Building Information Modeling at MSU

White Paper

Abstract

BIM is a revolutionary approach to design, construction, and maintenance operations that promises to speed construction, improve collaboration among construction stakeholders, manage change in a less costly manner, reduce inefficiencies and redundancies, and enhance overall productivity. This paper discusses some advantages of BIM for the owner, explains and defines BIM in a non-technical manner, and provides some suggestions to initiate a BIM project.

"On a typical $10 million dollar (or more) project there are approximately:

- 420 companies involved
- 850 individuals involved
- 50 different types of documents generated
- 56,000 pages of documents
- 6 – 20" diameter, 50' high,, 20 year old trees harvested for paper documents

Scanning the paper documents is the electronic equivalent of about:

- 3,000 MB or
- 6 CD's"

(Source: BIM Handbook)

BIM defined:

"A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its entire life-cycle from earliest conception to demolition." NBIMS

BIM as a noun: (or a technology view)

A shared digital representation of the physical and functional characteristics of a facility

BIM as a verb: (or a process view)

Collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder

Overview

Academic administrators have long realized that a college campus is much more than just a disconnected agglomeration of buildings that house scholars working in isolation. The great universities foster a spirit of collegiality and collaboration among seemingly disparate entities that lead to great discoveries. Any institution can build facilities to house autonomous mathematics, physics, and chemistry programs; inspired leaders provide the means and environment to encourage these seemingly disparate entities to collaborate and combine to create a world-class nuclear science program and to construct a state-of-the art cyclotron. Collaboration and teamwork produce powerful results for researchers. A fairly new software tool, Building Information Modeling (BIM), has the potential to aid the efforts of the construction organizations at MSU reach even higher levels of success.

BIM, both as a software tool (used as noun) and to describe process changes brought about by enhancing teamwork and collaboration (using BIM as a verb), has capabilities that reach beyond the facility design and construction phases. It also holds great promise to help MSU reach university-wide strategic goals as embodied in sustainability initiatives, can streamline facility management functions over the lifecycle of the building, and can support marketing and security efforts.

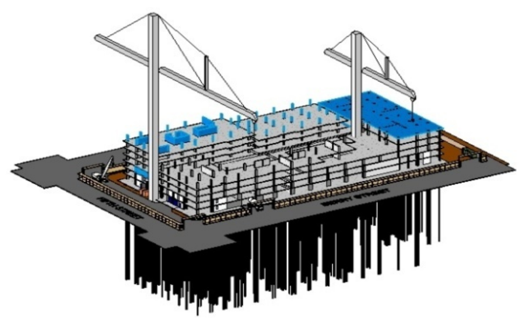
It has long been the goal of those involved in the design and construction of university facilities to work in a truly collaborative manner and as a team to deliver value and meet the unique needs of the academic customer. Given the almost unmanageable number of companies and individuals involved in a project (see insert) it is no wonder that confusion and conflicts sometimes seem to reign on large projects. BIM helps stakeholders coordinate and balance issues such as end-user requirements and needs against hard budget limits early in the design process – this helps to reduce changes later in the projects, shortens design and construction time, and helps to minimize errors and omissions. BIM can also help in the feasibility stage, when linked to a cost database, to determine if the project is within proposed budgets well before expensive design functions are performed and irreversible commitments are made. It can also help to detect potential interferences between trades (sometimes called "clashes") and thus reduce change orders.

MSU's commitment to environmental stewardship, as manifest in the university's "BESPARTANGREEN" program, is well known. BIM, as a pre-construction virtual modeling tool, can help university planners and designers to carefully evaluate the long-term impact and energy efficiency of a proposed structure to determine if it meets functional and sustainability requirements, such as those contained in the Leadership in Energy and Environmental Design (LEED) standards. Different alternatives can be quickly evaluated using energy simulation and analysis modules. BIM, as a digital tool, also holds the promise to reduce the amount of paper consumed by the construction process (see insert).

BM is a workhorse for the university long after the ribbon-cutting ceremony. It acts as a repository of vital information for the operations and maintenance of the facility. The BIM can hold all of the as-built documentation from the design and construction phases as well as the operations and maintenance data. Potential updates and renovations to the facility can be evaluated using the original design intent and the impact can be easily evaluated. With BIM facility management has a ready database to calculate rooms, spaces, and equipment. Using BIM as simulation tool the facility manager can work with other university departments, such as the fire and police departments, to analyze, for example, smoke propagation during a fire. This would help to evaluate evacuation routes in this and other crisis scenarios.

