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Role of BIM for Facility Management in Academic Institutions

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Abstract
Recent research suggests that 85% of the lifecycle cost of a facility occurs after construction is completed. It is estimated that approximately $10 billion are annually lost in the U.S. alone due to inadequate information access and interoperability issues during operations and maintenance phases. A building information model has the capability to store information about a building and its spaces, systems and components. Hence it could be extremely useful for daily operations and periodic and preventive maintenance of the facility. This study analyzes the industry's best practices concerning the use of BIM for facility management particularly in academic institutions and presents a preliminary plan for implementation of a BIM based facility management system at Auburn University. The paper begins by providing an overview of the use of BIM in the facility management industry. Next, brief case studies of some universities that have adopted, or are planning to adopt, BIM in the operation and maintenance of their facilities are presented. Finally, a plan for implementing BIM in the facilities division of Auburn University is discussed.

Keywords
Building Information Modeling, Facility Management, Operations and Maintenance

1. Introduction

A study by the Center for Integrated Facility Engineering (CIFE) at Stanford University conducted research on the long term productivity rate of the construction industry. Data was recorded over a span of forty years, from 1964 to 2004. The results found that productivity in the construction industry had decreased by ten percent over this time period. It was also determined that productivity in non-construction related industries had increased by 150 percent (Liu, 2010). This is largely due to the fragmented nature of the construction industry. Communication gaps that exist between owners, architects and contractors combined with the sheer volume of information involved in a construction project create opportunities for problems to develop. Omissions and errors in construction documents, as well as a lack of collaboration among parties have been proven to result in an extensive amount of wasted time and money throughout the lifecycle of a building (Liu, 2010).

A 2004 study conducted by the National Institute of Standards and Technology (NIST) estimated the monetary losses due to inefficiency in the Architecture, Engineering, Construction and Facility Management (AECFM) industry. It was found that the fiscal loss in 2004 associated with "inadequate interoperability among computer-aided design, engineering, and software systems" was $15.8 billion. This study also reported that two thirds of this cost was shouldered by owners and operators as a result of their ongoing issues related with facility operation and maintenance (Thuston, 2009). The figures reported in this study are astonishing, yet these losses stem from relatively simple problems (Jordani, 2010).

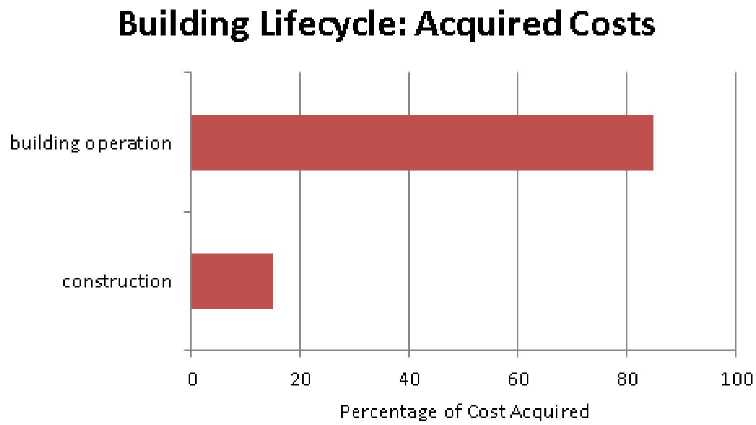

Figure 1: Acquired Costs over the Lifecycle of a Building

The construction industry accounts for roughly eight percent of the US's Gross Domestic Product (GDP); only the United States government employs more people than the construction industry (Liu, 2010). Inefficiency in construction is a large problem; the sheer size of the industry gives it the ability to significantly impact the economic status of the country. Not only is construction an extremely large industry, it is also very technically challenging. The technological advancements and variations from project to project make the learning curve steep and the opportunity for errors very high. In addition, innovations that have affected other industries such as integrated information systems, better supply chain management, and advancement in collaboration technology cannot be applied to the construction industry due to the extensive communication gaps among project participants (Meadati, 2010). Communication issues are evident in all phases of a project; however, they have the largest impact after construction is complete. Of the astounding $15.8 billion wasted in construction every year in the U.S. roughly $10.6 billion is attributed to the operation and maintenance phase of a buildings life cycle (Thuston, 2009).

