Building Information Modeling

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Foreword

The intent of this document is to give the AVIXA membership a strong understanding of what Building Information Modeling (BIM) is and to also provide a detailed look at what it means to the audiovisual professional both now and in the coming years.

The information provided in this document is a summary of industry reports, studies, surveys and editorials as viewed with an eye toward the audiovisual industry. This document details current state-of-the-industry information with respect to processes, statistics, software applications and resources.

This document provides a detailed look at the benefits and drawbacks of utilizing BIM, how BIM will affect the project delivery process, how to successfully begin implementing BIM and its business implications, and a look toward the near and distant future of what BIM means to the audiovisual industry.

The construction process involves many stakeholders. While this document is primarily intended for audiovisual designers and installers, an attempt has been made to introduce and detail the greater BIM picture. The intent is to help the reader understand how the audiovisual professional's work fits with other portions of the construction industry.

The use of BIM is the backbone of new, leaner design and construction methods such as Integrated Project Delivery (IPD) and Virtual Design and Construction (VDC). The ability that BIM provides to design, construct and operate a building virtually will prove to be an important instrument to increase productivity while at the same time improve the quality of work.

Additionally, BIM will be valuable in developing more sustainable buildings and their related systems. As sustainable design becomes the standard and not the exception, BIM's ability to capture and manipulate large amounts of data related to the built environment will prove to be an invaluable tool.

It is difficult to accurately and fully describe an emerging body of technologies in real-time. Therefore, this document is not intended to be an academic evaluation of the technology and application, but rather to give readers a head start on preparing their organization for the changing face of the design, construction and facilities management industry.

AVIXA members are encouraged to discuss this document and BIM in general by joining the BIM eGroup in the AVIXA Community: http://community.AVIXA.org.

Introduction to BIM in AV

Recently, a quiet revolution has been taking place which will fundamentally change the very fabric of the audiovisual design and integration business. This revolution is the increased utilization of Building Information Modeling (BIM). BIM is described as:

> ***… a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward.[1]***

To under stand the reason BIM is ascending in importance for the AV professional, we need to consider several facts.

1. Buildings consume huge proportions of our scarce resources. Resource allocation and reduction are major drivers toward BIM implementation, whether it be using renewable or recycled materials or reducing energy consumption. Stakeholders hope that BIM will be key in reducing construction resource consumption.

2. In 2004 the Construction Industry Institute estimated that **57% of money spent on construction is non-value-added—which is WASTE.[2] With the U.S. construction market estimated at US$1.288 trillion for 2008, at 57% waste, over $600 billion per year is being wasted.**

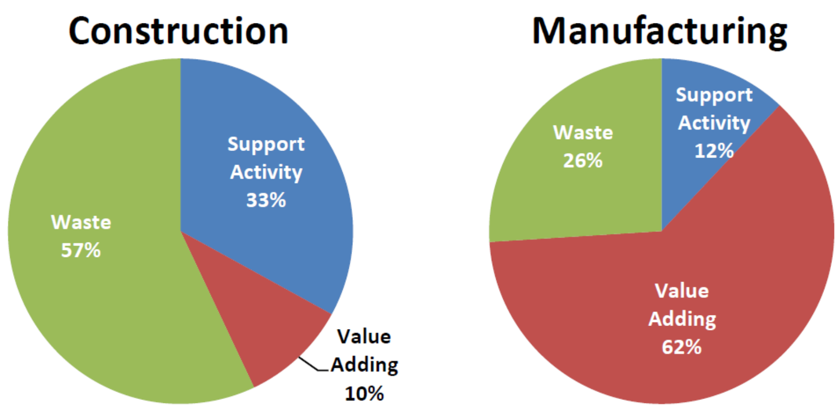

Figure 1: A large portion of the money spent in the construction industry is wasted, especially when compared to the manufacturing industry.

This is a stark condemnation of the construction industry, which we need to examine.

a. The bid process and resultant change orders have become the bane of many construction projects.

> ***More disputes arise and more adversarial positions are staked out because of actual or perceived changes in a construction project than for any other reason. Aggressive contractors will threaten slow-downs and work stoppages if they don't get paid. Overbearing owners will insist that unknown conditions, extra features, and an expanded project are covered by the original bid price.[3]***

The major culprit here is probably the design-bid-build paradigm, in which each bidder should complete a rough design in order to provide accurate bids. However, since this is not paid, and even if a company wins 1 out of 10 bids, the engineering time for all 10 bids will be aggregated into its winning job. Plus, if you gave accurate bids, you would probably not be the low bidder. The bid is then written in such a way that any deviations result in change orders, normally paid by the owner. This leads to cost overruns, delays, antipathy and errors.

Some owners prefer the design-build paradigm, which favors one contractor and one AV integrator. If the project is specified correctly, this reduces the bidding costs, but there is no communications vehicle between all of the contractors, causing change orders because a wall or ductwork appears where the AV system was to be installed. Thus, traditional design-build may reduce certain costs, but not eliminate errors and change orders.

[1] United States National BIM Standard V1, P1 Jan 2008
[2] Eastman et al, BIM Handbook, 2009, John Wiley and Sons
[3] George Berger, Change Orders -- The Bane of All Construction Projects, ForConstructionPros.com, July 8, 2008

The alternative to the design-bid-build and design-build paradigms is Integrated Project Delivery (IPD) — where all stakeholders share in the risk of the design and build process, and share in the rewards of productivity increases. IPD works well if there is an accurate BIM within which the project is designed.

b. There has been no productivity gain in the construction industry over the last 40 years — in fact, there has been a steady decline, whereas all other non-farming industries rose over 200% in productivity.

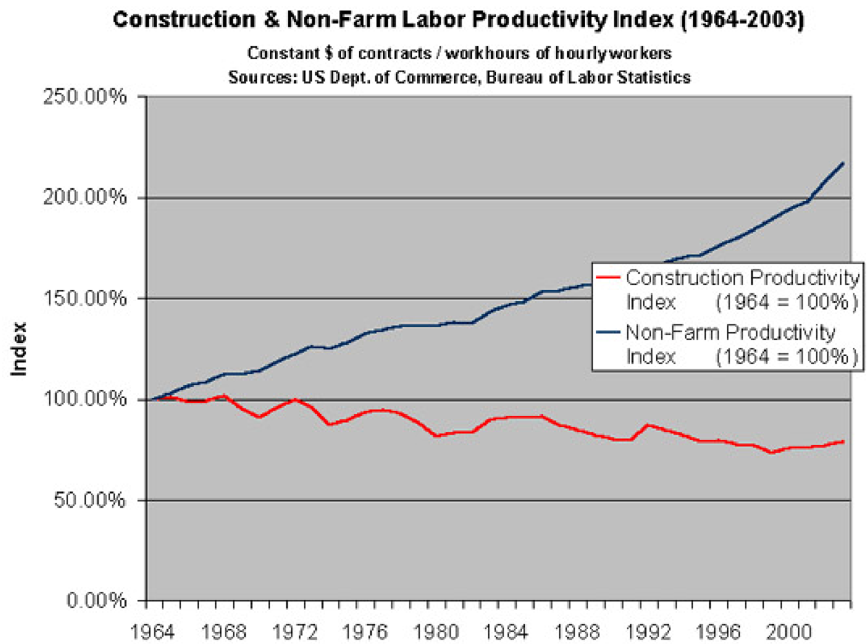

Figure 2: Teicholz Construction Productivity Index Graph. Indexes of labor productivity from construction and non-farm industries, 1964 - 2004[4], indicates no productivity gain in the construction industry.

Yet during this time period, we have implemented many labor-saving machines and design tools, including:

- PC Computer Aided Design (CAD) — AutoCAD v1 shipped December 1982
- Spreadsheets — VisiCalc released first PC Spreadsheet in 1979, Lotus 1-2-3 released in 1982
- PC Database — dBase II released in 1980

c. Buildings are becoming more complex and are taking longer to build.

One thing is certain, in either a shrinking or booming construction market, increasing productivity and coordination is imperative. A key tool for accomplishing this is BIM.

Why are Traditional 2D or 3D CAD Drawings Insufficient?

Current building practice relies upon drawings. Building designs are communicated through dozens or even hundreds of separate, often inconsistent documents. However, CAD documents usually exclude the very information necessary for effective design evaluation and construction, such as bid and contract documents, Bills of Materials (BOMs), timelines, specifications, price lists, installation and maintenance guides, cable lists and labels.

