areas. The applicants for IU projects fill out the matrix on the basis of their experience and capabilities. Then, their answers are evaluated by a consultant from IU. Scores are earned by one point per area and the scores are then all added up. All questions are weighted equally and the maximum score 32 since the matrix contains eight categories with four maturity levels (see fig. 6). By using BMP, IU can filter out an applicant who has a high level of BIM proficiency (Indiana University 2012b). It takes much time to fill out the matrix, so it may not be useful when an owner is interviewing a contractor.

| Category Number | A - Physical Accuracy of Model | B- IPD Methodology | C - Calculation Mentality | D - Location Awareness | E - Content Creation | F - Construction Data | G - As-Built Modeling | H- FM Data Richness |
|---|---|---|---|---|---|---|---|---|
| 1 | A.1 Basic Model Geometry — Point Achieved 0 | B.1 Creation of A BIM Execution Plan — Point Achieved 0 | C.1 Basic Model Information Export (Discipline) — Point Achieved 0 | D.1 Site Orientation — Point Achieved 0 | E.1 Geometrically Correct Content — Point Achieved 0 | F.1 Quantity Takeoffs — Point Achieved 0 | G.1 Post Bid Model Documentation — Point Achieved 0 | H.1 Space Management Data — Point Achieved 0 |
| 2 | A.2 Design Requirements — Point Achieved 0 | B.2 Introduction of Structural and MEP Model — Point Achieved 0 | C.2 IPD Integration — Point Achieved 0 | D.2 Existing Environment Awareness — Point Achieved 0 | E.2 Manufacturer's Specific — Point Achieved 0 | F.2 Object Scheduling — Point Achieved 0 | G.2 Coordination Modeling — Point Achieved 0 | H.2 Asset Management — Point Achieved 0 |
| 3 | A.3 Design Side Collision Detection — Point Achieved 0 | B.3 Model Managers Role Defined — Point Achieved 0 | C.3 Interdisciplinary Calculations — Point Achieved 0 | D.3 Global Accuracy — Point Achieved 0 | E.3 Design Intent — Point Achieved 0 | F.3 Material Procurement — Point Achieved 0 | G.3 Recapturing Design Intent — Point Achieved 0 | H.3 Manufacturer Specific Information — Point Achieved 0 |
| 4 | A.4 Model Accuracy Innovation — Point Achieved 0 | B.4 IPD Methodology Innovation — Point Achieved 0 | C.4 Calculations Innovation — Point Achieved 0 | D.4 Location Innovation — Point Achieved 0 | E.4 Content Innovation — Point Achieved 0 | F.4 Construction Innovation — Point Achieved 0 | G.4 As-Built Innovation — Point Achieved 0 | H.4 FM Data Innovation — Point Achieved 0 |

**BIM Maturity**

| Category | Points Achieved |
|---|---|
| A - Physical Accuracy of Model | 0 |
| B- IPD Methodology | 0 |
| C - Calculation Mentality | 0 |
| D - Location Awareness | 0 |
| E - Content Creation | 0 |
| F - Construction Data | 0 |
| G - As-Built Modeling | 0 |
| H- FM Data Richness | 0 |

**BIM Maturity Score**

0

| BIM Standard | | |
|---|---|---|
| BIM Score Between 0-12 | = | Working Towards BIM |
| BIM Score Between 13-18 | = | Certified BIM |
| BIM Score Between 19-24 | = | Silver |
| BIM Score Between 25-28 | = | Gold |
| BIM Score Between 29-32 | = | Ideal |

**Fig. 6.** IU's BIM Proficiency Matrix

The evaluation tools or systems that are mentioned above contain the important contents for assessing the contractors' BIM proficiency; they provide tools that categorize the BIM contents systematically and include helpful information regarding contractor assessment. However, the models fail to provide techniques of asking domain-specific questions for interviews. In other words, due to the lack of scaffolding, owners might struggle with constructing practical and exact questions during an interview to evaluate a contractor's BIM knowledge.

Moreover, the scoring matrix could be challenging and even cumbersome for many owners. The matrix itself contains a comprehensive range of categories and content that should be asked to evaluate contractors; however, its complexity and detail may be difficult for owners to understand. For example, when owners decide to use the matrix for assessment, they should match the matrix up with the RFP/RFQs that have

been submitted by contractors. Matching up all contents of RFP/RFQs and scoring matrix would be difficult for owners because often they do not have enough knowledge about BIM, and they would also have to spend additional time to decode and match data.

Additionally, bimSCORE and Vico's scorecard are self-grading systems that must be completely used with owners' discretion. Since the scores are calculated solely based on the participants' answers, it would be risky for the owners to depend entirely on the score. If contractors are selected by these scores, it is possible that the contractors exaggerated their BIM proficiency levels. Also, the questions in those systems are multiple-choice questions, as opposed to open-ended questions, providing less opportunity for the contractors to show extensive understanding of BIM. Thus, these two scores may not be as efficient and useful for owners during an interview.

Regarding IU's BPM, after the contractors fill out the matrix, the responses should be scored by BIM experts. Since this tool does not include the standards for judging a contractor's answers, owners need knowledge about BIM to judge the responses. However, most owners may not have enough knowledge and experience on BIM and it would be challenging for owners to grade the contractors' responses.

These weaknesses in the currently available BIM evaluations demonstrate the need for an improved method of evaluating a contractor's BIM proficiency. The next chapter will explore a possible solution.

# CHAPTER III

## RESEARCH METHODOLOGY

This chapter includes the research methodology that has been utilized for achieving the research objectives. As mentioned in Chapter 2, current contract evaluating systems are not fit for owners to implement during contractor interviews. Since some tools require longer periods of time in answering questions and others tools have cursory multiple-choice questions, they probably cannot be used by owners to accurately and efficiently determine the contractors' level of proficiency in BIM. Furthermore, owners may not have enough familiarity with BIM, much less the BIM evaluation tools. The tools contain significant content for evaluating contractors' capabilities, but owners would not know how to ask about the contents efficiently. To resolve this problem, a questionnaire that can be easily used by owners needs to be developed. This thesis suggests a possible questionnaire suited for client-contractor interviews, and then investigates the feasibility and applicability of the questionnaire. It also examines what should be added or dropped from the questionnaire.

Due to the nature of this study, qualitative research has been the preferred method of culling data. According to Creswell (2013), "We use qualitative research because quantitative measures and the statistical analyses simply do not fit the problem." Since this study investigates people's opinions, suggestions, and other non-numerical data, qualitative methods more aptly measure the properties focused on in this research.

The research contains two core steps for research methodology:

1. Content analysis for development of the questionnaire

2. Usability assessment methods for validation of the questionnaire

The following sections describe the details of each step for content analysis and usability assessment methods. Further information regarding the development of interview questionnaire such as the collection of BIM guidelines, analysis of the manuals, and suggestions of the questionnaire for interview, will be stated in next chapter.

**3.1 Development of the Questionnaire**

Since current evaluation tools may not helpful for client-contractor interviews, a questionnaire needs to be developed. BIM guidelines contain fundamental BIM information, as well as essential specifications and stipulations regarding implementation of a BIM project. As BIM requirements are central to constructing BIM projects, it can be used to qualify the contractors' level of proficiency. If a contractor has abundant knowledge and experience in implementing BIM projects, it implies that the contractor may have significant BIM competency. Using the BIM guidelines, the owner can ask about the requirements of a BIM project to find qualified contractors.

BIM guidelines are collected and analyzed in order to classify the necessary requirements of BIM project. Many BIM manuals have been published and each

guideline has included various contents about BIM depending on the publishers' consideration of the most important factors in using BIM. The requirements in guidelines are highlighted as significant factors; the more frequently they are stated, the more important they are. Thus, the guidelines are analyzed to first extract the requirements and then systematically classified by importance. The requirements were counted to verify their order of significance. In other words, frequently mentioned requirements would be valuable in implementing the BIM project. This scrutiny will allow owners to inquire about principal content and select competent contractors.

In order to extract the requirements of BIM projects from various guidelines, content analysis has been applied. According to Weber (1990), qualitative content analysis is one of numerous research methods used to analyze text data because of its flexibility. The focus on discourse and its meaning separates qualitative content analysis from other research methods; it studies the language found in manuals to draw implications and nuances in meaning that numbers cannot capture (Weber 1990). In this thesis, all requirements for BIM projects from various guidelines are extracted and counted by hand instead of using computer-aided analysis. Because there have been differently phrased texts with the same meaning, the investigator should understand the various definitions and forms of words to classify the language into appropriate categories. The requirements are sorted into categories based on process in different construction phases. After coding the data, a tree diagram can be developed to help understand the hierarchical structure of the categories (Mores & Field 1995). In the data analysis section of next chapter, the tree diagram for the categories of requirements is

provided. From the classification of the words by counting and sorting text based on the researcher's discretion, the significance of the categories for the requirements are identified because counting assumes that higher relative counts reflect higher concern with the category (Weber 1990). Lastly, the questionnaire is developed based on the most important categories.

To sum up, there are four steps for developing the interview questionnaire.

1. Collect BIM guidelines

2. Analyze BIM guidelines with content analysis

3. Identify the significance of the requirements

4. Suggest a questionnaire that can be used for interviews

## 3.2. Validation of the Questionnaire

The research methodology for questionnaire validation is the usability assessment method. Usability assessment method investigates whether or not the questionnaire is working, and the method receives feedback or suggestions from Subject Matter Experts (SMEs). This method was used for evaluation of the human factors and ergonomic literature before 1980 (Dumas and Salzman 2006). Usability engineering has been developed in the computer science field for twenty-five years (Leventhal and Barnes 2007). When computer system users and software developers want to know how consumers feel about their products, they have turned to usability assessment methods to assess customer satisfaction. Nowadays, these methods have developed into other

methods, such as the think-aloud method and the easy-to-use method (Dumas and Salzman 2006). There are four major categories of traditional assessment: usability testing; usability inspections; surveys, interviews, and focus groups; and field methods. Among these methods, interviews in usability assessment methods will be used.

Interviews are more flexible than questionnaires and allow for more detailed answers with follow-up questions (Nielsen 1994). Traditionally, interviews have been used for assessing the usability of a product to get the opinions of a small number of users (Dumas and Salzman 2006). Also, Dumas and Salzman (2006) state that an interview is the best method of getting detailed or voluminous information from a relatively small number of respondents. They recommend that five users are needed for interviews. In qualitative research, there is an In-depth Interview that is useful to get detailed information about person's thoughts and opinions from a small number of respondents (Boyce and Neale 2006). Leventhal and Barne (2007) mention that evaluation by experts is one of the major types of usability assessments. Experts clearly have more knowledge and experience than other users so that they can evaluate products or new designs based on a wide set of experiences. With this in mind, semi-structured interviews are used for this study. Semi-structured in-depth interviews are the most widely used method for qualitative research. A set of open-ended questions that are pre-determined are included, then unplanned, organic follow-up questions might emerge from the conversation between investigator and interviewees (Dicicco-Bloom and Crabtree 2006). The following are some important considerations for a qualitative research interview: Data Collection, Validity and Reliability, and Data Analysis.

3.2.1 Data Collection

Purposeful sampling was chosen for selecting participants in this research, because purposeful sampling perceives maximum the depth and richness of the data from the participants regarding the research question (Kuzel 1992). According to Dumas and Salzman (2006), the interview with key informants needs approximately five participants. Thus, a panel consisting of five Subject Matter Experts (SMEs) who are BIM professionals from the construction industry were selected. The participants are working as BIM coordinators or BIM Managers in one of the top 130 contracting companies in Texas or as officers in Texas City Halls. They must possess the following attributes among others:

- Professionalism in BIM

- Decision-making ability and influence

- Significant BIM experience


After selecting the SMEs, the interview process involved the following three phases:

1. Introduction of existing contracting evaluation tools

   The purpose of this phase was to allow the SMEs to understand the concept of contracting evaluation tools. The researcher explained the issues with current assessment systems, what needs be developed within or from those faulty systems, and why they should be developed. The SMEs not only have experience in terms of implementing BIM projects, but they also have knowledge of the requirements and processes of BIM projects. Since they have experience and

knowledge of BIM, they are able to understand that the existing evaluation tools would be difficult to use for the interview and a new type of questionnaire should be created.

2. Introduction of the suggested questionnaire

The research participants were then introduced to the questionnaire that had been developed for use during an interview. The components of the questionnaire and the method of use were explained. After introduction of the questionnaire, the participants were allowed to look at the questionnaire in detail. The questionnaire and other existing evaluation tools were compared based on the participants' knowledge and experience.

3. Interview about validation of the questionnaire

In this phase, several questions were asked to SMEs after the questionnaire introduction to figure out how much they understood. The questions consisted of predetermined open-ended questions, and they allowed for more diverse but accurate reading of the test subjects. The follow-up questions derived from their responses and also provided opportunities to clarify and prevent misunderstandings. The conversation between the SMEs and the researcher was audiotaped to gather the exact information from participants' answers. It was used to transcribe and analyze the interview dialogue later.

This interview about the questionnaire was conducted to recognize the following:

1. The feasibility and applicability of the questionnaire

2. Relevant information for the owners

3. Correlation for future questionnaires

3.2.2 Validity and Reliability

In-depth interviews with SMEs can obtain the necessary data and ideas related to the subject in question. SMEs are experts in their fields, so it is clear that they thoroughly know about the content and detailed requirements in executing BIM projects. Moreover, the selected interviewees have the executive power to make decisions for BIM projects in their companies. Through the semi-structured in-depth interview with open-ended questions, more detailed and reliable findings emerge in comparison to other research methods (Kvale 2004). This was manifested in the one-on-one interviews with the SMEs that helped drastically reduce any misunderstanding and misinterpretation by the researchers.

3.2.3 Data Analysis

The data analysis was performed after in-depth interviews with SMEs. Dicicco-Bloom and Crabtree (2006) state that "Qualitative data analysis ideally occurs concurrently with data collection so that investigators can generate an emerging understanding about research questions, which in turn informs both the sampling and the questions being asked." The transcriptions of interviews were created right after the interviews for clarity in the following interviews. In a typical data analysis process, the investigator distinguishes common themes from the transcriptions of the interviews. The

researcher should be unbiased during interpretation of the data and identification of the information (Leedy and Ormrod 2005). The theme of interest for this research is the usability and effectiveness of the questionnaire. The following four steps are the main process for analyzing the data—this is known as the data analysis spiral (Creswell 2007).

1. Organize the data

   In this step, break down large bodies of text into smaller units, or identify statements or comments related to research topic. The researcher identified statements that describe the usability of the questionnaire that assists in selecting contractors, drew general ideas about the questionnaire and suggestions for improving the questionnaire, and pulled out other relevant information. This step's objective was to cull a general understanding on the SME's perspective in light of the questionnaire.

2. Peruse the transcriptions for familiarity

   After organizing the data, the researcher made a few notes for the statements that were identified in first step. Potential notes suggest possible categories or interpretations or be added the researchers initial impressions (Leedy and Ormrod 2005).

3. Identify general themes

   In this step, interview transcripts were thoroughly examined and redundant statements were removed. Then the statements were classified into relevant, previously allocated categories. In doing so, the researcher scrutinized the statements to group them into representative categories.

4. Integrate and summarize the data

   Finally, the collected and categorized information was compressed and summarized. The researcher organized the overall ideas from interviews with SMEs regarding the suggested questionnaire. The description of the interviews with the five experts was recapped in terms of the usability of the questionnaire and pertinent feedback for the development of a better questionnaire.

## CHAPTER IV

## DEVELOPMENT OF QUESTIONNAIRE


In this chapter, the process of developing a questionnaire for owners to select competent contractors is described in detail. Several evaluation tools have already been introduced, such as BIM scorecard, BPM, BIM scoring matrix, etc.; however, those tools may be too complicated to be utilized for the interview between owner and contractor without sufficient knowledge about BIM. Thus, there is a need for a questionnaire to evaluate a contractor's BIM proficiency during interviews.

The questionnaire suggested to owners in this study addresses the following:

1. The questionnaire is for owners who have no background and knowledge in terms of using BIM in selecting high performing contractors for their BIM projects.

2. The questionnaire assists owners in asking questions that they wish to know regarding the contractors' capabilities.

3. The questionnaire includes the outlines of possible contractor responses that help owners understand the interview responses.

4. The questionnaire contains the standards with multiple-choices that help owners judge and score the contractors' level of proficiency depending on their answers.


The first step for developing the questionnaire was collecting the various guidelines. As mentioned in Chapter 3, all guidelines handle different information in

BIM because each prioritized BIM information differently. Each needed to be analyzed to identify the most important information for BIM projects. Since the guidelines explained general areas of BIM and covered an extensive amount of data, the task needed a more contained locus. Thus, in this study, the researcher used content analysis to extract the information, especially the requirements for implementing BIM projects because the requirements are the minimum knowledge needed for performing BIM projects. After extracting the requirements, they were organized by recurrence. The questionnaire was developed by the results, including the importance of the requirements regarding BIM projects. The owners could use the questionnaire to determine competent contractors for their projects by asking about important contents for implementing BIM. The following sections describe the process of developing the questionnaire in detail.

**4.1 Data Collection**

The collected guidelines were limited to their published year and publisher due to the vast amount of manuals. The researcher had collected the guidelines published by public institute, such as state, university, and public corporation in the US from January 2000 to June 2014. The total list of BIM guidelines is shown in Table 1.

**Table 1.** List of BIM Guidelines

| No. | Name of BIM guideline | Published by |
|---|---|---|
| 1 | Building Information Modeling (BIM) A Road Map for Implementation To Support MILCON Transformation and Civil Works Projects within the U.S. Army Corps of Engineers | US Army Corps of Engineers |
| 2 | General Buildings Information Handover Guide: Principles, Methodology and Case Studies | National Institute of Standards and Technology (NIST) |
| 3 | LACCD Building Information Modeling Standards | Los Angeles Community College District |
| 4 | BUILDING INFORMATION MODELING (BIM) GUIDELINES and STANDARDS for ARCHITECTS and ENGINEERS | State of Wisconsin |
| 5 | The VA BIM Guide | Department of Veterans Affairs |
| 6 | City of San Antonio BIM Standards v1.1 | CoSA Capital Improvements Management Services |
| 7 | BIM PROJECT EXECUTION PLANNING GUIDE v2.1 | CIC-The Pennsylvania state Univ. |
| 8 | Georgia Tech BIM Requirements & Guidelines for Architects, Engineers and Contractors v1.0 | Georgia Tech (GT) |
| 9 | Building Information Modeling (BIM) Guidelines v1.6 | USC |
| 10 | MIT CAD & BIM GUIDELINES | MIT CPEC Facility Information Systems |
| 11 | BIM Guidelines & Standards for Architects, Engineers, and Contractors | Indiana University (IU) |
| 12 | BIM Guidelines | New York City (DDC) |
| 13 | GSFIC BIM Guide | Georgia State Financing and Investment Commission (GSFIC) |
| 14 | Ohio - State of Ohio Building Information Modeling Protocol | State of Ohio Department of Administrative Services |
| 15 | GSA BIM Guide Series | GSA |

## 4.2 Analysis of BIM Guidelines

Content analysis was used for analyzing BIM guidelines to extract BIM project requirements from various guidelines. The guidelines were analyzed to first extract the requirements, and then each requirement was systematically classified by order of importance based on recognition. In other words, frequently mentioned requirements

would be significant in implementing the BIM project. This scrutiny will allow owners to inquire about principal content and select competent contractors.

This section first stated the overall information of each guideline and what requirements are analyzed by category counts in content analysis. The requirements that were mentioned in the guidelines are shown with tables. In the table, columns were divided by contents of manuals, and rows were divided by construction phase: general information, pre-design phase, design phase, construction phase, and post-construction. Since the table was divided by a manual's contents and construction phases, project team players could easily find related information about their scope of work.

Certain guidelines divide the construction phase in disparate ways, while others do not separate the construction phases, and utilize varying vocabulary for the same phases. Each BIM guide divided and titled each phase differently; for example, design phase was branded as "design development phase" in one guide, but as "Detailed design phase" in other BIM guides. Therefore the construction phase was set as a reference point before analyzing the guidelines in order for clarity and uniformity. For this research, five definitive phases were named for simplicity and organization. The various construction phases were amalgamated into the following five phases:

- General information: requirements for overall phase
- Pre-design phase: requirements for Pre-design, Schematic design phase, Criteria design phase, and Conceptualization phase

- Design phase: requirements for Design development phase, Preliminary design phase, Detailed design phase, Implementation documents phase, Bidding phase, and Construction document phase

- Construction phase: requirements for Construction phase

- Post-construction phase: requirements for Post-construction phase, Close-out phase, Facilities Management (FM) phase, and Operation and Maintenance (OM) phase

When the requirements were handled for the overall aspects of the project, they were categorized as general information. But if the requirements mentioned specific construction phases, they belonged to the respective construction phase. Each phase consisted of BIM requirements categories, since requirements for implementing BIM projects consist of extensive contents and numerous components and data, category counts were used to analyze the requirements. According to Weber (1990), "Counting is often useful because it may reveal aspects of the text that would not be apparent otherwise."

The requirements should be individually and manually counted and not counted by text quantity. In order to count these requirements, they must be accurately identified and extracted through content analysis. Normally, content analysis is run through a standard process of word or text count, but counting requirements necessitate classifying action items first. This requires a manual and cognizant look at the requirements as key words and text count alone do not sufficiently determine the requirements.

The requirement categories were classified and established; once the guideline requirements were counted, they were designated into appropriate categories. The categories were arranged into eleven groups: BIM Proficiency, Request for Qualification (RFQ), BIM Execution Plan (BEP) and Integrated Project Delivery (IPD) Methodology Plan, Roles and Responsibilities, Data Management, BIM Applications, Model Content & Level of Development (LOD), Clash Detection, COBie data, Assessment, and Deliverables. Fig. 3 organizes these requirement categories.

The researcher checked the table box with the number of frequency for the relevant categories of requirements. When the requirements were counted, the researcher applied the following rules:

- Read a sentence and then check the table with understanding. For example, when the sentence contains "require", "must," "should" or "shall", it was identified by requirement category, then correlated to the relevant number found in the table.

- Single count one requirement when similar ones are mentioned several times in one paragraph.

- Single count when the requirements contain similar contents. For instance, the different requirements for model content, such as style, font, color, text type, were mentioned in same paragraph, and were, therefore, counted as one.

| Categories for BIM Requirements | Various Requirements in Each Category |
|---|---|
| BIM Proficiency | Proficiency of BIM tools, Technology abilities, Knowledge, Skills, etc. |
| RFQ | Qualification, Capabilities, Experience, etc. |
| BEP & IPD Plan | BIM execution plan (BEP), Integrated project delivery (IPD) Methodology plan, BIM management plan (BMP), Request for Proposal (RFP), Implementation plan, Action plan, Master plan, Milestone, Programming, Scope, Information Delivery Manual, Project acquisition strategy, Strategic plan, Planning and Scheduling, Project goals, etc. |
| Roles and Responsibilities | Roles, Responsibilities, Team organization, Duties, Coordination meeting, etc. |
| Data Management | Communication, Collaboration, Cooperation, Change detection, Delivery of data, Updating, QA/QC of data, Editing and Copy of files, Server, File sharing, File submissions, BIM submittal, Data file, Change order, RFI, Codes, Data security, Reviews, Maintenance, Meeting minute, Data integration, File exchange, and archiving, historical data, Data organization, Linkage, Submittals in each phase, etc. |
| BIM Applications | BIM software, BIM tool, BIM Technology, Application for scheduling, cost estimation, energy analysis, System configuration, etc. |
| Model Content & LOD | All modeling, Model file, Sheet file, File format, Standards, Dataset, Group of model, Drawings, Plans, Elevations, Sections, Model components, elements and parts, IFC, File structure, Specifications, Level of Detail or Development, etc. |
| Clash Detection | Clash detection, Model interferences, Model conflicts, Visual check, Collision detection, Coordination of Models, etc. |
| COBie data | COBie data, Component worksheet, COBie spreadsheet, Description, Type, Name, etc. |
| Assessment | Assessment, Mentoring, Evaluation, Feedback, etc. |
| Deliverables | Deliverables, Closeout, Submittal of closeout documentation, Warranties, Record documents, etc. |

**Fig. 7.** The Organization Chart for Requirements Categories

4.2.1 BIM - US Army Corps of Engineers

The guideline named "A Road Map for Implementation to Support MILCON Transformation and Civil Works Projects within the U.S. Army Corps of Engineers" was published for projects under the US Army corps of engineers (US Army Corp of Engineers 2007). According to the manual, the objective of this guideline is "to outline the strategic and implementation plans for using BIM technology to improve the planning, design, and construction processes of the U.S. Army Corps of Engineers". Based on BIM user experience, the key for successful BIM implementation and viable strategic goals are addressed. Also, detailed information such as BIM implementation plans and guidance, teamwork instructions, and dataset instructions are provided in the appendices. This manual may be useful to implement BIM projects with important knowledge derived from their experience (US Army Corp of Engineers 2007). However, it does not mention any information about selecting a competent contractor. The requirements that were mentioned in the manual are shown in Fig. 8.



