

**THE CONTRACTORS'
GUIDE TO**

BIM

EDITION

1

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AGC is particularly proud of the cross-organizational effort put into the development of this document. All AGC “Occupational Divisions” (Building, Federal & Heavy, Highway & Transportation, and Municipal & Utilities) had representation on the Task Force. In addition, subject matter experts from AGC Committees and Councils including Contract Documents, Contractor Relations, Electronic Information Systems, Risk Management, Specialty Contractors, and Surety Bonding participated in the process. Individual contributions are acknowledged below.

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Foreword.	Page 2
BIM: What exactly does it mean?	Page 3
BIM Tools.	Page 7
The BIM Process: How is it to be conducted? . . .	Page 10
Clarification of Responsibilities.	Page 19
Risk Management.	Page 25
Summary.	Page 30
Appendix A: Glossary	Page 33
Appendix B: “Example BIM Tools”	Page 35

Foreword

The future of the design and construction industry is going to be driven by the use of technology. The best example emerging today is the use of three-dimensional, intelligent design information, commonly referred to as Building Information Modeling (BIM). BIM is expected to drive the construction industry towards a “Model Based” process and gradually move the industry away from a “2D Based” process. This “Model Based” process where buildings will be built virtually before they get built out in the field is also referred to as Virtual Design and Construction (VDC). This guide is for contractors who recognize this future is coming and are looking for a way to start preparing themselves so that when the future arrives, they will be ready. This guide is intended to help contractors understand how to get started.

What does “getting started” mean? It could mean finding a champion among your senior company leadership to provide the encouragement and support that change requires. It could mean educating yourself and your champion on what is happening and what other contractors are already doing. It could mean getting your champion and a few key people in your organization interested enough to at least start understanding what the software tools are and what they can do. It could mean appreciating the difference between receiving a “3D Design” versus “Converting” a 2D Design into 3D. It could mean either finding someone already on your payroll or hiring someone who is not intimidated by the software, but actually enjoys using it! It could mean all of these things or it could mean just understanding at a basic level what BIM and VDC stands for, in which case you can stop here. If you are interested in doing more, AGC of America would like to help and this guide is offered as a place to start.

Setting aside a couple of myths already spreading...

Myth #1: BIM is only for large projects with complex geometries

Fact: The benefits of using BIM on all projects, regardless of size and shape, are being proven by contractors using BIM today.

Myth #2: BIM is only for large contractors who can afford the investment.

Fact: The benefits of using BIM are being seen by contractors of all sizes. The level of investment and commitment is scalable.

The fact is that the construction industry is already beginning to go through what many predict will be a significant transformation. With all the press and related industry discussions, it can start to feel overwhelming.

This guide was prepared, in large part, by contractors who were where you are now, trying to sort it all out and determine where to start. Lessons based on their experiences were used in preparing this guide. Though the process is evolving rapidly and the guidance offered here may become dated quickly, it is hoped that the basic framework for how to get started will be useful to all contractors.

This guide is version number one, and as fast as this area is evolving, it is expected that updates will be provided periodically.

Please let us know if it was useful to you...

the Collaboration Techniques Tools and Technologies (C3T)
Task Force of AGC of America.

This Contractor's Guide is intended to assist in determining how to get started with using Building Information Modeling (BIM) or Virtual Design and Construction (VDC). Though focused on buildings, much of the guide is applicable to all types of construction. The guide provides answers to many of the common questions asked by both general and specialty contractors who believe that with the use of improved technologies this process is the way of the future and are trying to determine where to start in their own organization.

For purposes of this guide, Building Information Modeling and the Building Information Model (both referred to as BIM) are defined as follows:

***Building Information Modeling** is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a **Building Information Model**, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.*

The process of using BIM models to improve the planning, design and construction process is increasingly being referred to as Virtual Design and Construction (VDC).

The New "Tool" The extended use of 3D intelligent design (models) has led to references to terms such as 4D (adding time to the model) and 5D (adding quantities and cost of materials) and on and on from there. Perhaps a simpler way is to think of the 3D model as a "tool;" then the applications of its use throughout the planning, design, construction and facility operation processes are almost infinite. Based on this, when coordinating construction sequencing by integrating schedule data with the model data and calling it "4D," or doing the same when using the model data to quantify materials and apply cost information and calling it "5D," seems arbitrary since these are just two of the many applications of how the 3D "tool" can be used to improve all of the processes. Therefore, rather than continuing on with this numbering (6D, 7D, etc.) there is a growing trend to refer to all of the extended applications using the 3D tool as "**XD.**"

The benefits often cited with the use of BIM are numerous and growing. They include benefits for all participants in the process, including contractors, both general and specialty contractors.