Recently, members of the construction industry have been doing a better job of adopting much needed new technology to the design and construction phases of a project. The development of three dimensional design software that is capable of modeling all building systems (structural, architectural, mechanical, electrical and plumbing) digitally has already had a huge impact on construction. This technology is known as Building Information Modeling (BIM). The benefits that have stemmed from this new design technology are broad. However, until recently these benefits were not extending past the construction phase of a building's life cycle. Due to the fact that operation and maintenance account for roughly 85 percent of the total facility cost, as shown in Figure 1, it seems logical that the majority of this effort should be focused on the building after it is constructed (Sattenini & Thuston, 2009).

2. The use of BIM for Facility Management

Using Building Information Modeling for facility operation, maintenance and management is a recent development that has been catching the interest of many parties in the construction industry. The system abandons the out of date two-dimensional AutoCAD software (which is currently the status quo), and replaces it with a three-dimensional computer modeling software such as Vico's ArchiCAD®, or Autodesk's Revit®. Figure 2 shows a screenshot of the Autodesk Revit user interface. The three dimensional model serves as a mechanism for recording all information in the building, and provides a platform for effective management of the building information. Architects and facility managers are developing guidelines for BIM models so that the data entered during the design and construction phases can be extracted and stored for future use. There is now a growing interest among building owners and operators of using BIM models to assist in the daily operation and maintenance of their facilities (Ruiz, 2010).

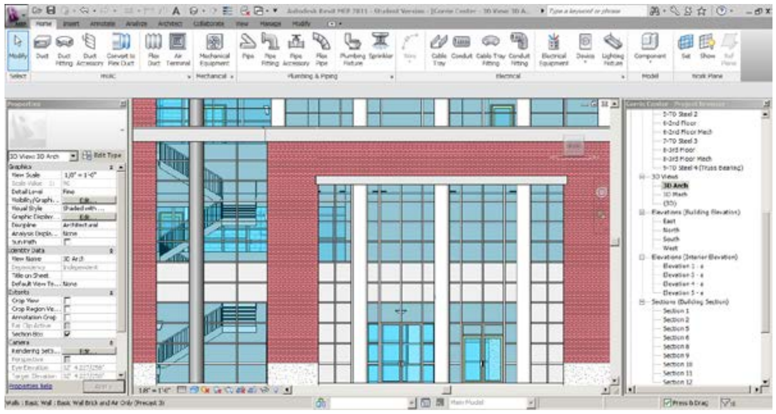

Figure 2: Screenshot of Autodesk Revit User Interface

The technical aspects of a facility are traditionally represented through two-dimensional construction drawings. These documents are imperative to the construction of the building, as they are needed to prepare the plan for construction, the construction schedule, and cost estimate (Hardin, 2009). The information in these plans is often misinterpreted, resulting in requests for information (RFI's), and change orders. In addition, misinterpretation and information omission can lead to communication gaps among owners, architects and contractors (Ruiz, 2010). The use of BIM promotes a collaborative process between project participants; it is able to mitigate these communication gaps by facilitating the exchange of information, and enhancing the interoperability of information management. The centralized approach of information storage and management creates increased teamwork and collaboration in the AECFM field. Due to the fact that the BIM models are able to store, and automatically update information as changes are made to the project, much of the opportunity for errors and omissions are eliminated (Ruiz, 2010).

The use of software to generate three-dimensional building models that can be used as a basis for information exchange between project participants is changing the construction industry. Digital models of a building make it much easier to visualize the project, which reduces misinterpretation. The impacts associated with changes on the project are easily demonstrated, and the decision-making responsibilities of owners, project engineers, and managers are eased (Liu, 2010). BIM began its life as, and still is primarily used as a visual tool. However, in recent years the information capabilities of the software have become a focus of the industry. The ability of BIM to efficiently store and manage information, while linking it to individual building components is proving to be extremely valuable. However, in order to be even more beneficial this technology must be extended into the post construction phase of a building's life cycle (Jordani, 2010).