**Fig. 8.** Frequency-of-Mention for Requirements in U.S. Army BIM Manual

According to Fig. 8, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, BIM Applications, Roles and Responsibilities, BEP & IPD Plan, and Clash Detection. The remaining categories have zero counts: BIM Proficiency, Request for Qualification, COBie DATA, Assessment, and Deliverables.

4.2.2 General Buildings Information Handover Guide - NIST

The National Institute of Standards and Technology (NIST) introduced the guideline for general building information handover including principles, methodology and case studies (NIST 2007). According to this manual, "The purpose of this guide is to assist users and developers of building information systems in the general buildings industry in making good use of advanced technology and avoiding the pitfalls, particularly those encountered in information handovers between parties". The significant aspect of BIM in this manual is to assist the BIM users in enhancing the data interoperability and improving management of the model with advanced technology. Also, each project process is laced with specific information for implementing BIM projects for thorough comprehension. The guideline provides six case studies that used advanced technology and electronic handover to quantify shortening construction schedule and saving costs. These cases help readers to better understand how to use technologies and assess their benefits. Some ideas are addressed from the owner's perspective, for example, the owner's strategies for information handover. Overall contents in the manual support the organization and owner with enhancing the

interoperability, providing information strategies, and suggesting the best implementation of the project information handover (NIST 2007). This guide does not contain any information that would help owners to select competent contractors.

This guideline mainly focuses on explaining the general information, key concepts, technical terminology, and industry background of BIM. Since the manual rarely mentions the requirements for performing BIM projects, the manual was not analyzed.

4.2.3 LACCD BIM Standards

Los Angeles Community College District (LACCD) (2011) published the guideline titled "LACCD Building Information Modeling Standards". This manual had been developed to enable the use of BIM technology for improving system coordination, utilization of 4D and 5D technology, and sustainable construction. Also, the LACCD had tried to establish requirement procedures in the various stages of their projects in terms of using BIM. This guideline consists of four main chapters: Introduction, BIM project requirements, BIM process and implementation, and Quality assurance and Implementation. In the introductory chapter, the overview and main objectives of the manual are stated. The BIM project requirements chapter contains the mandatory BIM project requirements for their projects and the management of project files. BIM workflow process, team collaboration procedure, BIM execution plan, and roles and responsibilities are mentioned in chapter 3. Lastly, the process of quality assurance and validation is included in chapter 4 (LACCD 2011). This manual thoroughly focuses on

the requirements for their projects. However, it was challenging to find the information that could be helpful to evaluate a contractor's level of proficiency in BIM. The mentioned requirements in the manual are shown in Fig. 9.



**Fig. 9.** Frequency-of-Mention for Requirements in LACCD BIM Manual

According to Fig. 9, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, BIM Applications, Roles and Responsibilities, BIM Proficiency, BEP & IPD Plan and Clash Detection, Request for Qualification, and Deliverables. The remaining categories have zero counts: COBie DATA and Assessment.

4.2.4 BIM Guidelines and Standards for AEs - State of Wisconsin

This guideline classified the requirements with the perspective of Architects and Engineers (A/E) (State of Wisconsin 2009). It states the requirements for implementing

BIM projects: roles and responsibilities of A/E, BIM authoring software, model quality and submittal, and model elements. This manual briefly states requirements that A/E should perform for a project to be considered utilizing BIM only, but does not mention the overview or explanation of BIM (State of Wisconsin 2009). It would be valuable for the readers who need the list of requirements for implementing BIM projects. The requirements that were mentioned in the manual are shown in Fig. 10.



**Fig. 10.** Frequency-of-mention for requirements in State of Wisconsin BIM Manual

According to Fig. 10, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, BIM Applications, Roles and Responsibilities and Data Management, Deliverables, and Request for Qualification and Clash Detection and Assessment. The remaining categories have zero counts: BIM Proficiency, BEP & IPD Plan, and COBie DATA.

4.2.5 The VA BIM Guide

Department of Veterans Affairs (VA) (2010) published the guide named "The VA BIM Guide". The purpose of the guide is "to deliver higher value and maximize lifecycle building performance to support VA's mission to deliver excellent medical services". The VA's office of Construction and Facilities Management (CFM) had tried to enhance technology and change a process to deliver high quality and cost effective facilities by digitization and standardization of building data. This guideline introduces the process of implementing a project with BIM and the appropriate requirements. It describes the specifications about a BIM Management Plan (BMP) and the roles and responsibilities of BIM managers. VA requirements, format, structure, usages of models, and the way to share the models for communicating collaboratively were also stated in the VA guideline (Department of VA 2010). However, it was difficult to find specific information for owners to select right contractors in this guideline. The requirements that were mentioned in the manual are shown in Fig. 11.
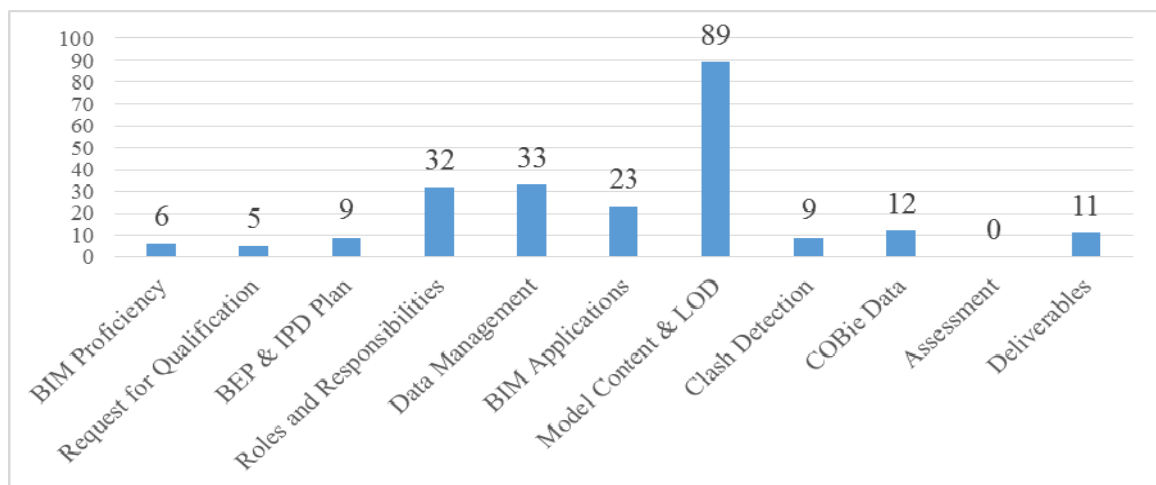


**Fig. 11.** Frequency-of-Mention for Requirements in the VA BIM Manual

According to Fig. 11, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, Roles and Responsibilities, BIM Applications, COBie DATA, Deliverables, BEP & IPD Plan and Clash Detection, BIM Proficiency, and Request for Qualification. The remaining categories have zero counts: Assessment.

4.2.6 City of San Antonio BIM Standards

According to the guideline, "the goal of CoSA's implementation of BIM is to deliver higher value projects and maximize lifecycle building maintenance and performance" (City of San Antonio 2011). CoSA had tried to standardize and digitize the building data to better implement BIM project. This guideline consists of five main articles: 1.Introduction, 2. BIM project requirements, standards, performance criteria, information integration, 3.Builiding information model protocol, 4.Independent information manager responsibilities, and 5.General contractor's BIM responsibilities during construction (City of San Antonio 2011). This manual did not contain any information for qualifying contractors' level of proficiency in BIM. The requirements that were mentioned in the manual are shown in Fig. 12.
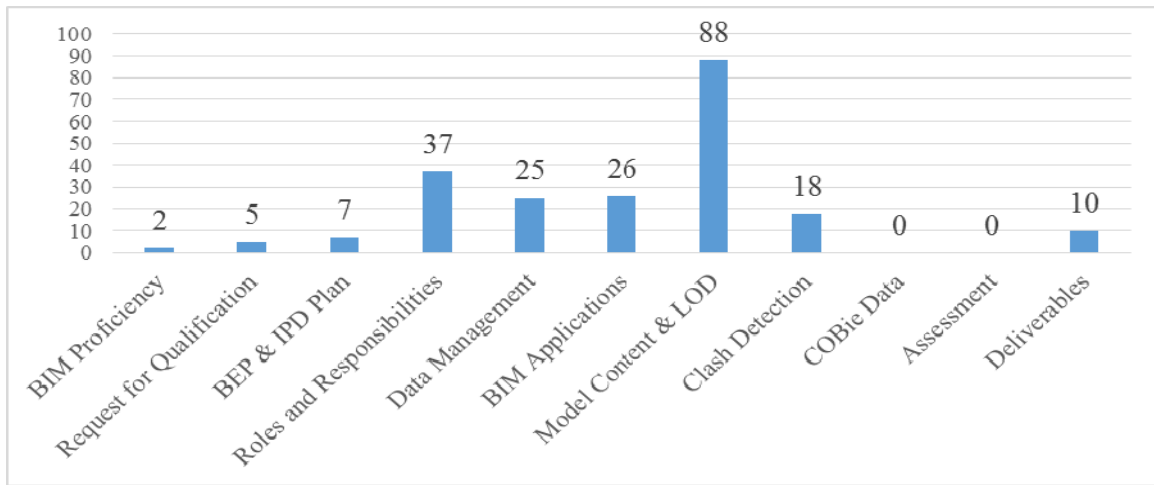
**Fig. 12.** Frequency-of-Mention for Requirements in CoSA BIM Manual

According to Fig. 12, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Roles and Responsibilities, BIM Applications, Data Management, Clash Detection, Deliverables, BEP & IPD Plan, Request for Qualification, and BIM Proficiency. The remaining categories have zero counts: COBie DATA and Assessment.

4.2.7 BIM Project Execution Planning Guide - CIC

According to the BIM project execution planning guide from the Computer Integrated Construction (CIC) research program (2012) at Pennsylvania State University, a project team must perform detailed and have appropriate responsibilities with a well-documented BIM project execution plan which is clearly defined in terms of implementing a BIM project. This guide covers not only a procedure for creating a BIM project execution plan but also a way to perform a BIM project successfully. Eight

chapters are contained in this guideline: (1) Overview of the project execution planning procedure for BIM, (2) Identifying BIM goals and uses for a project, (3) Designing the BIM project execution process, (4) Developing information exchanges, (5) Defining supporting infrastructure for BIM implementation, (6) Implementing the BIM project execution planning procedure, (7) BIM project execution planning for organizations, and (8) Conclusion and recommendation. The first chapter contains the information that general idea of BIM, the importance of BIM project Execution plan (BEP), BEP procedure, and the information that should be included in BEP. The second chapter handles how to set up BIM goals and select BIM uses for each phase. The third chapter explains the BEP process for designing such as mapping, detailed BIM use map, and usage of symbols for process map representation. In the fourth chapter, the information regarding exchanging the data during a project is mentioned. Chapter five covers the overview of BEP for infrastructure. It detailed the requirements for a project team and items that should be included in BEP. Chapter six explains how to develop the BEP and what should be done in the collaboration meetings for finalizing the BEP. Chapter seven stated the organizations for developing BEP effectively. The requirements for organization such as mission statement and goals, definition of BIM uses, process map, establish of standards for information exchanges, etc. Lastly, a conclusion and some recommendations for BIM project execution planning procedures are stated in chapter eight (CIC Research Group 2012). The requirements that were mentioned in the manual are shown in Fig. 13.
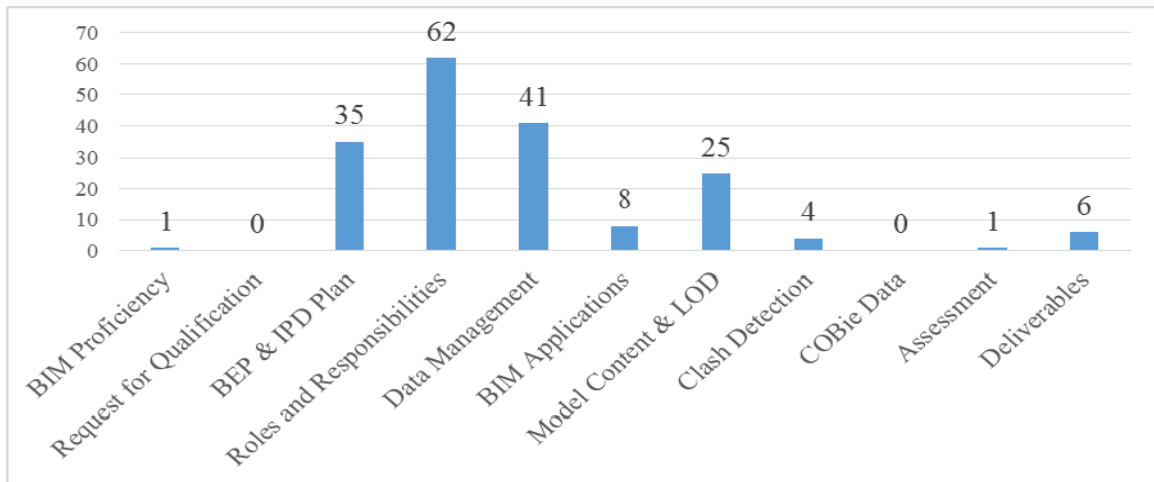
**Fig. 13.** Frequency-of-Mention for Requirements in the CIC BIM Manual

According to Fig. 13, the following is the descending order of frequency-of-mention requirements from highest to lowest: Roles and Responsibilities, Data Management, BEP & IPD Plan, Model Content & LOD, BIM Applications, Deliverables, Clash Detection, and BIM Proficiency and Assessment. The remaining categories have zero counts: Request for Qualification and COBie DATA.

4.2.8 Georgia Tech BIM Requirements & Guidelines for AECs

Georgia Tech (GT) (2011) published this guideline for encouraging team coordination among architects, engineers and contractors and for providing BIM requirements for GT projects. The information of the requirements and guidance are provided from pre-design phase through close-out phase. This manual mainly focuses on the requirements of submittals, modeling contents and applications, data analysis, and deliverables in each phase. The requirements for GT projects are clearly mentioned in

the manual (Georgia Tech 2011). However, the information that assists owners to select the right contractors for their projects is not mentioned. The requirements that were mentioned in the manual are shown in Fig. 14.
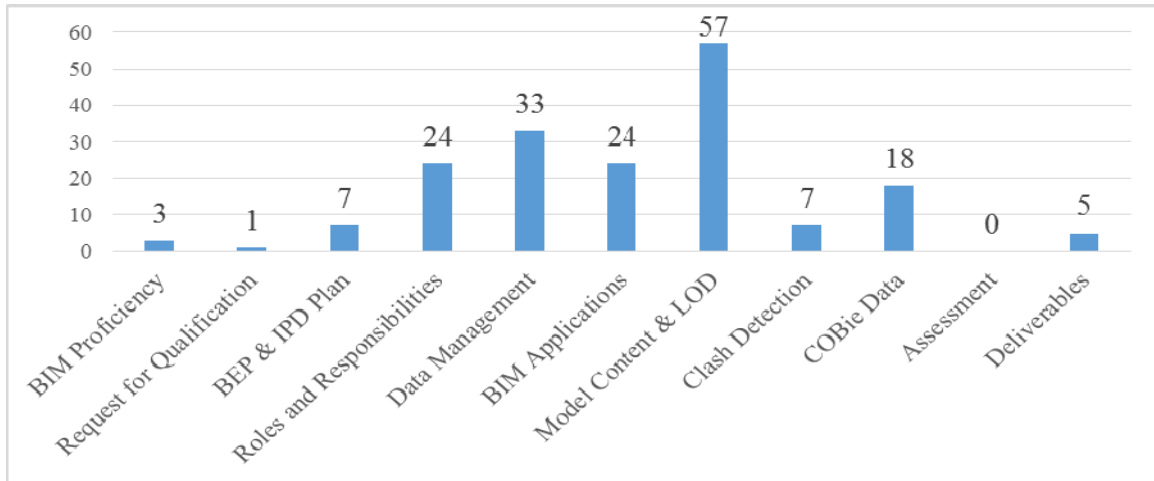


**Fig. 14.** Frequency-of-Mention for Requirements in GT BIM Manual

According to Fig. 14, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, Roles and Responsibilities and BIM Applications, COBie DATA, BEP & IPD Plan and Clash Detection, Deliverables, BIM Proficiency, and Request for Qualification. The remaining categories have zero counts: Assessment.

4.2.9 BIM Guidelines - USC

This manual provides guidance for USC projects through the definition of work scope, deliverables for using BIM, and the requirements for USC's construction (USC

2012). They provide the knowledge of using BIM to improve the coordination of design and construction procedures and reduce potential risks. The requirements of using BIM such as model components, level of detail, and COBie data, are mentioned concretely through design to construction phase. In the appendices, more detailed information for various models, format, worksheets, requirements, nomenclature, and specifications are stated for helping contractors implement on USC's projects. Also, they attached the template of BIM execution plan for their project (USC 2012). This guideline contains the essential information for executing USC's projects, but it does not include any information of selecting right contractors. The requirements that were mentioned in the manual are shown in Fig. 15.
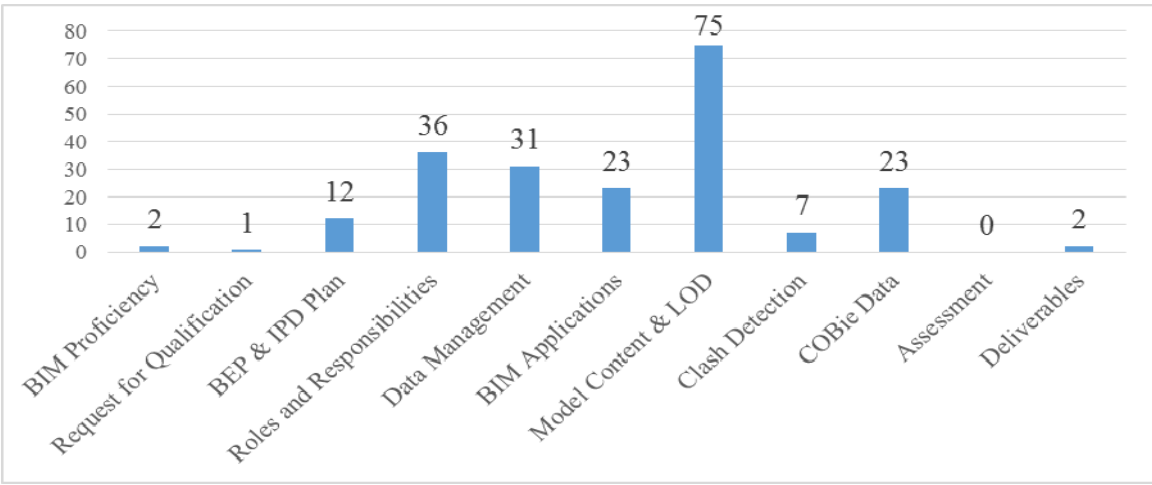


**Fig. 15.** Frequency-of-Mention for Requirements in USC BIM Manual

According to Fig. 15, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Roles and

Responsibilities, Data Management, BIM Applications and COBie DATA, BEP & IPD Plan, Clash Detection, BIM Proficiency and Deliverables, and Request for Qualification. The remaining categories have zero counts: Assessment.

4.2.10 MIT CAD & BIM Guidelines

This manual is for the MIT Department of Facilities CAD and BIM environment to enhance model efficiency and electronic drawing improvement (MIT 2012). It covers the standards and requirements that should be followed in order to submit a document to MIT. Details for drawing's requirements, such as file name and format, layers, styles, discipline codes, and attributes, are also explained (MIT 2012). The requirements that were mentioned in the manual are shown in Fig. 16.
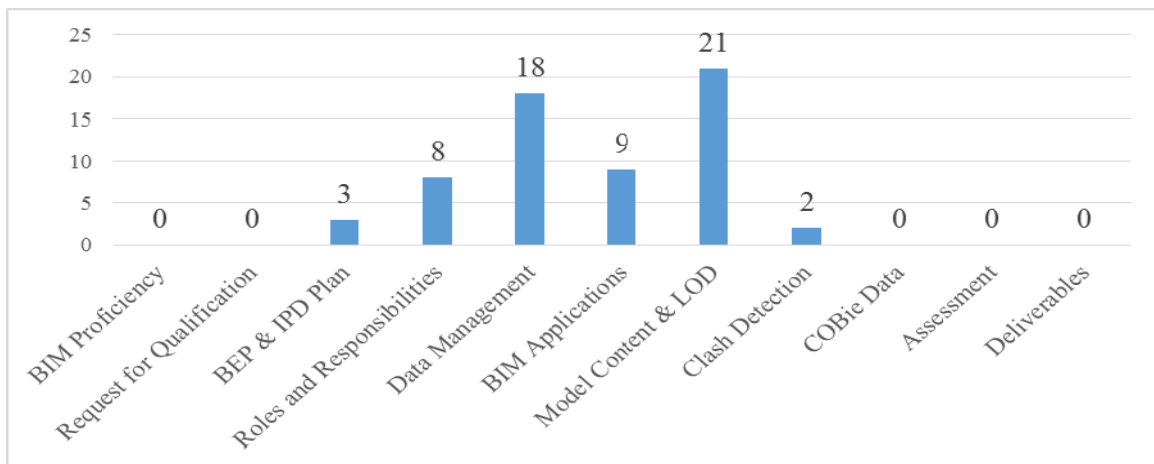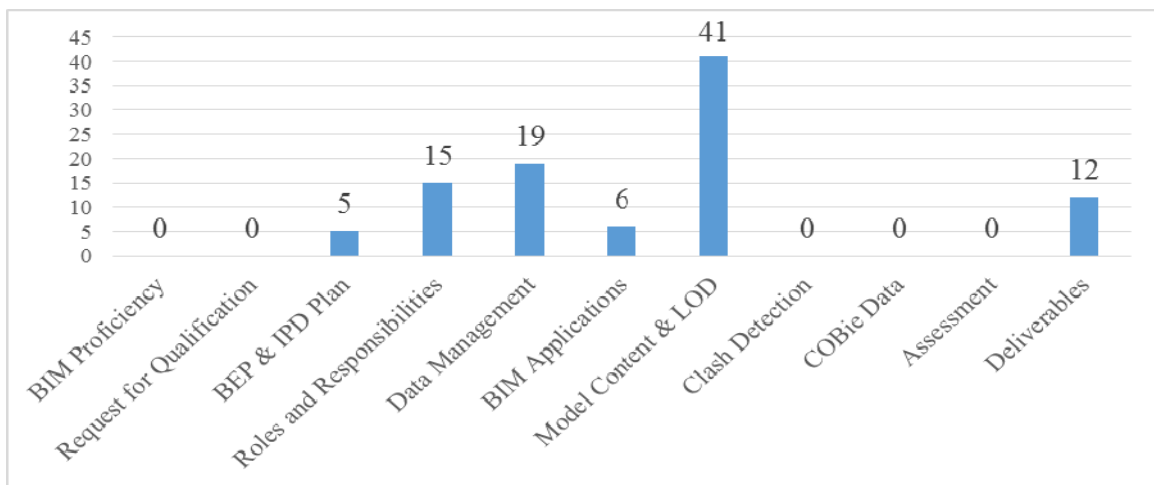


**Fig. 16.** Frequency-of-Mention for Requirements in MIT BIM Manual.

According to Fig. 16, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, Roles and Responsibilities, Deliverables, BIM Applications, and BEP & IPD Plan. The remaining categories have zero counts: BIM Proficiency, Request for Qualification, Clash Detection, COBie DATA, and Assessment.

4.2.11 BIM Guidelines & Standards for AECs - IU

This manual addresses the general requirements, process of the project, deliverables, and objectives and applications for performing an Indiana University (IU) project (Indiana University 2012a). This guideline mentions the requirements that the contractor who works with IU should follow such as BIM applications for design and cost analysis, energy modeling, BIM model, deliverables, and BIM execution plan. The objectives and application section are divided into construction phases so that the readers understand what the action items or requirements are needed in each phase. Since the contents in the guideline are mentioned through IU's perspective as an owner, this manual cannot be applied by owners for their BIM projects (Indiana University 2012a). The requirements that were mentioned in the manual are shown in Fig. 17.
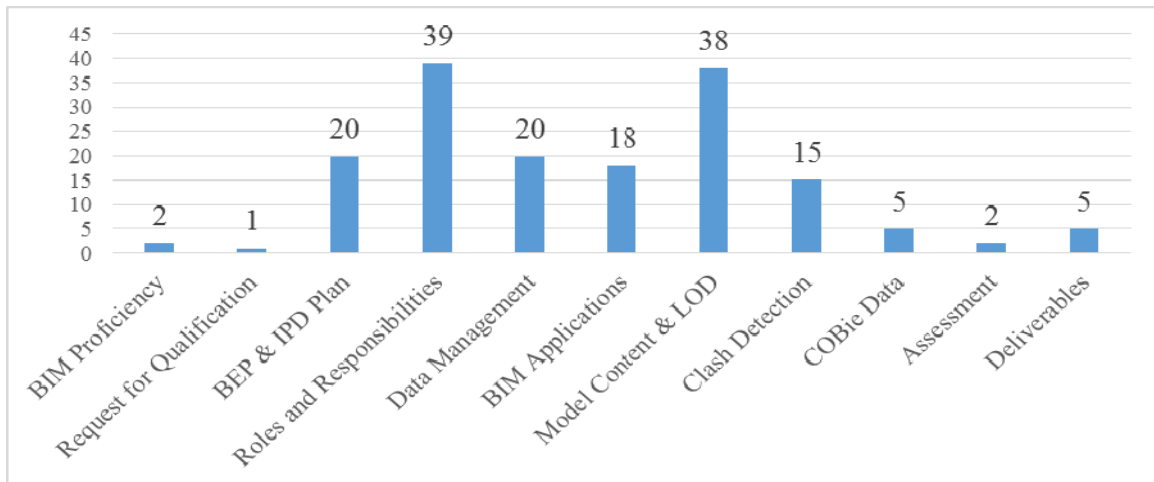
**Fig. 17.** Frequency-of-Mention for Requirements in IU BIM Manual

According to Fig. 17, the following is the descending order of frequency-of-mention requirements from highest to lowest: Roles and Responsibilities, Model Content & LOD, BEP & IPD Plan and Data Management, BIM Applications, Clash Detection, COBie DATA and Deliverables, BIM Proficiency and Assessment, and Request for Qualification.