Benefits to the contractors using BIM include:

- The ability to identify collisions (e.g., identifying ductwork running into structural members)
- The ability to visualize what is to be built in a simulated environment
- Fewer errors and corrections in the field
- Higher reliability of expected field conditions, allowing for opportunity to do more prefabrication of materials offsite, which is usually a higher quality at a lower cost

BIM: What exactly does it mean?

- The ability to do more “what if” scenarios, such as looking at various sequencing options, site logistics, hoisting alternatives, cost, etc.
- The ability for non-technical people (clients, users, etc.) to visualize the end product
- Fewer callbacks and thus, lower warranty costs

Those contractors who are using BIM will almost universally tell you that the number of new benefits they continue to discover seems endless. There are so many processes that we think of in the context of a “2D Based” mindset. As we continue to shift to a “Model Based” process, contractors continue to find innovative uses for their new tool (for example, design phases going away).

“Who should pay for the model?” The most common question asked is, “Who’s receiving the most benefit and therefore should bear the cost of developing the model?” The growing consensus is that everyone benefits and therefore everyone should bear some of the cost. It is generally accepted that there is an initial cost and loss of productivity while obtaining the necessary resources as firms go through the initial learning curve. Contractors who have made it through this initial learning curve (on average between 6 and 18 months) experience the benefits, including improvements in productivity, lower warranty costs, fewer field errors and corrections, etc. and for a period of time, a competitive marketing advantage. These benefits offset the costs and over time may actually reduce them.

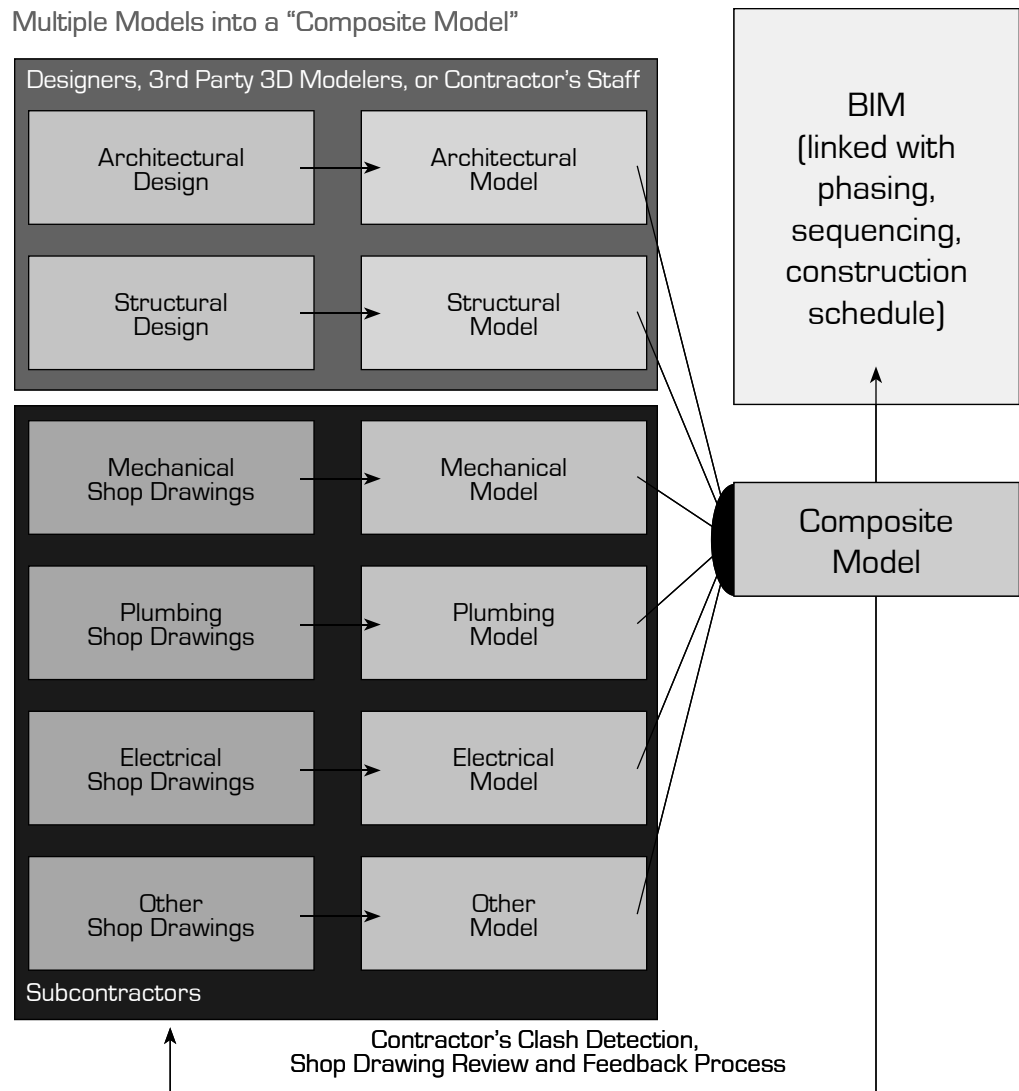
2D Conversions versus 3D Designs (a factor throughout the guide) This issue is a critical one for contractors, and is likely to remain until such time that the majority of design firms are designing using 3D design software. Projects using BIM are either designed in 3D or designed in 2D and converted into 3D. Since most of today’s issues are significantly affected by which of these two scenarios is applicable, this distinction is made throughout this entire guide. (For example, answering the question about the cost of the model is greatly affected by whether or not the design is being done in 2D and someone has to invest the time in doing a conversion. If the design is done using intelligent 3D design software, there is no conversion and the contractor’s ability to start using the “tool” is immediate and much less expensive to the contractor.)