Building Information Modeling is still somewhat new to the construction industry. However, if you wish to be competitive in the commercial, academic or institutional construction industries, it is becoming clearer every day that you must take advantage of the opportunities that BIM provides. BIM in the AECFM field promotes a collaborative process aimed at increasing productivity and decreasing errors. The BIM system creates three-dimensional models that incorporate structural, architectural, and MEP building elements. This family of elements is able to work together to store information, link it parametrically and organize it in an efficient format. When a three-dimensional BIM model with good useful information is acquired the information becomes "actionable" (Zyskowski & Valentine, 2010). This essentially means that BIM models can be continually updated as adjustments are made to the project, and the updates are automatically integrated into all aspects of the model, including equipment schedules and cost reports. This is due to the development of parametric building components. Parametric elements are different from traditional two-dimensional AutoCAD elements in that they are able to store information as small individual databases, and anything altered in the model will affect the relevant data automatically. This is due to the ability of building components to communicate with one another (Hardin, 2009). For example, if a wall is moved in the model all windows and doors associated with that wall will also move, and the room dimensions will automatically be changed. In addition, the information that is already being captured in BIM models can be stored and used downstream to streamline facility maintenance (Jordani, 2010).

One of the key aspects of BIM that must be understood is that it is a process. The software itself merely provides a framework which the designer can use to develop an idea, and the constructor can use to bring the building to life. Not only can this structure be created in a three-dimensional view, the actual elements of the facility, such as doors, walls, beams, and windows can be represented as objects in the digital model (Curtis, 2010). Information can be entered into the model any time from project conception to demolition. Due to this advantage, the model has the ability to serve as a database that provides information on all aspects of the building, which can be accessed by all project participants at any time. The solutions offered by them include: integration for fragmentation, reuse of model based digital data instead of data regeneration, and using spreadsheet type product modeling systems instead of traditional CAD systems to reduce errors (Curtis, 2010).

BIM has proved itself as being valuable by resolving constructability problems, space conflict problems, resource allocation, and hazard analysis. It has the potential to be just as valuable, if not more, in the operations and management phase of a building's life cycle. “BIM presents a simple, centralized facility management data solution in one relational database, eliminating redundant information, and linking 3D geometric building data to its function and use (Zyskowski & Valentine, 2010).” Mainstream BIM practices do not provide a benefit that extends past the pre-construction, and construction phases. Vast amounts of critical and relevant data that are failed to be stored in the final model could potentially be valuable resources, needed by facilities management for operation and maintenance, as well as commissioning and decommissioning efforts. In the near future multi-user interactive interfaces will allow data from a BIM model to be integrated with maintenance, operations, and asset management systems. Facility managers will be able to increase response time, increase effectiveness, and provide a better link to necessary information for support over its lifecycle (Curtis, 2010).

3. Use of BIM for Facility Management in Academic Institutes: Case Studies

The research on BIM is very extensive, as it has been a primary focus of the industry for years. However, the use of BIM for facility management is a relatively new topic, and research based on its use in an academic setting is limited. This creates an opportunity to develop new knowledge by thoroughly analyzing academic institutes that have experience with BIM for facility management.

One such university is the Worcester Polytechnic Institute (WPI), Worcester, MA. Research conducted by Liu (2010) as part of a master’s thesis is focused on the implementation of a BIM system at WPI, which was completed in May 2010. The focus of this study is the development of an interactive resource that holds information about a facility and forms a foundation for informed decision making throughout the building’s lifecycle (Liu, 2010). BIM has the capability to do just that. In order to create a system that will be beneficial to the owner, first guidelines have to be developed. Through interviews, in-depth case studies, collaboration with other colleges and review of material available on the subject three basic problems were identified: *what information should be incorporated into the BIM model, how to generate the BIM model, and what to do with the model once it is complete* (Liu, 2010). The guidelines developed aimed to solve this dilemma.

The study identified a conceptual framework that can be applied to both new and existing buildings; the framework can also be extended to other college campuses (Liu, 2010). Previous research conducted by WPI students developed an acceptable BIM model of Kaven Hall, which houses the civil engineering/construction department. Sufficient information for the scope of this research had already been input into the model. The second hurdle was to organize the accompanying information in an efficient, user friendly format that could easily be accessed by employees of the university. A website was developed that served as the interface for the end user. The system developed achieved its goal of successful integration between the website and the BIM model, eliminating the need for employees to update the system when changes are made. This benefit reduces labor cost, and mitigates the problems caused by inefficient information transfer through third parties (Liu, 2010). The system created was a successful example; however, it is simply a conceptual guideline. There is tremendous potential to expand on this research.

