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Building Information Modeling (BIM) Technology

Seamlessly Bridging Communication Throughout the Building Process

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PCI began to incorporate Building Information Modeling technology into our design process in early 2008. Our engineers and design professionals have utilized BIM on a number of projects, including office buildings, laboratories, manufacturing and pharmaceutical production facilities. In this paper, we will gather information from various sources to give you a better understanding of how the BIM approach differs from more traditional construction processes and how BIM technology may be used on your next project, saving you time, reducing costs, and improving the overall quality of the project.

What is Building Information Modeling (BIM)?

Building information modeling is an innovative approach to building design, construction, and management that is characterized by the continuous availability of highly accurate, consistent and reliable building information. BIM allows the project team to visualize, simulate, and analyze a project before construction even begins using a three-dimensional model representing all of the physical and functional characteristics of a facility.

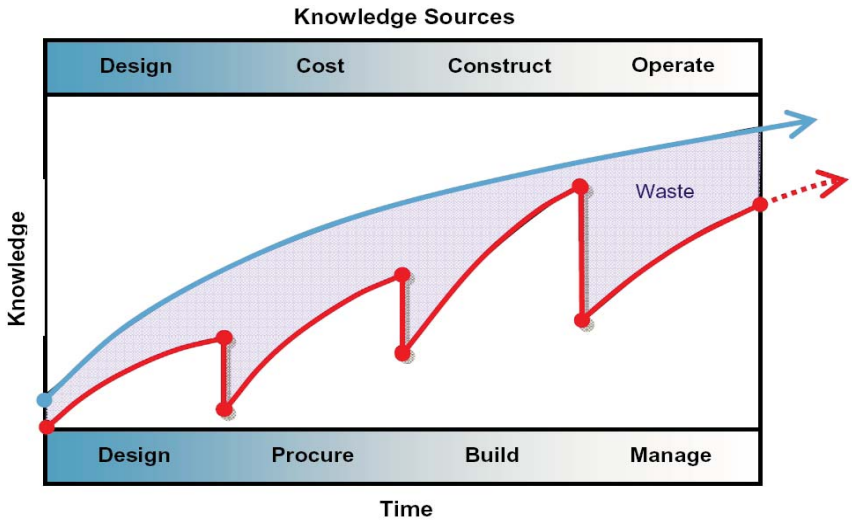
Here's an often cited analogy for understanding BIM: Just as Excel is a powerful tool for thinking about numbers, software built on parametric building modeling technology is a powerful tool for thinking about buildings. When a change is made anywhere on a spreadsheet, it will update everywhere in the document with no further input from the user. Similarly, a change made anywhere in a parametric building or BIM model is immediately reflected throughout the model. The update is dynamic -- automatic and complete.

Why was BIM developed?

BIM was developed in part to address the issues of data loss as a building project moves through the various stages of development – from initial design to construction to operation. Here's how the process is described in a whitepaper entitled "*BIM and Facilities Management*," put out by our vendor, Autodesk, developers of Revit, a leading parametric building technology solution:

> "There are a series of discontinuities in the transmission of building data that occur throughout the typical building process. Transitions from design to construction to operation result in loss of data, added cost to reconstitute the data, and overall reduction in data integrity—the impact growing at each handover, culminating with the handover to the facility operator. In a 2004 NIST study undertaken to estimate the efficiency losses in the U.S. capital facilities industry, it was reported that the annual cost (in 2002) associated with inadequate interoperability among computer-aided design, engineering, and software systems was $15.8B.
>
> The study went on to report that owners and operators shouldered almost two thirds of that cost as a result of their ongoing facility operation and maintenance. These statistics are borne out in the day-to-day activities of facility managers: manually updating occupancy reports via whiteout; calculating area for space charge-backs by counting ceiling tiles; digging through stacks of building documentation to find the maintenance manual for a water heater; or searching in vain for an as-built floor plan, only to find they never received it in the first place.

But the lack of interoperability highlighted in the NIST study is only part of the problem. Is the data trapped in those computer systems studied worth sharing? We tend to overlook the issue of data quality, glossing over the unfortunate truth that often the data produced by conventional design software is unreliable and thus not worth the effort required to share it. Whereas the hallmark of BIM is coordinated, consistent, computable information about a building project—information that's worth sharing and reusing."

