

Building Information Modeling Implementation for Facilities Management on U.S. University Campuses

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In university campuses, effective and efficient operations and maintenance of the university facilities supports effective operation of academic, research, and administrative activities. Facility information is often difficult to document, scattered, unstructured, and outdated. The growing use of Building Information Models (BIMs) offers a structured method for storing and accessing facility information. This research explores the status of incorporating BIM and other computerized management systems within Facilities Management (FM) on U.S. university campuses to provide a benchmark for other university FM groups looking to expand their BIM for FM adoption. The research developed a self-administered questionnaire to gauge the utilization of BIM for facility management in the top 100 U.S. university campuses. The presented results in this paper include perceived barriers to BIM for FM adoption, challenges faced by these universities, and top benefits for BIM for FM utilization. Lastly, the paper discusses areas of additional research.

Keywords: University Campus, Building Information Model, Facility Operations, United States, Utilization

Introduction

In capital investments, such as buildings on a university campus, the majority of the lifecycle cost of a facility is connected to the operations and maintenance phase of that facility. Design and construction personnel work with the owner to provide a high quality project of value to the owner. However, without ease of operation and maintenance, any value engineering cost savings can easily be lost multiple times over. Over a 30 year building lifecycle, Fuller (2010) documented that 2% of the total cost associated with the building cover design and construction while over 6% goes into the operation and maintenance of the facility. Salaries of personnel utilizing the structure make up the rest of the associated costs (Fuller 2010). After payroll, facility management costs are typically the greatest administrative expense to an organization (Cotts et al. 2010). Not only can a well-maintained and easily maintainable facility reduce some of these administrative costs but they can also enhance an organization's performance by contributing to the optimization of the working and business environment (Alsyouf, 2007).

In order to adequately operate and maintain the facility, proper information is imperative. In general, owners will utilize one of three methods to organize the diverse information required for operating and maintaining the facilities. These include: Direct reference of original project documents; paper-based or electronic spreadsheets that require manual reference and updating; or, most commonly used by larger

owners with complex facilities, the use of a technology-based solution such as a Computerized Maintenance Management System (CMMS), Computer Aided Facility Management (CAFM) system, or an Integrated Workplace Management System (IWMS) (Di Iorio, 2103; Teicholz, 2013). Even if the owner was to use a technology-based solution, most of these applications rely heavily on manual input of information.

One method to document the facility management information without the need for manually extracting and inputting the data is the use of Building Information Models (BIMs). BIM is an intelligent model-based process that provides insight to planning, designing, constructing, and managing buildings and infrastructure (Azhar, 2011). Building Information Modeling (BIM) is the process of creating a computer-generated model containing precise geometry and relevant data to support the entire facility lifecycle (Eastman et al. 2008). With careful planning, BIM can serve as an intelligent information repository to assist facility owners in managing the facility. BIM for FM offers uses such as locating building components, real-time data access, checking maintainability, asset management, space management, and others (Becerik-Gerber et.al, 2012). The slow adoption of BIM for FM can be attributed to many owners not understanding the technological capabilities that are available to support building management (Gleason, 2013). Many owners and facility managers think that BIM is another responsibility that they will be in charge of when they are already stretching their resources (Lewis and Whittaker, 2012). The realization of BIM for FM is limited because of the need to customize facility information for each operator and sometimes each building (Dias and Ergan, 2016). This requires clear guidelines for implementing BIM into FM, standard BIM protocol, and key deliverables for the purpose of managing the facility to be defined by the owner (Kiviniemi and Codinhoto, 2014; Teicholz, 2013). If an owner is requiring BIM on the project to support the use of BIM in facility management, the owner typically defines the requirements of BIM use and the information needed to operating the facility in a BIM Management Plan or BIM for FM Guidelines (Teicholz, 2013).