BIM is more than drawings — it is a data repository for building design, construction and maintenance information combined in one convenient model to share with all the stakeholders. As these stakeholders increase their commitment to project success using BIM, they should also profit from BIM combined with IPD.

This is why the new buzzword is modeling, instead of drawing.

[4] Paul Teicholz, "Labor Productivity Declines in the Construction Industry: Causes and Remedies." AECBytes, April 14, 2004

> ***The information that was sufficient for CAD drawings is often insufficient to meet the requirements of a model-based design process, as industry expectations for analysis using a model-based approach are expanding.***
>
> ***The purpose of BIM is to make the design information explicit, so that the design intent and program can be immediately understood and evaluated. A BIM-based approach supports 'on demand' generation of documents (e.g., drawings, lists, tables and 3D renderings) from a consistent BIM. In a sense, these documents present views of the current BIM. A BIM model, therefore, can live longer, contribute more to process efficiency, and provide superior accuracy than traditional 2D CAD drawings.***
>
> ***As a shared knowledge resource, BIM can reduce the need for re-gathering or re-formatting information. This can result in an increase in the speed and accuracy of transmitted information, reduction of costs associated with a lack of interoperability, automation of checking and analysis, and unprecedented support of operation and maintenance activities.***[5]

The Status of BIM for the AV Professional

Currently, Autodesk Revit is the predominant BIM platform for architects and building owners who are both leading the transition to BIM. But Revit is not the only option. The U.S. Army Corps of Engineers, the California Department of Transportation and others use Bentley BIM. The U.S. General Services Administration (GSA), owner of the most U.S. buildings, does not endorse any single program, but promotes interoperability.[6] The American Institute of Architects (AIA) has also issued its own statement promoting interoperability in BIM.[7] Even Autodesk and Bentley have pledged to become interoperable.[8]

The buildingSMART alliance was formed to encourage interoperability standards. Their purpose is:

> ***buildingSMART alliance™ has been established to coordinate the profound changes coming to the fragmented real property industry in North America. Our collective goal is open interoperability and full lifecycle implementation of building information models.***[9]

The primary vehicle for interoperability is the Industry Foundation Class (IFC), definitions which allow the various BIM software programs to interchange data between their models. The U.S. National BIM Standard is the developer of the IFC standard in conjunction with the International Technical Management Committee (ITM), an international alliance supporting the development and testing of IFCs and BIM practices.

Innovations in BIM Impacting the AV Professional

The world will see many major innovations in the BIM market that will have major impacts upon the AV professional. Here are a few examples:

- 3D Design: 3D visualizations allow customers to see historic preservation and site context with respect to the new project. They also allow for 3D coordination to reduce RFIs, errors and omissions[10]
- 4D Design (Time): Adds project phasing and construction sequencing to be added to the model

  4D modeling is the integration of a 3D (or BIM) model with a construction schedule in order to visualize the sequence of construction. 4D models can be created to various levels of detail, from high-level zone analysis during the design phase, to detailed subcontractor coordination during construction. The same model can be updated and maintained throughout the project based on the updated schedule and 3D model[11]

  In a 4D BIM, you would be notified that you cannot schedule installation of tie-lines until after the delayed cable trays have been installed
- 5D Design (Cost): Automated Quantity Take-Offs (QTO) and cost estimating, including the relationships between quantities, costs and locations
- Collision Detection: Automated ways for examining spatial and sequencing conflicts within a BIM. For instance, imagine automated notification that your speaker now collides with the revamped air ducts.
- Construction Operations Building Information Exchange (COBIE): COBIE is an information exchange format to capture the information created during design, construction and commissioning and allows this information

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[5] GSA BIM Guide Series 1, www.gsa.gov/bim, p. 4
[6] GSA BIM Guide Series 1, www.gsa.gov/bim, p. 11
[7] Interoperability Position Statement, http://aia.org/aiaucmp/groups/aia/documents/pdf/aiab082297.pdf, December 2009
[8] Autodesk and Bentley to Advance AEC Software Interoperability, July 2008 http://www.bentley.com/en-US/Corporate/News/News+Archive/2008/Quarter+3/Autodesk+Bentley+Agreement.htm
[9] www.buildingsmartalliance.org
[10] GSA BIM Guide Series 3, www.gsa.gov/bim, p. 14
[11] GSA BIM Guide Series 4, www.gsa.gov/bim, p. 2, 3

to be passed directly to the building operator. Now, the information from the model is passed directly into the owner's facility management program — without paying again for the same data.

- Engineering analysis: Detailed energy modeling and acoustical analysis can be performed utilizing data already in the model.

The Anticipated Result of BIM is Consistent Savings in Building Life Cycle

It is no longer a question of whether BIM will impact our industry — it has and it will. In considering options for corporate strategy, keep in mind the desired results of BIM:

> ***While only a very small portion of facility life-cycle costs occur during design and construction, those are the phases where our decisions have the greatest impact. Most of the costs associated with a facility throughout its lifecycle accrue during a facility's operations and sustainment. Carnegie-Mellon University research has indicated that an improvement of just 3.8% in productivity in the functions that occur in a building would totally pay for the facility's design, construction, operations and sustainment, through increased efficiency.***[12]

What is the Future for the AV Professional?

Building life-cycle efficiency is not only the true goal of BIM and all its stakeholders, but it is imperative for the AV profession. The responsibility for the model does not end with as-built documentation. The goal must not only be to design it better, build it better, but also these tasks must be completed in such a way that the facility is maintainable.

The path forward is becoming clearer: design professionals, contractors and building owners are moving toward BIM. This does not mean that all projects require BIM, but it is increasingly being required for major construction and retrofit projects.

Each major AV professional stakeholder must consider how BIM impacts him or her, including:

Consultant

As you move into BIM, you must input more information into the model. Will you be involved early in the conceptual stage, where your impact will be multiplied if the building is to be AV- and IT-centric? Are you increasing your liability and/or your profit potential? Are you also willing to share your BIM objects or try to protect them as your intellectual property? How will your role change as architects want you to provide nearly real-time responses to their changes? What will be the differentiation between the consultant role and the integrator? Are you prepared for design-build and IPD?

Integrator

Will you be involved earlier in the design stage, where your impact will be greater? Do you have a plan for developing your BIM proficiency so you will not create your drawings in 2D and hire someone else to put them into the model? Are you poised to take the risk and profit potential from design-build and IPD? Are you prepared to change to an AV life-cycle integration and maintenance business model?

System Designer

Are you a BIM novice or champion? Are you prepared for the fast turn-around which will probably be demanded from the other stakeholders?

Thus far, low-voltage signal diagrams are not normally created in BIM, but connected objects must all be created in BIM. Signal diagrams are often referenced into the BIM, but manual updates of the referenced drawing must be done. For BIM to be truly integrated into the AV professional's arsenal, it is imperative to maintain excellent linkage between your CAD diagrams and your BIM platform. Are you prepared to have 100% linkage? Even after the building is constructed, will your design and detailing stand the life-cycle reality tests? In other words, can the owner easily and economically maintain the infrastructure as modeled?

Manufacturer

Participation in BIM is more than building products and delivering CAD drawings on your website. It is more than contracting with somebody to convert your 3D CAD drawings to BIM objects. It is partnering with the consultants and integrators to easily provide not only the model objects at the level of detail required for their model, but also providing the pricing, installation and maintenance materials in ways which can meet the owner's needs for the life cycle of the model.

[12] NBIMS_v1_p1, pg. 1.

Benefits of BIM

BIM and IPD afford manufacturers, designers and integrators advantages in design efficiency and quality control. A single, connected model improves communication within the design and construction teams and the parametric elements of the model create a robust database. The building owner and facility manager can utilize the data within the model during the occupation of the building. Harvesting the information in that database can help everyone be more efficient and also create new opportunities for revenue expansion. Modeling, instead of drawing, is the new paradigm, fostering new cooperation, innovation and building life-cycle savings.

Modeling vs. 2D Drafting

Building modeling improves over 2D drafting by allowing designers to view the building and its contents from all angles, and revealing problems at earlier stages to allow for correction without costly change orders. Truly parametric design saves time by creating and editing multiple design portions simultaneously. Sections, elevations and three dimensional views can be created instantly, reducing the need for check plots. Changes to any one of these elements affect all of the others, including materials, costs and construction schedules. The two-dimensional printed documentation becomes the quick and accurate byproduct of parametric design.