### 4.2.12 BIM Guidelines - NYC DDC

Department of Design & Construction in New York City (NYC DDC) published the BIM Guidelines. The purpose of this manual is to establish the uniformity of standards for all NYC public buildings projects in terms of using BIM (NYC DDC 2012). The general information and the requirements for performing BIM projects are covered for enhancing their quality of projects. BIM content in the manual is explained with the general knowledge and value of each section. Since the submission and

deliverables part is divided by construction phase, the requirements and instructions for project implementation are addressed depending on each phase. This manual is for the contractor who works with NYC DDC to help them provide the framework for the project. (NYC DCC 2012). However, it does not cover the information about how to select competent contractors for BIM projects. The requirements that were mentioned in the manual are shown in Fig. 18.
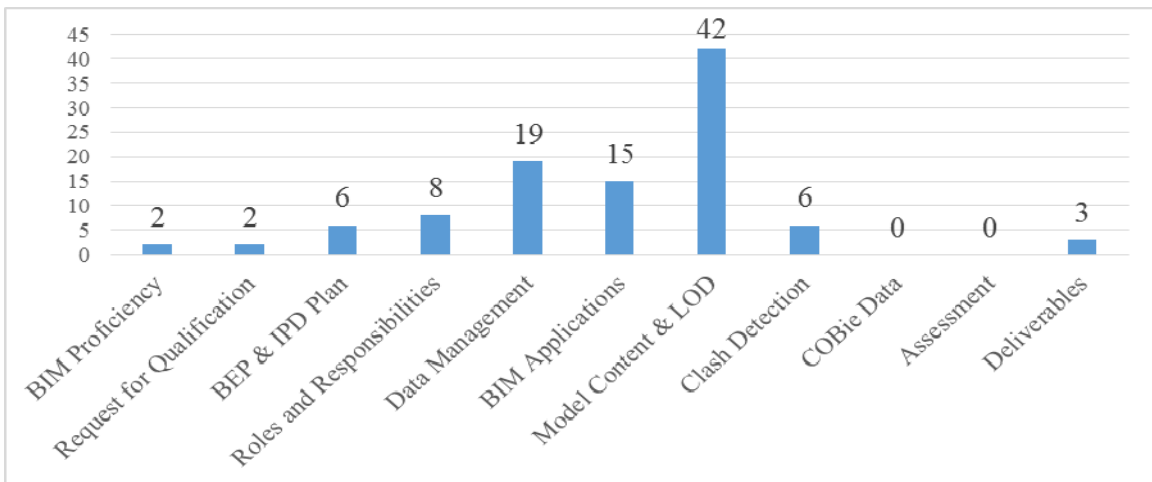


**Fig. 18.** Frequency-of-Mention for Requirements in NYC DDC BIM Manual

According to Fig. 18, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, BIM Applications, Roles and Responsibilities, BEP & IPD Plan and Clash Detection, Deliverables, and BIM Proficiency and Request for Qualification. The remaining categories have zero counts: COBie DATA and Assessment.

4.2.13 GSFIC BIM Guide Series 01

Georgia State Financing and Investment Commission (GSFIC) (2013) published this guideline to assist architects and engineers who are in their BIM-based projects. The requirements of this guide should be strictly followed and applied for their projects. GSFIC covers only design requirements for implementing BIM. This manual consists of four major sections: BIM for building construction review, Building life safety components, Building elements, and BIM analysis rules. All of those sections contain specific requirements for BIM projects and what should be reviewed by the GSFIC design review group (GSFIC 2013). The requirements that were mentioned in the manual are shown in Fig. 19.
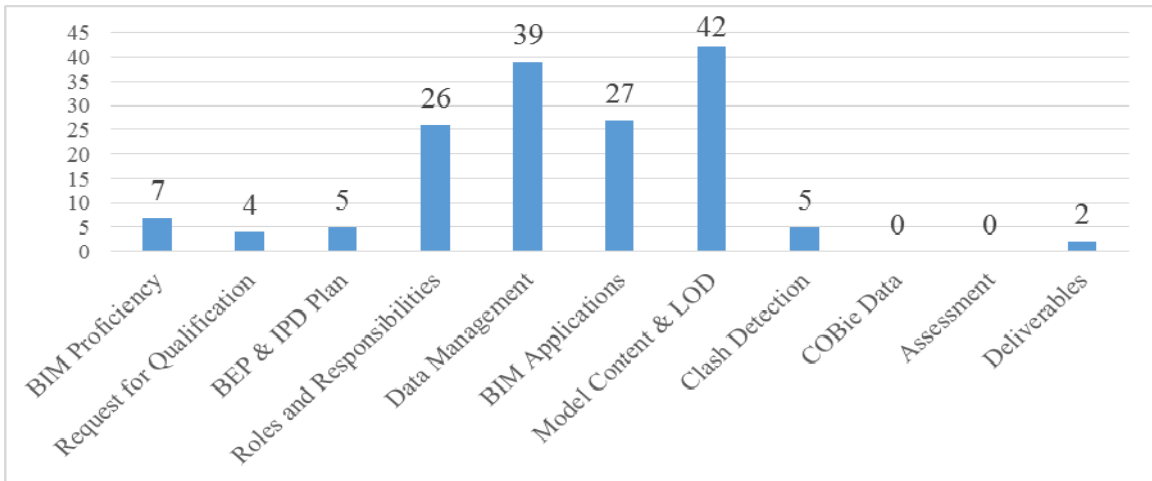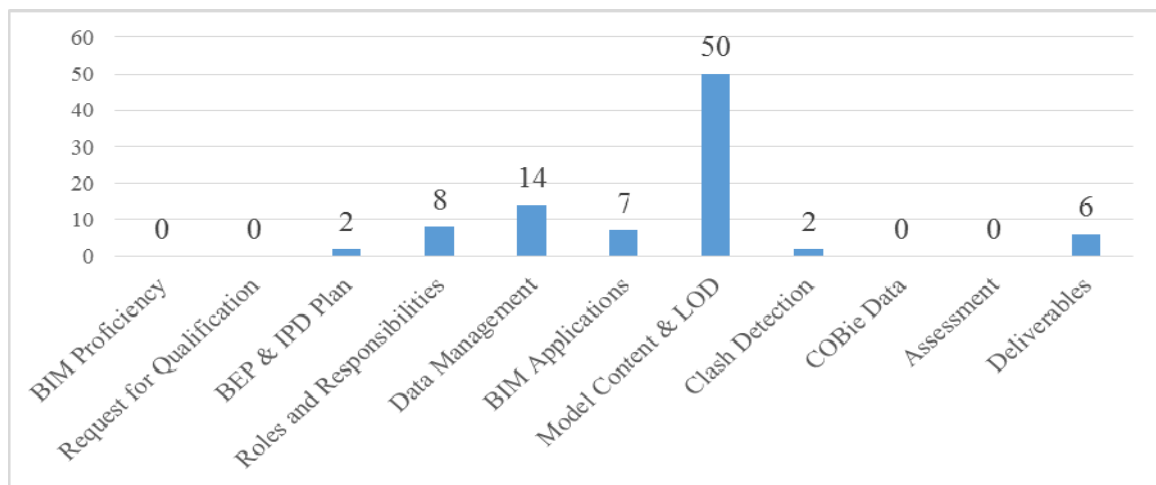


**Fig.19.** Frequency-of-Mention for Requirements in GSFIC BIM Manual

According to Fig. 19, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data

Management, Roles and Responsibilities, BIM Applications, Deliverables, and BEP & IPD Plan and Clash Detection. The remaining categories have zero counts: BIM Proficiency, Request for Qualification, COBie DATA, and Assessment.

4.2.14 State of Ohio BIM Protocol

According to this guideline, "The state of Ohio BIM Protocol does not establish a standard that requires specific software or hardware to be used by the state's venders, but provides general guidance that ensures that building owners know what they should include in their requests for qualifications, agreements, bidding requirements, contracts, and other documents affected by this new medium and process" (Ohio DAS 2013). Four sections are stated in this guideline: Statement of Purpose, The Protocol, Implementation, and Appendix. This BIM protocol covers the necessity of the protocol, the state of Ohio DAS's findings in terms of using BIM, general awareness of the concept of BIM in BIM practitioners, and goals for developing the guideline. Moreover, it provides owners a foundation of BIM use on projects, BIM standard for implementation, and the requirements for project deliverables. Some information for owners such as the model requirements for post construction, ownership, etc. are explained (Ohio DAS 2013). However, the way to select a contractor who has a high level of BIM proficiency is not addressed. The requirements that were mentioned in the manual are shown in Fig. 20.
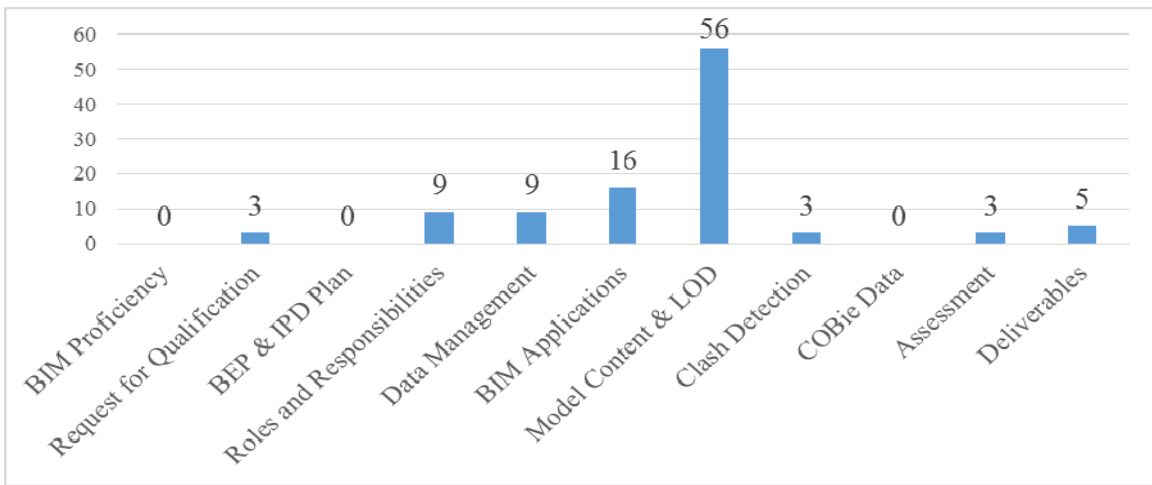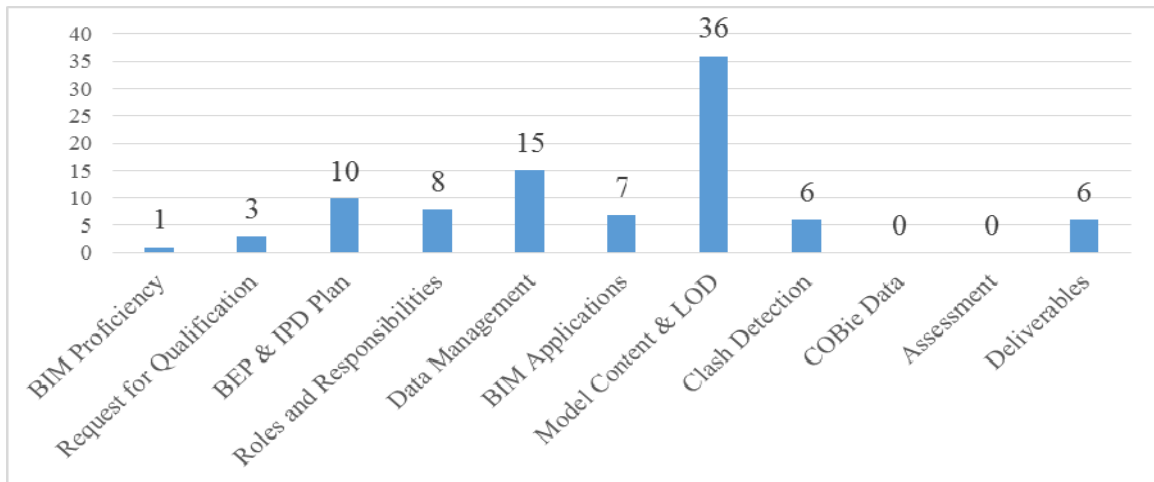
**Fig. 20.** Frequency-of-Mention for Requirements in State of Ohio BIM Manual

According to Fig. 20, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Data Management, BEP & IPD Plan, Roles and Responsibilities, BIM Applications, Clash Detection and Deliverables, Request for Qualification, and BIM Proficiency. The remaining categories have zero counts: COBie DATA and Assessment.

4.2.15 GSA BIM Guide Series

The US General Service Administration (GSA) (2007a) established the National 3D-4D BIM program in 2003, and they have published the GSA BIM guide series from 2007. In sharing the knowledge regarding BIM technology and satisfying customers with the enhanced power of BIM, they have continued to effectively develop ways to execute BIM projects. According to GSA, their mission is to "help federal agencies

better serve the public by offering, at best value, superior workplaces, expert solutions, acquisition services and management polices" (GSA 2007a). The list of BIM guide series is as follows: (01) BIM Overview, (02) Spatial Program Validation, (03) 3D Laser Scanning, (04) 4-D Phasing, (05) Energy Performance and Operations, (06) Circulation and Security Validation, (07) Building Elements, and (08) Facility Management. Since the 01 to 05 guide series have been published but series 06 to 08 are still being formulated, only series 01 to 05 were analyzed in this research.

The GSA BIM guide series 01 (GSA 2007a) introduces GSA's national 3-D to 4-D BIM program and the basics of 3D to 4D BIM projects. First, the section explains the definition, necessity, and benefits of 3D to 4D BIM and project opportunities, in addition to the implementation of 3-D and 4-D. The second section describes the BIM technology supplemented by pilot project case studies (GSA 2007a).

BIM guide series 02 (GSA 2007b) covers the spatial program using BIM, covering requirements, software, validation process, modeling elements, and rules of analysis. Specifically, the rules and requirements for modeling elements for BIM analysis are detailed in this guide (GSA 2007b).

3D imaging information is introduced in the BIM guide series 03. This section explains the definition of 3-D imaging and the process of utilizing 3-D imaging.

Evaluation for the 3-D data, which was created by 3D image scanning, is also provided in this manual. Finally, 3-D imaging project management for the GSA is detailed (GSA 2009a).

The guide series 04 (GSA 2009b) covers 4-D phasing that visualization through the use of 3-D models and schedule. In the guide, the basics, definition, necessity, and scope of 4-D phasing are covered. In addition, the guidance for developing 4-D model, including efficient ways to create 4-D models and processes linking 3-D model and schedule, is detailed in this manual (GSA 2009b).

Lastly, the BIM guide series 05 (GSA 2012) contains the information about energy performance. Since energy modeling can predict energy use and energy cost results, it would be beneficial for the project team to understand the analysis of the life-cycle cost. This manual covers the energy modeling for design, construction, and operations, including BIM data exchange, building elements and space, and software for checking the model. Furthermore, the manual provides case studies about saving energy cost using energy modeling (GSA 2012).

The requirements that were mentioned in the manual are shown in Fig. 21.
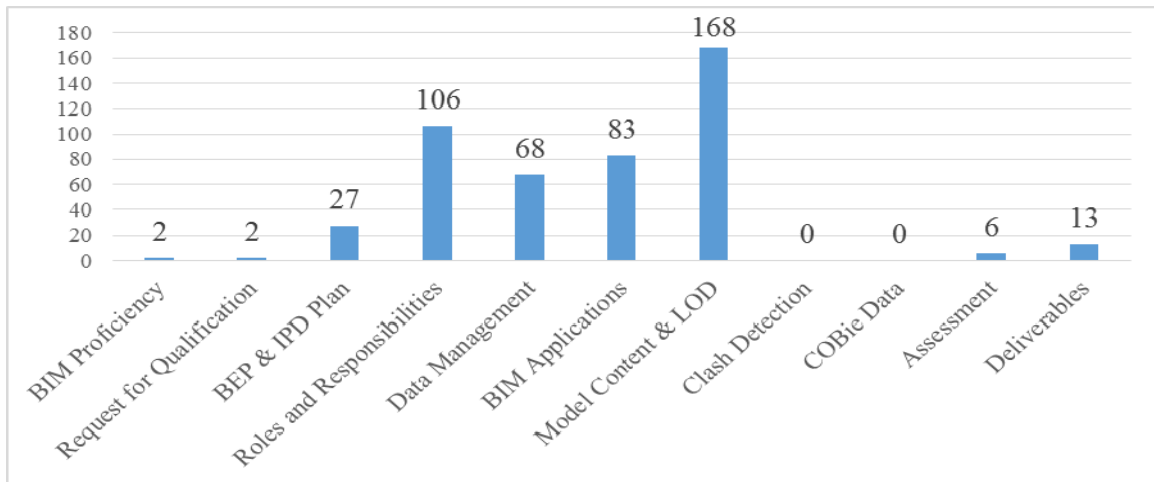
**Fig. 21.** Frequency-of-Mention for Requirements in GSA BIM Manual

According to Fig. 21, the following is the descending order of frequency-of-mention requirements from highest to lowest: Model Content & LOD, Roles and Responsibilities, BIM Applications, Data Management, BEP & IPD Plan, Deliverables, Assessment, and BIM Proficiency and Request for Qualification. The remaining categories have zero counts: Clash Detection and COBie DATA.

**4.3 Significance of BIM Requirements**

The requirements for BIM project were analyzed using category counts in content analysis methods. According to the analysis of requirements, the frequencies of categories for requirements in each BIM Guideline are shown in Table 2. The data table displays the mentioned frequency of any requirement within their respective guidelines.

**Table 2.** The Requirement Frequency-of-Mention in Each BIM Guideline.

| Publishers of BIM Guidelines / All BIM Guidelines | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | BIM Proficiency | Request for Qualification | BEP & IPD | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| 1. US Army Corps of Engineers |  |  | 3 | 6 | 8 | 3 | 6 |  |  |  |  |  |  |  |  |  |  | 2 | 10 | 6 | 15 | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Los Angeles Community College District (LACCD) | 7 | 4 | 5 |  | 7 | 6 | 17 |  |  |  | 4 | 4 | 4 | 4 |  |  |  | 12 | 14 | 11 | 9 | 4 |  |  | 10 | 13 | 6 | 11 | 1 |  |  | 2 | 1 |  | 1 |  |  |
| 4. State of Wisconsin |  | 3 |  |  | 5 | 6 | 12 |  |  | 3 | 5 | 1 | 7 | 8 |  |  |  | 4 | 1 | 2 | 33 | 3 |  |  |  | 1 |  | 1 |  |  |  | 5 | 1 | 1 | 2 |  |  |
| 5. Department of Veterans Affairs (VA) | 6 | 5 | 9 |  | 14 | 10 | 39 | 1 |  |  | 10 | 5 | 6 | 14 |  |  | 3 | 12 | 6 | 5 | 16 | 5 | 2 |  | 10 | 5 | 1 | 11 | 4 | 2 |  | 11 | 3 | 1 | 9 | 4 |  |
| 6. City of San Antonio (CoSA) CIMS | 2 | 5 | 7 |  | 13 | 12 | 26 |  |  |  | 9 | 2 | 4 | 13 |  |  |  | 15 | 2 | 5 | 26 | 14 |  |  | 13 | 4 | 4 | 14 | 4 |  |  | 10 | 4 | 1 | 9 |  |  |
| 7. CIC-The Pennsylvania state Univ. | 1 |  | 35 | 59 | 37 | 8 | 22 | 1 |  | 1 | 1 | 1 |  | 1 | 1 |  |  | 1 | 1 |  | 1 | 1 |  |  | 1 | 1 |  | 1 | 1 |  |  | 6 | 1 |  |  |  |  |
| 8. Georgia Tech (GT) | 3 | 1 | 7 |  | 7 | 1 | 11 |  | 2 |  | 9 | 5 | 11 | 19 |  |  | 4 | 6 | 8 | 6 | 15 | 3 | 3 |  | 9 | 11 | 4 | 9 | 4 | 5 |  | 5 | 2 | 2 | 3 | 4 |  |
| 9. USC | 2 | 1 | 12 |  | 6 | 2 | 25 |  | 3 |  | 10 | 6 | 7 | 16 |  |  | 6 | 14 | 10 | 6 | 20 | 4 | 7 |  | 12 | 8 | 6 | 7 | 3 | 3 |  | 2 | 1 | 2 | 7 | 4 |  |
| 10. MIT CPEC Facility Information Systems |  |  | 5 |  | 10 | 6 | 30 |  |  |  | 4 | 2 |  |  |  |  |  | 8 | 4 |  |  |  |  |  | 3 | 1 |  |  |  |  |  | 12 | 2 |  | 11 |  |  |
| 11. Indiana University (IU) | 2 | 1 | 20 | 1 | 2 | 5 |  |  |  | 2 | 15 | 6 | 7 | 8 | 6 |  |  | 15 | 8 | 5 | 17 | 7 | 1 |  | 9 | 3 | 4 | 6 | 2 | 2 |  | 5 | 2 |  | 2 | 2 |  |
| 12. New York City (DDC) | 2 | 2 | 6 | 2 | 6 | 5 | 14 |  |  |  | 3 | 4 | 3 | 9 |  |  |  | 2 | 1 |  | 4 | 2 |  |  | 3 | 5 | 5 | 8 | 4 |  |  | 3 | 3 | 2 | 7 |  |  |
| 13. Georgia State Financing and Investment Commission (GSFIC) |  |  | 2 |  | 4 | 3 | 20 |  |  |  | 2 | 2 | 1 | 10 |  |  |  | 5 | 4 | 3 | 15 | 2 |  |  | 1 | 1 |  | 1 |  |  |  | 6 | 3 |  | 4 |  |  |
| 14. State of Ohio Department of Administrative Services | 1 | 3 | 10 |  | 3 | 2 | 6 |  |  |  | 3 | 3 | 2 | 10 |  |  |  | 3 | 4 | 2 | 11 | 4 |  |  | 2 |  | 1 | 4 | 2 |  |  | 6 | 5 |  | 5 |  |  |
| 15. GSA | 2 | 2 | 27 | 90 | 51 | 70 | 136 | 0 | 0 | 4 | 5 | 4 | 1 | 6 | 0 | 0 | 0 | 11 | 9 | 11 | 20 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 13 | 3 | 1 | 5 | 0 | 2 |
| Total | 28 | 27 | 148 | 157 | 172 | 136 | 369 | 1 | 6 | 10 | 80 | 45 | 53 | 118 | 7 | 13 | 0 | 110 | 82 | 62 | 202 | 51 | 13 | 0 | 73 | 54 | 31 | 74 | 25 | 12 | 0 | 86 | 31 | 10 | 65 | 14 | 2 |

The tables for all guidelines with details of requirements are provided in Appendix A.

This information is potentially crucial in informing the BIM project requirements, as repetition in the text reveals emphases on certain requirements. Fig. 22 shows the requirement categories in descending order of frequency tallies.



**Fig. 22.** Total Frequency-of-Mention for Requirements in All BIM Guidelines

According to the outcome of the analysis, the requirements for Model Content and LOD were mentioned the most, followed by Roles and Responsibilities, Data Management, and BIM Applications. In BIM guidelines, Model Content and LOD regularly presented the requirements for 3-dimensional modeling, models that are needed for BIM projects, proper elements in 3-dimensional modeling, and directions on creating the model. "Roles and Responsibilities" is the second most recurring category. This category was generally counted by the roles, responsibilities, and duties of stake holders, such as the BIM manager, architect, engineer, technician, design team, and construction team when implementing BIM project. "Data Management" reiterated the

requirements for sharing, updating, saving, and transforming data, in addition to explaining document management and coordination data between team players. The requirements about various BIM authoring software or tools to successfully perform BIM projects, as well as the requirements for uses of data analysis in BIM applications were typically counted in the "BIM applications" category.