The presented research looks to identify the present status of the implementation of BIM for FM at U.S. university campuses to serve as benchmarks for other university FM groups looking to advance their implementation of BIM. The research also summarizes identified advantages and disadvantages from the owner's perspective of implementing BIM for FM. The research gathered information from professionals working in the facilities and capital projects departments of the top 100 US National Universities across the United States as listed in the *U.S. News and World Report* "National University Rankings" of 2015 (U.S.News 2015). Industry professionals completed a self-administered survey to document the extent of adoption of various technologies and the use of the technology for both new construction and renovation projects by their organizations. The primary purposes of the survey were to (1) identify the level of FM-systems integration (such as BIM for FM and the use of Computerized Maintenance Management Systems (CMMS)) and (2) document barriers to adoption based on owners' experiences. This paper presents the content of that survey, the survey findings, and analysis of the responses.

Methodology

The objective of the study was to identify a benchmark of where the top U.S. universities fall with the utilization of various technologies in terms of facility management, operations, and maintenance. The study also documented barriers, challenges, and advantages of adoption. These barriers and challenges, perceived or actual, help with identifying future research areas in the hopes of improving the adoption of

BIM for FM and other FM system technologies. Lastly, since large universities have large portfolios of existing structures, the study sought to identify how universities treat existing facilities and renovation projects as compared to new construction projects in terms of BIM and data documentation requirements.

The study utilized a self-administered survey based on insights gained through literature review and other related research efforts. Industry professionals and those versed with the domain subject pilot tested the survey to enhance the validity and reliability of the responses before distributing the survey to professionals serving university facilities departments of top ranked U.S. schools. The results were then analyzed.

The survey was designed using a web-based survey management system. The first section of the survey collected demographics of the respondents and the universities that they represented. The second section contained questions to narrow down the extent of systems and technologies the respondents had used for facility maintenance and operation. Lastly, follow up questions allowed respondents to clarify answers and include barriers and challenges related to the initial question. Based upon the respondents' responses of what types of systems they used, the survey design incorporated skip logic to identify appropriate follow-up questions. The survey contained a combination of multi-choice and open response questions. The multi-choice questions identified which systems each university and the BIM-FM or FM system requirements put in place. Open response follow-up questions then allowed for a better understanding of specific challenges, barriers, and benefits identified by each respondent. The Clemson University Institutional Review Board (IRB) reviewed and approved the survey and protocol before survey distribution.

The study targeted a specific population that included professionals from university campuses selected from the top 100 US National Universities listed during 2015 by U.S. News and World Report. The researchers identified a list of potential respondents based on publically available contact information through the organizations' websites. Potential respondents included directors, presidents, vice-presidents and senior managers within the facilities department of the listed universities. Respondents took up to six weeks to complete the survey. Out of the representatives of the one hundred (100) universities selected to participate in the study, twenty-six (26) individuals from different universities responded with complete surveys for a 26% response rate. The research considered respondents valid if they had knowledge and experience in the field of Facilities Management in universities within the U.S. and worked for a minimum of five (5) years within a management position of a facilities operation, building support, or capital projects group of the university. The respondents also needed to have an understanding of the extents of technology utilization for facility operations and maintenance on the campus. The survey contained qualification questions to ensure respondents met these parameters; all complete responses met the criteria.

Responses originated from across the country with the majority located along the eastern coast as seen in Figure 1. The respondents represented the following rolls within the University's facility maintenance and operation division:

- Directors and Presidents – 34% of respondents
- Assistant Directors and Assistant Presidents – 12% of respondents

- Project/ Regional/ Maintenance Managers – 20% of respondents
- Other (with qualified experience and management position) – 34% or respondents

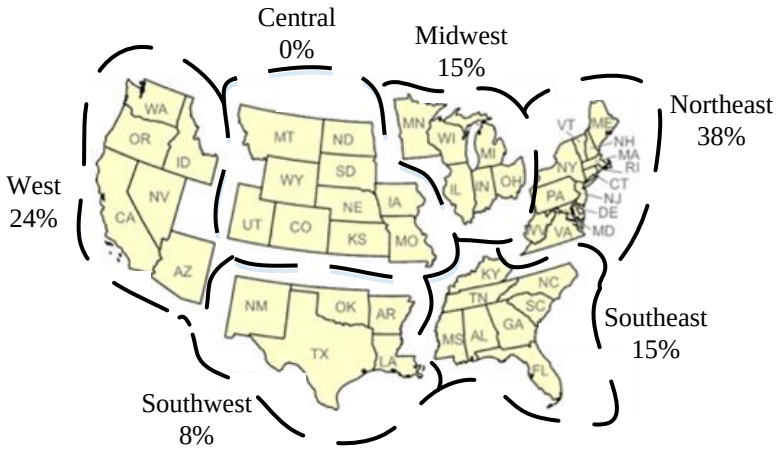

Figure 1: Respondent distribution

Recorded demographic information for the participating universities included the gross square footage (GSF) of all buildings on campus maintained by the organization and the number of employees working for the facilities and related departments in each represented university. As seen in results documented in Table 1, almost half fell between the 10 – 20 million GSF range and most employed between 500 and 1000 individuals for facility operations and maintenance. These responses represent large universities with a large workforce.