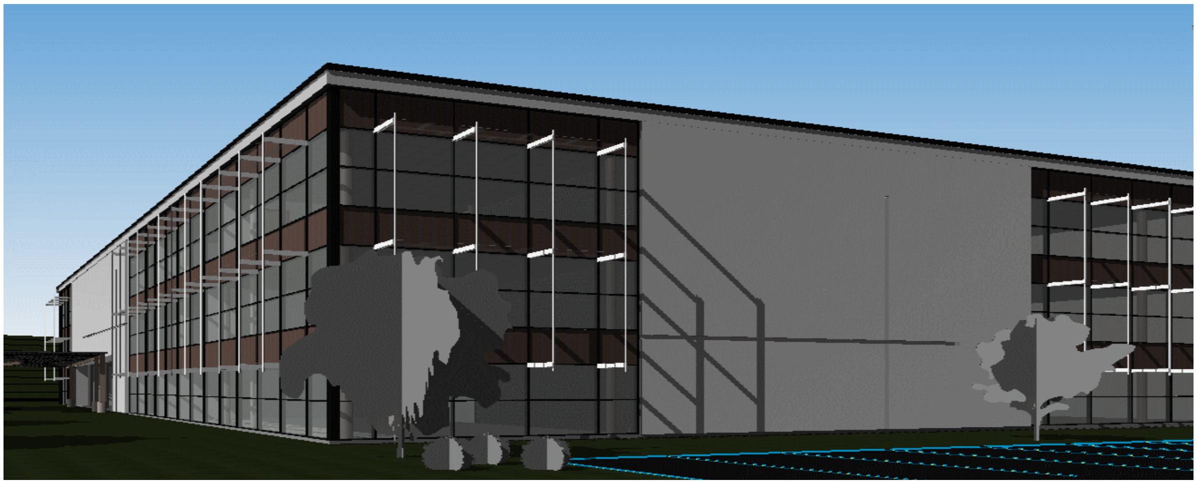

Figure 3: 3D perspective views of buildings can be quickly generated using BIM software.

Parametric Elements

Parametric elements allow for the creation of large, versatile sets of building components with little effort. One generic element can serve as a template with predefined ranges of characteristics. This parametric data allows the element to be easily reconfigured to suit the unique requirements of implementation in various areas of the model.

The following are examples of parametric data and element relationships:

- Chairs are arranged evenly across an elevation. If the length of the elevation is changed then the equal spacing of the chairs will be maintained. The data parameter in this case is proportional.
- The edge of an electrical box is related to an interior wall such that when the wall is moved, the electrical box remains connected. In this situation, the parameter is association or connection.
- The parametric data in a collaborative model can also save time during the design process and the construction administration phase by improving coordination and reducing the need for additional site visits, printing and manual drawing checks. Changes and additions to building elements update simultaneously across all views, schedules and sheets.

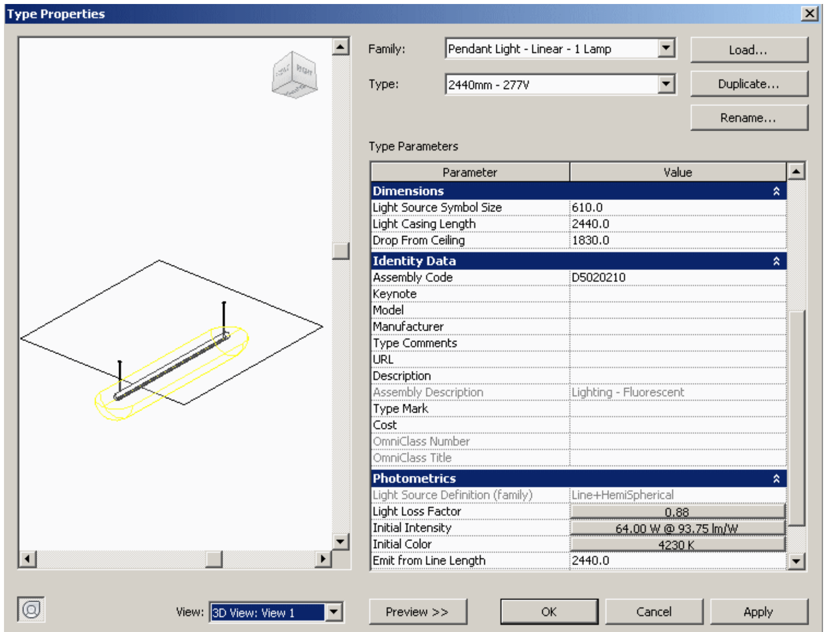

Figure 4: The type properties window shows parameter data for a pendant light fixture.

Change Management

Parametric elements that are changed in one location change in all corresponding views and locations. Warnings and flags can also be created between elements to allow managers to see element changes in any view. These warnings can be arranged into an element change report to facilitate coordination.

Leveraging Data

The Building Information Model is a database that contains manufacturer information, pricing, physical information (such as weight, size, and material finish) and electromechanical data for many of the devices in the building. Leveraging this data means that very accurate material schedules can be created from the parametric model elements and they will change automatically with visual component. Having accurate material schedules allows designers and integrators to project material usage before construction is complete and to create real-usage reports for building management after construction. Additionally, this data contained in the model can be used to identify and create manufacturer ubiquity to ease with service, or if desired, reveal opportunities for manufacturer variety.

Parametric data can be used to populate any database application and extracted to create take-offs, usage reports, and in some cases, shortcuts for photo-real rendering applications.

Value-Added Tasks

A powerful BIM adopter can turn commodity lighting level recommendations into a value-added Lighting for AV Study service, with included 3D renderings to demonstrate the need for appropriate video-teleconferencing lighting. Accurate photometric studies that are focused on AV can be marketed as added service.

The availability of building information that is inherent to the model aids in the generation of reports that may be provided to the client as value-added services. Power and heat load calculations can be converted into green AV reports. These reports can also be generated from building power usage data after the building is occupied. Because accurate usage data can be collected and stored in the Building Information Model, new value can be added to predictive usage reports.

Room drawing snapshots to accompany a training manual can be transformed into an online training manual which includes a user experience walk-through video. New usage scenarios can be explored after occupancy, and new training demonstrations can be created and sold.

Improved Coordination

With BIM, detailed information about each building component is contained within its modeled element. BIM allows all team members easy access to information, such as power consumption and weight, to verify that the building element in question will be compatible with the components of the building for which they are responsible. BIM improves coordination among team members by making design changes, and all consequences of those changes, evident and available to all users of the model and to all parametric model elements. Building element collision with AV devices can be caught early and clearly communicated to every member of the design and construction teams. Design team members stay in sync with one another's progress, leaving no trade trying to play catch up after a release.

BIM makes it possible to quickly create sections and elevations of a room without the need to create them from scratch or ask the architect to provide sketches.

The synchronized and collaborative nature of BIM allows for earlier clash detection between the numerous members of the design team. When areas of conflict are identified earlier, conflicts over space allocation are initiated and resolved sooner. Earlier clash detection therefore shortens the time required for building design and reduces costs associated with correcting clashes that were undetected during design reviews. Interference detection with BIM is as simple as identifying the elements that need to be checked and running a report. Clash detections also happen as elements are moved or added.