**Table 3**. Descending Order of Requirement Categories' Frequency-of-Mention

| No | Categories | Description | Frequency |
|----|-----------|-------------|-----------|
| 1 | Model Content and LOD | This category refers to the requirements of modeling, model quality, energy modeling, model criteria, model elements, etc. | 828 |
| 2 | Roles and Responsibilities | This category refers to the coordination meeting, roles and responsibilities of architect, contractor, engineer, etc. | 420 |
| 3 | Data Management | This category refers to the team collaboration, management of information, updating and revising files, protection of data, etc. | 384 |
| 4 | BIM Applications | This category refers to the BIM authoring software, BIM applications for cost estimation and analysis, program and space validation, planning, surveying, etc. | 292 |
| 5 | BEP & IPD Plan | This category refers to the requirements of BEP, IPD, Design plan, project strategy, etc. | 148 |
| 6 | Deliverables | This category refers to the deliverables, closeout, operations & maintenance manuals, contractor record documents, etc. | 86 |
| 7 | Clash Detection | This category refers to the collision report, collision detection, applications for clash detection, etc. | 84 |
| 8 | COBie | This category refers to the COBie component, COBie worksheets, COBie data, etc. | 58 |
| 9 | BIM Proficiency | This category refers to the idea and important factors of BIM proficiency, experience of BIM project, skills, etc. | 28 |
| 10 | RFQ | This category refers to the requirements of RFQ, importance of contractors' qualifications, etc. | 27 |
| 11 | Assessment | This category refers to the assessment for team performance. | 12 |

The analysis identified essential BIM requirements that some owners and contractors who are not good at BIM may need to pay attention to. The outcome of the analysis (see Table 3) revealed that "Model Content and LOD", "Roles and Responsibilities", "Data Management", and "BIM Applications" are most frequently mentioned in any BIM manual, which may indicate that the ability of creating a 3D model for the proper level of development is critically important. It may also indicated that good understanding of roles and responsibilities among project team is required for successful BIM project. Since that, owners may want to hire contractors who have clear idea about their roles and responsibilities of their team members in terms of using BIM for advancing their decision making process. What has been discovered from this investigation is directly related to major competencies that one needs to demonstrate to best utilize BIM for construction.

The categories for "BEP," "Clash Detection," "Deliverables," "COBie," "BIM Proficiency," and "RFQ" were mentioned least in the guidelines, though they still remain significant in their disparate roles. The research outcome reveals how many times each requirement was covered among various BIM guidelines, and does not assess the individual requirement's value or credibility. Therefore, the suggested questionnaire for owners in selecting competent contractors was developed with all requirements that were extracted in this section.

**4.4 Suggestion of Questionnaire for Evaluating Contractors' BIM Proficiency**

The suggested questionnaire (see Appendix B) was developed based on the exclusive portion of the guidelines. The questionnaire was divided by construction phase because project team players in the construction industry are very diverse. The team players' roles are different and depend on their positions. It means the information required by each player varies as per his or her needs. When the questionnaire is divided by construction phase, project team players can find relevant information about their scope of work easily.

The questionnaire consists of five chapters: General Information, Pre-design Phase, Design Phase, Construction Phase, and Post-construction Phase. Each of the chapters includes some categories among the following eleven categories based on the analysis in section 4.3.

- BIM Proficiency: to figure out the contractors' understanding of BIM proficiency

- Roles and Responsibilities: to figure out the BIM team's organization and strength in regard to BIM uses

- Deliverables: to figure out the contractors' knowledge of deliverables, such as closeout and manuals

- Data Management: to assess the contractors' management of data in terms of using BIM

- Request for Qualification (RFQ): to figure out the contractors' qualifications in terms of using BIM

- BIM Execution Plan (BEP) & Integrated Project Delivery (IPD) Methodology Plan: to evaluate the contractors' knowledge of execution plan and integrated project methodology plan in terms of using BIM

- BIM Application: to assess the contractors' capabilities and experience of various tools in terms of using BIM

- Model Content & Level of Development (LOD): to evaluate the contractors' knowledge of Modeling and LOD

- Clash Detection: to assess the BIM team's capability of detecting the clashes and knowledge of revision control

- Construction Operation Building Information Exchange (COBie): to figure out the contractors' usage of COBie data

- Assessment: to figure out the contractors' evaluation for their team performance in terms of using BIM

Questions were designed to assess the contractors' BIM competency regarding these categories (The exact numbers of questions are shown in Fig. 23).
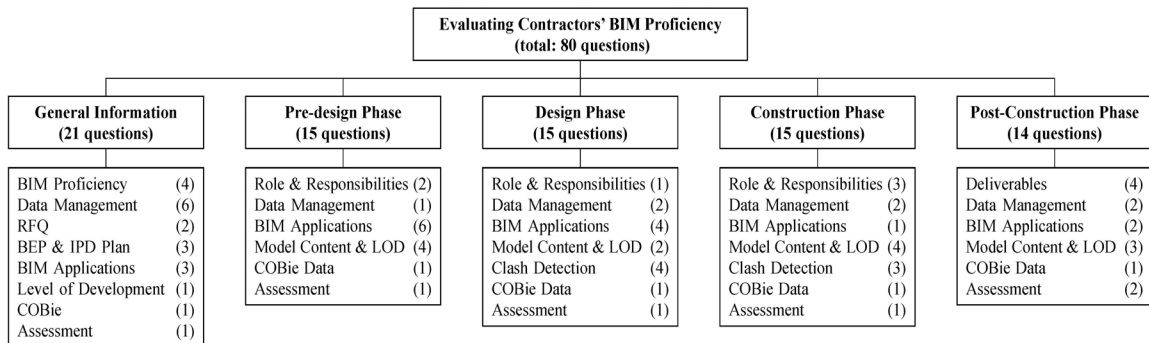


**Fig. 23.** Index of the Questionnaire

**Fig. 24.** One of Sample Question in the Questionnaire

The questions in the questionnaire consist of four main parts:

1. Questions which can be directly utilized by owners

2. Guidelines for contractor response analysis

3. Standards for grading the contractor responses

4. Blank space for owners to take notes or provide comments

Each question included a question statement, directions in assessing responses, multiple-choices for grading that will be selected by the owners depending on the contractors' answers, and blank space for additional comments or notes. One of sample question is shown in fig. 24.

First of all, owners see the questionnaire and select the questions that they wish to evaluate the contractors on. Owners can ask contractors the same question that appears in the questionnaire. Owners will take a look at the direction for each and every

question to get some idea as to what questions they want to ask, how they want to understand contractors' answers, and how they want to score contractors' answers: A through D (A being the best score and D being the lowest score). Lastly, based on the average of the rating, the owners would be assisted in determining the appropriate contractors for their projects.

**CHAPTER V**

**DATA COLLECTION**


The research methodology was usability assessment methods with in-depth interviews to scrutinize the validation of the questionnaire that suggested in Chapter 3. These interviews investigated the usability of the questionnaire to be used by owners for selecting competent contractors during owner-contractor interviews. The interviews were also typically audio-recorded for accurate transcription, and then analyzed for achieving the data regarding the research objectives. Moreover, audio-recording also allows the researcher to probe for deeper meaning and understanding (Guion et al. 2011).

The usability assessment methods for qualitative research require a minimum of five interviewees for in-depth interview with experts, and all of interviewees must have had experience and expertise related to the research topic (Nielsen 1994). Nielsen (2000) states that "Elaborate usability tests are a waste of resources. The best results come from testing no more than five users and running as many small tests as you can afford." Since the researcher has found and observed the recurring themes by the fifth user, the researcher ultimately wastes time without learning new much. Five interviewees who were professionals in AEC industry with various experiences participated in this research. The five participants were Innovations Director, BIM Manager, Senior Program Manager, BIM Engineer and Pre-construction Manager, working as different positions in different companies. The anonymity of the participants and their information

that would be shared must be maintained (Dicicco-Bloom and Crabtree 2006). In order to maintain their privacy, the researcher named the participants as interviewees 1, 2, 3, 4, and 5. The outcome of this research is based on the participants' responses and feedback for the interview, so the participants' credibility is a major factor in obtaining reliable results. The interviews for the validation of the questionnaire were conducted to recognize the following:

1. Feasibility and applicability of the questionnaire

2. Possible information for owners

3. Feedback and suggestions for the questionnaire


    The qualified participants for this study are as follows:

1. Innovations Director

    Interviewee 1 has eight and half years of experience in design and construction industry with BIM, Revit, Virtual Design, LEED, Laser Scanning, etc. He is responsible in providing technologies and process change strategies for his international group of architects and contractors.

2. BIM Manager

    Interviewee 2 has about five years of construction experience in 3D and 4D modeling, design models/shop models coordination, micro BIM and macro BIM estimation, development and monitoring of BIM execution plan, and other similar processes. He is one of the BIM instructors for AGC in San Antonio.

3. Sr. Program Manager

   Interviewee 3 has about thirty years of extensive experience in architecture and construction. He is responsible for the overall management and implementation of city architectural designs and construction projects. He coordinates and collaborates with Higher Education Institutions and the other largest municipalities in Texas in developing guidelines for BIM.

4. BIM Engineer

   Interviewee 4 has about five years of experience in BIM engineering and estimating. He is responsible in creating BIM management plans for construction projects, creating 4D models and visualization, and utilizing both BIM and estimating tools.

5. Pre-construction Manager

   Interviewee 5 has about seven years of experience as an estimator and BIM manager and Preconstruction manager. He is responsible for providing accurate budget, schedule, and constructability information to clients. Also, he works with his project teams for competing 3D coordination process and helping the project team evaluate how to utilize BIM to minimize project risk and add value to projects.

   The following questions were asked by the researcher during the in-depth interviews with SMEs:

1. Do you think this questionnaire is applicable?

2. Do you think these questions in the questionnaire (guideline) would help owners get what they want?

3. Can you suggest anything that would improve this questionnaire (guideline)?

From the interviews, the researcher perceived the general perspective of the SMEs about the questionnaire for selecting high performance contractors. Specifically, the experts' opinions about the applicability of the questionnaire, inclusion of the correct contents that owners wish to ask, and suggestions or feedback for developing the questionnaire in the future were collected during the interviews. The transcripts for five interviews are included in Appendix C.

# CHAPTER VI

## RESULTS AND DISCUSSION

This chapter consists of outcome and discussion sections. The first section covers the results of the in-depth interviews in usability assessment. Included is the feasibility of the questionnaire, suitability of the question contents, and suggestions for the questionnaire. Next, the discussion section organizes the opinions or feedback from experts about suitability of individual questions in the questionnaire. It also includes data about the necessity of question revision or relevance in the scope of the entire questionnaire.

### 6.1 Results

The audio file that was recorded during the interviews with SMEs was transcribed and analyzed to understand the usability of the questionnaire and achieve advices for developing the questionnaire. The findings from interviews were grouped into related topics of interests. The topics are as follows:

1. Whether or not the questionnaire is feasible to be used for evaluating contractors' proficiency in BIM.

2. The questionnaire contains related contents that owners wish to inquire of contractors.

3. Any suggestions or feedback from experts that will help develop the questionnaire.

6.1.1 Feasibility of the Questionnaire

The participants were provided the background and objective of this research, current evaluating systems, the general concept of the questionnaire, and such to better understand the research topic; next, they were given the questionnaire. Finally, they were asked about feasibility and applicability of the questionnaire.

Interviewee 1, the Innovations Director, stated that this questionnaire has potential but it provides challenges, such as considering the owners' the level of knowledge about BIM. When owners ask questions using the questionnaire and receive responses from the contractors, the owners need to be more technical to better understand the data. Additionally, if the owners have proficient BIM knowledge, they do not need the questionnaire because they already know what questions they should ask for determining the contractors' level of proficiency in BIM. So, this questionnaire would be helpful but it should be adjusted to be able to use by the non-technical owner.

Interviewee 2, the BIM Manager, stated that the questionnaire is overwhelming but its extensive coverage is beneficial in its details and applicability. Also, the interviewee said "It is going to be applicable depends on projects to projects, and people to people who will be using it." It means that sine the every project has own specific challenges, the questions should be specified depends on projects, market place and client type.

Interviewee 3, the Senior Program Manager, mentioned that "when selecting or considering a contractor, the owner may best be served by asking for this information as part of his proposal or bidding requirements." Moreover, the interviewee said that interviews utilizing this questionnaire have contractors explain their information or qualifications with more flexibility and in detail. Since the owners judge the contractors' communication skills, creative thinking, organizational skills, etc. through interviews, it would prove to be beneficial to owners.

Interviewee 4, the BIM Engineer, stated that "this is not always the case when qualifying contractors. The most of the time, hard copies of proposals are presented for RFPs." This implies that the questionnaire could be a part of the RFP as a separate attachment for the contractors to complete.

Interviewee 5, the Pre-construction Manager, mentioned that "Yes, there needs to be a way for contractors to get feedback on these BIM services." It means that the questionnaire would be utilized not only for owners to evaluate contractors' level of proficiency in BIM but also for contractors to assess their projects for better services in the future.

6.1.2 Relevant Information for the Owners

The questionnaire was shown to interviewees who were working in the AEC industry. Some of them had great ideas about what the important things to implement BIM projects are, and some others knew what should be asked by owners to understand contractors' level of proficiency in BIM so that the interviewees could decide the

suitability of the questions. Some questions were immediately used by owners and others needed to be modified for interview use.

Interviewee 1 stated that the questionnaire had a fairly good set of questions but some questions were too technical to be used by owners. In other words, since some owners have zero technical knowledge in evaluating contractor capabilities, it would be extremely difficult for them to examine the contractors despite having the questionnaire availability. Some questions are too broad to provide answers, so they may need to be narrowed down to smaller groups of questions.

Interviewee 2 strongly agreed that it would help owners get what they wish to know. The interviewee stated that "if these questions are developed in a certain way, owners can use these questions as a way to support their argument." Also, the interviewee mentioned that even the contractors will use it when they see the value and benefit of the questionnaire. Additionally, owners could greatly benefit from the questionnaire by what it reveals about the contractors. Specifically, the questionnaire, when intentionally administered, would allow owners to better grasp what the contractors understand about BIM projects, despite the owners' lack of BIM knowledge.

Interviewee 3 answered that "These questions are only a portion of a contractor's overall proposal, bid, or qualifications. But depending on what the owner wants will help determine the type and extent of the questions."

Interviewee 4 said, "Yes, one of the items that we run into often is BIM manpower issues. So, one question to ask would be is if a person is going to be dedicated

completely to the project." It means that if not, then the question would be, "What methods are in place to ensure that the needs of the project are met?"

Interviewee 5 stated that "Most private sector owners are only concerned with whether the services provided add value to their projects." This means that the contents of questionnaire would be not suitable for owners because they tend to focus on the services and values which are provided from contractors during the construction.

### 6.1.3 Suggestions for Future Questionnaire

Suggestions and feedback for the questionnaire from Interviews with professionals in the AEC industry were gathered and organized. Diverse and useful ideas of developing questionnaire were received from the experts. The suggestions for the questionnaire can be summed up as follows:

- Separate the questionnaire into two categories: interview questions and technical questions
- Group the questions into three categories: Why, How, and What
- Administration of the evaluation criteria can be done by a non-technical person
- Clearly and coherently detail the basis for evaluation
- Broaden the questions to answer their own capabilities by contractors
- Categorize phases into five groups, each with detailed sub-questions
- Categorize the questionnaire depending on the project types
- Differentiate questionnaires based on project size and its delivery
- Provide more scoring flexibility when rating contractors

- Differentiate category weights for question groups

- Develop the questionnaire for post-job survey

- Scale down the questionnaire with significant questions


Interviewee 1 suggested separating questions into two categories: interview questions and technical questions. He stated that interview questions cover "overall strategy direction, how these things are achieved, how they fit in the projects schedule, how your company utilizes the models for the scheduling," and other administrative application. On the other hand, the technical questions might ask about how to make a 3D model, how to link the schedule and model element, and similarly methodical operations. In other words, technical questions are more suited to pre-qualify people on BIM rather than inspect the depth of executive BIM application.

He also suggested that the questions should be categorized into "Why," "How," and "What". "Why" questions would be ideally asked for the top company positions, such as the CEO. In this category, the owners gain insight into the BIM's value for the company. The second category, "How," are the most appropriate questions for interviews. These questions examine strategies for projects and tactile activities so that owners can best understand the contractors' work processes. Finally, "What" questions proved to be the most inefficient questions for an interview. Most interviewees are usually unable to provide valuable answers because those questions cover very technical issues. Ancillary to the prior issue, clients are incapable of effectively evaluating the responses.

The other suggestion from interviewee 1 was that the basis for evaluation should be clear and coherent. Since the questionnaire would be used by non-technical owners, the questions need to be easily accessible and comprehensive in both administration and evaluation.

Interviewee 2 stated that the some questions are too specific for contractors to answer well. When owners ask open-ended or broad question, contractors are able to answer with more flexibility regarding their own abilities and strategy for BIM projects. He also suggested that the questions should be arranged from general to specific. General questions covered in major categories should branch into sub-questions, which would cover details and definitive concepts. When the questions are arranged like this, owners can comfortably segue into the desired direction.

The second suggestion from interviewee 2 was to categorize the questions by project type. He believed that "making the questions generic and creating trees of main question and then going through categorizing project types depending on different project like K-12, health care, retail, government, and federal because every different project has different owners and requirements."

Interviewee 3 suggested developing different types of questionnaires depending on project size and delivery method, and questions could be asked accordingly. He also recommended a numeric scoring system for flexibility in grading several contractors simultaneously. Lastly, he proposed variegating question weight as asked to each interviewee.

Interviewee 4 suggested that the document should be identified to ask for hiring an architect or a general contractor. Since the questions vary depending on the contract delivery method, such as Design Bid Build, Design Build, and Construction Management, the questionnaire could be better developed if it were classified by project delivery method.

Interviewee 5 mentioned that this questionnaire assumes that the owners have a certain level of BIM awareness for their projects, however, a lot of clients do not have such BIM awareness. If the questionnaire is designed for more of a post-job survey like asking whether the owners' expectations were met on the project or not, that would be suitable for owners.

All suggestions cannot be simultaneously implemented; however, the suggestions provide the right direction for developing the best questionnaire in the future. Since the questionnaire contains eighty questions, it was difficult to make an exhaustive investigation and mention all questions in the questionnaire. Thus, the questions that SMEs commented or suggested something for being corrected are stated. The following consists of the suggestions for individual questions in the questionnaire.

1. LOD Question

    One of the interviewees declared that "the best possible answer is following the BIM execution document," because depending on project to project, the requirements in the given scope are different. Also, he mentioned that the questions need to be narrowed down for answer flexibility.

2. COBie Data Question

   One interviewee stated that this question looks extremely technical for an owner, and he also said that the requirements of COBie data depend on a BIM execution document. Another interviewee said this question is suitable and applicable for the owner who is experienced with COBie data. The following questions are suggested revisions to the question: How do you use COBie data? How do you prepare COBie data? How do you produce COBie data? What software do you use to produce COBie data?

3. Energy Analysis Question

   One interviewee said that this question is not appropriate for U.S. contractors as General Contractors in the US do not do this. This question would be good for a MEP engineer or a sustainability consultant.

4. Roles and Responsibilities Question

   One interviewee stated that BIM manager's roles and responsibilities depend on the BIM execution document, so the question cannot be ask for general information regarding roles and responsibilities. Also, he suggested parsing the question with specific goals so that it could provide a challenge for contractors to answer.

5. Coordination Meeting Question

   One interviewee approved its specificity; however, the standards for grading should be modified. Depending on the jobs and works, the schedule for the

meeting should be optimized. The criteria that he suggested should focus on construction schedule compatibility, and not meeting times.

6. BEP, BMP Question

One interviewee stated, "It is a great question but the possible answers in this question cover so many bullet points to fully answer the question." He recommended that the researcher ask only one of each category and provide evaluation criteria for each.

7. Interference Check Question

One interviewee proposed changing this question to "What is your plan for checking interference during the construction phase?" and the evaluation criteria to the following rubric: A is "the plan is related to schedule"; B is "the plan is clearly defined"; C is "the plan is loosely defined"; and D is "doesn't have a plan". Since the evaluation criteria will be used by the non-technical person, the researcher should make align the question and criteria for maximum efficacy.

**6.2 Discussion**

This section discusses several aspects of the questionnaire based on the feedback provided by SMEs. For applicability of the questionnaire, SMEs had positive responses. Most interviewees responded that the questionnaire contained many questions in terms of using BIM, and the wide range of inquiry would assist owners when selecting contractors for their projects. However, since the questionnaire contains a surplus of

questions for client-contractor interviews, it should be scaled down and clearly rearranged. Several interviewees stated that the questionnaire covers enough information through content questions; however, other interviewees did not agree. Based on the overall responses of interviewees, the questionnaire would be most effective if the questions were modified according to project-specific demands. Interviewees frequently mentioned that the questionnaire should be organized, such as classifying questions according to question type, project type, client types, delivery methods, or cost. In addition, the interviewees were divided on the technicality of some questions, resulting in an overarching suggestion that the questions should consider the owner's BIM knowledge and accordingly develop the questionnaire for individual use. Although the current questionnaire displays flaws and gaps that should be corrected, it lays the groundwork for future questionnaires. If the suggestions and feedback from SMEs is applied to the questionnaire and it is thoughtfully developed to meet individual criteria and requirements, the questionnaire could prove to be very efficacious when the owners evaluate their contractors' BIM proficiency.

## CHAPTER VII

## CONCLUSION

This section provides a summary of this research and recommendations for future studies. The summary of research section briefly covers the study framework and outstanding data, such as the research problem, motivation, objectives, and findings. Further recommendation for the future study of questionnaire development is also provided.

### 7.1 Research Summary

BIM usage in construction projects has been flourishing, as well as owners' demands in adopting BIM technology for their projects. However, many project owners do not possess sufficient BIM knowledge or experience, leading them to ineffectively select competent contractors to execute BIM projects. Although several contracting evaluation systems had been introduced for qualifying contractors, some tools were required enough knowledge and experience about BIM to use them and the others were self-grading systems for improving the contractors' weaknesses regarding BIM. For these reasons, those systems would not be suitable for owners to use for evaluating contractors' BIM proficiency during client-contractor interviews. Thus, a questionnaire that can be used for evaluating contractors during interviews is needed to be developed for assisting owners in selecting the best contractors. In this research, questionnaire for

owners to evaluate contractors' BIM proficiency were developed based on the requirements for implementing BIM projects. The usability of this questionnaire was then investigated using a usability assessment methodology. Interviews with Subject Matter Experts (SMEs) were conducted to obtain further insight and different perspectives. SMEs participated in this investigation pointed out that: First, the questionnaire inquired a wide-range of content knowledge in terms of implementing BIM projects; however, some content required exhaustive knowledge of using BIM, which would be challenging for non-technical clients. Second, since the questionnaire contains a surplus of questions, it may burden on owners to read the whole questionnaire. It needs to be scaled down and clearly rearranged. Third, different BIM projects examined and required different qualifications. The questionnaire would be much more instrumental and effective if it is developed in certain ways, such as categorizing by project type, size, or delivery method. Based on the SMEs interviews, it is reasonable to conclude that the questionnaire for selecting appropriate contractors is feasible and applicable but needs to be developed and updated for easier usability and efficiency.

## 7.2 Future Research

These suggestions for future research are based on the responses from professionals in the AEC industry:

1. Separate the questions into two groups: non-technical questions (interview questionnaire for owner) and technical questions (prequalifying questionnaire).

2. Categorize by project types, project size, or project delivery methods. Each questionnaire project type of includes main questions with detailed sub-questions.

