BIM Guidelines Review for Public Post-secondary Institutions

Beda Barkokebas[a], Samer Bu Hamdan[a], Aladdin Alwisy[a], Ahmed Bouferguene[a], Mohamed Al-Hussein[a]

[a]Hole School of Construction Engineering, University of Alberta, Canada
E-mail: Barkokebas@ualberta.ca, Buhamdan@ualberta.ca, Alwisy@ualberta.ca, Ahmedb@ualberta.ca, Malhussein@ualberta.ca

Abstract

Despite its documented success, the use of Building Information Modelling (BIM) continues to raise questions related to its implementation at an institutional level. Therefore, several institutions have produced guidelines specific to BIM to communicate their expectations in regard to BIM in their projects. However, such guidelines do not exist among Canadian post-secondary or public institutions despite the wide implementation of BIM technology. To better address the requirements of BIM usage by public post-secondary institutions, a review of existing BIM guidelines is needed. The research includes three phases: (1) assessment of existing processes; (2) a comprehensive review of twelve guidelines from institutions with various backgrounds; followed by (3) recommendations for further BIM implementation. We reach the conclusion that no one institution's BIM guidelines are capable of fully accommodating the context and requirements of all Canadian public post-secondary institutions. Hence, a BIM guideline based on the key findings of the analyzed documents for each stage of the building lifecycle, as well as knowledge about current operations and local context, is recommended as future research. To achieve a comprehensive set of guidelines, the local construction industry should be consulted to account for existing BIM expertise; the guidelines should also incorporate important documents found in the guidelines of other institutions. Moreover, it is recommended that the future guidelines focus on the management of the BIM model for the operation and maintenance phase since this phase incurs the highest costs in a building's lifecycle, and is the responsibility of the owner (i.e., the institution).

Keywords –

BIM; BIM Guidelines; Post-secondary institutions; BIM Implementation;

1 Introduction

Building Information Modelling (BIM) has made a significant impact on the construction industry, affecting all areas of a facility's lifecycle. However, there is a lack of standardization with regard to the implementation of BIM across different areas, thus constituting a major barrier to the adoption of BIM with its associated benefits for the construction industry [1].

To streamline BIM requirements and expectations, organizations develop documents that regulate the technical and contractual aspects of the BIM models provided to the owner/client by the consultants and contractors. These documents, i.e., BIM Guidelines or BIM Standards, help the local design and construction market to standardize design and construction services and the use of BIM models to contribute to the maturation of the local industry [2].

A guideline consists of a "general rule, principle, or piece of advice", while a standard is a "required or agreed level of quality or attainment" [3]. According to [4] the implementation of BIM at an institutional level is highly dependent upon guidelines and standards since they provide a common orientation to the local community. However, these documents are dependent on the level of understanding, readiness, and implementation of BIM within the given jurisdiction, such that applying the guidelines or standards from one jurisdiction to another one is an ineffective practice.

Considering this, the University of Alberta—one of the leading post-secondary institutions in Canada—performed a review of existing BIM guidelines and standards in North America, since the adoption of BIM in Canada is still in its early stages and no other post-secondary or government institution in Canada has this kind of documentation in place.

1.1 Methods

The research presented in this paper consists of a

review of existing guidelines with the objective of investigating procurement strategies and the potential use of BIM by the University of Alberta. Figure 1 provides an overview of the methodology employed in this research, which is performed in three phases: (1) an assessment of the existing processes within the University of Alberta to gain understanding of its existing process and expectations pertaining to the use of BIM; (2) selection and review of existing guidelines in North America relevant to the context of this research; and (3) a set of recommendations for the procurement and use of BIM models for the University of Alberta.