Overview of the Guide The guide addresses the following:

- The 3D vs. Conversion Issue—addressed as it applies throughout each section of the document
- Collaboration and BIM Tools—groups and highlights the basic software tools that support BIM
- The BIM Process: How is it to be conducted?—explains what the BIM process looks like
- Clarification of Responsibilities—highlights fundamental responsibilities relative to the BIM process
- Risk Management—identifies the major areas that contractors should begin to think about

One Model or a Composite Model One of the earliest lessons learned is that there is rarely one model. In fact, on many projects the use of BIM can be as basic as the availability of a 3D model produced by one or more of the specialty contractors or suppliers, such as the steel fabricator or mechanical contractor. It is not unusual, particularly while the 2D conversions continue to be the norm, for multiple models to be made available on the same project. The good news is that there are software applications that can now combine models produced in different design packages and into one file, to be viewed as one **composite model**. This is where the low-hanging fruit of visualization and conflict detection can be found. This is just one of many examples of lessons that contractors using BIM have learned and can be found throughout this guide.

Multiple Models into a “Composite Model”



What does it mean to "use" BIM? What defines a project "using BIM"... It is not necessary to model the entire project to be “using BIM” on a project. In fact, many contractors are involved in projects with intelligent models without realizing it. The designer and/or some of the suppliers and specialty contractors may be using models for their own benefit and not sharing the information with the other members of the

BIM: What exactly does it mean?

team. Use of the BIM “tool” is encouraged even if it is only available for a portion of the project, such as the structural steel or the mechanical systems.

Also, contractors are making use of intelligent models for portions of the project scope to assist them with many of their traditional activities. Many of these “partial uses” of BIM include:

- Assisting with scoping during bidding and purchasing
- Reviewing portions of the scope for analyses such as value engineering
- Coordinating construction sequencing (even if just for two trades)
- Demonstrating project approaches during marketing presentations

In each of these cases, only portions of the scope and only specific trades may be modeled. These “partial uses” of BIM, versus full blown project models, are likely to be the way that many contractors will find it easier to get started using BIM. These “partial uses” can be much less overwhelming to create, and the benefit of having them is much more tangible to everyone. In other words, taking BIM in smaller bites might be easier for many contractors, and has proven to be a great way to get started.

Get Started Now BIM or VDC clearly appear to be the future of our industry. For some contractors, the future is now. Contractors have a choice. For those that choose to start now, this guide offers a place to begin. However, even if you decide to wait, every contractor is encouraged to at least start familiarizing itself with the key terms, the acronyms (see the Glossary) and the current available software applications. Experience has shown that having an awareness of all of these will provide a good framework for gathering knowledge on the subject, and better prepare you when you are ready to get started. For those who are ready now, let’s get started...

So you are ready to try out BIM... but a number of questions arise: What tools do you use? What will it cost? Where do you get help? This section provides a summary of BIM tools that will help you get started. While any tool can appear complicated, if you know what to look for in a tool and make a commitment to learn how to use the tool, great results can be achieved. BIM tools are based on current software applications, so they are constantly being upgraded. Despite all the change, now is the time to get started.