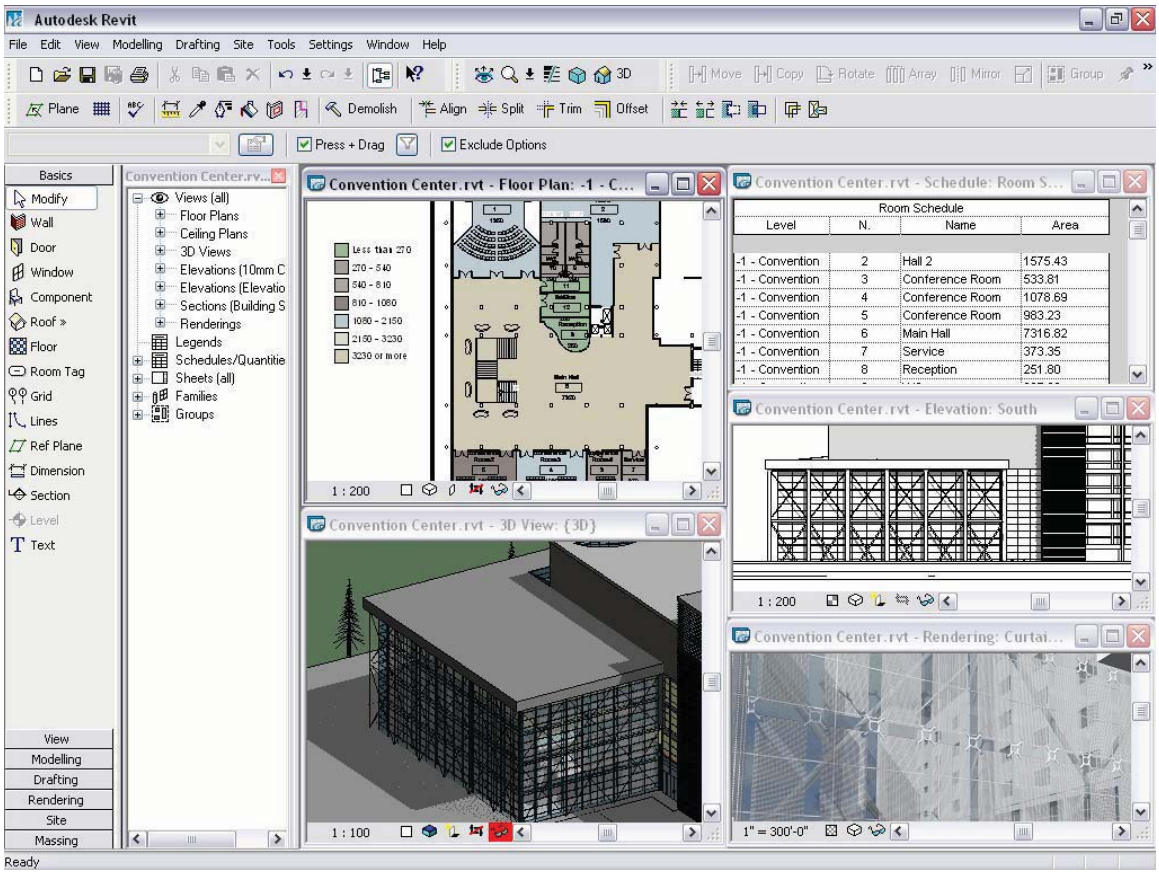


Transitions from design to construction to operation result in loss of data. The impact grows at each handover, culminating with the handover to the facility operator.

Parametric Modeling

Parametric Modeling is an approached to building construction that is characterized by designing with objects having real-world behaviors and attributes. Here's how it is described in another whitepaper from Autodesk called, "*Parametric Building Modeling: BIM's Foundation*."

> "Original (2 and 3 dimensional) CAD engines used explicit, coordinate-based geometry to create graphic entities. Editing these "dumb graphics" was cumbersome and extremely error prone. Documentation was created by extracting coordinates from the model and generating standalone 2D drawings. As graphic engines matured, graphical entities were combined to represent a design element (a wall, a hole, etc.). Depending on the software, the models became "smarter" and were a bit easier to edit. Surface and solid modelers added more intelligence to the elements and enabled the creation of complex forms.
>
> But the result was still an explicit (coordinate-based) geometric model, which was inherently difficult to edit and had a tenuous relationship to extracted drawings that easily fell out of synch with the model.
>
> Then came parametric modeling engines that used parameters (numbers or characteristics) to determine the behavior of a graphical entity and define relationships between model components. For example, "the diameter of this hole is 1 inch" or "the center of this hole is midway between these edges." This meant that the design criteria or intent could be captured during the modeling process. Editing the model became much easier and preserved the original design intent."



With state-of-the-art parametric building modeling, BIM software can coordinate a change made anywhere and everywhere it matters: in 3D views and drawing sheets, schedules and elevations, sections and plans.

The essence of the design of a building is in the relationships that can be embedded in the building model. The creation and manipulation of these relationships is quite literally the act of designing. Parametrics gives designers direct access to these relationships and are natural and intuitive ways of thinking about buildings using a computer.