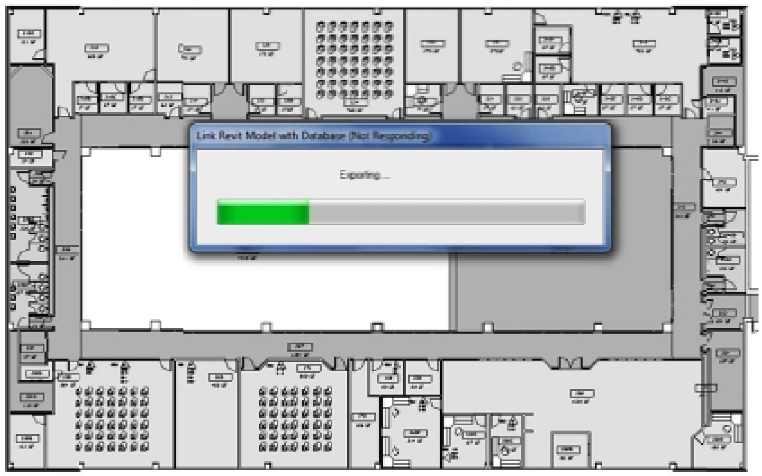

Figure 3: Exporting Building Information from BIM model to On-line Database (Liu, 2010)

While the possible implementation of BIM has been examined at WPI, other colleges, such as Indiana University (IU) have had the foresight to realize the benefits that BIM brings and have already put a BIM based system in place. As a solution to the fundamental issues discussed which include what information should be incorporated into the BIM model, how to generate the BIM model, and what to do with the model once it is complete, IU has created a BIM Execution Plan which is now used for all construction and building operation on campus (Liu, 2010). The plan lays out specific parameters that must be addressed. However, it also allows for participants on each individual project to decide on variables such as level of detail, specific responsibilities of each party and the option to include or exclude items such as an energy analysis model. This methodology allows for increased collaboration, and improves communication between parties (Liu, 2010). The plan serves as a contract between parties, which include the owner (IU), the architect, construction manager and all systems engineers involved in the project (civil, mechanical, electrical, plumbing).

"The intent of the BIM Execution Plan is to provide a framework that will let the owner, architect, engineers, and construction manager deploy building information modeling (BIM) technology and best practices on each project faster and more cost-effectively. This plan delineates roles and responsibilities of each party, the detail and scope of information to be shared, relevant business processes and supporting software (Liu, 2010)." There are ten possible BIM models that can be incorporated into the project, which include the civil model, architectural model, mechanical, electrical and plumbing models, energy model, construction model, estimate model and coordination model. These models all provide individual benefits; however, it is not necessary to include all models in the project. All building information is entered by the architect and engineers. A format is provided in the execution plan for information classification and organization. This allows for significant benefits for the facility operator, as the efficiency of tasks such as location of equipment information are easily accessed (Liu, 2010).

Brigham Young University (BYU), Provo, UT is another example of an academic institute that has had the foresight to invest in BIM integration into their facility management system. BIM is currently being used to assist the Facilities Planning and Space Management departments in recording, tracking and planning the gross and net square footages of all facilities on campus, allowing for more efficient management of assignable spaces (Curtis, 2010). BYU is also in a transition stage of replacing their legacy AutoCAD based building database with a system that uses Autodesk Revit® for facilities and asset management. BIM models are constructed by private architects/engineers as part of the design requirements, much like the system at Indiana University. Building information is recorded throughout design and construction in an organized format, and is turned over to facilities at the completion of construction. The BIM model created in *Autodesk Revit* is able to export building information such as window, door and room schedules, equipment lists, dimensions, etc. efficiently to a file created in Microsoft Access, where it can easily be managed by employees without the need for extensive training on complicated software (Curtis, 2010). It is difficult to quantify the benefits that have been achieved through BIM implementation at BYU; however, their continued investment in the system suggests that a beneficial return on investment is expected.

4. Preliminary Plan for Auburn University

This study uses a complete BIM model (structural, MEP and architectural) of the McWhorter School of Building Science, located in the college of Architecture, Design and Construction on Auburn University's main campus. See figure 4 for a screenshot of the Autodesk Revit BIM model. This particular building was chosen due to its availability of access, as well as the building's size, which is opportune for this experiment, the exposed mechanical systems in the building and the fact that there is an available BIM model completed as part of previous work by Auburn University Building Science students. The BIM model was constructed in Autodesk Revit 2010, and contains sufficient information for this study. Autodesk Revit was chosen as the design software due to its common use in the industry, and its availability for use in the School of Building Science.