What should you be concerned with when starting down the BIM path? The best way to get started is to have the right plan and keep it simple. First, make sure you pick a specific BIM objective you want to accomplish for your company—pick a new job that will help you prove a return on investment. Keep it simple and specific—an objective you can measure for tangible results. Consider the following in your plan:

- **Steering Committee** – create a senior management group involved in the BIM implementation process to ensure leadership support.
- **Dedicated Effort** – dedicate someone to this project who has a keen interest in BIM and will see the project through. Then keep them focused on attaining results by empowering them with the authority to make decisions toward achieving your goals with effective regular status updates.
- **Integrate the Effort** – ensure that the project works with your existing business processes and partners. Work with what you currently have for processes, whether starting with a new 3D model or converting 2D drawings to 3D, and identify where the new BIM tools will require change in your processes. Pick a project with team members who will readily share the data.
- **Collaboration** – BIM tools work best in a truly collaborative environment with your partners. Sharing information at various times throughout the model life cycle will be critical to success, so make sure you and those you work with can be flexible in collaborating. Use standards wherever possible to ease the collaboration efforts.
- **Hardware Requirements** – the BIM tools will require appropriate computer hardware to make the tools work properly. Avoid the temptation to throw the tools on inadequate equipment for expediency's sake, since this will cost more time and frustration in the end. Follow the minimum recommendations for the tools.
- **Connectivity** – because BIM tools work best in a collaborative environment, make sure you have appropriate connectivity to the Internet and your office network as well as your job site. Being able to update a model from the office or the work site may become invaluable. Typical DSL connection speeds of at least 256 kbps should be adequate, but as with most applications, the more bandwidth, the better.

Do not over complicate the plan—the goal is to get started and see results quickly. Pick a specific case and stay focused on it. All too often, projects fail because of the dreaded scope creep, just like out-of-control change orders on a job. Stick to your goal until achieved, then learn from the results and adjust for ongoing use.

An alternative to using BIM for the first time on a new project is to take an existing project and use BIM tools to remodel it, to see if you would really have gained savings. The problem with this is the added cost to remodel a past project without an actual return on that investment. However, you can consider this an investment if you achieve an ROI on future jobs.

BIM Tools

What should you look for in a BIM tool? Once you have your specific plan, finding the right BIM tool(s) for your use is best accomplished by making your selection based on the following criteria:

- **Simplicity** – make sure the software is easy to learn and use. Read the instructions.
- **Functionality** – ensure that the tool meets your specific needs and usage by reading about the tool before you start using it.
- **Interoperability/Collaborative** – the tools you use should work well with other software, as being able to interchange document formats or convert documents helps.
- **Providers Longevity** – despite a quickly changing technology environment, make sure you are confident that the vendor will be around for the long run.
- **Support / Training** – the tool should have quick, effective help and the provider should include appropriate training (electronic and in-person).
- **Environment** – double-check that the tool will work in your environment with your hardware, communications, and collaborative partners. You may want to consider using one of the various technology hosting services to provide the environment for your tools (especially in the beginning, until you determine your specific needs).

How do you pick a BIM tool? This may seem like a daunting task, but if you have a plan and know what you are looking for in the tools, the best BIM solution to choose can be much more obvious. To help with selection, this guide includes a matrix of “Example BIM Tools” (Appendix B), that can serve as a starting point for understanding currently available BIM solutions. The matrix includes sections for both BIM software and BIM services showing:

- **Product Name** – tool specifically for BIM (note that this matrix does not contain 2D Drawing tools, which are already plentiful)
- **Manufacturer** – the company that makes the tool
- **BIM Use** – how the tool is intended to be used in modeling
- **Description** – a brief manufacturer’s description of the tool
- **Supplier** – who supplies the tool
- **Hardware Requirements** – specifications for manufacturer’s recommended hardware with which to run the tool
- **Approximate Cost** – an approximate cost for relative comparing and planning purposes only (always check with vendors/suppliers about free downloads, trial subscriptions, volume discounts, etc.)

The sections of the “Example BIM Tools” matrix include:

- **Software**
 - 3D Modeling – software tools that create and manipulate 3D models
 - 2D to 3D Conversions – software tools that convert 2D to 3D models (At this time, this type of tool is custom developed based on specific requirements. While many of the 3D tools will import 2D drawings, 3D tools may not be able to update the 2D drawing.)
 - 3D Interoperability – tools that allow you to work with a variety of different types of 2D drawings or 3D models, regardless of format
 - Tracking – tools that allow you to track changes among drawing sets

- **Services**
 - Training – these are service providers or tools that train specifically in the use of BIM tools
 - Consulting – these are service providers that offer consultation on installation, support, integration or other implementation needs specifically for BIM tools
- **Hardware**
 - Lists typical hardware that meets the minimum requirements of BIM software from several popular hardware providers.

What will BIM tools cost? There are several components involved in identifying the cost for using BIM tools, from software and hardware to time needed to set up and use the solutions. The “Example BIM Tools” matrix includes the range of cost for the solutions listed. Note that the suppliers of these tools may have a number of differing pricing options, depending on the number of users you have and how you use the software. It is wise to check with the supplier to determine current pricing models and offers. Hardware costs vary depending on what solution you choose, but can be estimated from the pricing in the table included in Appendix B.