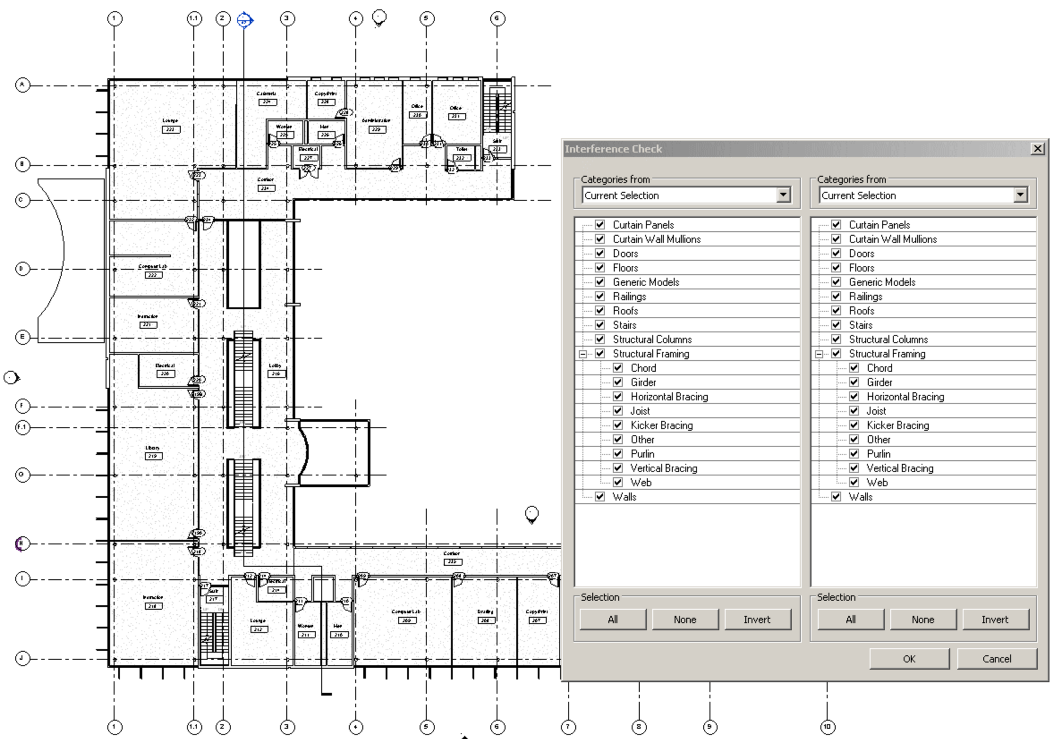

Figure 5: An interference check performed in Revit can identify conflicts earlier than past methods of clash detection.

Improved Accuracy and Efficiency

BIM affords integrators increased accuracy for quantity takeoffs. Metadata attached to objects allows for accurate counting and price modeling, improving the accuracy of bids and project pricing. Designers can enjoy receiving fewer requests for information and change orders. Integrator scheduling based on material availability and construction progress can be mapped visually. This allows project managers to quickly optimize construction schedules with ever-changing material deliveries, seasonal costs and availability.

BIM helps reduce errors and omissions (E&O) which should in turn reduce E&O claims and professional liability. A reduction in insurance costs, bonding fees and a positive impact on firm reputation should increase the number, scale and variety of opportunities available to design and integration firms.

Delivery Process Efficiencies

Design and drawing production requirements should evolve so that managers, designers and drafters spend less time developing designs and more time providing creative solutions for clients. The physical demand for the creation of multiple views of a building in 2D can be reduced to a short time with a BIM solution. A workflow shift should begin to occur in design departments following the adoption of BIM practices, moving away from lower-level drafting positions and toward the creation of more technical design positions.

Electronic reviews of every portion of the building design including equipment schedules, room views, system designs, fabrication schedules, green building information, pricing and more are possible as BIM is the single repository for all of this information. With the possibility of full electronic reviews, delivery to the client can be expedited.

Virtual conflict resolution saves time and money over traditional conflict resolution by providing a clear and automatic view of conflicting issues and a quick demonstration of the resolution paths.

Parametric Building Information Models allow for the discovery of design errors early and significantly reduce the probability of extensive redesign. Model elements that are dependent upon one another maintain their relationships throughout changes to either element. For example, an electrical outlet in a wall will remain at the correct location in the wall if the wall is moved. The cost of repairing design errors increases as the project design progresses and the earlier discovery of these errors lessens schedule overrun from redesign.

Client Satisfaction

Visual verification of design intent and knowledge sharing through Virtual Design and Construction (VDC) and BIM make for happier clients. The rapid preparation and exchange of visual information mitigates the time needed for communicating complex ideas and allows more time to be creative for your clients, which should result in repeat business and excellent references.

Ongoing Technology Management

Technology professionals can use the information in a model to schedule routine maintenance, plan special events, tie to room scheduling applications and issue trouble reports to technology service personnel. The administration of service contracts can become more predictive and less reactive. Parts replacement becomes easier and quicker and maintenance can be completed with fewer errors.

Facility Management

BIM can link data from manufacturers, construction data and communications into one fully integrated and robust facility dashboard. Facility managers can use BIM to gather usage data, prepare maintenance schedules using predictive data, manage daily operations and plan for future purchases and construction additions. Full equipment data including operating parameters, usage data, predictive data, service history, replacement price and links to other manufacturer data, combined with a fully rendered 3D depiction of the equipment creates a powerful tool for facility managers.

Considerations and Limitations of BIM

BIM has the potential to improve the communication and coordination between the different stakeholders of a project. BIM's benefits range from simple improvements in efficiency and coordination to greater client satisfaction.

With all of the perceived benefits of BIM, AV professionals should also be aware that there are a number of considerations and current limitations that must be taken into account.

Cost of Software and Hardware

Every organization currently utilizing 2D or 3D CAD drafting software can attribute a cost element against purchasing, maintaining and upgrading software licenses to keep a competitive market advantage. Current trends show that the cost of BIM software packages tends to be more expensive than CAD software packages available on the market.

With the introduction of BIM software, the requirements on hardware have increased significantly. Currently, CAD software can be operated (with limitations) on a vast majority of professional laptops. Yet with the introduction of BIM software, dedicated high-specification workstations, equivalent to those required by advanced modeling and rendering software, are required.

Software and program requirements are ahead of hardware availability. With BIM software, it is essential to know exactly what parameters of the hardware improve performance and what elements have no major effect at all.

More details on the hardware requirements for BIM software may be found in the *Getting Started section.*

Cost of Training

With new software, there is a great demand to train staff quickly so that the investment can be justified. It is not realistic to assume professionals with CAD proficiency will be able to learn new BIM software quickly or without specialized training. Given the fundamental differences between BIM and CAD, training should be considered a requirement for all professionals involved with designing and producing documentation.

BIM provides the ability for every member of the team to be involved in the design and modeling process, giving them complete control of the end product. Investment in training for early adopters provides them a competitive edge with projects that have clearly specified requirements to be documented utilizing BIM.

Transition from Drafting to Modeling

When moving from a CAD-based drafting environment to a BIM-based modeling environment, a change in the workflow will surround what used to be simple drafting tasks such as copying markups or picking up redlines. These tasks now require a higher-level skilled design drafter who has an understanding of the project and the materials used. The costs associated with training and maintaining a skilled design modeler are higher than a draftsman with no knowledge of the trade. Some companies may even be compelled to stay out of the BIM world altogether due to the time- and knowledge-intensive nature of BIM.

The transition from traditional CAD will also place an increased level of responsibility on the designer to ensure that all system components are coordinated with the other design professionals such as architecture and engineering services and that site issues are reduced to a minimum.

Companies have a few different business models to consider when thinking about staff training with respect to BIM.

- The first option involves the training of current designers to undertake all of their design work in the BIM environment.
- The second involves up-skilling all of their drafting staff to a higher technical level to undertake design responsibilities.
- The third is a combination of the first two where there is a specific set of rules and guidelines for mark-ups so that design mark-ups can be translated into the model clearly and efficiently.

In any case, the BIM process allows for coordinated delivery earlier in the design process so that potential double handling or redesign is avoided. This benefit outweighs the cost of any additional training to up-skill staff no matter what business model for the delivery of BIM projects.

Compatibility Between Software Platforms

One of the biggest issues with early adaptors of BIM is the issue of inter-product compatibility. Due to the relatively new nature of the market, every software manufacturer is doing something different with its software. This interoperability challenge can make it difficult for projects to function if different team members own different software packages.

This interoperability issue is not limited to different software platforms; due to the rapid development of the BIM software industry newer versions of programs within the same platform can have interoperability issues.

One alternative to the current product-specific models is a vendor-independent, neutral-file format. One such file format is the Industry Foundation Classes (IFC) format which captures both geometry and properties of intelligent building objects (objects with associated usable metadata) and their relationships within Building Information Models, thus facilitating the sharing of information across otherwise incompatible applications.

Innovation

Since a goal of BIM is to assign constraints and parameters to intelligent objects to improve efficiency, there is a potential to inhibit innovation which would possibly otherwise occur without the automated processes and shared knowledge that BIM now provides. Those firms implementing BIM should view the parameters and metadata constraints as a global database that allows designers to save time associated with updating and configuring product-specific data repetitively on different projects, hence increasing the amount of time spent on system design and innovation.