Finally, BIM can be used as a marketing tool by both housing and admissions. As a 3-D visualization tool, BIM has a feature that allows a virtual "fly-thru" of a building or room. The prospective student or conference organizer could "virtually" visit their room(s) prior to occupancy. Someday, in the future, a potential student could virtually visit every building on campus without ever stepping foot in East Lansing.

The remainder of this paper discusses other advantages of BIM for the owner, explains and defines BIM in a non-technical manner, and provides some guidelines to initiate a BIM project.



BIM Explained

The idea of BIM has been on the designer's wish list for many years. Technology has finally advanced to the point where the dream is now realized. The definition of BIM at the beginning of this paper is just one of many in the industry. BIM is a software tool but it also holds the promise to change the process of construction and "business as usual." First, lets look at "under the hood" in a mostly non-technical way at explaining BIM as a "noun," and how the software works. Then, we look at what the real "buzz" is about BIM, the "verb" part. This is the promise of enhancing collaboration and teamwork.

Under the Hood

At the heart of the BIM is a large common database that can be digitally manipulated to create a complete representation of a facility prior to construction. This includes traditional 2-dimensional (2D) plans consisting of elevation, section, and plan views, 3D views, and construction documentation such as door and window schedules. This database holds all of the information for the objects and elements that make up the building. What makes this important - even huge, is that information only has to entered once and can be accessed accurately multiple times. This means that those who need the data, such as consultants, can electronically access the data input by the architect and use it in analysis programs unique to their trade.

This has several benefits. For one, the consultant doesn't have to re-enter the data by hand, saving time, improving communication, and minimizing the chance for input errors. Changes made by the consultant can be fed back into the database. Here is the amazing part, the changes made by the consultant are reflected in other parts of the structure that are affected by the change! For instance, say a mechanical engineer sizes a return vent that is to be places on a wall. The vent impact on the wall dimensions are automatically reflected in all of the representations (2d, 3D, and material schedules.

Major BIM System Vendors

BIM product	Vendor
Revit Architecture	Autodesk
Bentley Architecture	Bentley Systems
ArchCad	Graphisoft
Digital Project	Gehry Technologies

How does this magic work? The scholars in the computer science department call this database property *bi-directional associativity*. This just means that changes to any part of the design are immediately reflected (or updated) in all of the associated parts. The objects and elements (wall and doors for example) that make up the building are defined by their *parameters*, as are the relationships among the model components. What this means is that in the model a wall knows that it is a wall, not just a series of unrelated lines. The design intent (i.e. how the architect wants the wall to be composed and how it should behave) is captured by these parameters. The parametic features fully describe how that the wall is so many feet long and tall, made of steel studs and has drywall on each side. It also knows that it has a sound and insulation rating. It is also an "intelligent" wall – it knows when something is being added to it, like a vent, and adjusts its parameters accordingly. By defining parameters among building elements (think of this as linking them together), the modeler can instantaneously update the model as changes are made to the database. As an example, a modeler might want the vent mentioned previously to be parametrically linked to a fixed location in the wall, say a certain number of feet from the floor and ceiling and away from the door. Now suppose that the end-user wants to move the wall to accommodate say, a bigger and better cyclotron. This change could impact a bevy of building components that might not be realized until the trades are in the field. But, because the building is virtually modeled long before groundbreaking, these parametrically linked elements change in relation to one another and are updated as the wall is changed to accommodate the customers requirements. The model may tell you that the change cannot be made, which is still valuable information – computers can't solve every problem.

BIM programs are also interoperable with other common construction scheduling and estimating programs. This is referred to as "xD" capabilities. The 3D capability was previously mentioned. This is probably the most common use of BIM, to present a full pictorial representation and rendering of the proposed facility. This helps all users visualize the finished product and judge aesthetics characteristics in relation to the surrounding structures. The 3D capability also allows virtual walk-throughs and simulations as described previously. Incidentally, BIM programs can also generate traditional 2D drawings that are historically associated with building construction.

The BIM can also express construction sequence and scheduling dimensions of the project. This is referred to as a "4D" capability. Here, the facility is built virtually in a time-lapse fashion so that constructability and other issues can be addressed. The program can also be linked to an external scheduling program to run simulations and forecasts of various resource allotments of not only time but also other resource allocation issues such as labor. Here the project team can visualize things such as how scheduling multiple crews on-site can affect productivity and safety. The 4D capability can help an owner decide if a project can be built in the allotted time.