- The “Example BIM Tools” Matrix identifies approximate costs for hardware that meets the minimal requirements of BIM software. While your existing hardware may work for BIM software, it is wise to make sure that the speed of the computer and graphics capability are sufficient to give a positive experience when using the tools. Hardware is relatively inexpensive, so do not skimp on obtaining the best hardware for your needs.

Other costs that you may incur are for consulting services to help you set up and use BIM tools or help you develop appropriate processes that use BIM tools effectively for your firm. The bottom line is: For as little as \$5,000 you can get started with BIM and begin to see the benefits. A wise plan would be to consider an investment of \$10,000 to \$50,000 depending on your needs, recognizing that these costs will quickly be recovered by the benefits your company attains.

Note that this matrix is meant as a guide only and is not a recommendation of any one tool over another. Nor is it an exhaustive list of tools. Items were selected for inclusion in the list based on high availability and popularity. The costs shown are approximate and any specification may change over time. AGC cannot guarantee the accuracy of information, as it may change at any time.

The BIM Process: How is it to be conducted?

With an understanding from the previous section of the basic tools and software systems that are available and how they can help increase collaboration in a “Model Based” process, contractors should understand the basics of this new process and how it compares to the traditional “2D Based” process. What does a “Model Based” process using BIM look like?

From a contractor’s perspective, the “Model Based” BIM process depends on whether the project is designed initially in 3D or if it is designed in 2D and later “converted” to 3D. This section outlines the process of using Building Information Models, using these two approaches:

- 1) 2D Conversions
- 2) 3D Designs

In both of these scenarios, the BIM Process basics in a typical project scenario are outlined, answering the “what, when, where and how” of BIM in a “Model Based” process. Contractors reading this are assumed to have an appreciation and understanding of “why” BIM is worthwhile. The “who” (the responsibilities of each of the team members) is addressed in the next section. Few projects, if any, are “typical” but the basic BIM Process tenets outlined here should apply to most construction projects.

Each of the five parts of this section assumes that most of the project is being modeled in an intelligent 3D design. As mentioned earlier, many contractors have found it simpler to start using partial models, for portions of the project scope or for specific trades such as structural steel or mechanical. The second part of this section addresses some of these partial uses of BIM. The last section addresses other considerations for contractors trying to understand the process of using BIM.

- 1. Comparison of a “2D Based” vs. a “Model Based” industry**
- 2. Partial BIM Uses—What are these?**
- 3. 2D Conversions**
- 4. 3D Designs**
- 5. Other Considerations**

A special note about the “cost of BIM” which is addressed in each approach: The out-of-pocket expense, even after spreading out the initial technology and training investment, is generally believed to be much less than the cost benefits. Research efforts are underway to prove this point, but until results are in, the biggest challenge is aligning who is receiving the benefit versus who is paying the out-of-pocket expenses. The delivery method, the contract type and the basis of reimbursement may dictate how and to whom the cost benefits will flow.

The information offered is intended to give a contractor a sense of what the BIM process will look like. Where enough experience has been gathered by the industry, suggestions are offered. More experience will eventually lead to better practices, but for now, this information should be a good place for a contractor just learning BIM to get started.

The BIM Process: How is it to be conducted?

1. Comparison of a “2D Based” vs. a “Model Based” industry

The traditional 2D Based design evolved from pencils, to mylar, to overlay drafting, to the layers and levels seen in CAD programs. These long market-accepted “flat” media, the separate nature of the layers, and multiple design and consulting disciplines have contributed to the 2D, layered, disconnected process prevalent today.

In the 2D process, the tools and process available to the team contribute to a distinct inability to see, think and document in an integrated 3D (and beyond) way. The implications of a moved beam on a duct simply cannot be known or seen in a 2D environment. They must be imagined. The 2D Design process allows the possibility that designs are not complete, as all areas are not drawn.

In a 3D Based process, the technology and tools allow us to see, and collaborate in 3D. More important than the technology-enabled way we see in 3D, is the information we get, the interactivity and linkages it fosters, and the intelligence and analysis this linked data promotes. Use of the intelligence housed within a BIM allows us to see and interact differently, and can make us far more intelligent than teams using a 2D process.

What does this next evolution of “3D BIM” require? Certainly it does not take one “all-knowing” expert, who has won the “war of the BIM.” In fact, the reality is quite the contrary. More than ever in the BIM process, it looks as if it will take a village of BIM-enabled collaborators who can use the intelligent tools to cope with the pace and amount of information.

