What’s Involved

Industry practice has been for architects and engineers to use Computer Aided Design (CAD) software for planning and designing a new facility or retrofit project. Sets of two-dimensional drawings are produced and used to construct the building. From these sheets, Scopes of Work are developed to be bid and completed by various trades, changes to the design are tracked on site, and a post construction “As-built” revision of the original design is recorded and left with the building Owner for their records. Due to the static nature and hierarchy of this process, there is increased risk for common coordination issues to arise, and for information to be missed, resulting in schedule delays while RFI’s are answered.

With advances in computer technology, there is a change moving through the building design and construction industry. The Architectural and Engineering (A/E) community, as well as many general contractors, is increasingly implementing Building Information Modeling (BIM). BIM is the process of building a 3D data rich model of all architectural, structural, mechanical and electrical systems in the building. The model is not only used to design the building and document it for construction, it’s also used as the primary tool to create and coordinate design solutions. “It really is a game changer,” says Keith Holloway, a Project Manager with RLF, “A lot of companies are trying to treat it like a traditional drafting tool, but doing it that way just adds extra steps that aren’t necessary and are counter productive to the end deliverable.”

When using BIM on a project, early involvement of all parties responsible for final completion of the facility is recommended. Everyone including the owner, architect, design engineers, general contractor, and associated trades have input in the process from the beginning. This early input means combining field experience with vision and the BIM model helps merge real-world with design-world. Much of the reason that there is a need to create as-built documentation following construction is the fact that adjustments are made in the field, whether it be for constructability, cost savings, etc. It is often the case that ‘rules of thumb’ may be applied during the early stages of design and will remain unless and until they are vetted out by the design team and owner. On large projects it is possible that these items, especially if small by relative significance, go unnoticed until the tradesman is trying to route equipment or apply a finish that can’t be done to specification.

Figure 1: Using a 3D modeling program to design all systems within the building, design disciplines can work together to more effectively coordinate space requirements, designing a leaner, more efficient building.

Clash detection can occur during design, reducing RFI’s once the project gets to the construction phase. For example if a light fixture is placed in the path of a supply duct, this could be a problem during construction, wasting time and money, and could result in the electrician having to return to the site to move the light fixture, or an RFI to the design team to redesign the duct work. A project using BIM can identify the conflict during design, saving the owner time and money before those issues arise during construction.

Photo courtesy of RLF
In addition to creating and detailing design solutions, BIM increases coordination among the many disciplines involved in the building delivery process. As mentioned before, the more typical practice is for A/E firms to produce electronic drawings for a project that include two dimensional ‘floorplan’ layouts on a by-floor or by-section basis. The architectural views within this electronic CAD file act as the background and layout for spacial reference of the engineering systems and other infrastructure. Layers are then placed over top of this reference to view mechanical, electrical, structural, plumbing, fire protection, and any assortment of other specialty systems or details that need be applied. Working in 2D means that many calculations and measurements are done outside the CAD model, to ensure everything will fit above the specified ceiling height, or to do area take offs for cost estimating. This process leaves a lot of room for error, as the structural engineer who is planning beam depths is simultaneously doing their calculations with the mechanical engineer who is sizing ductwork.

**Verticality is Key**

Applying a third dimension to the drawing set is not a new idea, but allows for greater detail and understanding of the building. Architects have applied three dimensions to their projects throughout history to allow greater representation of the intended finished product to the client. Models began as cutouts and handmade structures to demonstrate orientation within surroundings or proximity to other buildings within a campus. Naturally these have progressed to simulated BIM renderings through programs like Revit or Navisworks to review external finish work and perspectives of the intended facility. What this provides is a greater depth of understanding and analysis to members of the design team and support staff. Being able to ‘walk’ through a hallway virtually, see how daylighting plays across the room, what fixtures hang from the ceiling above, to the detail of how ductwork will run from the air handler to interior offices. This model is about reviewing and ensuring that the owner's criteria and basis of design are met efficiently while providing a look at the final result. The author of ‘Engineering-centric BIM’ states that “Creating a multidisciplinary 3D integrated model of a building is a valuable tool…but if it does not enable interoperability, then it is not truly BIM.”