Changes to the Delivery Process

The delivery process is the method by which a project is taken from initial, conceptual programming, through design and construction to the delivery of a completed facility to the owner. Prior to the introduction of BIM for design and documentation, traditional project delivery methods such as Design-Bid-Build (also called Design-Award-Build) dominated the construction industry. While these traditional methods are still very much in use, there has been a strong movement toward more streamlined processes to reduce construction times and enhance collaboration of team members. The Design-Build delivery method is one example of this streamlining. By taking the competitive bid phase out of the middle of the delivery process and placing the entire design contract under the scope of the general contractor, there is no longer a procedural or contractual separation between the design and construction of the project. The owner only has to carry one contract for both design and construction services. This allows for the construction to begin well in advance of the completion of all design documentation as the design documentation is produced in concert with the construction almost on an as-needed basis.

While the Design-Build methodology is perhaps more efficient than Design-Bid-Build, these “traditional” methods both share some fundamental flaws which the newest delivery method, Integrated Project Delivery (IPD), is capable of eliminating.

Because IPD is so new there is no official definition, however the California chapter of the AIA offers this working definition:

> ***Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction. Integrated Project Delivery principles can be applied to a variety of contractual arrangements and Integrated Project Delivery teams will usually include members well beyond the basic triad of owner, architect and contractor. At a minimum, though, an Integrated Project includes tight collaboration between the owner, the architect, and the general contractor ultimately responsible for construction of the project, from early design through project handover.***[13]

Project Factor	Traditional Delivery	Integrated Delivery
Team	Fragmented, assembled on “as-needed” or “minimum necessary” basis, very hierarchical, controlled	Integrated team entity of key stakeholders, assembled early in the process, open, collaborative
Process	Linear, distinct, segregated, knowledge gathered “as-needed”, information hoarded, silos of knowledge and expertise	Concurrent and multi-level, early contributions of knowledge and expertise, information openly shared, trust and respect
Risk	Individually managed, transferred to the greatest extent possible	Collectively managed, appropriately shared
Reward/Compensation	Individually pursued, minimum effort for maximum return, often first cost-based	Team success tied to project success, value-based
Communication/ Technology	Paper-based, two dimensional, analog	Digital, virtual, Building Information Modeling, 5+ dimensional
Agreements	Encourage unilateral effort, allocate and transfer risk, no sharing	Encourage, foster, promote and support multilateral open sharing and collaboration, risk sharing

Figure 6: A comparison of traditional delivery methods vs. IPD methods on key project processes reveals the advantages of IPD.[14]

While IPD is seen as the possible future of project delivery that is being fueled by BIM, it is still the exception and not the rule. Before IPD becomes commonplace on all projects, a transitional period will ensue during which delivery requirements will begin to change as well as the relationships and expectations of the owner, designer, integrator and manufacturer.

[13] Integrated Project Delivery: A Guide, www.aia.org/ipdg, Foreword.
[14] Integrated Project Delivery: A Guide, www.aia.org/ipdg, p 1

Owners will become more involved in all aspects of the project simply because the model will provide them immediate and vast information. Rather than having to try to interpret a stack of 2D plans, owners now have access to an immense amount of information which can be formatted to meet their needs. This includes virtual walkthroughs, detailed equipment lists and accurate cost estimates.

BIM allows for the building to be built in a virtual environment before being actually built. With this change, designers will become more involved in decisions which might previously have been considered “means and methods” and left to the contractor to figure out during the installation. Some examples include more detailed routing of infrastructure and placing devices in their exact location.

BIM acts as a central database for the project and as such it is regularly evolving. Due to this constant state of flux, expectations must be set and agreed to among team members regarding the expected level of completion at various points during the project. Most projects consist of multiple models which are linked together. These models are typically exchanged between team members on a regular schedule whether it be weekly or daily. These exchanges are independent of the major scheduled deliverables of the project such as 50% Design Development or 90% Construction Documents. When these models are shared, they are usually not in a completed state; therefore, there must be an understanding between parties about the level of completion and coordination expected for model exchanges between the deliverables established by contract.

The entire project team will have increased communication and will begin to work as one entity rather than separate team members who only exchange documents at predetermined milestones. The model will become a consolidated design document which evolves on a constant basis during design, through construction and into the management of the facility. This consolidation requires a tighter and more constant information exchange which sometimes takes place via co-locating of team members either physically or virtually.

In contrast to traditional CAD-based design, BIM is a front-loaded process with substantial benefits reaped toward the end of the process which consist of manipulation of the database’s data points. It should be noted that this requires substantial effort up front to not only put information into the database but to also collect more data from the very start. If the data is not available at a given time, there should be an effort made to analyze what data might or will be required so that the correct pigeon hole can be created in the database from the very beginning. The model is only as good as the data set that goes in.

Traditional delivery methods invoke inefficiencies because participants are contractually placed into silos of scope. These silos have a two-fold detriment to the efficiency of a project. First, when any knowledge needs to transfer from one team member to another, such as from the design team to the contractor, there is inefficiency created when the contractor has to take the time to get up to speed on the design documents to be able to move forward with the scope of work. Secondly, a team member’s success is only tied to the success of the individual silo rather than the overall success of the project.

Key Steps to Successful BIM Implementation

BIM implementation requires proper planning, patience and full commitment from all levels of the organization. When introducing BIM to an organization, proceeding with only a minimum amount of knowledge is a common mistake and can be costly.

Develop a BIM Action Plan

Developing a solid BIM action plan should be the first step toward getting your organization up and running in a BIM environment. Without this plan in place it is easy to lose track of what information is required to be successful. The plan should consist of two major sections: analysis and implementation.

Analysis:

A majority of the plan should be focused on information gathering about current methods, procedures and business strategy. The transition to a BIM workflow is a major shift for any organization on all levels; as such, it is an excellent time to look deep into your workflow to find any inefficiency that can be fixed. The analysis portion of a BIM action plan should include:

Existing Processes Identification and Analysis

It is important to conduct a detailed analysis of existing internal and external business processes to help establish a base line for where to start to achieve the goals established later in the plan. This analysis should include a detailed review of how projects are currently being processed through the organization from initial marketing through completion.

Technology Analysis

A detailed technology analysis identifies existing hardware and software technologies and their associated costs utilized by the organization. A review of current document and data management should also be included in the analysis.

Personnel Analysis

A detailed review of personnel should be conducted to help establish a few key pieces of information by providing answers to the following:

- What are the current roles of your project teams?
- Who will need to be trained with the new software?
- What level of training will each type of employee require?
- How will the new requirements of a BIM-based project modify the current make-up of your teams?
- Do you still require pure drafters?
- Can your current drafters become junior-level designers?

Cost Analysis

The transition from a CAD-based organization to a BIM-based organization carries a significant cost impact on three major fronts:

Hardware: Current BIM software requires a higher-performance workstation when compared to a CAD software on a comparable-sized project. This BIM implementation may require a significant upgrade of current systems to ensure efficient workflow.

Software: BIM software will need to be purchased. The best resource for information regarding the best version of software and support to purchase are the many resellers out there. With resellers you can discuss the details of your needs and business plan to help identify the correct route to take – whether it is a single license or a full blown subscription with technical support.

Personnel: Educating and training employees to use BIM software and the new associated delivery processes costs money. This cost will most directly be related to training but there will also be a temporary loss of productivity while existing processes are transitioned to a new methodology.

Once the aforementioned analyses have taken place, the next step is to develop an overall phased strategy for implementation. The implementation should include:

Timeline

A detailed timeline is required to ensure that the overall strategy is being implemented in a timely and organized process.

Personnel Changes

A change to a BIM delivery process represents a big change to an existing CAD workflow and thus a change to individual employee roles. The biggest change is a move away from pure drafters. With the BIM process focused around building a project in the virtual environment, those who are interacting with the model require more trade knowledge to be efficient.

Generally speaking, two new roles will be defined within the organization: a company BIM manager and project BIM managers. A company BIM manager will lead the charge for the company and be the guiding force behind implementation, standards development and software decisions. On each project, a project BIM manager should be assigned who is responsible for project-related BIM decisions, interacting with other project team members, BIM managers and maintenance of the model.