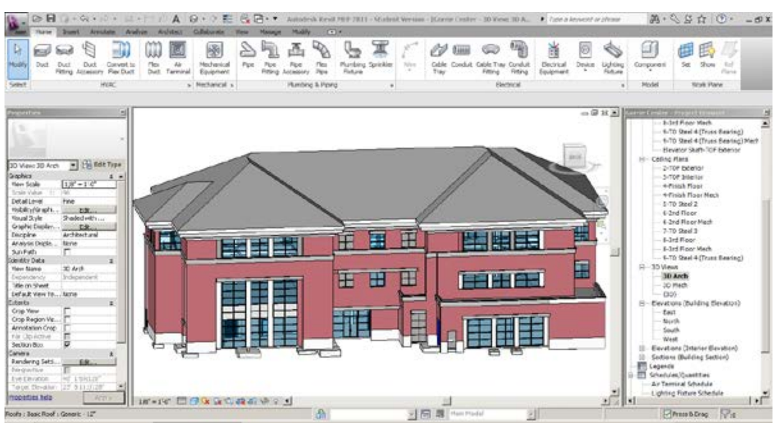

Figure 4: BIM Model of McWhorter School of Building Science in Autodesk Revit

The BIM model will be used to demonstrate how building information from Autodesk Revit can be transferred, and integrated parametrically with the web-based facility management software *FM Systems*®. Through review of available software, FM Systems® was selected and a copy of the software was obtained for the study from funds available through a research grant. FM Systems® is a leading facility management software that offers benefits to facility owners and operators in the following areas: improved space management, efficient use of energy, streamlined preventative maintenance, economical retrofits and renovations and enhanced lifecycle management (Ruiz, 2010). FM Systems' "FM Interact" system accepts two-dimensional or three-dimensional documents; however the documents are all viewed two dimensionally in the program. The FM interact system contains space management, asset management and strategic planning modules. These modules can be used for varying tasks, providing a number of benefits to the operator. Additional modules can be purchased that include move management, project management, real estate portfolio management and sustainability. These modules all offer additional benefits to the user. Figure 5 provides a screenshot of the FM Systems user interface.

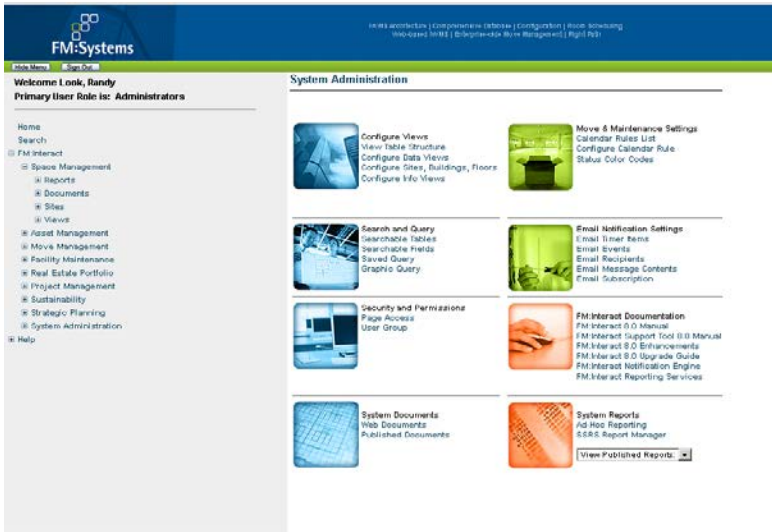

Figure 5: Screenshot of FM Systems User-Interface

Selected activities that are related with space and asset management, as well as mechanical operation and maintenance will be selected that have a defined workflow in the facilities division at Auburn University, and these tasks will be completed using a BIM-based framework. Any benefits, and or problems that can be demonstrated by comparing the two methodologies will be identified, and analyzed. This study will be completed by the end of this year and full results will be published in another paper.

5. Concluding Remarks

This study proposes a preliminary plan for implementing a BIM-based online database (FM Systems) to assist in facility management on the campus at Auburn University, specifically the McWhorter School of Building Science. It is anticipated that this plan will provide benefits to the University's facilities division; specifically in the areas of space and asset management, and equipment operation and maintenance. Due to the monetary inefficiencies related with faulty building operations, it is projected that a BIM-based system will yield positive results if put in place, by mitigating gaps in communication and saving wasted man hours, and the accompanying labor costs. The main objective of this paper is to give an overview of BIM being used in the facility management field, especially academic institutes. Future papers will demonstrate the implementation of a BIM-based facility management system for Auburn University's facilities division.

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