In a 3D BIM approach, model reviews, virtual huddles, and electronic CAVES (computer-aided virtual environments) change the environment, duration, nature and results of our process. Shop drawings might be waived in favor of shop models or CNC (computer numerically controlled) fabrication models. RFIs might become obsolete, or at least significantly reduced in number, and be resolved much quicker if the model is deployed as a jobsite tool.

The BIM Process: How is it to be conducted?

The following table looks at many of the common tasks of the construction process and compares the traditional 2D method versus the Model Based process:

2D Based Process		Model Based Process
Linear, Phased	Design	Concurrent, Iterative
Paper 2D	Drawings	Digital 3D Object based tied to intelligent data
Evaluated over days in 2D	Value Engineering Alternatives	Evaluated in 3D instantly
Unclear Elevations	Site Planning	Relief Contours
Slow and Detailed	Code Review	Expedited and Automated
Light Tables	Design Validation	Clash Detection with Audit Trails
2D Drawings	Field Drawings	2D Drawings and Perspectives
Assembled near completion	Closeout Documents	Intelligent models for operations and maintenance instructions; Constantly updated during construction
Stand Alone Activities	Scheduling	Activities linked to Models
Limited Scenarios evaluated	Sequence Planning	Extensive Scenarios Evaluated earlier in the process
Paper Shop Drawings	Field Coordination	Overlaying Digital Models using collision detection software
Use manuals	Operation Training	Visual

The BIM Process: How is it to be conducted?

2. Partial BIM Uses – What are these?

Most contractors are likely to start using BIM through “partial uses.” The list of partial uses of BIM seems almost infinite. For contractors already using BIM, the list seems to grow daily. For those getting started, the following list represents some of the more common “early” uses that most contractors experience in their experimentation with BIM:

- a. Visualization
- b. Scope Clarification
- c. Partial Trade Coordination
- d. Collision Detection/Avoidance
- e. Design Validation
- f. Construction Sequencing Planning/Phasing Plans/Logistics
- g. Marketing Presentations
- h. Options Analysis (see example: “Partial use: Value Engineering Analysis,” which shows Precast versus Brick)
- i. Walkthroughs and Fly-throughs
- j. Virtual Mock-Ups
- k. Sight Line Studies



Item e., “Design Validation.” is a task the contractor would perform during design phases: preparation of design documents or construction documents. The concept of “design validation” is a task performed by the contractor, distinct from the “design coordination” task performed by the design team. The contractor does not take responsibility for “design coordination” simply by engaging in “design validation.” The design validation is performed by detecting significant clashes. Perhaps a more detailed clash detection is performed by the contractor after the subcontractors have integrated their shop drawings into the consolidated model.

3. 2D Conversions

When will most designs be delivered in 3D? Most estimates range between five and ten years. In the meantime most projects that “use BIM” are designing in 2D and “converting” to 3D.

a. What is a “2D Conversion”?

A 2D Conversion is the process of taking the traditional CAD files (such as .dwg) and using the attributes necessary to add the third dimension that allows the 2D Design to begin taking its 3D form. There are a number of software programs, primarily the same software that designs in intelligent 3D, that allow a person with relatively little training to take 2D Designs and add the attributes that allow it to become 3D.

b. Typical Process—2D Conversion

Once the reasons to convert a 2D Design into 3D have been established, and how the model will be used has been determined, the 2D Design files are opened in 3D Modeling Software. Attributes and 3D elements are drawn over

The BIM Process: How is it to be conducted?

the 2D Design. Here are examples of some tasks that must be addressed:

- Determine the level of detail necessary (this affects how much information will come from the model)
- Establish roles (who is doing what in 2D? 3D?)
- Assuming there are multiple models, determine who will assemble the composite model
- Establish exchange methods of files and formats
- Locate a central, shared repository for the drawings
- Establish (0,0,0) the origin point for model alignment
- It should be noted that there is still a review process (similar to the review of a paper set of 2D drawings) to confirm that the design does not have any major conflicts or errors. For example, there may be an error in a wall type in the 2D Design that is likely to be caught during the assigning of 3D elements to the design.
- Implement regularly scheduled quality checks of the model.

Once you have reviewed the 3D model and are confident it is complete, how you actually use the model from this point forward is essentially the same as if it were a 3D design. In other words, once you have the model to use as a tool, it should not matter where the model came from or whether it was converted to 3D or designed in 3D.

c. How do I do a 2D Conversion?

Anyone with the right software and training can convert 2D Designs into 3D. (Most contractor's modelers have been able to make remarkable progress with less than a week's worth of training.) The length of time it takes to do a conversion is of course proportional to the amount of experience the modeler has. Once a modeler becomes reasonably proficient, a typical project conversion should take one to two weeks to create. Conversions can be done by the contractor or by a growing number of third-party service providers.

d. How much does a 2D Conversion cost?