3. Classify questions into three groups: why, how, and what questions.

4. Create a flexible scoring system with different weights for each question.

5. Suggest a questionnaire for post-job survey to evaluate the owners' satisfaction.

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**APPENDIX A**

**TABLES OF BIM GUIDELINES' REQUIREMENTS ANALYSIS**

| Contents of BIM Guideline — Building Informatino Modeling(BIM): A Road Map for Implementation To Support MILCON Transformation and Civil Works Projects within the U.S. Army Corps of Engineers | GI BIM Proficiency | GI Request for Qualification | GI BEP & IPD Methodology Plan | GI Roles and Responsibilities | GI Data Management | GI BIM Applications | GI Model Content & LOD | GI Clash Detection | GI COBie Data | GI Assessment | PD Roles and Responsibilities | PD Data Management | PD BIM Applications | PD Model Content & LOD | PD Clash Detection | PD COBie Data | PD Assessment | DES Roles and Responsibilities | DES Data Management | DES BIM Applications | DES Model Content & LOD | DES Clash Detection | DES COBie Data | DES Assessment | CON Roles and Responsibilities | CON Data Management | CON BIM Applications | CON Model Content & LOD | CON Clash Detection | CON COBie Data | CON Assessment | PC Deliverables | PC Data Management | PC BIM Applications | PC Model Content & LOD | PC COBie Data | PC Assessment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2 BIM Status, Requirements, and Goals** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.3 USACE Technology Requirements | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.4 Customer Technology Requirements | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Appendix B: BIM Implementation Plan for the U.S. Army Corps of Engineers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Implematation Plan Guideline | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. Environment | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. BIM Team Organization | | | | 4 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. Standards, Configurations, and Datasets | | | | | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. Evolution of Data | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. BIM Design Team Work Instruction | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. Support from Management | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Appendix C: Dataset Evolution Instructions** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Procedure | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Additions and Changes to the Dataset | | | | | 2 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. Quality Control | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. Editing of the Dataset and Module Catalogue | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. Distribution of Updated Dataset | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Appendix D:BIM Design Team Work instructions** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Responsibilities | | | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | |
| 5.1 Corps of Engineers BIM Dataset | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | |
| 5.2 Modeling Workflow | | | | | | | | | | | | | | | | | | 1 | | 2 | 1 | 1 | | | | | | | | | | | | | | | |
| 5.3 Types of Changes to the Dataset | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| 5.4 QA/AC and Detection of Changes to the Dataset | | | | | | | | | | | | | | | | | | 1 | 3 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| 6. Example BIM Submittal Requirements | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | | | | | | | | | | | | | | | |
| 6.1 Interim Submittal (General) | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | |
| 6.2 Architectural Model Minimum Requirements and Output | | | | | | | | | | | | | | | | | | | 1 | | 6 | | | | | | | | | | | | | | | | |
| 6.3 Specific Drawings requirements | | | | | | | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | | | | | |
| Total | 0 | 0 | 3 | 6 | 8 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 6 | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.2.3 Table of Frequency-of-Mention for Requirements in LACCD BIM Guideline

| Contents of BIM Guideline / **LACCD Building Information Modeling Standards - Los Angeles Community College District (LACCD)** | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **2. BIM PROJECT REQUIREMENTS** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.1 Summary | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.2 Technology Platform and Software | | | | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.3 Application of BIM | | 1 | 1 | | 1 | 2 | 6 | | | | 1 | | 1 | 3 | | | | | | | | | | | | | | | | | | | | | | | |
| 2.4 Modeling Requirements | | | | | 1 | 1 | 5 | | | | 2 | 2 | 1 | | | | | 2 | 2 | 1 | | | | | 2 | 2 | | 1 | | | | 1 | | | | | |
| 2.5 Drawing Requirements | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.6 Project Folder Structure | | | | | 3 | | 1 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| 2.7 Information Delivery Manual (IDM) | | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| 2.8 Data Security | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | 1 | 2 | | | | | | | | | | | |
| **3. BIM PROCESS AND IMPLEMENTATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 BIM Workflow Summary | | | | | 1 | | 1 | | | | | | | | | | | 5 | 5 | 4 | 5 | 3 | | | 3 | 3 | 1 | 8 | 1 | | | | | | | | |
| 3.3 Project BIM Work Plan | 1 | 1 | 3 | | | | | | | | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 | 1 | | | | | 1 | 1 | 1 | | | | | | | | | |
| 3.4 BIM Roles and Responsibilities | 6 | 2 | | | | 1 | 1 | | | | | | | | | | | 2 | 4 | 4 | 3 | 1 | | | 2 | 5 | 4 | 1 | | | | | | | | | |
| **4. QUALITY ASSURANCE AND VALIDATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2. Quality Assurance Checklists | | | 1 | | | | | | | | | | | | | | | 2 | 1 | | | | | | 1 | | | | | | | 1 | 1 | | 1 | | |
| Total | 7 | 4 | 5 | 0 | 7 | 6 | 17 | 0 | 0 | 0 | 4 | 4 | 4 | 4 | 0 | 0 | 0 | 12 | 14 | 11 | 9 | 4 | 0 | 0 | 10 | 13 | 6 | 11 | 1 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 |

## 4.2.4 Table of Frequency-of-Mention for Requirements in State of Wisconsin BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUILDING INFORMATION MODELING (BIM) GUIDELINES and STANDARDS for ARCHITECTS and ENGINEERS - State of Wisconsin | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **1. Requirements** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1. Architects and Structural Engineers | | 1 | | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 1.2. Mechanical, Electrical, Plumbing, Fire Protection, and Civil engineers | | 1 | | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | 1 | | | | | | | | | | | 1 | | | | | |
| 1.3. Specialty Consultants | | 1 | | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 1.4. BIM Authoring Software | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.5. IFG compliance | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.6. Open Standards for Interoperability | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.7. Geo-referenced model | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2. Process** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.1. Model quality | | | | | 1 | 1 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.2 Work Effor and Compensation Schedule | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | |
| **3. Objectives and Application** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1. Pre-Design (Conceptualization) Phase | | | | | | | | | | | 1 | 1 | 3 | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 3.2. Schematic orPeer Review milestone (Criteria Design) | | | | | | | | | | | 4 | | 4 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3.Preliminary Design (Detailed Design) Phase | | | | | | | | | | | | | | | | | | 3 | | 2 | 32 | 1 | | | | | | | | | | | | | | | |
| 3.4. Final Design Construction Documents (Implementation Documents) Phase | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| 3.5. Bidding (Buyout) Phase | | | | | | | | | | | | | | | | | | 1 | 1 | | | 1 | | | | | | | | | | | | | | | |
| 3.6. Construction Phase | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | | | |
| 3.7. A/E Contract Colse-out | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | | |
| Total | 0 | 3 | 0 | 0 | 5 | 6 | 12 | 0 | 0 | 3 | 5 | 1 | 7 | 8 | 0 | 0 | 0 | 4 | 1 | 2 | 33 | 3 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 1 | 1 | 2 | 0 | 0 |

# 4.2.5 Table of Frequency-of-Mention for Requirements in the VA BIM Guide

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The VA BIM Guide – Department of Veterans Affairs | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **2. Implementation** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.2 BIM Responsibilities | | | | | 2 | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.6 Open Standards | | | | | 2 | 1 | 1 | | | | 1 | | | | | | | | | | | | | | | 1 | | 1 | | | | 1 | | | | 1 | 1 |
| **3. BIM Management Plan (BMP)** | 1 | | 2 | | 1 | | 1 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1 Design BMP | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 Construction BMP | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 Software Compatibility and Data Flow Testing | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **4. BIM Roles and Responsibilities** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.1 Design Team BIM Manager | 1 | 1 | 1 | | | | | | | | 1 | 1 | 1 | 1 | | 1 | | 1 | | | 1 | | | | | | | | | | | 1 | | | | | |
| 4.2 Technical Discipline (Design) or Trade (Construction) Lead BIM Coordinators | 1 | 1 | | | | | | | | | 1 | 1 | 1 | 1 | | 1 | | 1 | | | | | | | 1 | | | | | | | | | | | | |
| 4.3 Construction BIM Manager | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | | |
| **5. Model Sharing** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.1 Design | 1 | 1 | | | | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 5.2 Construction Bidding | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.3 Construction Phase | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 2 | | 2 | 1 | | | | | | | | |
| 6. Collaboration Procedures | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | |
| 6.2 BIM Coordination Room(s) | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **7. VA Requirements for Using BIM** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.1 Space and Medical Equipment Validation | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.2 Architecture - Spatial and Material Design Models | | | | | | 3 | | | | | | | | | | | | 1 | 1 | | 2 | | | | | | | | | | | | | | | | |
| 7.3 Energy Analysis | | | | | | | | | | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | |
| 7.4 Design Visualization for Communication, Functional Analysis, and Constructability | | | | | | | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.5 Building System Models - Structural, MEPF, and Interiors | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.6 Masterplan Space Scheduling and Sequencing - 4D | | | 1 | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.7 Communication of Construction Scheduling and Sequencing - 4D | | | 1 | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.8 COBIE/Commissioning | | | | | | | 1 | | 1 | | | | | 1 | | 1 | | | | 1 | 2 | | | | | | | 1 | 1 | | | 1 | | | | 1 | 1 |
| 7.9 Clash Detection/Coordination | | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | 1 | 1 | | 1 | 1 | | | | | | | | |
| 7.10 Virtual Testing and Balancing | | | | | | | | | | | | | 1 | 1 | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | |
| **8. 3-D Models, Formats, and Model Structures** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.1 General | | | | | 1 | | 1 | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 Subcontractor Coordination | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | | | | |
| 8.3 Digital Fabrication | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | | | | | | | | | | |
| **9. Technology Platform and Software** | | | | | | | | | | | | | | | | | | 1 | 1 | | 1 | 1 | | | | | | | | | | | | | | | |
| 9.1 Approved BIM software for VA Projects | | | | | | 1 | 1 | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | 1 | | 1 | 1 | |
| **10. Modeling Requirements** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.1 General | | | | | | 1 | 1 | | | | | | | | | | | 1 | | | 1 | 1 | | | 1 | | | 1 | | | | 1 | | | | | |
| 10.2 Types of Model Elements | | | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.3 Model Geographical Location | | | 1 | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.4 Points of Reference | | | | | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.5 Requirements for Modeling Space | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.6 Space Naming and Coding | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | | | |
| 10.7 Medical and Mechanical Equipment, Etc, Coding | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | | | |
| 10.8 Final BIM Deliverables | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | 5 | 1 | | 5 | 2 | |
| **11. Files, Security, Waivers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.1 Project Folder Structure | | | | | 3 | | 2 | | | | 1 | | | 1 | | | | 1 | | | | | | | 1 | | 1 | | | | | | | | | | |
| 11.2 Data Security | | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | 1 | 1 | | | | | | | | | 1 | | |
| 11.3 Waivers | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | 1 | | |
| **12. Drawing Requirements for Paper Printing** | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| 12.1 General | | | | | | | 1 | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| 12.3 Font | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.4 Line Styles and Line Weights | | | | | | | 1 | | | | | | | | | | | 1 | | | 1 | | | | | | | | | | | | | | | | |
| 12.5 MEP Details | | | | | | | 1 | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | |
| 12.6 Room naming Abbreviations | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.7 Titleblocks | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| 12.8 Uniform Parameters for Objects | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.9 VA Standard Details | | | | | | | 1 | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 12.10 Casework/Millwork Finishes | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.11 Casework/Millwork Finish Legend | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.12 Doors | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.13 Interior Partition Types | | | | | | | 3 | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| 12.14 Model Integrated Text | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.15 Room Finishes | | | | | | | 1 | | | | | | | | | | | 1 | | | 1 | | | | | | | | | | | | | | | | |
| 12.16 Finish Legend | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.17 Room Numbering | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.18 Wayfinding | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 6 | 5 | 9 | 0 | 14 | 10 | 39 | 0 | 1 | 0 | 10 | 5 | 6 | 14 | 0 | 3 | 0 | 12 | 6 | 5 | 16 | 5 | 2 | 0 | 10 | 5 | 1 | 11 | 4 | 2 | 0 | 11 | 3 | 1 | 9 | 4 | 0 |

## 4.2.6 Table of Frequency-of-Mention for Requirements in City of San Antonio BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Building Information Modeling (BIM) Development Criteria and Standards for Design & Construction Projects - City of San Antonio** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **ARTICLE 1: INTRODUCTION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.2. CoSA - Building Information Modeling (BIM) Life Sycle Vision | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.4. Ownership Rights of the Data and Model | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **ARTICLE 2: BIM PROJECT REQUIREMENTS, STANDARDS, PERFORMANCE CRITERIA, INFORMATION INTEGRATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.1. General | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.2. Technology Platform and Software | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.3. Approved BIM Software for CoSA Building Projects | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.4. Modeling Requirements | | | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 2.5. Drawing Requirements | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.6. Types of Model Elements | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| 2.7. Model Based Quantity Take-Offs | | | | | | | 1 | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | |
| 2.8. Specifications | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.9. Data Security | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.10. Program Spatial Requirements | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.11. As-Built BIM | | | | | 1 | | 2 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 2 | 1 | | 1 | | |
| 2.12. Applications of BIM | | | 1 | | | 1 | 1 | | | | 1 | | 2 | 6 | | | | 1 | | 2 | 6 | | | | 1 | | 1 | 3 | | | | 3 | 1 | 1 | 3 | | |
| **ARTICLE 3: BUILDING INFORMATION MODEL PROTOCOL** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3. Transmission of Data and Model | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.4. Defined Levels of Development (LOD) | | | | | | | | | | | | | | 2 | | | | 1 | | | 2 | 1 | | | | | | 2 | 1 | | | 1 | | | 2 | | |
| 3.6. Specific Responsibilities for Development of Model Elements | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | |
| 3.7. Protocol | | | | | 2 | 1 | 2 | | | | 1 | 1 | | | | | | 3 | 1 | | 2 | 1 | | | 1 | | | 1 | | | | | | | | | |
| 3.8. Project BIM Execution Plan | | 2 | 3 | | 1 | 1 | 1 | | | | 1 | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | |
| 3.9. BIM Roles and Responsibilities | 2 | 3 | 2 | | 2 | | 1 | | | | 2 | | 2 | | | | | 2 | | 2 | | | | | 2 | | 2 | | | | | | | | | | |
| 3.10. Model Elements | | | | | | | 2 | | | | 1 | | | 2 | | | | 1 | | | 2 | | | | 1 | | | 2 | | | | | | | | | |
| 3.11. Model Element and Author Table | | | | | | | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | | | | | | | |
| **ARTICLE 4: INDEPENDENT INFORMATION MANAGER RESPONSIBILITIES** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2. Quality Assurance and Validation | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | |
| 4.3. Quality Assurance Checks | | | 1 | | | | | | | | 1 | 1 | | 1 | | | | 1 | 1 | | 1 | | | | 1 | 1 | | 1 | 1 | | | | | | | | |
| 4.4. Review of Electronic Documents Required to be Linked to the BIM Model | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **ARTICLE 5: GENERAL CONTRACTOR'S BIM RESPONSIBILITIES DURING CONSTRUCTION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.2. Clash Dectetion Testing and Reporting | | | | | 2 | 1 | 1 | | | | | | | | | | | 3 | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| 5.3. Trade Colors for Clash Detection | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | | |
| 5.4. Minimum Requirements for Spatial Coordination and Clash Detection | | | | | | | | | | | | | | | | | | | | | 10 | 10 | | | | | | | | | | | | | | | |
| 5.5. Construction Phase Documents Required to be Linked to the Construction BIM Model by Contractor | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | 1 | 1 | | 1 | | |
| 5.6. Development of the As-Built BIM Model during Construction | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | 2 | | | | 1 | 1 | | 1 | | |
| Total | 2 | 5 | 7 | 0 | 13 | 12 | 26 | 0 | 0 | 0 | 9 | 2 | 4 | 13 | 0 | 0 | 0 | 15 | 2 | 5 | 26 | 14 | 0 | 0 | 13 | 4 | 4 | 14 | 4 | 0 | 0 | 10 | 4 | 1 | 9 | 0 | 0 |

# 4.2.7 Table of Frequency-of-Mention for Requirements in the CIC Research Group BIM Guideline

| Contents of BIM Guideline / BIM Project Execution Planning Guide - The Computer Integrated Construction (CIC) Research Program | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **Chapter 1.Overview of the Project Execution Planning Procedure for BIM** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Introduction to Building Information Modeling | | | 1 | 2 | 1 | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Why should the Project Team Develop a BIM Project Execution Plan? | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The BIM Project Execution Planning Procedure | | | 1 | 3 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| What Information is Included in a BIM Project Execution Plan? | | | 2 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| Who should Develop the BIM Plan? | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| What Meetings are Needed to Successfully Develop the BIM Plan? | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 2.Identifying BIM Goals and Uses for a Project** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Define the BIM Goals for the Project | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Begin with the End in Mind | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Use Selection Procedure | | | 5 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 3.Designing the BIM Project Execution Process** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mapping the Project Execution Process | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Creating a BIM Overview Map | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Creating a Detailed BIM Use Map | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Symbols Used for Process Map Representation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 4.Developing Information Exchanges** | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pulling the Information Through the Project | | | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Information Exchange Worksheet | | | 3 | 5 | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 5.Define Supporting Infrastructure for BIM Implementation** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Project Execution Plan Overview | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project Information | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Key Project Contact | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project BIM Goals/BIM Uses | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Organizational Roles and Staffing | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Process Design | | | 1 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Information Exchanges | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Collaboration Procedures | | | | 3 | 4 | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Quality Control | | | | 2 | 2 | | 2 | 1 | | | 1 | 1 | | 1 | 1 | | | 1 | 1 | | 1 | 1 | | | 1 | 1 | | 1 | 1 | | | 2 | | | | | |
| Technology Infrastructure Needs | | | | 2 | 1 | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project Deliverables | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | | |
| Delivery Strategy | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Team Selection Procedure | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Contractual Language | | | | 2 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| **Chapter 6.Implementing the BIM Project Execution Planning Procedure** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Meeting Structure for Developing a BIM Project Execution Plan | | | | 4 | 10 | 5 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Planning Meeting Schedule | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Monitoring Progress against the BIM Execution Plan | | | | 1 | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 7.BIM Project Execrution Planning for Organizations** | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Mission Statement and Goals | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Uses | | | | 1 | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Process Maps | | | | 2 | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Information Exchanges | | | | 2 | 1 | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Infrastructure | | | | 2 | 5 | 2 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| Developing the BIM Project Execution Plan | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Chapter 8.Concusions and Recommendations** | | | | 4 | 3 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 1 | 0 | 35 | 59 | 37 | 8 | 22 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 |

## 4.2.8 Table of Frequency-of-Mention for Requirements in Georgia Tech (GT) BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Georgia Tech BIM Requirements & Guidelines for Architects, Engineers and Contractors - Georgia Tech (GT)** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **3 BIM Requirement** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1 Overview | | | | | 1 | 1 | 1 | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | 2 | | | 1 | 1 | |
| 3.1.1 General Requirements | | 1 | | | | | 2 | | | | 1 | | 1 | | | 1 | | 1 | 1 | | 1 | | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | |
| **4 Process** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.1 BIM Proficiency | 3 | | | | 1 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2 BIM Execution Plan (BEP) & Integrated Project Methodology Plan (IPP) | | | 2 | | 1 | | | | | | 1 | 1 | | | | | | 1 | | 1 | | | | | 1 | 1 | | | | | | | | | | | |
| 4.3 Open Architecture for Interoperability | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | | | |
| 4.4 Model Quality | | | | | | | | | | | | | 2 | 1 | | | | 2 | | | 1 | 1 | | | | | | | | | | | | | | | |
| 4.5 Energy Requirements Overview | | | | | | | | | | | | | 2 | 1 | | | | | 2 | | 1 | | | | | | | | | | | | | | | | |
| 4.6 Project Team Milestone Deliverables | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **5 Objectviews and Application** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.1 Pre-Design (Conceptualization) Phase | | | | | | | | | | | 4 | 1 | 6 | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| 5.2 Schematic Design (Criteria Design) Phase | | | | | | | | | | | 2 | 3 | | 8 | | 2 | | | | | | | | | | | | | | | | | | | | | |
| 5.3 Preliminary Design (Detailed Design) Phase | | | | | 1 | | | | | | | | | | | | | 1 | 2 | 2 | 3 | 1 | 1 | | | | | | | | | | | | | | |
| 5.4 Construction Documents Phase | | | | | | | | | | | | | | | | | | | 3 | 2 | 3 | 1 | | | | | | | | | | | | | | | |
| 5.5 Agency Coordination & Bidding Phase | | | 1 | | 1 | | | | | | | | | | | | | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 5.6 Construction Phase | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | 6 | 9 | 3 | 7 | 3 | 3 | | | | | | | |
| 5.7 Project Closeout Phase | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | 2 | 2 | 2 | 1 | |
| **6 Ownership and Rights of Data** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.2 Initial Guidelines for Model Correctness | | | | | | | 3 | | | | | | | | | | | | | | 6 | | | | | | | | | | | | | | | | |
| 6.3 GT Facilities Management System Data Structure | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| 6.4 COBie Data Roles and Responsibilities | | | | | | | | | | | 1 | | | | | 1 | | 1 | | | | | 1 | | 1 | | | | | 1 | | | | | | 1 | |
| Total | 3 | 1 | 7 | 0 | 7 | 1 | 11 | 0 | 2 | 0 | 9 | 5 | 11 | 19 | 0 | 4 | 0 | 6 | 8 | 6 | 15 | 3 | 3 | 0 | 9 | 11 | 4 | 9 | 4 | 5 | 0 | 5 | 2 | 2 | 3 | 4 | 0 |

## 4.2.9 Table of Frequency-of-Mention for Requirements in USC BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USC's Building Information Modeling(BIM) Guidelines V1.6 | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **2. USC Responsibilities** |  |  |  |  | 1 |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |
| **3. Deliverables** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.1 BIM Execution Plan |  |  |  |  | 1 |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.2 Model and Data Delivery |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  |  | 1 | 1 |  | 1 | 1 |  |
| **4. Design Team: BIM Process and Modeling Requirements** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.1 BIM Authoring Software |  |  |  |  |  |  |  |  |  |  | 1 | 1 | 1 |  |  |  |  | 1 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.3 Project Collaboration Server |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.4 Design BIM Facilitator | 1 |  |  |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 |  | 1 |  | 1 | 1 | 1 | 1 |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 Model Quality and Level of Detail: Architectural and MEPF |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |
| 4.7 COBie |  |  | 1 |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 |  | 2 |  | 1 | 1 | 1 | 1 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. MEPF Specifications** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.1 Shared Parameters |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 | 1 |  |  |  | 1 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.2 Nomenclature |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.3 Worksets |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.4 Isolateable Systems and Zones |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6. Design Phases** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.1 Deliverable Schedule and Milestones |  |  |  |  |  |  | 1 |  |  |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  | 1 |  |  | 1 | 1 |  |
| 6.2 Schematic Design Phase |  |  |  |  |  |  |  |  |  |  | 1 | 1 | 2 | 6 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.3 Design Development Phase |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 | 3 | 1 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.4 Construction Documents Phase |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 1 | 1 | 3 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.5 Bidding Phase |  |  |  |  |  | 2 | 1 |  |  |  |  |  |  |  |  |  |  | 1 | 3 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **7. Construction Team: BIM Process and Modeling Requirements** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.1 BIM Execution Plan Feedback and Revisions |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 7.2 Construction BIM Facilitator | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 |  |  |  |  |  |  |  |  |
| 7.3 COBie Construction Data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 2 | 1 |  |  | 1 |  |  |  |  |  |  |  |
| 7.5 Construction Model Updates |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  | 1 |  |  |  |  |  |  |  |  |  |
| 7.6 Trade Coordination |  |  |  |  |  |  | 1 |  |  |  | 3 | 1 |  | 1 |  |  |  | 4 | 1 |  | 2 | 1 |  |  | 7 | 2 | 4 | 3 | 2 |  |  |  |  |  | 1 |  |  |
| **APPENDIX A: Model Elements and Level of Detail for Models** |  |  | 6 |  |  |  | 17 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **APPENDIX B: BIM Data Acquisition Guideline for Facilities Management Services** |  |  |  |  | 1 |  | 4 |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  | 2 | 2 |  |  |
| **APPENDIX C: Nomenclature** |  |  | 1 |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **APPENDIX E: Revit Model Requirements and Warnings** |  |  | 1 |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **APPENDIX F: Collision Detection and Design Review** |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total | 2 | 1 | 12 | 0 | 6 | 2 | 25 | 0 | 3 | 0 | 10 | 6 | 7 | 16 | 0 | 6 | 0 | 14 | 10 | 6 | 20 | 4 | 7 | 0 | 12 | 8 | 6 | 7 | 3 | 3 | 0 | 2 | 1 | 2 | 7 | 4 | 0 |

# 4.2.10 Table of Frequency-of-Mention for Requirements in MIT BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIT CAD & BIM GUIDELINES - MIT Facility Information Systems | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **1. INTRODUCTION** |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  |  |  |  |
| 1.1 Renovations and Space Change Projects Requirements |  |  |  | 1 |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  | 3 | 2 |  |  |  |  |  | 1 | 1 |  |  |  |  |  | 1 |  |  | 1 |  |  |
| 1.2 Capital Project Requirements |  |  |  |  |  |  |  |  |  |  | 2 | 1 |  |  |  |  |  | 4 | 2 |  |  |  |  |  | 1 |  |  |  |  |  |  | 1 |  |  | 2 |  |  |
| **2. CAD DRAWING PRODUCTION** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.1 File Format and Setup |  |  |  |  | 2 | 1 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.2 Title Blocks |  |  |  |  | 1 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |
| 2.3 Layering |  |  |  |  | 3 |  | 9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.4 Translating AD Files to DWG Format |  |  |  |  | 2 | 1 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |
| **3. USE OF BUILDING INFORMATION MODELING (BIM)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |
| 3.1 BIM Execution Plan |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |
| 3.2 BIM Standards |  |  | 3 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |
| 3.3 BIM Models and Deliverables |  |  | 2 |  | 1 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |
| **4. RCHIVAL PRINT FILES** |  |  |  |  | 1 | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.1 PDF File Creation |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.2 TIF File Creation |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. FILE IDENTIFICATION AND NAMING CONVENTION** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |
| 5.1 DWG Sheet Identification |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.2 File Organization, and Transmittal to MIT |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  | 1 |  |  |
| **6. APPENDICES** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  | 1 |  |  |
| Total | 0 | 0 | 5 | 0 | 10 | 6 | 30 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 8 | 4 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 12 | 2 | 0 | 11 | 0 | 0 |