Training Plan

Training on a BIM platform is best completed using a “Just in Time” method. A lot of the concepts involved with BIM are very different when compared with a traditional CAD workflow and therefore are best learned working on an actual project. A proven method of success is to have multiple training days consisting of half a day for classroom instruction followed by half a day of actual project work with the instructor available for hands-on teaching. Training should start with only a small group of employees on a single project so that they can help streamline the BIM workflow prior to getting the entire organization up to speed.

It is also advantageous for at least a single employee to receive in-depth training and then act as the BIM manager for the company. This person can then be the “go-to person” for help and can lead the establishment of standards.

Keys to Success

Successful BIM implementation within a company starts with the shared vision of change and buy-in from all members of the organization. Senior leadership needs to support the change and be willing to sacrifice a little in the beginning to reap the future rewards.

Other organizations are at all stages of the BIM implementation process - from thinking about it, starting to implement and fully operating in a BIM workflow. Additionally, there are many local and regional BIM and IPD groups that meet on a regular basis to discuss BIM-related topics. It is important to network with industry peers to share successes and failures to help better the industry as a whole.

The key to success in any BIM project is collaborative effort among all team members, which includes but is not limited to the project owner, the design team, general contractor, subcontractors and vendors/suppliers. Information data must flow freely between all of the BIM project team members to obtain maximum advantages in a BIM project. The project owner plays a central role in leading the discussion and decision-making process when it comes to applying BIM to his/her project.

Use available BIM resources to further understand of more advanced BIM concepts and practice. Set aside enough resources to ensure that your organization is not just buying software but is engaging in a business process that will meet your current and future business needs and opportunities.

With an intelligent implementation of BIM technology, your team starts to develop skills and techniques, build confidence in the software and pace the future work for potential benefits. For your organization it will mean new opportunities to provide the highest level of product.

Business Implications of BIM

While major shifts occur in design and construction processes utilizing BIM and related technology, the construction industry faces a new set of legal and business challenges. Most of the legal issues stem from the deep collaboration between trades and firms working in the same building model, affecting liability concerns as well as reconsidering roles and relationships between trades, firms and stakeholders. In addition, BIM is catalyzing business and operational challenges affecting technology, hiring and training plans across the industry.

Operational Aspects

Companies, depending on their business strategies, roles and internal cultures, will respond differently to the shift toward virtual design. Some companies will eagerly adopt the new technologies, finding satisfaction in helping pioneer industry standards and processes despite the apparent costs involved. Other companies will assume a "wait and see" strategy, resisting adoption as long as possible to make sure they are using a well-vetted technology before they make a costly switch. Most companies, however, will find themselves between these opposing strategies, working to keep clients happy while keeping up with industry trends.

In the May 2010 edition of *Harvard Business Review,* authors David A. Lubin and Daniel C. Esty discuss the sustainability megatrend affecting so many companies. Of note is the assertion that, like all megatrends, there are certain phases of adaptation that the most successful company will go through. The following is an adaptation of their proposed stages as they apply to this document.

Doing Old Things in New Ways

As a starting point, most companies will do their best to reproduce the same types of documentation that they have produced in the past. Design processes will likely stay the same during this phase as users learn how the software tools work.

Doing New Things in New Ways

As BIM users and managers hone their skills and become comfortable with the tools and technology, they will learn new ways to leverage the software tools to improve document production as well as refine the design and delivery processes associated with their trade. For example, real-time coordination with other trades both in the design phase and construction phase can be utilized in ways rarely possible before.

Transform Core Business

In this stage, BIM technology ceases to feel like a revolution and becomes standard operating procedure. Users and managers are familiar with the usage and advanced capabilities of BIM. Design and delivery processes have been adapted. Businesses may start to see greater returns on their investment in BIM as less overhead is spent procuring equipment, software and training. Further, because of the expertise in an emerging technology and the fundamental shifts of the industry, entirely new products and services can be explored with the potential of shifting priorities and business activities.

New Business Model Creation and Differentiation

Once the skills and innovations of BIM have been mastered and the company has introduced new services and methods, a successful company may be able to differentiate itself from peers. The company may be repositioned as a more critical part of the construction process by offering more, deeper and better services than its competitors. For example, a designer may be able to provide better visualization and budgetary estimates to owners for planning purposes, better design coordination with architects and engineers and closer partnership with integrators by providing equipment schedules, complex coordination details, phasing information and more. True differentiation may come in the form of assisting clients with life-cycle cost analysis or another key innovation.

It is encouraged to spend as little time as possible in the first stage. Because of the particular challenges of BIM, focusing too much on doing old things in new ways may lead to unnecessary frustration. It is recommended to quickly move toward intelligently and realistically enhancing your company's product for all of your clients and team members.

Legal Aspects

Liability

Effective risk allocation strategies place the burden of liability on the entity most able to control the variables influencing its execution. BIM technologies are shifting responsibilities and in so doing are blurring traditional lines of liability.

Following are some examples representing just a few of the challenges BIM technologies pose to traditional risk allocation models:

- In traditional 2D design processes, design coordination between trades is expected and required to ensure constructability; however, the means and methods of installation are generally left to the constructors to coordinate between trades and finalize routing of ductwork, cable trays, conduits, etc. Coordination drawings are often required from the constructors. Utilizing BIM technology, the design team goes substantially further than the traditional model by coordinating with other trades and defining more data in the model. The risk and liability challenges: Does the standard of care become more complex under BIM? Does the design team assume greater liability for constructability of building systems? Hopefully the builders will encounter fewer field coordination issues, but when they occur, do the constructors have a lower standard of care and less liability given that the burden of coordination has shifted toward the design phase?
- Few firms today outsource basic CAD drawing work, but given the investment and skill level required, many firms will be tempted to outsource their BIM development work, at least in the short term. Should the third-party BIM developer assume any risk for the accuracy of the model? To what standard of care should they be held?
- The database functionality of a BIM model is powerful, but the proliferation of data will soon reach a point that no single person could reasonably be held responsible for all of its accuracy. Assuming that drawings and specifications will continue to be required to be stamped by licensed professionals, how will this increased risk of incorrect data be dealt with? Will the practice of holding an individual personally liable persist in the BIM paradigm?

Currently few court cases provide insight into the future of BIM law, risk and liability. While the details of industry legal standards are still in transition, it is important to start thinking about how your firm may be exposed in new ways and attempt to deal with those challenges before they become a problem. Ask your professional liability insurer if special provisions or vehicles will be recommended or required for work in virtual design.

Contracts

Of immediate concern in any new BIM-based project is ownership and control of content. The traditional document model paradigm allows each team member to largely own and control most of his or her own content. However, by its nature BIM technology allows everyone with access to the model to access any other team member's intellectual property.

The major concern that arises stems from the resolution of potential disputes. If an error in the model causes a problem, it may be difficult to track who made the error and under what circumstances the error was made. If an error is discovered in the field, for example, it could have been a genuine error by a designer. It could have been inadvertently caused by another user with access to the model. It could have been unintentionally caused by the constructor after the designer turned over the model, or it could simply be due to a misunderstanding about the level of development or intended use of the model.

A thoughtful approach to BIM execution should set clear expectations between team members. The American Institute of Architects (AIA) Document E202, Building Information Modeling Protocol Exhibit, can be used as a template or guideline for documenting expectations and establishing the level of development and acceptable use of the content. The intent is to establish how heavily the data entered into the model may be relied upon and in what contexts.

Even if additional contract language is not imposed, it is advised to produce a BIM implementation plan with the other team members to avoid interoperability, schedule or development problems. Keep in mind when agreeing to level of development or standard of care that using a third party BIM developer to produce the model without the skills to review and verify the work yourself could expose the company to liability concerns.

It is worth mentioning that the collective and collaborative nature of virtual design has inspired and perhaps necessitated the introduction of the new project delivery method discussed earlier, IPD. Theoretically, IPD extends the collaborative design paradigm afforded by BIM technology to the entire project delivery by tying each party's interests to the project as a whole rather than their own portion. The IPD model has many proponents, but is new and not without its own risks, including ineffective or costly insurance. Careful consideration and planning should be implemented for IPD projects.