Assuming a contractor has made the initial investment in software and training, and is past the initial learning curve, the actual labor cost of the conversion itself tends to average between 0.1% and 0.5% of the total construction costs.

Remember that portions of the project may be designed in 3D and/or converted by some of the suppliers or trade contractors. These models can be combined to create the "Composite Model" where all of the models are viewed as a single model, even though they are really separate models.

e. When and where to do a 2D Conversion?

This has been one of the biggest challenges, particularly on fast-track projects; everyone wants the benefit of the 3D model as early as possible. However, recognizing the nature of the typical linear design process, it is not unusual for designs to change substantially from the early phases to the later design

The BIM Process: How is it to be conducted?

documents. (This is a temporary problem unique to 2D Designs, and there is no clear best practice on when is the best time to do the 3D conversion.)

For now, the best advice is probably to wait until the major program (including square footages, architectural floorplans and basic structural scheme) has been developed. Otherwise, it may be necessary to do 2D conversions more than once, or at least update them.

f. **What are the benefits of 2D Conversion?**

There are many benefits derived from doing the conversion in-house. Most importantly, your firm benefits from the experience of doing the model. It is a good idea not to pass up this opportunity.

4. **3D Designs**

a. **What is a "3D design"?**

The term "3D design" is intended in this section to mean an intelligent BIM model-based design. A 3D design is one that is produced with one of a number of BIM software applications. The BIM is in a three-dimensional, geometric, object-oriented representation of the project and has data attributes making the model "intelligent."

Eventually the data embedded into the BIM can include design criteria, detailed specifications or performance criteria. Commissioning, maintenance data and spare parts list, and other information that may be useful later in the life-cycle of the project also may be included. This kind of data is not typically available today and should not be expected until data exchange standards (interoperability), currently in development, are established.

b. **Typical Process—3D design**

Upon receipt of a 3D design file, the first step is determining how best to open the file. The software it was created in and how you are planning to use it will affect this determination. Are you planning on just viewing it? Are you planning on extracting data? If so, which data? Are you planning on adding data to make it construction-ready by, for example, taking a single solid slab and breaking it into multiple slab pours?

(Important Note: Almost all 3D modeling software offers some type of a free viewer application. Therefore, a contractor who is being provided a 3D design from the design team, but has not made any initial effort towards investing in BIM technology itself, should at least take advantage of the visualization of the 3D model. With the free viewers, this most basic application should be available to any contractor at virtually no cost!)

As in the process of a 2D Design, an initial review of the 3D model is necessary. A basic review for overall completeness and accuracy is necessary. Though similar to 2D Design, it is easier because of the added benefit of seeing the design in 3D. Depending on how you are going to use the model, and on its

The BIM Process: How is it to be conducted?

completeness and accuracy, you may need to refine it before you can use it. Depending on the amount of refinement necessary, you may need to have the designer do the updates, or if they are minor, you may go ahead and do them yourself. Either way, a process of communicating the results of this review should be established with the designer-of-record.

Once you have determined how you plan on using the 3D model and the best software application to open it, and have actually opened the file, you will need to take time to understand what you have been given. Among the things you will need to understand are the standards used by whoever created the model. This includes what objects and labels were used (e.g., how did they distinguish wall types?), and how they actually used the objects.

Once you have reviewed the 3D model and are confident it is complete, how you actually use the model from this point forward is essentially the same as if it were a 2D Conversion. In other words, once you have the model to use as a tool, it should not matter where the model came from or whether it was designed in 3D or converted to 3D.

c. How do I use a 3D design?

If you are fortunate enough to be given a truly intelligent, 3D design from the design team, using it is as simple as opening the files. The software could be the native software programs that the design was done in, or it could be viewed and coordinated with a collision-detection viewing software such as Navisworks.

Rarely will a 3D design be “construction ready,” and some effort of adding detail to the models is typically required. For example, adding pour breaks to a slab to be able to align schedule activities of individual slab pours is something that the contractor will need, but the designer may not.

d. How much does 3D design cost?

From the contractor’s perspective, the cost is relatively minimal. The major part of this effort is usually only to take the designer’s model and combine it with other models.

e. When and where to use a 3D design?

Since the 3D design is available at any time, using it for some purpose almost from the very beginning of the design process is practically a given. Early efforts with this appear to be similar to the process of getting phased design documents. However, a 3D design likely will not be as linear as a traditional 2D “phased” design approach.