# 4.2.11 Table of Frequency-of-Mention for Requirements in Indiana University (IU) BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BIM Guidelines & Standards for Architects, Engineers, and Contractors - Indiana University (IU)** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **SECTION 1: General Requirements** | | | | | | 1 | 3 | | | 2 | 3 | | 1 | | | | | 3 | | 1 | | | | | 1 | | | | | | | 2 | | | | | |
| **SECTION 2: Process** | 1 | 1 | 4 | | 1 | 1 | 2 | | | | 3 | | | | | | | 3 | | | | | | | | | | | | | | | | | | | |
| **SECTION 4: Objectives and Application** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.1: Pre-design Phase (Conceptualization) | | | 1 | | | | | | | | 3 | 3 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2: Schematic Design Phase (Criteria Design) | | | 1 | | | | | | | | 6 | 3 | 4 | 5 | 6 | | | | | | | | | | | | | | | | | 1 | | | | | |
| 4.3: Design Development Phase (Detailed Design) | | | 6 | | | | | | | | | | | | | | | 3 | 4 | 2 | 12 | 4 | | | | | | | | | | | | | | | |
| 4.4: Construction Documents Phase | | | 1 | | | | | | | | | | | | | | | 4 | 2 | 2 | 3 | 3 | 1 | | | | | | | | | | | | | | |
| 4.5: Bidding Phase | 1 | | 1 | | | | | | | | | | | | | | | 1 | 1 | | 1 | | | | | | | | | | | | | | | | |
| 4.6: Construction Phase | | | 4 | | | | | | | | | | | | | | | | | | | | | | 8 | 3 | 4 | 6 | 2 | 2 | | | | | | | |
| 4.7: Project Close-out | | | 1 | | | | | | | | | | | | | | | 1 | 1 | | 1 | | | | | | | | | | | 1 | 1 | | 1 | 1 | |
| 4.8: Project As-built and Record Document Deliverable Matrix | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | 1 | 1 | |
| Total | 2 | 1 | 20 | 0 | 1 | 2 | 5 | 0 | 0 | 2 | 15 | 6 | 7 | 8 | 6 | 0 | 0 | 15 | 8 | 5 | 17 | 7 | 1 | 0 | 9 | 3 | 4 | 6 | 2 | 2 | 0 | 5 | 2 | 0 | 2 | 2 | 0 |

# 4.2.12 Table of Frequency-of-Mention for Requirements in NYC DDC BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **BIM Guidelines - NEW YORK CITY Department of Design + Construction** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **PART ONE: GENERAL INFORMATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Objectives | | | | | | 1 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Software | | | 1 | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Project Delivery Models | | | 1 | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Model Ownership | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| BIM Roles and Responsibilities | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Manager | 1 | 1 | 1 | | 1 | 1 | 1 | | | | 1 | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | |
| Discipline Trade BIM Coordinators | 1 | 1 | | | 1 | 1 | 1 | | | | 1 | | | | | | | | | | 1 | | | | | | | | 1 | | | | | | | | |
| BIM Execution Plan | | | 1 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PART TWO: BIM USE AND REQUIREMENTS** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Uses | | | 1 | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Parametric Modeling | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Model Discrepancies | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Uniformat Classification and Omniclass | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coordinate System | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Model Continuity | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Model Level of Development | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Model Granularity | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PART THREE: SUBMISSION AND DELIVERABLES** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Submission Requirements | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | 1 | | | | | | 1 | | | | | |
| Pre-Schematic Design | | | | | | | | | | | 1 | 1 | 1 | 6 | | | | | | | | | | | | | | | | | | | | | | | |
| Schematic Design | | | | | | | | | | | | 2 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | |
| Design Development | | | | | | | | | | | | | | | | | | | | | 4 | 1 | | | | | | | | | | | | | | | |
| Construction Documents | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | 3 | 2 | | | | | | | | |
| Bid, Award and Registration | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | |
| Services During Construction | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 4 | 4 | 1 | | | | | | | | |
| Submissions & Deliverables | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 3 | 2 | 7 | | |
| Total | 2 | 2 | 6 | 0 | 6 | 5 | 14 | 0 | 0 | 0 | 3 | 4 | 3 | 9 | 0 | 0 | 0 | 2 | 1 | 0 | 4 | 2 | 0 | 0 | 3 | 5 | 5 | 8 | 4 | 0 | 0 | 3 | 3 | 2 | 7 | 0 | 0 |

## 4.2.13 Table of Frequency-of-Mention for Requirements in GSFIC BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GSFIC BIM Guide - Georgia State Financing and Investment Commission (GSFIC)** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **Introduction** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Objective of this Guide | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | 1 | | |
| Requirements and Deliverables | | | | | | | | | | | 1 | 1 | 1 | 2 | | | | 1 | 1 | 1 | 2 | | | | | | | | | | | 1 | | | 1 | | |
| **1.0 BIM for Building Constructability Review** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1 Required Constructability Review Information | | | 2 | | | 1 | 1 | | | | | 1 | | 4 | | | | | 1 | 1 | 6 | | | | | | | | | | | 1 | | | | | |
| 1.2 Other Constructability Review Items | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2.0 Building Life Safety Components** | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | |
| 2.2 Required Spatial Information for all Projects | | | | | | | | | | | 1 | | | 2 | | | | 1 | | | 2 | | | | | | | | | | | | | | | | |
| **3.0 Building Elements** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1 Modeling Precision | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 Retaining Original Global Unique Identifiers (GUIDs) | | | | | 1 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 Handling Multiple BIM Versions | | | | | | | 1 | | | | | | | | | | | 1 | | | 2 | | | | | | | | | | | | | | | | |
| 3.4 Model Containment Hierarchy | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.5 Model setup | | | | | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.6 Required Model Elements and Proper Modeling Methods | | | | | | | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **4.0 BIM Analysis Rules** | | | | | | | | | | | | | | | | | | 1 | | | 1 | 1 | | | | | | | | | | | | | | | |
| Appendix A (File Clean Up process) | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| Appendix C (Instruments of Service) | | | | | | | | | | | | | | | | | | 1 | 1 | | 1 | | | | 1 | 1 | | 1 | | | | 2 | 2 | | 1 | | |
| Appendix D (GSFIC Naming Conventions) | | | | | 1 | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 0 | 0 | 2 | 0 | 4 | 3 | 20 | 0 | 0 | 0 | 2 | 2 | 1 | 10 | 0 | 0 | 0 | 5 | 4 | 3 | 15 | 2 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 6 | 3 | 0 | 4 | 0 | 0 |

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## 4.2.14 Table of Frequency-of-Mention for Requirements in State of Ohio BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATE OF OHIO BUILDING INFORMATION MODELING PROTOCOL - Ohio DAS | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment |
| **THE PROTOCOL** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Protocol Framework | | | 1 | | | | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | | | | | | | | |
| Data Requirements | | | | | 1 | 1 | | | | | 1 | | 1 | 4 | | | | 1 | | 1 | 4 | | | | | | | | | | | | | | | | | |
| Model Management | | | 1 | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Selection Process Fators | 1 | 2 | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | |
| Compensation Expectations | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | | | | | |
| **IMPLEMENTATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Implementation | | | 1 | | | 1 | 3 | | | | | | 1 | 2 | | | | | | 1 | 2 | 1 | | | | | 1 | 2 | 1 | | | | | | 1 | | | |
| Deliverables | | 1 | 3 | | | | | | | | | 2 | | 2 | | | | | 3 | | 3 | 3 | | | | | | 1 | 1 | | | 2 | 2 | | 2 | | | |
| Contractual Provisions | | | 1 | | | | | | | | 1 | 1 | | 1 | | | | 1 | 1 | | 1 | | | | 1 | | | | | | | 1 | 3 | | 1 | | | |
| **APPENDIX** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Execution Plan Outline | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BIM Execution Plan | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 1 | 3 | 10 | 0 | 3 | 2 | 6 | 0 | 0 | 0 | 3 | 3 | 2 | 10 | 0 | 0 | 0 | 3 | 4 | 2 | 11 | 4 | 0 | 0 | 2 | 0 | 1 | 4 | 2 | 0 | 0 | 6 | 5 | 0 | 5 | 0 | 0 | 0 |

# 4.2.15 Table of Frequency-of-Mention for Requirements in GSA BIM Guideline

| Contents of BIM Guideline | General Information | | | | | | | | | | Pre-Design Phase | | | | | | | Design Phase | | | | | | | Construction Phase | | | | | | | Post-Construction Phase | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GSA BIM Guide Series - The United States General Services Administration (GSA)** | BIM Proficiency | Request for Qualification | BEP & IPD Methodology Plan | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Roles and Responsibilities | Data Management | BIM Applications | Model Content & LOD | Clash Detection | COBie Data | Assessment | Deliverables | Data Management | BIM Applications | Model Content & LOD | COBie Data | Assessment |
| **BIM Guide Series 01. BIM Guide Overview** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 1: GSA's national 3d-4d-bim program | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 2: 3d-4d-bim projects - the basics | 1 | | 1 | 6 | 2 | 8 | 7 | | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **BIM Guide Series 02. BIM Guide for Spatial Program Validation** | | | | 6 | | 3 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | 1 | 2 | | |
| Section 1: spatial program bim | | | | 1 | | | | | | | 2 | 4 | 1 | 3 | | | | 9 | 8 | 11 | 17 | | | | | | | | | | | | | | | | |
| Section 2: spaces and zones | | | | 8 | 3 | 7 | 15 | | | | 1 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| Section 3: building elements | | | | 4 | | 9 | 13 | | | | 1 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| section 4: bim-analysis rules | | | | 7 | | 1 | 21 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| **BIM Guide Series 03. BIM Guide for 3D Imaging** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 1: Introduction | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 2: solicitation phase | | | 4 | 15 | 10 | 4 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 1 | | 1 | | |
| Section 3: evaluation phase | | | 3 | 5 | 11 | 7 | 4 | | | 2 | | | | | | | | | | | | | | | | | | | | | | 3 | 1 | | 1 | | 1 |
| Section 4: project management | 1 | | 3 | 6 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | | | 1 | | 1 |
| **BIM Guide Series 04. BIM Guide for 4D Phasing** | | | | 2 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 1: 4d phasing - the basics | | | 3 | | | 1 | 3 | | | | | | | | | | | | | | 1 | | | | | 1 | | 1 | | | | | | | | | |
| Section 2: defining 4d phasing scope | | | 2 | 8 | | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Section 3: technical guidance on 4d modeling | | | 7 | 7 | 3 | | 12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **BIM Guide Series 05. BIM Guide for Energy Performance** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1. Energy Modeling for Design, Construction, and Operations | | 2 | 4 | 5 | 5 | 6 | 9 | | | | 1 | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | |
| 2. Energy Modeling and BIM | | | | 10 | 13 | 20 | 32 | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| 3. Energy Modeling Case Studies | | | | | 1 | 1 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 2 | 2 | 27 | 90 | 51 | 70 | 136 | 0 | 0 | 4 | 5 | 4 | 1 | 6 | 0 | 0 | 0 | 11 | 9 | 11 | 20 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 13 | 3 | 1 | 5 | 0 | 2 |

# APPENDIX B

## QUESTIONNAIRE FOR EVALUATING CONTRACTORS'

## BIM PROFICIENCY

INDEX

## I. General Information

## II. Pre-design Phase

## III. Design Phase

## IV. Construction Phase

## V. Post-construction Phase

# Questionnaire for Evaluating Contractors' Proficiency in BIM

This questionnaire consists of 5 chapters such as General Information, Pre-design Phase, Design Phase, Construction Phase, and Post-construction Phase. Each of the chapters has several questions to assess the contractors' proficiency in BIM. You can use the questions that you wish to evaluate the contractors. Please take a look at the direction for each and every question to get some idea as to what questions you want to ask, how you want to understand their answers, and how you want to score their answers: A through D (A being the best score and D being the lowest score).

## I. General Information

The following questions are what you want to ask to collect general information about the contractors in terms of using BIM. 8 categories are included in the General Information chapter: BIM Proficiency, Data Management, Request for Qualification (RFQ) BIM Execution Plan (BEP) and Integrated Project Delivery (IPD), BIM Applications, Level of Development (LOD), Construction Operation Building Information Exchange (COBie), and Assessment.

### BIM Proficiency

The following are questions to figure out the contractors' understating of BIM proficiency.

| 1. How would you define the BIM proficiency? | |
|---|---|
| **Direction:** See if the interviewees cover the following. Capability for BIM to **1)** provide appropriate information to other systems or processes for reporting and calculation. Ideas about **2)** Physical accuracy of the Model, **3)** IPD Methodology, **4)** Calculation Mentality, **5)** Location Awareness, **6)** Content Creation, **7)** Construction Data, **8)** As-Built Modeling, **9)** FM Data Richness, etc. | **Score** |
| Possess significant expertise in BIM proficiency. | A |
| Limited knowledge about BIM proficiency. | B |
| Have a general idea about BIM proficiency. | C |
| Have no knowledge of BIM proficiency. | D |
| Comment: | |

| 2. How would you prioritize the factors important to BIM proficiency? | |
|---|---|
| **Direction:** See if the interviewees cover the following example factors of BIM proficiency.<br>- Experience of BIM Project Execution Planning<br>- Collaboration Experience<br>- Proficiency of BIM tools<br>- Technical Capabilities<br>- Etc. | **Score** |
| Have vast knowledge of most factors, and have a systematic approach to their respective priorities. | A |
| Mentioned several factors with proper reasons. | B |
| Mentioned very few factors. | C |
| Have no idea. | D |
| Comment: | |

| 3. Can you present outlines or standards relevant to the level of maturity in BIM? | |
| --- | --- |
| **Direction:** See if the interviewees have their own idea about the level of maturity in BIM. | **Score** |
| Have excellent standards of BIM proficiency following established guidelines to access the maturity. | A |
| Have general standards for evaluation but not in detail. | B |
| Have an idea about BIM proficiency conceptually. | C |
| Have no idea. | D |
| Comment: | |

| 4. Expound upon your company's BIM experience, skills, expertise, etc. | |
| --- | --- |
| **Direction:** See if the interviewees have enough experience and various skills in terms of using BIM. | **Score** |
| Varied and significant experience, professional skills with BIM. | A |
| Adequate experience and skills with BIM for a project. | B |
| Minimum experience and skills with BIM for a project. | C |
| No experience about BIM. | D |
| Comment: | |

**Data Management**

The following are questions to assess the contractors' management of data in terms of using BIM.

| 5. Do you use BIM for updating and recording changes and revisions so that you can access it easily in the team? | |
| --- | --- |
| **Direction:** See how often the interviewees update revisions and how they access the data easily. | **Score** |
| Update and record changes and revisions making them easily accessible in real time. | A |
| Updates are infrequent but easily available. | B |
| Updates are infrequent and difficult to access. | C |
| No BIM communication. | D |
| Comment: | |

**6. How do you use BIM to promote collaboration between the design team and the construction team?**

| Direction: See if the interviewees use BIM to update changes in real time and if both the design team and the construction team access the files simultaneously. | Score |
|---|---|
| Update and record changes and revisions in real-time allowing simultaneous and ready access to both design team and construction team. | A |
| Use BIM for collaboration, but only requires scheduled access by authorized team members. | B |
| Use BIM superficially. | C |
| No BIM uses for collaboration. | D |
| Comment: | |

**7. How do you manage BIM data (files)?**

| Direction: See if the interviewees manage BIM data well with high priority. | Score |
|---|---|
| Fully control and manage BIM data systematically with high priority. | A |
| Access and record the data only through authorized personnel. | B |
| Some protection and security of the data in the computer. | C |
| Zero protection. | D |
| Comment: | |

**8. How do you use BIM to manage revision control?**

| Direction: See if the interviewees revisit conflicts in real-time. | Score |
|---|---|
| Address conflicts in real-time. | A |
| Have some procedures for revision control. | B |
| Changes and conflicts are not immediately addressed. | C |
| Do not use BIM for revision control. | D |
| Comment: | |

**9. How do you track or record all changes?**

| Direction: See if the interviewees track all changes with high priority | Score |
|---|---|
| Record and manage all changes in real-time and treat these changes with high priority. | A |
| Track changes but not in real-time. | B |
| Keep recording with paper work only. | C |
| Do not record all changes. | D |
| Comment: | |

| 10. Do you have a dedicated server using proprietary Management Information System for the project? | |
|---|---|
| **Direction:** See how the interviewees store and manage data. | **Score** |
| Have a proprietary system or server for storage and reporting. | A |
| Store data but not on a server. | B |
| Manage data on isolated independent drives, available only upon formal request. | C |
| No management of data. | D |
| Comment: | |

## Request for Qualification (RFQ)

The following are questions to figure out the contractors' qualifications in terms of using BIM.

| 11. Identify the information that should be included in the Request for Qualification (RFQ). | |
|---|---|
| **Direction:** See if the interviewees describe the specific BIM and owner defined requirements, level of development to be achieved within the models, deliverables, and owner's intended use of the model after construction. The RFQ will describe how the proposing firms should address their BIM expertise or processes in their submittal. | **Score** |
| Understand most contents that should be addressed in RFQ and its benefits. | A |
| Mentioned few items in detail, but not all that were important to the project. | B |
| Explained RFQ conceptually but not in detail. | C |
| Have no idea about RFQ. | D |
| Comment: | |

| 12. In your opinion, what criteria are most relevant to an owner in evaluating your qualifications? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- BIM experience and/or proposed management and implementation of the BIM process<br>- The proposing firm's ability to perform the work<br>- Management of quality construction documents<br>- Clarity of responsibilities<br>- Etc. | **Score** |
| Understand most criteria that would be important to an owner. | A |
| Could not mention fully, nor in precise terms. | B |
| Emphasize very few criteria. | C |
| Have no knowledge. | D |
| Comment: | |

**BIM Execution Plan (BEP) & Integrated Project Delivery (IPD) Methodology Plan**

The following are questions to evaluate the contractors' knowledge of execution plan and integrated project delivery methodology plan in terms of using BIM.

| 13. What relevant contents should be addressed in the BIM Execution Plan (BEP)? | |
|---|---|
| **Direction:** See if the interviewees cover the following items. <br> - Project Information, Goals and Objectives <br> - Assumed roles and responsibilities of the team <br> - Collaboration plan <br> - Planned Models, Model Components, and Model Analysis plan <br> - Project deliverables <br> - Project Milestones | **Score** |
| Have direct and expert knowledge of BEP. | A |
| Mentioned minimum BEP with limited experience. | B |
| Mentioned general execution plan not related to BEP. | C |
| Have no idea about BEP. | D |
| Comment: | |

| 14. What should be demonstrated in the IPD Methodology Plan? | |
|---|---|
| **Direction:** See if the interviewees cover the high level of project integration and technological workflows by **1)** identifying project methodology and modeling procedures, **2)** quality control, and **3)** scheduling and model information validation. | **Score** |
| Mentioned most contents for maturity of project workflows. | A |
| Mentioned few components related to IPD. | B |
| Know the concept of IPD only, and did not mentioned any content of these. | C |
| Have no idea. | D |
| Comment: | |

| 15. How do you define the Integrated Project Delivery (IPD) Methodology Plan detail of your company? | |
|---|---|
| **Direction:** See if the interviewees cover the following. <br> - Declare how the project team will achieve the goals of an IPD Methodology. <br> - The plan can have several components and is encouraged to be part of the BEP. <br> - Examples: The completion of a Reverse Phase Schedule or Critical Path Modeling | **Score** |
| Have various plans for integration and technological workflows. | A |
| Have a general idea but cannot be detailed. | B |
| Know about IPD but no plans. | C |
| No plan for the Integrated Project Delivery Methodology. | D |
| Comment: | |

**BIM Applications**

The following are questions to assess the contractors' capabilities and experience of various tools in terms of using BIM.

| 16. What BIM applications do you use? | |
|---|---|
| **Direction:** See if the interviewees use various applications collaboratively to advance their decision making process. | |
| Examples of applications: Autodesk Revit. Navisworks, Bentley, AutoCad Civil 3D, Tekla, etc | **Score** |
| Apply diverse tools synchronized for maximizing BIM. | A |
| Use some BIM tools which are adequate for the Project. | B |
| Very limited use of BIM tools. | C |
| Mentioned BIM tools but did not know how to use. | D |
| Comment: | |

| 17. Why do you use these particular applications? | |
|---|---|
| **Direction:** See if the interviewees can explain the advantages of various applications they use in terms of getting maximum effectiveness. | **Score** |
| Understand the advantages of the tools and know how to use them for maximum effectiveness. | A |
| Mentioned some benefits of using the tools with first-hand experience. | B |
| Mentioned general advantages of using the tools not related to their experience. | C |
| Use tools as a requirement of a project. | D |
| Comment: | |

| 18. Explain the experience of using the tools that you mentioned. | |
|---|---|
| **Direction:** Quantify the interviewees' experience of tools with benefits. | **Score** |
| Have varied experience using the tools and fully understand the inherent benefits. | A |
| Have some experience but do not fully understand benefits. | B |
| Know about the benefits but no hands-on experience with tools. | C |
| No understanding. | D |
| Comment: | |

## Level of Development (LOD)

The following question is to evaluate the contractors' knowledge of LOD in terms of using BIM.

| 19. How precise is your Level of Development (LOD)? | |
| --- | --- |
| **Direction:** See if the interviewees understand the following. The definition of Level of Development (LOD) was developed by the American Institute of Architects (AIA). According to the AIA document E202, characteristics of model elements of different building systems should be illustrated at different Levels of Development. This clear articulation allows model authors to define what their models can be relied on for, and allows downstream users to clearly understand the usability and the limitations of models they are receiving. | **Score** |
| Understand fully the concept of LOD and the advantages of LOD for projects clearly. | A |
| Explained LOD exactly but did not mention why LOD is applied. | B |
| Mentioned LOD conceptually but did not detail. | C |
| Have no idea about LOD. | D |
| Comment: | |

## Construction Operation Building Information Exchange (COBie)

The following question is to figure out the contractors' usage of COBie data.

| 20. How do you use COBie data? | |
| --- | --- |
| **Direction:** See if the interviewees use COBie data for providing the information of operation, maintenance, and facilities management electronically. | **Score** |
| Use COBie data extensively for maximizing BIM advantages. | A |
| Understand what the advantages using COBie are. | B |
| Use COBie data but only as a requirement for a project. | C |
| Do not use COBie data. | D |
| Comment: | |

**Assessment**

The following question is to figure out the contractors' evaluation for their team performance in terms of using BIM.

| 21. How do you evaluate the overall performance of your BIM team? | |
|---|---|
| **Direction:** See if the interviewees are evaluated by one of these examples and provided feedback. ex) Survey, Assessment, Test, Evaluation report, Evaluation Program, etc. | **Score** |
| Have program for evaluating BIM performance and feedback is encouraged. | A |
| Evaluate the performance properly without advice and critique. | B |
| Cursory evaluation only. | C |
| None. | D |
| Comment: | |

## II. Pre-Design Phase

The following questions are what you want to ask to collect information about the contractors in terms of using BIM in the Pre-Design phase. 6 categories are included in this chapter: Roles and Responsibilities, Data Management, BIM Applications, Model Content & Level of Development (LOD), COBie Data, and Assessment.