**Advantageous to the Owner**

However, increased coordination and better modeling are not the only advantage of using BIM tools on a project. The following benefits can also result from creating a 3D model before construction begins:

- Promotes sustainable design through less material use and integrated tools for energy and daylight simulation.
- Provides better information for cost estimating purposes. This is very important when it comes to access issues and timing for installation of critical, large, or specialty components.
- Promotes efficient scheduling; reducing costs associated with rework in the field.
- Reduces materials being stored on site; creating a safer site and less chance for items to be damaged prior to install.
- Allows analysis of alternative design options to resolve conflicts early in the process and increase value.

**BIM Still Improving: ASHRAE Headquarters Remodel**

Ultimately the goal of the BIM method is to create a single packet of data referring to the building. This should include energy modeling and performance analysis, even at the basic level, to provide the owner with operational cost projections and trade-offs from design decisions. The challenge lies in formatting the data set to be compatible with the most appropriate energy/ daylight modeling software for the building type and proposed systems. During a recent test of the BIM method by the American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE), researchers conducted a trial using imported information from a BIM model for their headquarters renovation and found that the “models produce impressive graphics” but “BIM has been overhyped” when it comes
necessary to conduct analysis in other useful software packages, and in some cases, export data back into the BIM model. This “streaming data concept” allowed for increased coordination, and for each team member to have the final information needed to complete their project responsibilities. In addition, from the project initiation phase, the BIM model was intended to be used by the contractor and eventually the owner for facility management purposes.

Not only did the software provide a 3D model of the building for design coordination purposes, but data was also extracted to manage program, equipment counts and other information important to project stakeholders. For example, Figure 2 below shows a data table generated by the BIM program that compares client programming requirements to those achieved by the final design solution. This information was used to illustrate accomplishment of project goals to the client, and it was used by medical planners during design to develop an optimal solution.

The following benefits that were attributed to the use of BIM were identified for the VA Medical Center project:
- Ability to manage costs and budgets
- Streamline the workflow
- Improve team communication
- Resolve conflicts
- Analyze design options
- Calculate lifecycle usage

These benefits were recognized by some of the key players in the project, represented by these statements:

**Architect:**
“Due to the enormous scale of the project,... the use of BIM and associated technologies has been key to providing an integrated medical campus...”

**Owner:**
“The use of BIM has assisted the owner in numerous ways including showing a three-dimensional fly-over... and developing lists of equipment items. Information directly from BIM is used as...procurement planning and preliminary equipment budgets”

**Contractor:**
“As construction began...it was extremely evident that the use of BIM enabled the entire project team to identify and resolve potential issues that may have had a substantial impact to the future phases of the project.”

**In the Industry**
As it stands currently, there is no formal oversight committee or group that defines and manages what BIM entails and the extent of its use. However, there are groups such as GSA, DOD and the VA who are currently working to...
establish standards for BIM solicitation and contract language, constructing BIM toolkits and publishing BIM Guides. In addition, the buildingSMART Alliance, part of the National Institute for Building Sciences (NIBS) is developing a standard, dubbed NBIMS-US that is scheduled for release in December 2011. There are many options for BIM software available and appropriate software must be chosen carefully to ensure accurate data sharing between software packages when necessary. For example, AutoCAD, Revit or Navisworks, Radiance or AGI32 (for lighting), and Design Builder or Equest (for energy analysis) may be used on a single project. The selection of software will also determine up front licensing costs and training needs for the individuals utilizing the software.

For references and resources there are many networking and professional groups that can provide lessons-learned about the BIM process. Trade groups like the American Institute of Architects (AIA) post articles and resources for designers. Multiple user-groups have formed on sites like LinkedIn to network design and construction individuals.

The exciting truth of BIM is that the concepts are not necessarily new in and of themselves. Where the innovation comes is the application of those same tools that we rely on for proper design and construction to new points in the process and including additional trained personnel to ensure quality design and delivery becomes a reality. We design all manner of retail products in this virtual environment to be reviewed and approved before the first generation is off the line. Many of the same concepts apply to the buildings we construct today. The result is one chance to build it right and the effects of mistakes early on only compound time, cost, and stress in team relationships. With the increasing use of the BIM approach to facility design and planning, additional advances will be made in modeling software integration and centralization of project data. Trained professionals can also begin to establish best-practices for use in the years to come.