Linking the BIM to an external cost database can provide almost instantaneous estimates on changes to the proposed design configurations. In BIM-speak, this is called "5D." This means that owners, in the feasibility stage, have a better idea if the proposed facility is within the means of the budget.

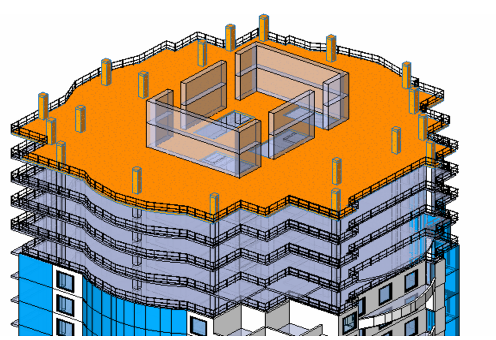
BIM holds the promise of many future "x's" in the "xD" capabilities. Many of these promises are well into the development stage. A proposed "6D" is involves supply-chain integration. A "7D" will improve the operational life-cycle analysis. Certain BIM products are already available for facilities management. The "x's" seem only to be bound by technology – users will come up with new and better ideas to use BIM.

The Buzz About BIM

The technology that drives BIM is certainly impressive. However, we are reminded by our brethren in the anthropology and industrial psychology departments that we live in a *socio-technical* world. The impact of the social aspects of BIM are equally as exciting as the technological impacts. BIM affects the way people perform work and how they work together. Using BIM changes the fundamental processes of how construction is traditionally conducted. Early collaboration and teamwork are the keys to a successful project and the use of BIM helps to ensure success.

Why is early collaboration important? Programs that perform analysis's, such as for energy efficiency, traditionally are completed after the 2D drawings are finished. In a BIM environment, multiple designers can work in tandem at the beginning of design to make modifications that improve building quality and functionality as well as decrease design time. Another benefit of collaboration is the involvement of other stakeholders at critical junctures or the project. For instance, when using BIM the end-user can easily visualize the finished projects prior to and during construction. The full effects of proposed changes can be visualized, the cost and schedule impacts can be evaluated, and a decision can be made – perhaps all in one session. Collaboration can reduce errors and omissions and detect conflicts in fieldwork among the trades. Finally, BIM reduces Requests for Information (RFI's) - the model contains the information!

Getting Started



BIM has been proposed as digital modeling strategy for the owner that enables greater project collaboration, promotes better communication, aids in environmental sustainability initiatives, enhances productivity improvements by eliminating inefficiencies and redundancy, and facilitates process changes, and as a tool to manage the facility over its lifecycle, to name but a few. There are many other benefits of BIM too numerous to mention in this short treatise; for instance BIM seems especially suited as an enabler for construction initiatives such as Lean Construction, in particular as a tool to utilize the Lean strategy of prefabricating components offsite to facilitate construction progress. BIM benefits the entire construction team, not just the owner, far beyond the first costs of implementing the model.

Many large construction owners are implementing BIM. The General Services Administration (GSA) mandated that all major projects in fiscal year 2007 and beyond use spatial program BIM's (the GSA sometimes uses the term phrase Virtual Building Model (VBM) instead of BIM) and recommends the use of mature VBM's on all technologies. Other large owners using BIM include General Motors Corporation, The U.S. Army Corps of Engineers, The U.S. Coast Guard, and Sparrow Hospital in Lansing, Michigan. BIM has even been used at MSU on a limited basis by Chrisman Construction on the University Apartments project clubhouse.

Because of the long-term and far-reaching benefits of BIM MSU should consider including specifying BIM as a requirement in solicitations and contract documents. BIM technologies are quickly becoming less expensive and more user friendly. The initial increase in cost to the University is offset by the long-term benefits as discussed and a more competitive, albeit in the future, bidding market. As BIM becomes more common constructors will require fewer managers to run work, thus lowering costs.

References

"The BIM Handbook" by Chuck Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston

"The Perfect Storm – Construction Style" the FMI/CMAA Eighth Annual Survey of Owners

"2007 Construction Information Technology Guide" Paul Levin, Editor

"Revit Architecture 2008 –Student Guide Core Concepts" by Autodesk Corporation

Some BIM Websites of Interest

http://www.bentley.com/en-US/Promo/Build+As+One/

www.gsa.gov/bim

www.wbdg.org/resources/bim.php

www. Autodesk.com/PowerofBIM

http://www.bimworld.com/