### Roles and Responsibilities

The following are questions to figure out the BIM team's organization and strength in terms of using BIM.

| 22. Identify the personnel in the BIM team of your company. | |
|---|---|
| **Direction:** See how well organize interviewee's BIM team in the company. Examples: BIM manager, BIM champion, BIM modeler, BIM consultant, etc. | **Score** |
| Understand fully the definitive roles and responsibilities of BIM team members. | A |
| Able to identify some of the roles and responsibilities of BIM team members. | B |
| General idea of the roles and responsibilities of BIM team members. | C |
| Have no idea. | D |
| Comment: | |

| 23. What is the strength of your BIM team? | |
|---|---|
| **Direction:** See if the interviewees explain the strength of their team in terms of BIM. Experience, BIM application skills, leadership, communication skill, etc. | **Score** |
| Explained several BIM capabilities with extensive experience. | A |
| Explained some abilities of BIM. Just adequate to work. | B |
| Mentioned one skill with detail. But not enough to owner's expectation. | C |
| Mentioned general idea of BIM without details. | D |
| Comment: | |

**Data Management**

The following question is to figure out the contractors' responsibilities for managing data and Information in terms of using BIM.

| 24. Who will be responsible for updating and recording the information in the Pre-design phase? | |
|---|---|
| **Direction:** See if the team members have allocated the responsibilities for information management and treat the data with high priority. | **Score** |
| Team members charged with responsibility for updating and recording the data and treated with highest priority. | A |
| One experienced individual responsible for updates. | B |
| Responsibility is allocated in an ad hoc manner. | C |
| Unable to define clearly. | D |
| Comment: | |

**BIM Applications**

The following are questions to evaluate the contractors' capabilities and experience of various BIM tools in the Pre-design phase.

| 25. What BIM authoring software do you use for program and space validation in the Pre-design phase? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for program and space validation. | **Score** |
| Have several tools for validating program and space, apply those tools for different cases. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for data analysis. | D |
| Comment: | |

| 26. How do you use BIM to create the surveying deliverables? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for surveying. | **Score** |
| Have several tools for surveying and apply those tools for different cases. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for surveying. | D |
| Comment: | |

| 27. How do you use BIM to achieve quantity information? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for gathering quantity information. | **Score** |
| Have several tools for quantity information. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for quantity take-off. | D |
| Comment: | |

| 28. How do you use BIM to capture target cost? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for capturing target cost. | **Score** |
| Have several tools for target cost and apply those tools for different cases. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for target cost | D |
| Comment: | |

| 29. How do you use BIM to calculate the target schedule? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for calculating the target schedule. | **Score** |
| Have several tools for target schedule and apply those tools for different cases. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for target schedule. | D |
| Comment: | |

| 30. How do you use BIM for Energy analysis? | |
|---|---|
| **Direction:** See if the interviewees have expertise of using BIM applications for Energy analysis. | **Score** |
| Have several tools for energy analysis and apply those tools for different cases. | A |
| Have one tool with expertise for analysis of energy use. | B |
| Have general idea about tools but do not use. | C |
| Do not use BIM for energy analysis. | D |
| Comment: | |

## Model Content & Level of Development (LOD)

The following are questions to assess the contractors' knowledge of model requirements with LOD in the Pre-design phase and usage of historical data in terms of using BIM.

| 31. Describe the requirements of model content with LOD in the Pre-design phase. | |
|---|---|
| **Direction:** See if the interviewees understand the following. According to AIA Document E202, **LOD 100** is "The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200." Models include elements such as **1)** Masses and are used for preliminary studies, **2)** overall building massing indicative of area, **3)** height, **4)** volume, **5)** location and **6)** orientation | **Score** |
| Understand the requirements of LOD clearly with extensive knowledge. | A |
| Explained LOD exactly but did not mention why LOD is applied. | B |
| Mentioned LOD conceptually but did not detail. | C |
| Have no idea about LOD in this phase. | D |
| Comment: | |

| 32. How much historical data do you apply to a new project? | |
|---|---|
| **Direction:** See how much historical data is used for a project. The greater the amount of available historical data, the better the ability of the company to design and construct for efficiency. | **Score** |
| Have large quantity of historical data which is rigorously applied on a new project. | A |
| Apply historical data for some part of a new project. | B |
| Have limited historical data but not enough to be applied. | C |
| Do not have enough experience. | D |
| Comment: | |

| 33. How have you recorded the historical data? | |
|---|---|
| **Direction:** See if the interviewees manage the historical data well with high protection. | **Score** |
| Systematic recording and management of the historical data with high protection and high priority. | A |
| Store the historical data on a common server, but minimal management of the data. | B |
| Manage by a single team member. | C |
| No management of the historical data. | D |
| Comment: | |

| 34. What benefits have you realized through the application of historical data? | |
|---|---|
| **Direction:** See if the interviewees received various benefits from previous projects in terms of using historical data. | **Score** |
| Have achieved significant advantage from using historical data and encourage using the data for new projects. | A |
| Have achieved some benefits from the use of historical data. | B |
| Know general advantages of using historical data but did not notice any advantage from their experience. | C |
| Have no idea. | D |
| Comment: | |

**COBie Data**

The following question is to figure out the contractors' knowledge of COBie data in the Pre-design phase.

| 35. What COBie data should be provided in the Pre-design phase? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Contact: Project team members (all fields)<br>- Facility: Facility(ies) referenced in the file (all fields)<br>- Floor: Description of vertical levels (all fields)<br>- Space: Spaces referenced in a project (all fields)<br>- Zone (all fields) | **Score** |
| Understand almost all contents with expertise. | A |
| Mentioned several items but not in detail. | B |
| Explained conceptual idea about COBie in this phase. | C |
| Have no idea. | D |
| Comment: | |

**Assessment for Pre-design Phase**

The following question is to figure out how evaluate team performance in terms of using BIM.

| 36. How do you evaluate the performance of BIM in the Pre-design phase? | |
|---|---|
| **Direction:** See if the interviewees are evaluated in their performance systematically in this phase for better performance. | **Score** |
| Detailed and systematic programs for evaluation with feedback. | A |
| Have a specific evaluation tool in the company. | B |
| Have cursory assessment. | C |
| No performance evaluation. | D |
| Comment: | |

## III. Design Phase

The following questions are what you want to ask to collect information about the contractors in terms of using BIM in the Design phase. 7 categories are included in this chapter: Roles and Responsibilities, Data Management, BIM Applications, Model Content & Level of Development (LOD), Clash Detection, COBie Data, and Assessment.

### Roles and Responsibilities

The following are questions to figure out the contractors' idea of the roles and responsibilities of BIM managers in terms of using BIM.

| 37. What are the roles and responsibilities of BIM managers on the design team? | |
|---|---|
| **Direction:** See if the interviewees understand the following.<br>The design team BIM manager shall be assigned an individual who has sufficient BIM experience for the size and complexity of the project, relevant proficiency in the proposed BIM authoring and coordination software. | **Score** |
| Understand fully the roles and responsibilities of BIM managers. | A |
| Explained the roles and responsibilities of BIM managers conceptually. | B |
| General idea of the roles and responsibilities of BIM managers. | C |
| Have no idea. | D |
| Comment: | |

### Data Management

The following are questions to figure out the contractors' knowledge of BIM Management Plan (BMP) and responsibilities for managing data in terms of using BIM.

| 38. Who will be responsible for managing the information in the Design phase? | |
|---|---|
| **Direction:** See if the team members have allocated the responsibilities for information management and treat the data with high priority. | **Score** |
| Allocated between members and treated with high priority. | A |
| One experienced individual responsible for updates. | B |
| Responsibility is allocated in an ad hoc manner. | C |
| Have no idea. | D |
| Comment: | |

| 39. What should be addressed in the Design BIM Management Plan (BMP)? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Project acquisition strategy (DBB, DB, IDC)<br>- Overall plan for achieving VA BIM requirements<br>- Strategy for hosting, transfer, and access of data<br>- Animations/graphic showing major building equipment for operations, repair, maintenance, replacement<br>- BIM Software<br>- Energy modeling strategies<br>- Project Schedule<br>- File formats<br>- Strategy for COBIE integration<br>- Documentation of any proposed deviation from VA BIM Standards for VA approval<br>- Legal status of the Design Model<br>- Strategy for updating and coordinating changes during construction into the final BIM model deliverables files<br>- BIM qualifications, experience, and contact information | **Score** |
| Have direct and expert knowledge of BMP | A |
| Mentioned minimum BMP | B |
| Mentioned general execution plan not related to BMP | C |
| Have no idea about BMP | D |
| Comment: | |

## BIM Applications

The following are questions to evaluate the contractors' capabilities and experience of various BIM tools in the Design phase.

| 40. What BIM authoring software do you use to design in the Design phase? | |
|---|---|
| **Direction:** See if the interviewees use several BIM tools with expertise for design. | **Score** |
| Have various tools for design and apply those tools for different cases. | A |
| Have some tools with expertise. | B |
| Have one tool with adequate knowledge. | C |
| Have general knowledge about BIM tools but do not use. | D |
| Comment: | |

**41. How do you use BIM to support comparative Quantity analysis?**

| Direction: See if the interviewees use several BIM tools with expertise for comparative quantity analysis. | Score |
|---|---|
| Have several tools to compare quantity analysis and apply those tools for different items. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for quantity analysis. | D |
| Comment: | |

**42. How do you use BIM to develop comparative costs analysis?**

| Direction: See if the interviewees use several BIM tools with expertise for comparative costs analysis. | Score |
|---|---|
| Have several tools for costs analysis and apply dedicated tools for different items. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for costs analysis. | D |
| Comment: | |

**43. How do you use BIM to promote comparative energy analysis?**

| Direction: See if the interviewees use several BIM tools with expertise for comparative energy analysis. | Score |
|---|---|
| Have several tools for energy analysis and apply those tools for different items. | A |
| Have one tool with expertise. | B |
| Have knowledge about tools but do not use. | C |
| Do not use BIM for energy analysis. | D |
| Comment: | |

## Model Content & Level of Development (LOD)

The following are questions to assess the contractors' knowledge of model requirements with LOD in the Design phase.

| 44. Describe the requirements of model content with LOD in the Design phase. | |
|---|---|
| **Direction:** See if the interviewees understand the following. According to AIA Document E202, **LOD 200** is "The Model Element is graphically represented within the Model as **1)** a generic system, **2)** object, or assembly with approximate **3)** quantities, **4)** size, **5)** shape, **6)** location, and **7)** orientation. Non-graphic information may also be attached to the Model Element." | **Score** |
| Understand the requirements of model in LOD 200 clearly with extensive knowledge. | A |
| Explained LOD 200 partially and mentioned some requirements of model. | B |
| Mentioned LOD 200 conceptually but not in detail. | C |
| Have no idea about LOD in this phase. | D |
| Comment: | |

| 45. Who will be responsible for updating and recording the model files in the Design phase? | |
|---|---|
| **Direction:** See who has responsibility for managing and updating the model files. | **Score** |
| Manage the data systematically and distribute responsibilities to team members. | A |
| Only design BIM manager and BIM modeler manage the file. | B |
| Responsibility is allocated in an ad hoc manner. | C |
| Have no idea. | D |
| Comment: | |

## Clash Detection

The following are questions to assess the design team's capability of detecting the clashes and knowledge of revision control in the Design phase.

| 46. How do you use BIM for Clash Detection in the Design phase? | |
|---|---|
| **Direction:** See if the interviewees find the clashes with Architectural Systems, Structural Systems, HVAC Systems, Plumbing Systems, Fire Protection Systems, Electrical Systems, and Electronics Systems. | **Score** |
| Use several tools to find different collisions with extensive experience. | A |
| Find some clashes with limited tools. | B |
| Mentioned the idea about Clash Detection conceptually. | C |
| Do not use BIM for Clash Detection. | D |
| Comment: | |

| 47. Do you understand the process of Clash Detection and Design Review? | |
|---|---|
| **Direction:** See if the interviewees cover the process of Clash Detection.<br>The following is a sample process of tracking collision issues.<br>1. Assemble Design BIMs<br>2. Clash Detection & Visual Inspection<br>3. Create Viewpoint<br>4. Team review of all issues<br>5. Team members resolve issues<br>6. Re-assemble revised BIMs<br>7. Re-Clash Detection & Visual Inspection<br>8. Coordination Complete | **Score** |
| Explained the process with extensive experience and have their procedure for maximizing BIM. | A |
| Understand the process clearly but have limited experience. | B |
| Mentioned general idea of the process without details. | C |
| Have no idea. | D |
| Comment: | |

<br>

| 48. What is the procedure for revision of collision? | |
|---|---|
| **Direction:** See if the interviewees understand the procedure for revision of collision with expert knowledge. | **Score** |
| Explained the process for revision with definitive expertise. | A |
| Mentioned the process but could not offer details. | B |
| Mentioned conceptual idea of the process. | C |
| Have no idea. | D |
| Comment: | |

<br>

| 49. How often do you check interference in the Design phase? | Score |
|---|---|
| In real-time when the design is changed. | A |
| Check interferences occasionally. | B |
| Just one time when the design is finished. | C |
| None. | D |
| Comment: | |

**COBie Data**

The following question is to figure out the contractors' knowledge of COBie data in the Design phase.

| 50. What COBie data should be provided in the Design phase? | |
|---|---|
| **Direction:** See if the interviewees cover the following items. <br> - Contact (all fields) <br> - Facility (all fields) <br> - Floor (all fields) <br> - Space (all fields) <br> - Zone (all fields) <br> - Type (Name, CreatedBy, CreatedOn, Category, Description, AssetType, ExtSystem, ExtObject, ExtIdentifier) <br> - Component (Name, CreatedBy, CreatedOn, TypeName, Space, Description, ExtSystem, ExtObject, ExtIdentifier) <br> - System (all fields) | **Score** |
| Understand almost all contents with expertise. | A |
| Mentioned several items but not in detail. | B |
| Explained conceptual idea about COBie in this phase. | C |
| Have no idea. | D |
| Comment: | |

**Assessment for Design Team**

The following question is to figure out the design team's evaluation for their performance in terms of using BIM.

| 51. How do you evaluate the performance of BIM in the Design phase? | |
|---|---|
| **Direction:** See if the interviewees are evaluated in their performance systematically in this phase for better performance. | **Score** |
| Detailed and systematic programs for evaluation with feedback. | A |
| Have a specific evaluation tool in the company. | B |
| Have cursory assessment. | C |
| No performance evaluation. | D |
| Comment: | |

## IV. Construction Phase

The following questions are what you want to ask to collect information about the contractors in terms of using BIM in the Construction phase. 7 categories are included in this chapter: Roles and Responsibilities, Data Management, BIM Applications, Model Content & Level of Development (LOD), Clash Detection, COBie Data, and Assessment.

### Roles and Responsibilities

The following are questions to figure out the contractors' idea of the roles and responsibilities of BIM managers in terms of using BIM.

| 52. What are the roles and responsibilities of the Construction BIM managers? | |
|---|---|
| **Direction:** See if the interviewees understand the following. | |
| The construction BIM manager shall have the appropriate level of relevant BIM experience required for the project complexity and acquisition delivery strategy. | **Score** |
| Understand fully the roles and responsibilities of BIM managers. | A |
| Explained the roles and responsibilities of BIM managers conceptually. | B |
| General idea of the roles and responsibilities of BIM managers. | C |
| Have no idea. | D |
| Comment: | |

| 53. How often do you usually do a coordination meeting with the design team and the construction team? | |
|---|---|
| **Direction:** See how often the interviewees have a coordination meeting. | **Score** |
| More than 1 time per week. | A |
| Minimum 1 time bi-weekly. | B |
| Have the meeting when it is needed. | C |
| Have no idea. | D |
| Comment: | |

| 54. What do you do in a coordination meeting? What is the purpose of the meeting? | |
|---|---|
| **Direction:** See if the interviewees understand the following. | |
| - Facilitate BIM design review | |
| - Clash detection/coordination | |
| - Discuss technical discipline coordination issues using BIM models | **Score** |
| Understand agenda and purpose of the meeting clearly. | A |
| Mentioned several items but not in detail. | B |
| Explained conceptual idea about the meeting. | C |
| Have no idea. | D |
| Comment: | |

## Data Management

The following are questions to evaluate the contractors' knowledge of BIM Management Plan (BMP) and responsibilities for managing data in terms of using BIM.

| 55. What should be addressed in the Construction BIM Management Plan (BMP)? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Project acquisition strategy (DBB, DB, IDC)<br>- Strategy for compliance with VA BIM Project requirement<br>- Construction analysis with BIM<br>- Animation/graphic showing installed major building equipment<br>- Strategy for software compatibility, file formats, hosting, transfer, and access of data between trades.<br>- Trade coordination strategy (clash detection)<br>- Usage of digital fabrication<br>- Updating as-built conditions in As-built/Record BIM<br>- Utilization of 4D scheduling and construction sequencing technology<br>- Identification of the legal status of the Design Model to construction<br>- List of sub-contractors using digital fabrication<br>- BIM software<br>- Strategy to assure all trade information is modeled and coordinated<br>- Proposed sub-contractor BIM workshops and training integrated into project schedule<br>- Strategy for COBIE integration and submittals<br>- Documentation of any proposed deviation from VA BIM Standards for VA Approval<br>- Strategy for updating and coordinating changes during construction into the final BIM deliverable<br>- BIM qualifications, experience, and contact information | **Score** |
| Have direct and expert knowledge of BMP. | A |
| Mentioned minimum BMP with limited experience. | B |
| Mentioned a general execution plan not related to BMP. | C |
| Have no idea about BMP. | D |
| Comment: | |

| 56. Who will be responsible for managing the information in the Construction phase? | |
|---|---|
| **Direction:** See if the team members have allocated the responsibilities for information management and treat the data with highest priority. | **Score** |
| Allocated between members and treated with highest priority. | A |
| One experienced individual responsible for updates. | B |
| Responsibility is allocated in an ad hoc manner. | C |
| Have no idea. | D |
| Comment: | |

| 57. How do you use BIM to track and update the information? | |
|---|---|
| **Direction:** See if the interviewees track files with high priority. | **Score** |
| Use BIM for tracking and updating files to the fullest. | A |
| Use BIM for tracking and updating data but it is not highest priority. | B |
| Track and record only some significant information through BIM. | C |
| No BIM uses for tracking and updating files. | D |
| Comment: | |

## BIM Applications

The following question is to evaluate the contractors' capabilities of BIM applications in the Construction phase.

| 58. How do you use BIM to manage the project schedule? | |
|---|---|
| **Direction:** See if the interviewees manage the schedule with BIM application. | **Score** |
| Use BIM for managing and updating the schedule to the fullest. | A |
| Use BIM for managing the schedule but it is not highest priority. | B |
| Use BIM for the scheduling only with significant problem. | C |
| No BIM uses for managing the schedule. | D |
| Comment: | |

## Model Content & Level of Development (LOD)

The following are questions to figure out the contractors' knowledge of model requirements with LOD in the Construction phase.

| 59. What models will be included in the Construction phase? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>**1)** Architectural Model, **2)** Structural Model, **3)** Drywall/Framing Mode, **4)** Concrete Model, **5)** Mechanical Model, **6)** Electrical Model, **7)** Plumbing Model, **8)** Sprinkler Model, **9)** Process Piping Model, **10)** Control Model, **11)** Fabrication models, **12)** Coordination models, or **13)** Shop drawing models. | **Score** |
| Understand almost all models that should be include in this phase and why its benefits. | A |
| Mentioned some models with detail. | B |
| Explained some models conceptually but not in detail. | C |
| Have no idea. | D |
| Comment: | |

**60. Describe the requirements of model content with LOD in the Construction phase.**

| Direction: See if the interviewees understand the following. According to AIA Document E202, **LOD 400** is "The Model Element is graphically represented within the Model as **1)** a specific system, **2)** object or assembly in terms of **3)** size, **4)** shape, **5)** location, **6)** quantity, and **7)** orientation with detailing, **8)** fabrication, **9)** assembly, and **10)** installation information." Non-geometric information such as **11)** text, **12)** dimension, **13)** notes, **14)** 2D details, etc., may also be attached to Model Elements. | Score |
|---|---|
| Understand the requirements of LOD 400 clearly with extensive knowledge. | A |
| Explained LOD 400 partially and mentioned some requirements of model. | B |
| Mentioned LOD 400 conceptually but not in detail. | C |
| Have no idea about LOD in this phase. | D |
| Comment: | |

**61. Who will be responsible for updating and recording the Model files in the Construction phase?**

| Direction: See who has responsibility for managing and updating the model files. | Score |
|---|---|
| Update the data systematically and distribute responsibilities to team members. | A |
| Only design BIM manager and BIM modeler manage the file. | B |
| Responsibility is allocated in an ad hoc manner. | C |
| Have no idea. | D |
| Comment: | |

**Clash Detection**

The following are questions to figure out the construction team's capability of detecting the clashes and knowledge of revision control in the Construction phase.

**62. How do you use BIM for Clash detection in the Construction phase?**

| Direction: See if the interviewees use BIM applications for clash detection with expertise and revisit changes in real time. | Score |
|---|---|
| Use several tools to find different clashes between building information model and facilities under construction with expertise. Update clashes in real time. | A |
| Use limited tools to find clashes in the field but could not update them in real time. | B |
| Mentioned conceptual idea about Clash Detection. | C |
| Do not use BIM for Clash Detection in the field. | D |
| Comment: | |

| 63. How often do you check interference in the Construction phase? | |
|---|---|
| **Direction:** See if the interviewees check clashes with BIM applications in real time. | **Score** |
| Investigate clashes In real-time during construction. | A |
| Check interferences between model and facilities under construction occasionally. | B |
| Check collision only when the design is changed. | C |
| Do not use BIM for clash detection during construction. | D |
| Comment: | |

| 64. What should be addressed in collision reports? | |
|---|---|
| **Direction:** See if the interviewees cover the following components.<br>- Description of Collision Report<br>- Date of Collision Report Run<br>- List of all Collisions detected<br>- Collisions' status<br>- Collisions' proposed solution | **Score** |
| Mentioned most contents of collision reports with expertise and experience. | A |
| Mentioned some components related to collision reports. | B |
| Know the concept of collision reports but not in detail. | C |
| Have no idea. | D |
| Comment: | |

**COBie Data**

The following question is to figure out the contractors' knowledge of COBie data in the Construction phase.

| 65. What COBie data should be provided in the Construction phase? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Contact (all fields)<br>- Facility (all fields)<br>- Floor (all fields)<br>- Space (all fields)<br>- Zone (all fields)<br>- Type (all fields)<br>- Component (all fields)<br>- System (all fields)<br>- Spare (all fields)<br>- Resource (all fields)<br>- Job (all fields)<br>- Document-for those documents that are assignable to an associated BIM element or system (installed equipment documentation)<br>- Attribute (all fields, manufacturer-provided attributes) | **Score** |
| Understand almost all contents with expertise. | A |
| Mentioned several items but not in detail. | B |
| Explained conceptual idea about COBie in this phase. | C |
| Have no idea. | D |
| Comment: | |

**Assessment for Construction Team**

The following question is to figure out the construction team's evaluation for their performance in terms of using BIM.

| 66. How do you evaluate the performance of BIM in the Construction phase? | |
|---|---|
| **Direction:** See if the interviewees are evaluated in their performance systematically in this phase for better performance. | **Score** |
| Detailed and systematic programs for evaluation with feedback. | A |
| Have a specific evaluation tool in the company. | B |
| Have cursory assessment. | C |
| No performance evaluation. | D |
| Comment: | |

## V. Post-Construction Phase

The following questions are what you want to ask to collect information about the contractors in terms of using BIM in the Post-construction phase. 6 categories are included in this chapter: Deliverable, Data Management, BIM Applications, Model Content & Level of Development (LOD), COBie Data, and Assessment.