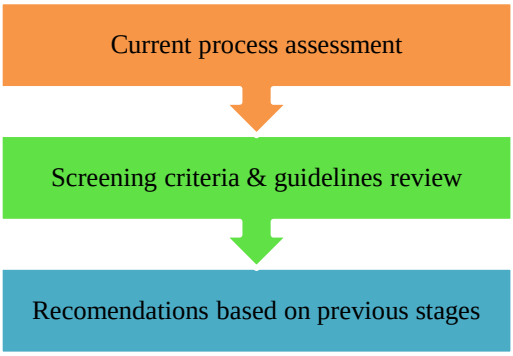

Figure.1 Overview of research methodology

This assessment endeavors to define the needs of a given organization with regard to the implementation, use, and management of BIM, and thereby tailor the development of future guidelines accordingly. Based on the requirements of an organization, a set of criteria is developed to assist in the selection of existing relevant documentation that is to form the basis of the new guidelines. Existing guidelines that satisfy the selection criteria are then reviewed to match the BIM requirements of the organization with the components of the existing BIM guidelines.

Although it is a qualitative assessment, the research presented in this paper makes use of semi-structured interviews and structured questionnaires in order to provide metrics and quantitative data to be used during the screening and review processes and direct the process toward addressing existing issues pertaining to the use of BIM at the University of Alberta. These methods are explained in detail in the following sections.

2 Current Process Assessment

The current process assessment aims to identify the existing requirements and expectations of the University of Alberta's Facilities and Operations (F&O) with regard to the use of BIM, to evaluate the existing procedures of each organizational unit, and identify possible improvements that could be realized by adopting BIM for its capital projects. Table 1 summarizes the organizational units assessed and their primary responsibilities under the F&O portfolio.

As described in Table 1, these organizational units which F&) comprises are responsible for the planning, design, construction, operation, and maintenance of all facilities at the University of Alberta, thus controlling every aspect of the performance of each building in the institution's portfolio throughout its lifecycle. The Office of the University Architect (OUA) carries out the planning for new facilities and retrofit of existing buildings. After the Request for Proposals (RFP) stage is complete, the Project Management Office (PMO) procures the project to a general contractor and oversees the construction until the facility is commissioned and handed over to the University; Operations & Maintenance (OM) then assumes the role of maintaining and operating the facility.

Table **Error! No text of specified style in document.**1 Units investigated and their respective roles

Unit	Main role
Office of the University Architect (OUA)	Planning of new construction or retrofit while overseeing design compliance during construction
Project Management Office (PMO)	Procurement and control of new construction or retrofit
Design and Technical Services (DTS)	Document management for operation and maintenance of existing buildings
Operations & Maintenance (OM)	Maintenance of existing buildings and management of daily operations
Energy Management & Sustainable Operations (EMSO)	Optimization of operations of existing buildings with a focus on energy management

During commissioning, Design and Technical Services (DTS) receives all drawings and documents related to the project and manages these documents throughout the facility's lifecycle, including updates and generating new documentation as necessary. Energy Management & Sustainable Operations (EMSO) assesses performance of existing buildings in order to optimize their operations and provides key information to OUA that can inform future renovations and new construction across campus. A semi-structured interview is developed to gain understanding about the requirements and

expectations of each organizational unit while generating data for use in future assessments. Using the data collected during this process, a review of the guidelines is conducted for addressing the needs identified and concerns raised by the various organizational units.

Table 2 presents the results of the semi-structured interviews. It is clear that the different organizational units vary considerably in size, but all face challenges in with regard to communication, lack of resources, and tight schedules as per the first and second questions. The response to the third question indicates that each unit has their own experience with BIM in isolated cases with little to no communication between units. In fact, the use of BIM—since it is not mandated by the University—is driven by consultants and contractors that already use BIM in their own operations and is perceived by the University as an add-on rather than a fundamental component of its design, construction, and facility management operations.

Despite the fragmented use of BIM in F&O's existing operations, organizational units such as OUA, PMO, and DTS acknowledge the potential use of BIM to improve communication among units and other stakeholders (e.g., consultants, general contractors, etc.) while OM and EMSO see value in the application of BIM to improve other decision-making processes such as predictive modelling and lifecycle assessments.

Still, as can be seen in Table 2, responses to the final two questions indicate three main challenges and concerns regarding BIM implementation at an institutional level: (1) further maturation of the existing BIM implementation framework, and training both of University personnel and other stakeholders in its capital projects (e.g., consultants, trades, etc.) in order to increase the University's capacity to implement BIM in its projects and facility management; (2) the interoperability of BIM models between various platforms and other existing management systems (document and asset management); and (3) concerns about the ownership of the model.