The Future

BIM and Virtual Design and Construction (VDC) will continue to grow as 2D design processes recede from prominence. VDC is being embraced by design and project teams which are looking to leverage BIM to the furthest degree. While the current application of VDC is pragmatic in regard to clash detection and project coordination, the ability of the design team to virtually model a building's annual performance overnight is the way of the future. The dominance of VDC and BIM in the design and construction industry will "tip" when it becomes measurably more efficient, productive and profitable to use that project process.

Near-Term Future (2011):

VDC and BIM will continue to grow to be the dominant workflow in larger projects. In fact, many universities as well as local and federal government projects now require this work process and documentation methodology in North America. Outside of North America, such as in Abu Dhabi, U.A.E. and Saudi Arabia, many master plans and building projects require this documentation and workflow as well. Project teams globally are evolving to adopt this project process as a result of these requirements.

The adoption of a BIM workflow is driven by these project requirements as well as by innovative and forward-thinking architects and design teams. In many instances smaller firms have turned to a BIM workflow to better serve their clients. This workflow and process change has slowed to a certain degree because of the downturn in the design and construction industry as a whole; however, many architecture and MEP firms are continuing to make the transition as a way to differentiate themselves from their competitors.

Major architecture firms are looking for the rest of the consultants on the design teams they lead to adopt BIM in order to also reduce their production costs. To provide the traditional 2D architectural backgrounds to the consultants, architects need to add an export step to their project process. If the architects could avoid this step, which typically happens at least once per project phase, they could be more efficient. Additionally, by working from the model, the process of getting title blocks, fonts, references, etc., correct across the project can be accomplished automatically.

This client demand then becomes the incentive for consultants to adopt this workflow to differentiate themselves and provide a higher value to the architects.

Different types of project processes, such as IPD or design-build, are suited to utilizing a BIM workflow. As design and project teams move away from the design-bid-build project process, BIM will become more predominant.

Additionally, in the near future, manufacturers will be providing BIM models with their specifications included in the metadata. This additional information should assist the design teams in accelerating their workflow and creating more detailed models with no additional effort.

Energy modeling, currently completed by different applications such as eQuest, Trane Trace, Ecotect and IES, cannot yet gather meaningful, time-saving energy-use metadata from mechanical, electrical, lighting, computer and AV equipment. As this evolves, potentially leveraging the gbXML metadata text format and/or IFC, manufacturers will begin to standardize on a methodology that design teams can leverage for energy use monitoring.

Interestingly, a lot of the innovation and adoption is being driven by the construction side of the business. General contractors, construction managers and trade contractors are pushing the envelope due to the efficiencies that BIM offers.

As an example, through leveraging the BIM model, mechanical and plumbing contractors are placing their ceiling anchors for pipes and ductwork into the concrete slab form before the concrete is poured. This is significantly safer and faster than hammer-drilling into the slab above one's head to install and secure the anchors. It does not slow down the concrete slab construction and allows the interior fit-out work to happen at a faster pace. This innovative new work process, enabled through BIM, makes the process more efficient for the team – as well as safer and more profitable for the contractor.

A Little Further Out (2-4 years):

Construction-Operations Building Information Exchange (COBIE) could become more widely adopted and accepted, providing a better value to building owners and facility managers. With a model that is fully populated with all of the building components, facility managers and owners would have a much more powerful tool with which to manage a building. The model can become a complete repository of building information and data that formally had no shared, centralized collection point.

Many firms are also including Construction Specifications Institute (CSI) specification information in the metadata of the models. A schedule of this metadata can automate the creation of the narrative specification documentation.

Additionally, as the design and bidding process continues to evolve, the model with all of its schedules and metadata could become the central element in the bidding and pricing process instead of the traditional, 2D bid package. This transition will be able to occur as more and more designers (architects and consultants) and constructors (GC/CM/trades) utilize the BIM tools that are available, and they can leverage coordination tools such as Navisworks and Solibri Model Checker.

Some of the biggest changes will occur because of the evolution of both computing processing power and the further development of the software tools. Currently, BIM applications cannot effectively utilize the processing power that is available in multi-processor computers.

BIM applications will hopefully also share the same “model” harmoniously to more fully realize the potential of virtual design. The following elements will need to evolve in order for this to happen:

- Building element models will need to be interoperable between the various platforms (ArchiCAD, Revit, Bentley, etc.). This interoperability is a goal of the Industry Foundation Class, or IFC.
- Applicable building element models will contain actual energy-use data depending upon their operation. At a minimum this would include standby power draw (quiescent), in-use draw, as well as maximum draw. This will require manufacturers to test and reliably provide this data in a standards-oriented manner within their building element models. This data could also include a “function use timer” for items like shades, projection screens, projector lifts, mechanical equipment, appliances, etc.
- Plug loads and “process” energy use will be able to be designed based upon the devices that are virtually “plugged in” in the model.
- Lighting panels and electrical panels will be able to be easily designed and configured through the leveraging of the energy-use data in the model elements.
- The energy modeling applications will be able to pull the energy-use data directly from the element models and build a true, in-use model based upon the power draw of all of the building elements.
- Ideally, the energy modeling will also take into account the micro-climate data that is already being leveraged by applications such as Ecotect.

In the (Hopefully) Not Too Distant Future:

Ultimately, the building model will be able to run virtually in the design phase of the project. With this in mind, a single model will be able to run and the energy use may be determined automatically based upon the virtual devices within the building model. This virtual building modeling will empower the design and project team to make well-informed decisions about all of the building systems and their respective functionality. This analysis will only be possible once all of the different building models are united into a single model and the design team silos work cooperatively to maximize efficiency.

Ideally, the virtual building automation “brain” will be able to be transplanted into the actual building upon the completion of construction. The system should be able to run the real building very efficiently Day 1 because it had been running the virtual building model prior to being transplanted.

Conclusion

The audiovisual professional has an opportunity, with BIM and ultimately IPD, to add more value to the project team. BIM and IPD are both important revolutions in the construction and building management industries, and firms that can quickly become competent adopters will have an edge on the competition. With increased profitability, reduced professional risk, less waste, less rework and improved efficiency, audiovisual firms can use BIM to create new revenue streams and add to profitability. BIM will be the main method in which buildings are constructed and managed. It is crucial for audiovisual firms to become early and professional adopters of this technology and embrace the associated cultural change to ensure the growth of our industry.

Glossary

2D export Also known as a “2D take-off”. A 2-D export is a set of two-dimensional drawings derived from the design model. This is required for design team members who are still working in 2D. It is also utilized for pricing sets and final construction sets for bidding by trades.

4D Leveraging BIM for project time allocation and construction sequence scheduling presentations (phasing\sequencing)

5D Leveraging BIM for cost and simulation of construction, focusing on building sequence, cost, and resources (cost estimating)

BIM Building Information Modeling, was coined in early 2002 by industry analyst Jerry Laiserin to describe virtual design, construction and facilities management. BIM processes revolve around virtual models that make it possible to share information throughout the entire building industry.

BSA buildingSMART Alliance, operates within the independent nonprofit National Institute of Building Sciences (NIBS). This public/private initiative expands on goals of the North American Chapter of the International Alliance for Interoperability (IAI-NA), whose Industry Foundation Classes (IFCs) have initiated open standards for national and international links among industry players. It provides developers and users of Building Information Models (BIMs) the digital tools that are increasingly helping to share highly accurate information throughout a facility’s life cycle. (www.buildingsmartalliance.org)

clash detection is a process of discovering the building system conflicts and issues by collaborating in 3D during the MEP model coordination process. Sometimes referred to as interference checking.

COBIE Construction-Operations Building Information Exchange, is a standard way to manage information from a BIM model that is essential to support the operations, maintenance and management of the facilities by the owner and/or property manager. The COBIE approach is to enter the data as it is created during design, construction and commissioning. Designers provide floor, space and equipment layouts. Contractors provide make, model and serial numbers of installed equipment. Much of the data provided by contractors comes directly from product manufacturers who also participate in COBIE.

constructability model is a BIM model used to simulate the actual components of a building in 3D, created as the building would be built, used primarily for MEP model coordination, 4D simulations and 5D estimating or quantity take-offs (compare with design model).