Table 1

Approximate Gross Square Footage of buildings located on campuses by the respondents

Gross Square Footage (GSF) Range	**Percentage of Respondents**
More than 20 million	11%
10 million – 20 million	46%
5 million – 10 million	15%
1 million – 5 million	19%
Less than 1 million	4%
Number of Employees	**Percentage of Respondents**
More than 1000	4%
500 – 1000	46%
100 – 499	31%
Less than 99	19%

Lastly, the survey documented the approximate dollar amount invested in renovation and new construction projects over the previous five-year period. The results show that most of the universities invested between $100 million and $1 billion in new construction but less than $500 million on renovating old facilities (Table 2). This can have an influence on the ability to implement and adopt BIM

more easily since there are identified challenges within literature about how to document existing buildings.

Table 2

Investment amount in renovation and new construction

Approximate $ Value (millions)	Renovation % Respondents	New Construction % Respondents
More than 1,000	8%	12%
500 – 1,000	12%	32%
100 – 499	48%	36%
0 – 99	32%	20%

Findings and Analysis

The survey first addressed what issues respondents commonly face in both new construction and renovation of existing buildings related to the collection and use of operation and maintenance related information at the end of the construction phase. The questions compiled commonly faced issues identified through the literature review. The survey allowed respondents to select all the choices that apply. Table 3 shows those responses. Because of the response rate of 26 respondents, the margin of error and confidence interval represented throughout the paper were calculated using the Adjusted Wald Method with a confidence level of 95% (Bonett and Price, 2012). The confidence in these calculations represent the range of a larger population that would likely have the same response to the identified issue.

Table 3

Respondent Identified Issues for Collecting Operation and Maintenance (O&M) Information

Issues in New Construction	Response	Interval	Margin of Error
1. O&M procedures for assets	23 (88%)	0.70-0.96	0.13
2. Collecting equipment specifications and warranties	20 (77%)	0.57-0.89	0.15
3. Identifying location of equipment in drawings	14 (54%)	0.35-0.71	0.18
4. Identifying proper replacement part information	14 (54%)	0.35-0.71	0.18
5. Identifying information for energy performance analysis	13 (50%)	0.32-0.68	0.18
6. Linking parent/child assets (e.g. fans in an air handler unit)	12 (46%)	0.28-0.65	0.18
Issues in Renovations of Existing Buildings	**Response**	**Interval**	**Margin of Error**
1. O&M procedures for assets	22 (85%)	0.65-0.95	0.14
2. Collect equipment specifications and warranties	22 (85%)	0.64-0.95	0.14
3. Identifying the location of equipment in drawings	15 (58%)	0.38-0.75	0.17
4. Identifying proper replacement part information	15 (58%)	0.38-0.75	0.17
5. Identifying Existing Equipment Conditions	15 (58%)	0.38-0.75	0.17
6. Performance of efficiency of existing assets	15 (58%)	0.38-0.75	0.17
7. Linking parent/child assets	13 (50%)	0.32-0.68	0.18
8. Identifying information for energy performance analysis	11 (42%)	0.25-0.61	0.18

The survey questions included an "other" category to allow respondents to document additional issues they have faced when collecting information for post-construction use of the new facility. These user-added responses include proper as-builts, tracking post-warranty information, incomplete punch list issues, and incomplete commissioning reports. The respondents did not identify additional issues related to the collection of information for renovations of existing buildings.

Status of Requirements of Using BIM for Project Delivery and Facility O&M

The next set of questions dealt with the use of technology and types of technology required for delivering a construction project. Respondents were asked if the facilities department requires the use of BIM for delivering new construction and renovation of existing building projects, the results are summarized in Table 4.