Table 2 Results of semi-structured interview according to each unit

Question	OUA	PMO	DTS	OM	EMSO
Number of employees in each unit	6 to 10	15 to 20	13	200 + 200 from subcontractors	4
Current challenges in unit	Short deadlines	Bureaucracy and change management	Communication among various stakeholders	Communication across different stakeholders and short-term planning	Lack of trained personnel
Current use of BIM	3D imaging during conceptual phase	Mainly used to communicate consultant's proposal	Uses parametric tools non-related to BIM for document management	None	Uses model (when available) for energy modelling
Potential use of BIM	More information during conceptual phase and design oversight	Enhance communication and constructability analysis	Enhance communication and integrate operation documents with drawings	Predictive maintenance and personnel training	Lifecycle assessment and decision making
Current challenges for BIM implantation	Personnel training	Scope required from the model and actual benefit from BIM	Interoperability between existing infrastructure and BIM systems	Personnel training, incomplete models, and clarity regarding the ownership of the model	Sharing information across different platforms
Questions about BIM and its applicability	Possible interaction between BIM and existing systems	Maturity of local community (consultants and general contractors)	None	Ownership, cost of the model, and impact on daily routine	Ability to develop custom solutions for each project

3 Screening Criteria & Guideline Review

Based on the current process assessment, this section will discuss the screening criteria used to select which documents shall be included in the analysis and the review of these documents based on the findings of the previous sections.

3.1 Screening Criteria

Based on the data gathered in the assessment of existing processes, a series of questions is developed by the research team which are then incorporated into a structured questionnaire to streamline the review process and create data that can be compared on a quantitative basis when applicable. The following is a list of statements incorporated into the structured questionnaire:

1. Information exchange through the model during its lifecycle.
2. Workflow change due to the use of BIM.
3. Which software to use (use of open or closed architecture application approach).
4. Ownership of the model.
5. Costs incurred from BIM.

The criteria used to select which documentation to review are described below:

1. Only documents from North America are considered due to the geographic location of the case institution, with the exception of standards from the United Kingdom and Singapore due to their relevant work on BIM implementation at an institutional level.
2. Guidelines from post-secondary institutions: to evaluate the requirements of other similar institutions imposed on their contractors.
3. Guidelines from public institutions to address how these institutions overcome barriers such as interoperability and how they standardize their requirements across a larger sample of contractors.
4. Standards from national standardization organizations to address general requirements from each jurisdiction of origin.

Table 3 presents the documents selected for review based on the presented criteria, listed according to the areas of interest addressed during the current process assessment stage. As per Table 4, the documents are separated into three groups: (1) third-party organizations, which regulate the use of BIM through standards and have a national range; (2) guidelines from government organizations, which regulate the use of BIM in their respective jurisdictions (e.g., state/province, city, etc.); and (3) university guidelines, which regulate the use of BIM for a given post-secondary institution.

All the documents selected encompass the use of BIM during the design stage and address the interoperability of the various systems involved, and thereby speak to the questions raised in the current process assessment of the case institution. Moreover, the government and university guidelines reviewed predominantly encompass the use of BIM during the construction stage, while relatively few cover the use of BIM for facility operation or energy modelling assessments.

It is also important to note that most of the documents reviewed specify procedures to be performed during the delivery process of BIM models and the respective legal aspects of that delivery.

3.2 Guidelines Review

This section presents a summary of all the guidelines reviewed, important findings regarding the questions raised during the current process assessment, and relevant information for each stage of the facility lifecycle. The structure of this section corresponds to the list of questions raised during the assessment of existing processes.

3.2.1 Information exchange through the model during its lifecycle

Government and university guidelines provide further clarity in addressing this question since these institutions need to inform consultants and general contractors of their requirements throughout the entire project. The guidelines identified as having the greatest potential to clarify information exchange through the BIM model are from the University of Southern California, the City of New York, and the State of Ohio, and these guidelines are thus recommended for use as a benchmark by the case institution when preparing their BIM guidelines.