CSI Construction Specifications Institute

design model is a BIM model developed by an architect from whom the automated construction documents are derived, along with automated schedules, details and client presentations (compare with constructability model).

energy model is the virtual representation of how a building will consume energy. These models are required to achieve the highest number of LEED points for energy efficiency. DOE2, eQuest, IES and Ecotect are common applications for this modeling.

families are parametric 3D building components used in Revit.

gbXML Green Building Extensible Markup Language (XML) is a file format standard that allows one energy analysis program to talk to or interoperate with another. (See XML for more information.)

GDL Geometric Descriptive Language is a scripting programming language exclusive to ArchiCAD software that writes a .GSM file format.

GIS Geographic Information System is a 3D modeling approach that captures, stores, analyzes, manages and presents data that refers to or is linked to a geographic location.

GreenFORMAT, a classification system in development to assist the construction industry list and find products using post-consumer, pre-consumer and rapidly renewable content, low-emitting materials and products complying with ASTM, LEED, ASHRAE and other performance standards. (www.csinet.org)

ICC International Code Council is an association dedicated to building safety and fire prevention. ICC develops the codes and standards used to construct residential and commercial buildings, including homes and schools.

IFC Industry Foundation Class is a data exchange method that specifies elements that are used in building construction in an agreed manner that define a common language for construction. IFCs provide a foundation for the exchange and sharing of information directly between software applications of a shared building project model. The IFC data model is a neutral and open specification that is not controlled by a single vendor or group of vendors. It is an object-oriented file format to facilitate interoperability in the building industry, and is a commonly used format for BIM. The format is known as ifcXML. ifcXML2x3 (current version) is currently supported by Autodesk, Graphisoft, Nemestchek and Bentley. (www.iai-international.org)

IPD Integrated Project Delivery, a new project workflow method and supporting contracts developed by the AIA, which leverages early contributions of knowledge and expertise through the utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project life cycle. IPD avoids the realization phase challenges by allowing project data to be analyzed and understood prior to construction.

iRoom, a conference/presentation room dedicated to MEP coordination meeting sessions, usually found on a job site, managed by the general contractor; a conference/presentation room dedicated to collaboration by all members of the design and construction team during the IPD approach to project delivery.

MasterFormat is the recognized industry standard for categorizing building products for more than 40 years. MasterFormat 2004 Edition replaces MasterFormat 1995, expanding the well-known 16 divisions to 50 divisions of construction information. www.csinet.org

MEP coordination is the process undertaken during pre-construction to uncover any building system conflicts with mechanical, electrical, plumbing or fire protection systems using 3D models integrated into one master model that can facilitate interference checking or clash detection.

NCS National CAD Standard, a U.S. government-sponsored standard that coordinates the efforts of the entire industry by classifying electronic building design data consistently allowing streamlined communication for the industry. (www.buildingsmartalliance.org)

NIBS National Institute of Building Sciences, a U.S. government organization that serves as an interface between government and the private sector. The institute's public interest mission is to serve the nation by supporting advances in building science and technology to improve the built environment. This organization leads the buildingSMART Alliance, National Building Information Model Standard (NBIMS) and National CAD Standard (NCS) programs. (www.nibs.org)

NBIMS National Building Information Modeling Standards exist to provide a national BIM standard to improve the performance of facilities over their full life cycle by fostering common and open standards and an integrated life-cycle information model for the A/E/C & FM industry. The efforts of this program continue that of the FIC which was integrated into NBIMS in 2008. (www.buildingsmartalliance.org/nbims)

objects are parametric 3D building components used in ArchiCAD and stored in object libraries.

parametric modeling is defined by rules and constraints, which define aspects of the building and their relationships to each other. Variables control behavior in 3D geometry.

point cloud survey is a 3D laser scan of existing conditions which captures points in space (x, y, z coordinates).

rendering For development of the design, presentations and client sign-off, very detailed and life-like images of the model are created.

SMARTcodes International Code Council's effort to support automated code check of BIM models. (www.iccsafe.org)

UNIFORMAT Uniform Classification System is a system for organizing preliminary construction information into a standard order or sequence on the basis of functional elements. Functional elements, often referred to as systems or assemblies, are major components common to most buildings that usually perform a given function regardless of the design specification, construction method or materials used. UNIFORMAT users can easily understand and compare information since it is linked to a standardized elemental classification structure. The use of UNIFORMAT can provide consistent comparable data across an entire building life cycle. The use of UNIFORMAT's elemental framework reduces the time and cost of evaluating alternatives in the early design stages of a project, assuring faster and more accurate economic analysis of alternative design decisions. (www.csinet.org)

VDC Virtual Design and Construction is becoming a more accepted industry term to describe the use of BIM and the other new design tools to design and construct a project.

XML Extensible Markup Language is a general-purpose specification for creating custom markup languages for computer software. It is classified as an extensible language because it allows the user to define the mark-up elements. XML's purpose is to aid information systems in sharing structured data, to encode documents and to serialize data.

Appendices

Appendix I – Industry Association Publications

Organization	Title/Description	Website
ASHRAE	Introduction to Building Information Modeling (BIM) document is intended to be a good starting point for those who are beginning to work with BIM	http://cms.ashrae.biz/bim/
Department of Veterans Affairs	BIM Guide - Useful overview of how BIM is implemented	http://www.cfm.va.gov/til/bim/BIMGuide/lifecycle.htm
Wikipedia	Another interesting overview on BIM	http://en.wikipedia.org/wiki/Building_Information_Modeling_
McGraw-Hill Construction	BIM SmartMarket Report	http://construction.ecnext.com/mcgraw_hill/includes/BIM2008.pdf
McGraw-Hill Construction	The Business Value of BIM in North America	http://bim.construction.com/research/
McGraw-Hill Construction	The Business Value of BIM in Europe	http://bim.construction.com/research/FreeReport/BIM_Europe/
McGraw-Hill Construction and SMPS	The Impact of BIM on Business Development	http://bim.construction.com/research/pdfs/2009_BIM_on_Mktg.pdf
McGraw-Hill Construction	Integrated Project Delivery	http://bim.construction.com/research/pdfs/2009_IPD.pdf
AIA	Integrated Project Delivery: A Guide	http://www.1stpricing.com/pdf/IPD_Guide_2007.pdf

Appendix II – Relevant Blogs/Newsletters

Title	Description	Website
All Things BIM	Blog	http://allthingsbim.blogspot.com/
Revit Beginners	Blog	http://revitbeginners.blogspot.com/
Do-U-Revit?	Blog	http://do-u-revit.blogspot.com/
BIMBoom/Revit 3D	Blog	http://bimboom.blogspot.com/
CSI NewsBrief	email newsletter	http://www.smartbrief.com/csi/

Appendix III – Websites/Resources

Organization	Description	Website
AutoDesk SEEK	The online source for product specifications and design files	http://seek.autodesk.com/
SMARTBIM	Reed Construction Data, includes BIM objects	http://smartbim.reedconstructiondata.com/
McGraw Hill	BIM Portal	http://www.bim.construction.com
Sweets BIM Collection	Revit drawing library	http://construction.com/BIM/
ARCAT	BIM Objects/Systems - Free Library of BIM (Building Information Modeling) Objects	http://www.arcat.com/bim/bim_objects.shtm

Appendix IV - Software

BIM software tools are geared to either architectural, structural or MEP disciplines. Examples of a few are listed:

Architectural/Structural

Vendor	Software	Website
Autodesk	Revit Structure	http://usa.autodesk.com/adsk/servlet/pc/index?id=5523749&siteID=123112
Bentley	Bentley Structural Modeler	http://www.bentley.com/en-US/Products/Bentley+Structural/
Bentley	RAM Steel	http://www.bentley.com/en-US/Products/RAM+Steel/
Tekla Corporation	Tekla Structures (X Steel)	http://www.tekla.com/us/Pages/Default.aspx
Graphisoft	ArchiCAD	http://www.graphisoft.com/

MEP

Vendor	Software	Website
Autodesk	AutoCAD MEP	http://usa.autodesk.com/adsk/servlet/pc/index?siteID=123112&id=3290681
Autodesk	Revit MEP	http://usa.autodesk.com/adsk/servlet/pc/index?siteID=123112&id=6861034
Graphisoft	MEP Modeler – ArchiCAD	http://www.graphisoft.com/products/mep-modeler/
4M	FineHVAC	http://www.4msa.com/FineHvacENG.html
AEC Design Group	CADPipe	http://www.cadpipe.com/
Design Master Software	Design Master HVAC	http://www.designmaster.biz/