Table 4
Respondent Status for Requiring the use of BIM

Status	**Response Rate**
BIM as a formal requirement for new construction and renovation	24%
BIM as a formal requirement for new construction only and actively considering it for existing buildings in the next 5 years	8%
BIM as a formal requirement for new construction and not considering for existing	8%
BIM as a formal requirement for existing buildings and actively considering for new construction	4%
Total Requiring BIM in some way	*44%*
No formal BIM requirement and none being considered	11%
Actively considering for the next five years for renovation projects only	4%
Actively considering for the next five years for new construction only	11%
Actively considering for the next five years both new construction and renovation	30%
Total Not Currently Requiring BIM	*56%*

The ranked reasons for currently requiring BIM use or actively exploring its use were for: (1) Asset Management, (2) Capturing and Integrating with FM Systems, (3) Space Planning, (4) Energy Analysis, (5) Scheduling Maintenance, and (6) Emergency Planning. The respondents who are not considering formal requirements for BIM use identified lack of skill, cost of system implementation, and lack of knowledge as the reasons why this is the case. Respondents who are not considering formal requirements for BIM did not correlate to size or volume of work the organization is responsible for due to variation in respondent demographic information for those responding to the question.

Status of Utilizing Computerized Systems for Facility O&M

When asked about their use of computerized systems to manage the facility post-construction, 85% of the respondents used FM systems and 15% of the respondents do not use any FM systems for the operation of

the facilities. Of the 85% of the respondents who use FM systems, 32% utilize AiM by Asset Works, 22% utilize TMA, 18% utilize TRIRIGA, and 8% utilize Maximo. Open response questions allowed users to self-report the systems they used. When also asked in an open-ended response of the top three benefits of utilizing the given FM system, the replies were consistently: Work Order Management, Asset Management, and Configurable Ability to Support Specific Needs. When asked about how the information was translated into the FM system, 90% of the respondents used a spreadsheet based format (ex: .cvs or .xml) and 10% used COBie or a proprietary integration method.

With the 85% of the respondents using FM systems to operate the facilities in the universities, only 15% of them are currently integrating a BIM within the FM system. Another 55% of the respondents were planning to integrate BIM into their FM systems within the next five years. The respondents currently integrating or planning to integrate BIM into their FM system within the near future identified visualization of the facility, improved operations, operating and maintenance procedures, and scheduling maintenance activities as benefits for the integration of BIM and FM systems.

The respondents who are not planning to integrate BIM into their FM system cited lack of knowledge, lack of skill, and cost as the perceived barriers. Due to the variability of university demographic information for those who cited these concerns, no correlations between size of organization or volume of work performed and these barriers were drawn.

Limitations

Limitations of the research existed with the response rate of 26 universities. It is hard to claim with statistical accuracy that the results are translatable across the larger university and college setting. The majority of the universities represented within the responses maintain over 10 million GSF and have at least 500 employees. These are large universities. With fewer responses from smaller universities, the results may not directly translate across the entire population. In addition, of the initial population, the results with a response rate of 26 out of 100 account for a large margin of error (16%). Yet, the results provide insight to some of the situations that may face universities looking to expand their adoption of BIM and FM Systems. For a better and more complete understanding of the status of all types of university and college campuses, future research can conduct an expanded survey to make claims with a higher level of confidence.

Conclusion and Recommendations

This study provides an overview of where top U.S. universities stand in terms of BIM use for Facility Management to operate and maintain their campuses. Researchers distributed a survey to potential respondents of the top 100 universities and received 26 completed responses. The survey found that lack of knowledge, lack of skill, and cost are three barriers inhibiting some owners from expanding their use of BIM. Lack of knowledge is not a new issue, nor is it necessarily unique to university campuses, as other literature identified it as a barrier in other industry sectors (Gleason, 2013).