3.2.2 Workflow change due to the use of BIM

After the analysis of the guidelines is complete, it is observed that the introduction of BIM is not substantially disruptive to the way projects are being developed, coordinated, built, and operated. Rather, BIM is a key to enhancing existing processes by allowing construction practitioners to process information more rapidly and make important decisions regarding project performance based on accurate information. However, the guidelines for USC, the City of New York, and Singapore recommend specific full-time positions to oversee the management of the BIM model and the process associated with it (e.g., BIM Facilitator/Engineer, BIM Trade Coordinator, etc.). Post-secondary institutions, including the University of Alberta's F&O, should acknowledge the importance of BIM-facilitating roles and consider including these roles in its projects' contracts.

Table 3 Documents reviewed within research scope

Name	Country	Release Date	Organization Type	Organization Name	Design	Construction	Operation	Energy Modeling	Procedures	Implementation	Legal	Interoperability
National BIM Standard - United StatesTM	US	July, 2015	Third party	buildingSMART alliance (bSa)	X	X	X	X		X		X
AEC (UK) BIM Technology Protocol	UK	June, 2015	Third party	AEC (UK) Intiative	X				X	X		X
AEC (CAN) BIM Technology Protocol	CA	September, 2014	Third party	CanBIM	X				X	X	X	X
Singapore BIM Guide	SG	August, 2013	Government	Singapore Government	X	X	X		X	X	X	X
New York City BIM Guidelines	US	July, 2012	Government	City of New York	X	X				X	X	X
GSFIC BIM Guide	US	March, 2013	Government	State of Georgia	X	X			X		X	X
State of Ohio BIM Protocol	US	July, 2011	Government	State of Ohio	X	X	X	X		X	X	X
Texas Facilities Commission Professional Architectural/ Engineering Guidelines	US	February, 2008	Government	State of Texas	X	X			X	X	X	X
USC BIM Guidelines	US	April, 2012	University	USC	X	X	X		X	X	X	X
Georgia Tech BIM Requirements & Guidelines	US	September, 2011	University	Georgia Tech	X	X	X	X	X	X	X	X
IU BIM Guidelines and Standards	US	July, 2015	University	IU	X	X		X	X	X	X	X
MIT CAD & BIM Guidelines	US	April, 2012	University	MIT	X	X					X	X

3.2.3 Which software to use (use of open or closed architecture application approach)

Figure 2 depicts the recommended working platforms and file-delivery format based on the reviewed guidelines. The importance of defining the working platforms and file format upon delivery arises from the need to eliminate the dependence on specific software vendors, which is substantial for the integrity of public bidding and contracting process.

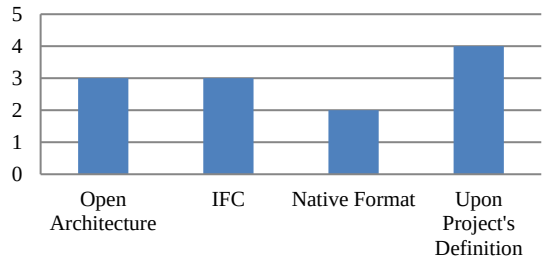

Figure.2 Summary of recommended work platforms required by guidelines

An intriguing finding from this study is that, although most guidelines encourage the use of open file formats for project coordination, several institutions require specific file formats for submittals. The authors believe this is since these institutions have obtained licenses and personnel training for specific software companies. To overcome this potential barrier, the University of Alberta's F&O can adopt a provision from the Texas Facilities Commission guideline, which states that, in the case that a consultant or contractor is using a different software than the one used by the client's F&O department, the consultant may provide the software license and necessary training as necessary for the given project. Figure 3 demonstrates the deliverable formats specified in the guidelines reviewed. It is clear that Autodesk products are preferred, along with the requirement for COBie at the Operation & Maintenance stage. This is presumably due to the predominance of these products in the North American market. In light of possible inconsistencies or problems encountered from not using a native file format, further reading in Singapore's guidelines and extra documentation is recommended since they have specific documentation for each of the notable commercial BIM authoring software suites available.