Project Delivery Comparison – Traditional vs. BIM

Traditional Project Delivery Method	Project Delivery utilizing BIM
Interoperability • Architects and Engineers design systems utilizing analysis and design software • Cad Drafters create drawings based on information provided by the engineers and architects • Contractor vendors/sub-contractors develop shop drawings based on construction documents provided by design firm • The project is constructed • After the project is built the owner receives "record drawings" along with O&M manuals for the equipment for their use in the maintenance and operation phase of the building lifecycle.	**Interoperability** • Architects and Engineers design systems utilizing analysis and design software that transfers data seamlessly to parametric modeling software that builds a model of the project • Trade specific fabrication software can then receive data from the parametric model to develop fabrication drawings • The project is constructed • After the project is built the owner receives an intelligent project model with high-quality building information that will aide in the maintenance and operation phase of the building lifecycle.
Coordination & Collaboration • Traditional project delivery relies on the communication abilities of the Owner, Architects, Engineers, and Contractors that typically work independently.	**Coordination & Collaboration** • On projects where BIM technology is utilized the Owner, Architects, Engineers, and Contractors work from a shared project model that has the latest developed information.
Owner Visualization and Communication • The suitability of a project to meet the needs of the owner relies heavily on the owner's ability to read construction prints. Many times the owner doesn't fully understand what they are getting until the construction is well underway.	**Owner Visualization and Communication** • On BIM projects, the owner can view the building model before construction and evaluated how the building will satisfy their needs and desires.

Project Changes

- Project changes frequently take place during the construction phase due to poor communication between the owner and the designers, and the limited ability of owners to read construction prints. These changes typically are costly requiring construction rework and schedule delays.

Project Changes

- With BIM models, project information is generated very early in the design process. Given this, owners can view the models well before construction has started and make changes during the early design phases when they can easily be incorporated into the design at a relatively low cost, or at no cost.

Construction Planning

- The information used by construction contractors to plan the projects construction is limited to the quantity and quality of information provided with the construction documents. Specifically, the information is limited by the level of design and how well the documents are coordinated. The quality of the construction planning is also affected by the time it takes to get acclimated to the project and its requirements.

Construction Planning

- Projects utilizing BIM technology have access to all the information included in the BIM model. With this information, construction contractors can easily build a virtual schedule of the construction process utilizing the model. This also enables them to anticipate and fix potential conflicts and field coordination issues reducing RFI's during construction, coordinate trade schedules, utilize additional prefabrication of assemblies, and better anticipate and make provisions for potential safety issues.

Prefabrication

- Prefabrication on traditional projects is limited to the quality of information provided on the construction documents. This information is not typically detailed or coordinated sufficiently to allow for substantial prefabrication.

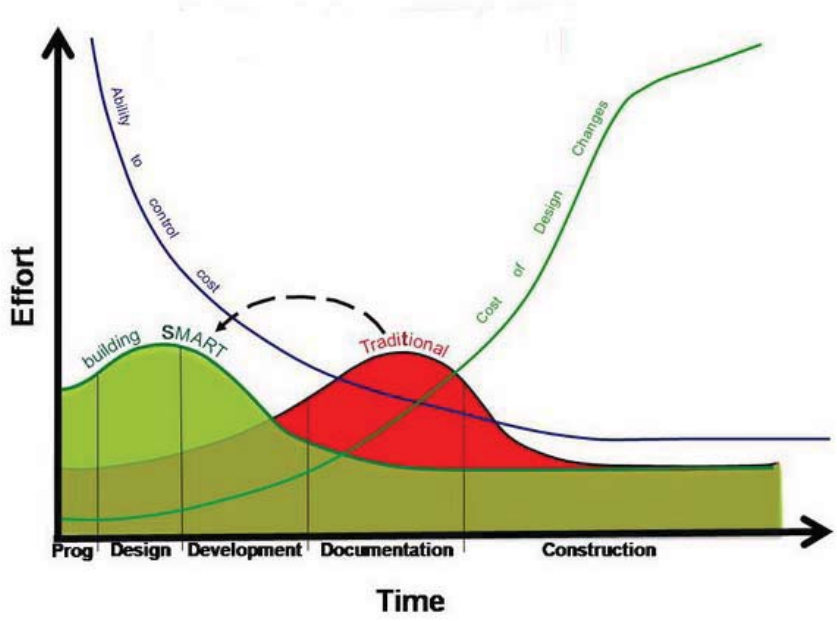
Prefabrication

- Due to the high-quality of coordinated information on projects utilizing BIM technology, large assemblies can be prefabricated. These include assemblies of ductwork, pipe and pipe racks, HVAC equipment assemblies, wall panels, and electrical assemblies.

Benefits of BIM

Using the BIM approach, our customers have seen lower project costs, faster project delivery, and improved overall quality of the finished product.

- **Virtual "walk-throughs"** allow owners to predict how the building will satisfy their needs before construction. Design changes can be identified and modified early in the design process.



- **Better communication with client** due to the improved 3-D visualization. The ability to visualization is key to keeping owners informed.

- **Improved project outcomes** due to the improved coordination of the project team, 3-D visualization, fewer RFI's and changes during construction.

- **Increased construction productivity and efficiency.** The model visualization improves construction planning and sequence workflow while improving the ability to manage the supply chain.

- **Improved project quality.** The improved construction coordination and design accuracy allows for more shop fabrication, which improves the overall quality of the project.

- **Improved facility lifecycle management.** Utilizing the BIM model, Facility Managers have quick access to detailed information about their building, supporting its long-term operation and maintenance.