The lack of skill is also a relevant concern. Becerik-Gerber (et. al, 2012) noted lack of technological experience and skills of facility management employees as a barrier to the implementation of BIM for facility management. The fact that facility managers within U.S. universities identify the same issue should not be surprising, especially when they are not aware of the capabilities of available systems. Technologically capable design and construction professionals should work with owners early in the building process and educate them through the promotion of new means and methods of managing data of the benefit of utilizing the software. Owners who utilize the technology should promote their successes and share strategies. Software companies can also develop marketing and training strategies to increase awareness. With these initiatives, the task of identifying information needs and turnover processes between design/construction and the owner will become a less daunting task. Advancing the knowledge of BIM would potentially increase the motivation of facility managers, owners, and staff to learn and implement the systems, thus developing the appropriate skills.

The last barrier, cost, needs further examination. Various owners could define associated costs in different ways. Some would argue the return on investing in an FM system is well worth the initial cost of the software, hardware, and technical training. However, cost can be more complex, especially when a university campus with many existing buildings and associated data is involved. If a campus with millions of square feet of managed space changes systems, efficient transfer of information from existing systems and documents to the new system could be quite costly. This takes time and money or data could be lost. Potential additions to cost include handling and managing historic data commonly kept in boxes and would now need to be put into the system, handling inadequate or outdated models that were turned-over and never used, and identifying missing information in historic buildings that have poor as-built drawings and were constructed before BIM was ever a possibility. There is a need for additional research in the area of cost and potential savings of adopting BIM for FM and FM systems, especially if an owner chooses to document existing facilities.

Future research areas that can help with the improved adoption of BIM for FM and FM systems include the development of case studies to document the successes and failures of respondents who indicated interest in helping with future steps of research. Compiling these case studies could lead to developing a series of best practices to guide other owners through the process of adopting and implementing new technologies.

References

Alsyouf, I. (2007). The role of maintenance in improving companies' productivity and profitability. *International Journal of Production Economics, 105* (1), 70-78.

Azhar, S. (2011). Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering, 11* (3), 241-252.

Becerik-Gerber, B., Jazizadeh, F., Li, N., & Calis, G. (2012). Application Areas and Data Requirements for BIM-Enabled Facilities Management. *Journal of Construction Engineering and Management, 138* (3), 431-442.

Bonett, D.G. & Price, R.M. (2012). Adjusted Wald Confidence Interval for a Difference of Binomial Proportions Based on Paired Data. *Jounral of Educational and Behavioral Statistics, 37* (4), 479-488.

Cotts, D. G., Roper, K. O., & Payant, R. P. (2010). *Facility Management Handbook (3rd Edition)*, AMACOM - Book Division of American Management Association, New York, NY.

Di Iorio, C. (2013). BIM to FM – Realities, Goals, Challenges and Future. BIM MEP AUS.

Dias, P. & Ergan, S. (2016). The Need for Representing Facility Information with Customized LOD for Specific FM Tasks. *Construction Research Congress (CRC 2016)*, ASCE Reston, VA.

Eastman, C. M., Teicholz, P., Scaks, R., & Liston, K. (2008). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*, John Wiley & Sons, Inc., Hoboken, New Jersey.

FacilitiesNet (2008). *BIM Software as a Facility Management Tool* [WWW document]. URL http://www.facilitiesnet.com/software/topic/BIM-Software-As-A-Facility- %20Management-Tool--18790 (visited 2016, October 14)

Fuller, S. (2010), Life-Cycle Cost Analysis (LCCA), *Whole Building Design Guide*, National Institute of Building Sciences. [WWW document]. URL http://www.wbdg.org/resources/lcca.php (visited 2016, October 16)

Gleason, D. (2013). Getting to a Facility Management BIM. *Lake Constance 5D-Conference*, Constance, Germany, October 29-29.

Kiviniemi, A. & Codinhoto, R. (2014) Challenges in the Implementation for BIM for FM – Case Manchester Town Hall Complex. *Computing in Civil and Building Engineering Workshop*, ASCE, Reston, VA.

Lewis, A., & Whittaker, J. (2012). Identifying and Overcoming Industry Challenges to Reach the BIM FM Vision. *Journal of Building Information Modeling*, Spring, 18-19.

Teicholz, P. (2013). *BIM for Facility Managers*. John Wiley & Sons, Inc., Hoboken, N.J.

U.S. News and World Report (2015). *National Universities Ranking*, [WWW document] URL http://colleges.usnews.rankingsandreviews.com/best-colleges/rankings/national-universities