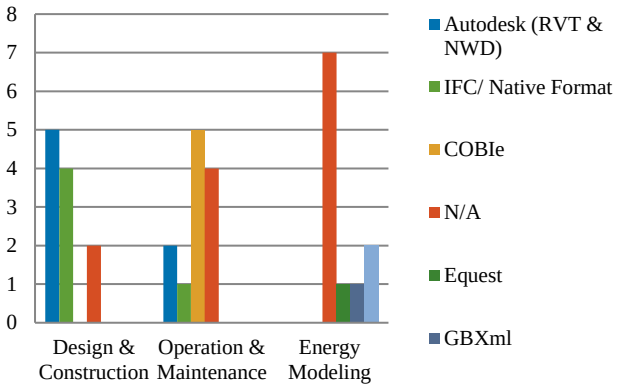

Figure.3 Deliverables format required in the guidelines reviewed

3.2.4 Ownership of the model

Clarification regarding the ownership of the model is a key component for successful implementation of BIM in any institution. Figure 4 summarizes the provisions laid out in the guidelines reviewed regarding this matter. It is noted that institutions with a broad portfolio do not have clear provisions regarding this matter (probably because of the high variability of projects within their scope). Most institutions require full ownership of the model and any related documents, establishing a precedent for the case institution to do the same. For more information about this matter, CanBIM and the State of Ohio's guidelines are recommended for further reading.

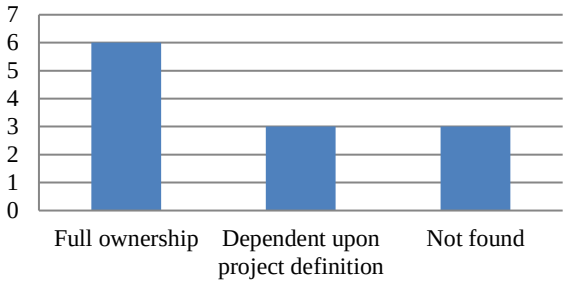

Figure.4 Stances of analyzed institutions regarding ownership of the model

3.2.5 Financial investment incurred from BIM

Manging the cost of BIM is also a cornerstone of its successful implementation. This issue is best characterized in terms of two questions: (1) from a cost perspective, when does it become feasible to implement BIM in a project as opposed to using conventional tools? and (2) how much are other institutions investing in BIM services? (The State of Ohio recommends using BIM for projects with a value of $4M or greater, while Georgia Tech and Indiana University recommend a threshold of $5M.) In order to quantify the potential savings resulting

from the use of BIM, Table 5 summarizes the cost incurred from the use of BIM tools and services in consultant fees gathered from the BIM guidelines of Singapore and the State of Ohio. As shown in Table 5, these institutions do not intend to pay any premium for the use of BIM in their projects, but instead reallocate money among each project's stages to account for cost increases due to BIM implementation.

Table.4 Cost incurred from the use of BIM in total consultant fees (Adapted from Building and Construction Authority, 2013 and Ohio General Services Division, 2011)

Project Stage	% change from the use of BIM	
	Singapore	Ohio
Preliminary Design	+2.5%	0%
Schematic Design	0%	+5%
Design Development	+2.5%	+5%
Construction Documents	0%	-10%
Bid and Award	0%	0%
Construction Administration	-5%	0%
Contract Closeout	0%	0%

3.3 Define requirements of BIM guidelines for post-secondary institutions

After performing a comprehensive review of twelve guidelines from various institutions/jurisdictions, the authors conclude that there is a need for the case institution to develop their own guidelines, as no guidelines exist that fully address the expectations of the stakeholders. In this regard, three recommendations are made:

- The guidelines should span BIM uses and implementation during all project phases as per the project's lifecycle breakdown followed in the practice of the case institution.
- As per the guidelines reviewed, the case institution's guidelines should incorporate the following:
    - **BIM Execution Plan:** a document demonstrating which tools, responsible personnel, and strategies are employed by the Design Team and/or General Contractor regarding BIM tools.
    - **BIM Objective & Responsibility Matrix:** a document intended to define the level of detail of BIM objectives according to the design stage and personnel responsible for developing the model.
- The operational stage of a facility represents the largest proportion of cost in its lifecycle. Hence, the BIM guidelines should also consider the use of BIM to reduce the operational cost of the facility.
- The guidelines should clearly address the ownership of the models and other legal aspects of BIM implementation and use in the institution's regular practice.

These recommendations can be applied to public post-secondary institutions with similar responsibilities as the University of Alberta.

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