### Deliverables

The following are questions to figure out the contractors' knowledge of closeout and Operation & Maintenance (O&M) manuals in terms of using BIM.

| 67. What should be provided for closeout from Design Team? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Concurrent As-Built Modes<br>- Record Document Project Drawings (.pdf)<br>- Record Document Drawings consisting of two sets of full size drawings, Two half size sets<br>- COBie data | **Score** |
| Mentioned all contents with expertise. | A |
| Mentioned some items with details. | B |
| Explained some contents not related to closeout. | C |
| Have no idea. | D |
| Comment: | |

| 68. What should be provided for closeout from Contractor? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- All As-Built Coordination and Fabrication Models<br>- Scanned Field Set Drawings (.pdf)<br>- O&M manuals (.pdf)<br>- As-built COBie Data (with O&M document links) | **Score** |
| Mentioned all contents with expertise. | A |
| Mentioned some items with details. | B |
| Explained some contents not related to closeout. | C |
| Have no idea. | D |
| Comment: | |

| 69. What should be included in Operations & Maintenance (O&M) Manuals? | |
|---|---|
| **Direction:** See if the interviewees cover the following contents.<br>- The make, model and serial number of each piece of installed equipment.<br>- The location of any equipment installed in the building.<br>- Manufacturer's documents including cut sheets, installation instructions, and recommend maintenance tasks, testing or other reports.<br>- O&M manual documents should be independently linked to components and systems within the COBie deliverable. | **Score** |
| Mentioned almost all contents with expert knowledge. | A |
| Explained several items in these contents. | B |
| Mentioned a general idea of O&M Manuals. | C |
| Have no idea about O&M Manuals. | D |
| Comment: | |

| 70. What should be provided in a contractor record document Deliverable? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- BIM Proficiency Matrix<br>- BIM Execution Plan<br>- Owner's Architectural Floor Plan (Interim As-Built Drawing & Interim Record Drawing)<br>- Telecommunications Drawings (Interim As-Built Drawing & Interim Record Drawing)<br>- As-Built Field Data Set Scans<br>- Operations & Maintenance Manuals (O&M)<br>- COBie Construction Data<br>- As-Built CAD Drawings by Contractor<br>- As-Built BIM Model(s) by Contractor<br>- As-Built BIM Model(s) by A/E<br>- Record Document CAD Drawings by A/E | **Score** |
| Mentioned almost all contents with expertise. | A |
| Mentioned some items with details. | B |
| Explained some contents not related to contractor record documents. | C |
| Have no idea. | D |
| Comment: | |

**Data Management**

The following are questions to evaluate the contractors' capabilities of tracking changes and protection of the data and files in terms of using BIM.

| 71. Can you specify precisely what information was changed from the "as-designed" information to "as-built" information? | |
|---|---|
| **Direction:** See if the interviewees can provide all changes with BIM. | **Score** |
| Provide all changes in the construction with BIM. | A |
| Provide some important changes with BIM data but not for all changes. | B |
| Provide the significant changes only with electronic files. | C |
| Provide all changes with paper work only. | D |
| Comment: | |

| 72. How do you protect Central model file from being copied or moved? | |
|---|---|
| **Direction:** See if the interviewees store and manage the central model file with protection. | **Score** |
| Control and manage BIM data fully and systematically with high priority. | A |
| Access and record the data only through authorized personnel. | B |
| Some protection and security for the data in the computer. | C |
| Zero protection. | D |
| Comment: | |

**BIM Applications**

The following are questions to assess the contractors' capabilities of various BIM tools for Facilities Management (FM) and management of FM data.

| 73. What BIM applications do you use for Facilities Management (FM)? | |
|---|---|
| **Direction:** See if the interviewees treat the following applications. Examples: Bentley Facilities, Vintocon ArchiFM, Onuma System, EcoDomus, etc. | **Score** |
| Have several tools for FM and apply those tools for different types. | A |
| Have one tool with expertise. | B |
| Have conceptual knowledge about tools but do not use. | C |
| Do not use BIM tool for FM. | D |
| Comment: | |

| 74. Do you have a dedicated system for the Facilities Management (FM) data? | |
|---|---|
| **Direction:** See how the interviewees control and store the information for FM. | **Score** |
| Have a proprietary system or server for facilities management. | A |
| Store FM data but not on a server. | B |
| Manage FM data on isolated independent drives, available only upon formal request. | C |
| No management of FM data. | D |
| Comment: | |

## Model Content & Level of Development (LOD)

The following are questions to figure out the contractors' knowledge of model requirements with LOD in the Post-construction Phase.

| 75. What LOD should be provided in the "as-built" model? | |
|---|---|
| **Direction:** See if the interviewees understand the following. According to AIA Document E202, **LOD 500** is "The Model Element is a field verified representation in terms of **1)** size, **2)** shape, **3)** location, **4)** quantity, and **5)** orientation." Non-geometric or physical attributes are included as **6)** parameters to the geometric shape. At this level, the model is capable to be used for operations and maintenance. | **Score** |
| Understand the requirements of LOD 500 clearly with extensive knowledge. | A |
| Explained LOD 500 partially and mentioned some requirements of Model. | B |
| Mentioned LOD 500 conceptually but not in detail. | C |
| Have no idea about LOD in this phase. | D |
| Comment: | |

| 76. Do you assess the correctness of Building Model for different uses? | |
|---|---|
| **Direction:** See if the interviewees assess the correctness of a model after the completion of a project. | **Score** |
| Assess correctness of model exhaustively. | A |
| Assess the model adequately but not in detail. | B |
| Check some items superficially. | C |
| No assessment for model. | D |
| Comment: | |

| 77. What types should be assessed for accuracy of Building Model? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>**1)** Walls, **2)** Doors, **3)** Slabs, **4)** Windows, **5)** Curtain wall and glazing, **6)** Equipment,<br>**7)** Columns, and **8)** Space Objects, **9)** etc. | **Score** |
| Explained almost all types with proper reasons. | A |
| Mentioned some types with adequate reasons. | B |
| Mentioned limited items but not in detail. | C |
| Have a conceptual idea about model assessment. | D |
| Comment: | |

## COBie Data

The following question is to figure out the contractors' understanding about requirements of COBie data for Facilities Management (FM).

| 78. For long term Facilities Management Goals, what minimum COBie data should be provided by general contractor? | |
|---|---|
| **Direction:** See if the interviewees cover the following items.<br>- Contact (all fields)<br>- Facility (all fields)<br>- Floor (all fields)<br>- Space (all fields)<br>- Zone (all fields)<br>- Type (all fields)<br>- Component (all fields)<br>- System (all fields)<br>- Spare (all fields)<br>- Resource (all fields)<br>- Job (all fields)<br>- Installation: Location and serial no. of installed components<br>- Manual: Instruction manuals for sets of/or components<br>- Warranty: Warranty information for sets of/or components<br>- Document-for those documents that are assignable to an associated BIM element or system (installed equipment documentation)<br>- Attribute (all fields, manufacturer-provided attributes) | **Score** |
| Understand almost all contents with expertise. | A |
| Mentioned several items but not in detail. | B |
| Explained conceptual idea about COBie. | C |
| Have no idea. | D |
| Comment: | |

### Assessment for Overall Project

The following are questions to figure out the evaluation for labors' proficiency and the success of the project in terms of using BIM.

| 79. How do you assess the labor's BIM proficiency after completion of a project? | |
|---|---|
| **Direction:** See if the interviewees are evaluated in their performance systematically for better performance. | **Score** |
| Detailed and systematic programs for evaluation with feedback. | A |
| Have a specific evaluation tool in the company. | B |
| Have cursory assessment. | C |
| No performance evaluation. | D |
| Comment: | |

| 80. How do you rate the success of the BIM project? | |
|---|---|
| **Direction:** See if the interviewees rate the success of their projects with multiple factors. | **Score** |
| Assess the project with multiple factors such as quality, cost, schedule, etc. | A |
| Have a specific evaluation only with one factor. | B |
| Have cursory assessment. | C |
| Have no idea. | D |
| Comment: | |

**INTERVIEW-1**

*Interviewer*

Do you think this questionnaire is applicable?

*Interviewee-1*

"Here is the high level of challenge. I don't think owners know enough about BIM to effectively evaluate even with the questionnaire. I've got some high level of concerns about whether it is really an achievable objective. Let's assume and instead that we can get a questionnaire that somebody know almost nothing about BIM clients. You can ask some questions and actually get some positive information about contractor but you worked wonderfully hard to challenge yourself. Because the problem is that you need to be more technical. I think than you've gotten the data."

*Interviewer*

Yes, this questionnaire is a draft of the questionnaire. We plan to develop more and more. Also, owners are not going to use all questions in the questionnaire. They will select the questions that they wish to know about contractors.

*Interviewee-1*

"I understand. That would be helpful. I did not realize that. I am going to give some contradictory information. Some of them, I think, in this direction area, they really need

more technical information to evaluate the question. Maybe add some examples of sample answers or things like that will help them go through and kind of understand...."

LOD question:

"Best possible answer is follow the BIM execution Document. Because project to project, what is the requirements in given scope, needs to be different. And need to be more narrow down little bit and ask questions specifically about the different levels of detail. Ideally, we tend to be more flexible."

Energy analysis question:

"Not really appropriate for a contractor in the US. In the US, General Contractors don't do this. This question would be good for a MEP engineer or a sustainability consultant but not general contractors are going to generally speaking look at your cross side. They would say, I don't know why you are asking me this question."

COBie data question:

"To some degree, it really depends on BIM execution document. I am torn on this. Because these are the real basics for pre-design but probably some other fields they are missing....this is extremely technical for an owner. And the answer needs to be relatively technical. These different things of contract such as BBD, BD, GMP, etc. are going to impact when the contractor comes on board. Some of these factors may or may not be relevant. I can even ask "why is it important for them to know this?" Because in the Pre-design phase, they don't ever work on projects at this phase."

BIM managers' roles and responsibilities question:

"It really depends on the BIM execution document. And it is such an open-ended question right now. I think the better solution is to maybe to narrow the question. So, you know what you could do is to make it more direct as you can say if you were responsible for managing BIM on the project how would you do that? Right? Because then you are removing the other possibilities you are asking them very direct question. If you, Mr. Contractor, manage the BIM, how would you do it? But that is still a broad question so that is going to be very difficult to provide answers. You may even need to narrow it further.

How often do you Coordination meeting question:

"This is really good question because of this is very specific. But now you need evaluation. And again the challenge with this surveys and this is the one of those things right here. A lot of jobs doing it more than one time per week could be a waste of time. So why it has higher score than one time biweekly. Depending on the jobs and works, we can optimize the schedule for the meeting. I don't know the matrix should be how often you meet. I feel like the matrix should be do you have a clear plan that is well developed.

I look for the criteria as an owner. B would be "has a clear plan for coordination". A score would be "Has a clear plan for coordination with construction schedule". If the interviewer responses back we like to do is look at our construction schedule and really work out and necessary to meet the deliverable on deadline requirement for that schedule and we build our coordination schedule based on the construction schedule. That's the best possible answer.

So again, I think the evaluation criteria and kind of that evaluate narrative for evaluation that I think really important for somebody specific questions cause it's like you 've got very carefully work that lines between too technical and too prescriptive vs. not technical enough, not measurable."

How would you define BIM proficiency question:

"How do you measure that answer? If you ask the contractor that..you know.. How does the client make this evaluation based on that answer? People have experience and repeating successful experience utilizing BIM on actual projects. That will be my answer. How does a client judge that? Somebody can say those words even they have not done project before. Question like this one is really tough one."

What are you doing in coordination meeting? What is the purpose of the meeting? question:

"The coordination meetings really issued only being to review and resolve the multi trade issues or the issues do not have clear resolutions. The coordination meetings are used to identify and resolve issues. That to me is like baseline. That would be C or B. The coordination meetings are used to resolve issues previous identified might be B or A. you are trying to help clients understand like what is the best process of the meeting. If they do understand the process then they should know that's the waste of everybody's time to run the clash detective in the meeting."

BEP, BMP question:

"To this question, to fully answer this question, as evidence by the numerous bullet points, to answer this question well, will take 15-20 minutes. So it's probably too broad

question for an interview. So, what it maybe is you need to ask for each one of these things and give some evaluation criteria for each one of those things. So maybe that should be: Do you think that the project acquisition strategy should be covered in BIM execution plan or do you think it is relevant to BIM execution plan? And then the answers would be clear. If they are saying "No," they are idiots because… of course it is extremely important. If they have specific answer like "Yes, it is Design Bid Built, these are the challenges that we typically see, blur blur….that's holy crap. We might have an hour for the entire interview and usually the client is willing to give us about 5minutes to take about this stuff. The question seems to be very specific, and you can answer for the question effectively. But I love the question. It is a great question. And these are all very good things to talk about. I mean all they are critical things to include. I think this question is not for the contractor. That is the question for the owner. This question word for word something I ask most clients in our interviews. If somebody asked this, I will go, "It is your decision." I would change this question to "If you are going to manage the information in the construction phase, how would you do it?"

For the evaluation criteria, maybe B is fair. Maybe that there is a Baseline needs to get established.  Minimum requirement is B. That is the good thing in general, I think  B it is kind like you always want some ability people to exceed so that is why A as for but you know you want what is kind of industry standards is this that should be a "B". And let's have a little room for an improvement. Somebody that is really doing amazing work is going to be able to get an "A" and nobody else will. Because you also don't want to do

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is turn clients and everybody gets an A on everything. You have no basis for comparison. Everybody gets 100 grades.

Getting back to general level, it is going to be extremely difficult thing to do. Because somebody has zero technical knowledge to evaluate the capabilities of companies. While talking to people at that company who know almost nothing about that fame because that is the other challenge you ran into this issue where the people who go to the interviews are very rarely know this stuff. I go to interviews where the clients really care about BIM. Because of that way, they ask the questions.

It maybe has a value to think of these questions kind of as falling into two categories. One of them being interview questions and one of them being technical questions. The difference being interview question might be a question about kind of overall strategy, direction, how these things are achieved, how they fit in the project schedule, how your company utilizes the models for the scheduling etc. That is a pretty high level of question. On the other hand, Technical questions talk about what the strategy is for linking tasks in a schedule to model elements. That is really great technical question that most of people who go to the interviews are completely incapable to answer intelligently and shouldn't need to be able to answer intelligently if that makes sense. It is not an important for operation manager to understand how to link model objects to tasks. So, that is not a good interview question. But if you were an owner who wants to pre-qualify people on BIM, as supposed to ask the question in the interview, that would be a fantastic question. If somebody says "Well, what we do is use a work break down structure to classify all our tasks and our schedule, and we related that back our uni-

format structure in our modeling, our model authorized application which is related to that, so we can start to automatically group and assign objects to tasks but we haven't to manually link each one", that is an "A". Because not only they know how to link the tasks, but also they know how to automate task linking processes. That can be more efficient. Because I think that allows you in some cases to get over this kind of conundrum in the interview where you are a non-technical person is asking technical questions of a non-technical person. And it is like that is really tough bridge across. There is going to be so much noise in that process. The company that has a whole really good tool with technologies but the guy who has the interview does a bad job answering the questions and that company gets really bad score even though they are the most capable company because the other company does a better job answering because they brought their one guy who knows how to answer the questions well. So they are scored really well and they are selected. The client has really bad experience because that guy is 100% committed to another project and never shows up on your job. So I think that is not to say that interview questions are valuable cause they are. But cause shows like did you think it is important enough to bring right person on your interview team.

I think this questionnaire is valuable to somebody who wants to see how much they care about BIM. I am going to describe how much they care about BIM. "I hear that everybody else is doing it and it's really important. So, I want to make sure it's done on my job." Like That's who needs this.

Some questions I really don't see a client finding value and asking them in an interview but it is great technical question. I don't find that a lot of people who go to the interviews

are very well positioned to answer the technical question. Also, this is a very difficult thing to analyze effectively from a client standpoint without technical experience."

How often do you check interference question:

"I suggest changing this question to like "what is your plan for checking interference during the construction phase?" And the evaluation criteria is A is "the plan is related to schedule", B is "the plan is clearly defined", C is "the plain is loosely defined", and D is "doesn't have a plan".

You've got to make sure that whatever your evaluation criteria are can be done by a non-technical person, particularly for an interview question. Also, you have to make questions relates to that because you want to give a person answering the question a chance to answer effectively.

It is certainly possible but it is a challenge. I think the key things are like we talked about make sure that the evaluation criteria can be done by a non-technical person. The basis for the evaluation can be clearly and understandably detailed. That's the question has clear relation to that evaluation then let me have to be super obvious. You can ask questions that an owner can realistically evaluate with some minimal assistance from some description. I think those are the questions you should focus it on. I would, personally in my feedback would be that qualitative questions are more important than quantitative questions. I mean I think you are going to have challenge finding many qualitative questions that can be asked in evaluated by a non-technical person. Answer effectively by a non-technical person and the answers were actually be a fairly good representation of this company's BIM capabilities. I think those are kind of your three

things: can this person asked about evaluate, can somebody who is not technical but who works at company it's very good at this so they can answer that question. And then is that answer something that will be representative.

Another way to look at it is you can kind of loosely group questions into three kinds of categories: there is why, how, and what. Why questions are great questions to ask for CEO or the top level of company. Why questions might be relevant here. Kind of why does your company use BIM? You can conceal that at a less broad. What is the value your company receives from using BIM? You are asking why you use BIM. How questions which are kind of more tactical… some more between strategy and tactical which is like what is your strategy for clash detection on the job. That is a very how question, right? You don't have to know how to run Navisworks to answer that question. You just have to understand how the process works. That to me is kind of like that's the most technical you can ask. If you get to what question, that's the people who go to the project interviews aren't usually able to answer that question. And the client is not capable of evaluating whether that answer is good or not. I would say if your focus is interview's questions then you should ignore the technical questions. For example, how do you use BIM to manage the schedule? That's the great how question. That's an easy question to answer and it's an easy question to provide some basic criteria for client to evaluate. If you want to do interview questions, I think that's really narrowing down small group of questions.

I do think it is possible. I think the challenge is finding the direct questions. You are really getting good information. The really interesting thing is that in this case I think

highly technical questions are probably not the right ones to ask. The question about schedule, "how do you use BIM for the project schedule?" That is a fantastic question. That's short and simple. I think you can without the too technical ones you will still have a pretty good set of questions you can work with. The next step is then really kind of modifying the evaluation criteria and question to match and make sure that the evaluation is an evaluation can be made by a non-technical person and then it is not based on some kind of pre drive matric like one time per a week, something like that. I think from there it's kind of giving them the description that additional section which will help them evaluated better. It's certainly accomplishable."

**INTERVIEW-2**

*Interviewer*

Have you taken a look at the questionnaire?

*Interviewee-2*

"Yes, I have looked the questionnaire briefly. And my first impression was it's really overwhelming. But this is very good and very detailed."

*Interviewer*

Do you think this questionnaire is applicable?

*Interviewee-2*

"It is going to be applicable depending on project to project, and the people to people who will be using it. If you give it to people like me, if right now I am working for general contractors. Let's say tomorrow I work for Texas A&M and now I am

interviewing, I may not use it, because I would know what questions I need to ask to my contractor that I am interviewing. And the reality behind that is that I spoke in our office with different people about it. The reality of that is every project is going to be different and every project is going to have own specific challenges. Like for example, we interviewed for the project at Dallas. It was university of Texas. We didn't plan to do for any BIM. These are the capacities doing BIM this is why spectrum of using BIM and technology.

They didn't have to use this guideline because they know exactly what they want to do. So, it depends on a lot projects to projects. It completely depends upon projects at what kind project is and what market is. So, this is good. This is starting point. I think the applicability of this would be more effective if you categorize it in terms of projects, in terms of market, in terms of client type.

There was another thing that came out feel is….There are a lot of questions in here. They are big and not clear. Some questions should broad and general because some are too specific. Just like all of your fingers are not the same. Same way, all the contractors may not be the same. Every contractor uses BIM differently in their own unique way to provide that product to their customers. Being specific is going to confuse them."

*Interviewer*

It means that when the question is broad, they can answer their own abilities. Right?

*Interviewee-2*

"Exactly! So, how do you measure success on their projects? How do you measure success on last BIM project?  Tell me five success things to tangible to the job site. You

gained time for fabrication, you gained the time and installing special system? Did you save money? Did you save schedule time? Did you give additional things to the owner? What are those five things? So, it needs to be relative to that particular project. They don't need to be very specific about it. You need to be relative to that project. And you can be very generic. Just ask how did you measure the success of your last BIM project? What was your last BIM project in health care?

As I said, this is very good. It is applicable but you have got to get wise with it. And... like that how do you use COBie data? Great question. Absolutely applicable to contractors because they don't use COBie data. How do you prepare COBie data? That might be a good question. How do you produce COBie data? What software do you use to produce COBie data? That's a little bit technical but at same time very general.

How much historical data do you apply to a new project? That's a good question. My immediate reaction would be what do you mean by applying historical data? If an owner doesn't understand that question, he or she is not going to ask for it. You can hand over fifty questions to him, but he will ask the question that he himself understands. Also, the directions need to be clear. When I say historical data, it doesn't have to do anything to do with BIM.

This is just an idea. The great idea would be asking a big general question and then having sub-questions for that. Like a sub-set.

To me as a contractor, the pre-design phase and the design phase can be combined into pre-construction phase. I am assuming relevant document for contractors. To me, pre-construction has five big major general questions. And then within the five questions, I

will have sub-questions. So, and the each questions will have two sub questions. And under the two sub questions, you have detail-level questions. So, depending upon what that question is, and how that question is applicable to that owner, he will ask those detail questions. And then he will give those detail answers.

Depending upon the contractors, what contract you are going to give me? Owners set up their requirements. Those are the premises behind. So, you need to be very clear in those questions when you ask them.

Going back to applicability, it is very applicable. Intends to owners give to power so they can ask questions and grade contractors you got a simple though. But the owners don't have any idea about BIM; ironically these questions are too technical so, they are not going to understand these questions.

Those are two challenges that I would say: 1. Questions need to be clear, like a couple of questions. 2. It needs to dump-down to become more generic and then it needs to go into details depending upon the kind of projects, the kind of market, and project delivery methods. Depending upon that, you can pick those sub-questions. And those sub-questions have another list of sub-questions. That would be great idea."

*Interviewer*

Do you think these questions in the questionnaire (guideline) would help owners get what they want?

*Interviewee-2*

"Absolutely. I think if these questions are developed in certain way, owners can use these questions as a way to support their argument. And at the same time, they can use

this questionnaire to really over-complicate their allies by asking something that even they don't understand. I have seen that in the past since I actually worked on the project. The owners had no idea what they wanted to do in BIM. They hired a consultant. The consultant created that bad ass 29 pages BIM document. That was really stupid. It was RFP. We got on board. We did all of that and the owner had no idea. That consultant who created that document was not there anymore. The owner does not know what to do with BIM. They have no idea. We told them the document was really stupid. The morale of this story is owner ended up work that was more complicated and paying for the stuff that they were never going to use. So, they can use that as long as depending upon how owner is knowledgeable in BIM. When contractors see the value and benefit out of it, they will go head and use it. They don't want the owner to tell them what to do. But if it is in the contract, they will do all of that. So, if you make it generic, then the people who expect to use BIM even they can use it."

*Interviewer*

Can you suggest anything that would improve this questionnaire (guideline)?

*Interviewee-2*

"Yes, those are the things I have been suggesting is making it generic and creating trees of main question and then going through categorizing project types depending on different project what it is. K-12, health care, retail, government, federal, and every different project has different owners and they have different requirements. You can be that specific and the thing will be a cookie cutter. You need to be very specific when you want to be a cookie cutter. This is the whole idea you want it to be cookie cutter.

Anybody can use it. You need to be very generic. And it is a great tool to educate owners. Usually, the Q&A part is 15 minutes during interviews. BIM is an important part but never in priority. So, when you have 15 minutes to ask questions, they are going to ask max 2 questions about BIM in an interview. So that shouldn't be that specific and this is a very big document to ask those two questions. But it's very good start. You got a start somewhere so that you can finish it successfully. So, I really appreciate it."


**INTERVIEW-3**

*Interviewer*

Do you think this questionnaire is applicable?

*Interviewee-3*

"Questionnaire? A questionnaire may not be the best method to use. A questionnaire is very direct and legalistic. When selecting or considering a contractor, the owner may best be served by asking for this information as part of his proposal or Bidding requirements. If this is an interview, ask for this information and have them follow up or explain their information in more detail at the interview. This will allow the contractor more flexibility in presenting his qualifications. It will also help the owner judge other things, like how the contractor communicates effectively, thinks creatively, show his organizational skills etc. You can tell more sometimes about what you do not ask for, rather than what is asked for."

*Interviewer*

Do you think these questions in the questionnaire (guideline) would help owners get what they want?

*Interviewee-3*

"Only as it pertains to BIM. It will assist the owner, not help. There is a difference. These questions are only a portion of a contractor's overall Proposal or Bid or qualifications. But depending on what the owner wants will help determine the type and extent of the questions."

*Interviewer*

Can you suggest anything that would improve this questionnaire (guideline)?

*Interviewee-3*

"I strongly believe that you need to develop different types of questionnaires depending on the size of the project and the delivery method of the project. This list of questions is way too long for a contractor to answer in a $0 - $5mil project and a low bid or RFCSP delivery. However if this is CM at Risk on a $20mil, $30mil or $50Mil project, they are appropriate questions. I would put the questions with a different title, like "Additional Requested or Required Information". I would also score them 1-10, not A-D. Numbers give you more flexibility in rating contractors especially when you are rating several contractors. I would also put different weights on each group of questions, because some aspects may be more important to an owner than others."

**INTERVIEW-4**

*Interviewer*

Do you think this questionnaire is applicable?

*Interviewee-4*

"To me it feels like the questionnaire is designed to be used for a face to face interview. However this is not always the case when qualifying contractors. Most of the time, hard copies of proposals are presented for RFPs. In that case, the questionnaire would need to be a part of the RFP as a separate attachment for the contractors to fill out.

One thing to keep in mind, the contractor is being interviewed for a particular project with a specified set of BIM requirements and not being evaluated for just his BIM experience which might/might not be relevant to the project. Eg: BIM as built, comparing two contractors on their experience creating BIM as-built is not relevant if the project does not need a BIM as built deliverable."

*Interviewer*

Do you think these questions in the questionnaire (guideline) would help owners get what they want?

*Interviewee-4*

"Yes. One of the items that we run into often is BIM manpower issues. So, one question to ask would be if a person is going to be dedicated completely to the project. If not what methods are in place to ensure that the needs of the project are met."

*Interviewer*

Can you suggest anything that would improve this questionnaire (guideline)?

*Interviewee-4*

"One more item that is not clear is if this document is geared towards owners looking to hire an architect or owners looking to hire GCs. This depends on the contract delivery method too. So in case of an IPD project you have both the designer and contractor on board early as compared to a Design-Bid-Build. A little bit of direction on this might help."

**INTERVIEW-5**

*Interviewer*

Do you think this questionnaire is applicable?

*Interviewee-5*

"Yes, there needs to be a way for contractors to get feedback on these BIM services."

*Interviewer*

Do you think these questions in the questionnaire (guideline) would help owners get what they want?

*Interviewee-5*

"No, most private sector owners are only concerned with did the services provided add value to my project. Think about ROI."

*Interviewer*

Can you suggest anything that would improve this questionnaire (guideline)?

*Interviewee-5*

"The first problem I see is that this questionnaire assumes a certain level of BIM awareness from the owner that honestly a lot of clients don't have. If this was me I would tailor the document as more of a post-job survey to determine if the owners' expectations were met on the project. Also, this survey is entirely too long, no one is going to take the time to go through all this, especially a private sector client. All they are concerned with how is this adding value to my project, IE fast, cheaper, better."