5. Other Considerations

a. Using Converted 2D versus 3D Designs

Once a model has been created and reviewed for its intended purpose, from this point forward, how the model is used is essentially the same regardless of how

The BIM Process: How is it to be conducted?

it was created. Once you have a composite model, it should not matter whether it was converted from a 2D Design or designed from inception in 3D.

b. Linking the Model to the Schedule ("4D")

Either the native design software or a third-party application will allow you to link the objects in your model directly to the data from your scheduling software. Note that different modeling programs work with different scheduling software and this should be investigated for compatibility early on prior to the creation of both a model and a schedule. Various "what if" scenarios can be evaluated much more effectively to ensure maximum use of materials and labor. All participants benefit from "seeing" the building get built virtually, activity by activity.

c. Outsourcing or Building the Model In-house?

Ultimately experience has shown that developing the models in-house is better than outsourcing. The experience gained by going through the learning curve first-hand along with developing the in-house expertise for the future, make the in-house solution the better option.

d. Upkeep of the model during design? During construction?

Regardless of who is maintaining the model and updating during design and construction, someone has to take this responsibility. During the design phase, the model can be updated as each consultant issues its next release. It is recommended that you run collision/clash detection after each update.

During construction, your own project team and the major subcontractors must be involved and aware that the model is being maintained. Incorporating design changes into the model must be an identified process. Early experience has some contractors using a dedicated person, "the project modeler," while others have done it within their project team.

e. The Project Delivery Method/Lean Construction

Getting the maximum benefit from the technology and BIM is directly correlated to the ability to maximize collaboration on a project. This leads to a belief that to fully use BIM, it must be on projects delivered with some kind of collaborative approach such as CM at-Risk or Design-Build. However, experience has shown that there are still benefits to the contractor on traditional Design-Bid-Build projects.

Running clash detection and correcting design errors prior to starting construction in the field can save time and money, even if the design is complete and the project was awarded based on a low bid. Also, looking at "what if" scenarios on construction sequencing and scheduling can offer opportunities to improve project schedules.

The key is that BIM does not automatically guarantee collaboration. BIM does allow collaborative projects to be *more* collaborative. Using BIM and sharing

The BIM Process: How is it to be conducted?

the information allows the team to take teamwork and efficiency to higher levels. This is where Virtual Design and Construction brings the core concept of lean construction, eliminating waste, into the equation. Eliminating waste and lean construction become “givens” when teams are exploiting technology, sharing information and using BIM to be more efficient.

f. Getting over the Wall?

There are many barriers keeping contractors from using the latest technology and BIM. The barriers include fears (legal/risk fears, fear of change, fear of the unknown, etc.), initial investment costs, the time to learn how to use the software, and perhaps for many the biggest barrier: the lack of support from senior leadership of the company.

One suggestion is to include senior company management as a steering committee as you determine the best strategy for your organization. This can be an effective way to gain their buy-in and support. Additionally, they will receive factual information regarding the process and its implementation, avoiding the fear of the unknown.

These barriers represent a “wall.” On one side are contractors who have not used the technology or experienced first-hand the benefits it offers. On the other side of the wall are contractors who have begun to use the technology and have begun to experience for themselves the benefits BIM has to offer.

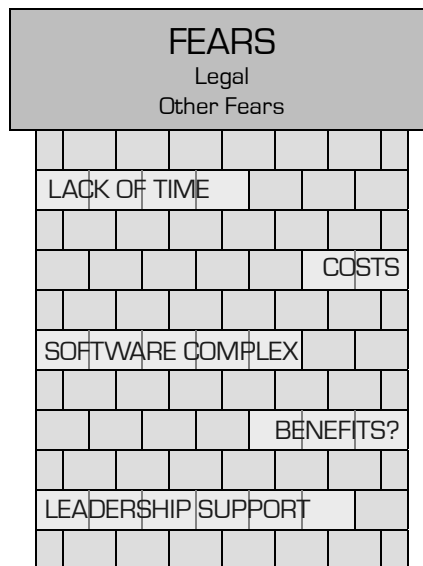
Are the fears legitimate? Probably, but as the rate of adoption increases, the technology becomes easier to use, the benefits become more widely understood and the new processes continue to evolve in the Model Based approach, these fears should dissipate.

Getting company leadership to have this vision of the future, buy into it, and commit the resources to invest in it is a decision the leadership of every company must make for themselves.

Little or No Experience
Don't see Benefits?



“THE WALL”



Have Experience
See the Benefits!



Overview of Responsibilities:

As stated in the introduction, BIM is a tool. Recent advances in computer hardware and software have made BIM technology available and relevant to the work of all members of a project team. The use of BIM may well change the ways that projects are conceived, designed, communicated and defined, but this tool will not change the core responsibilities of the members of the project team.

In a fully integrated 3D virtual construction environment contractors and construction managers will still need to organize and lead the onsite construction effort. No amount of technology will replace the need for a well-thought-out approach to construction that will allow each specialty contractor to apply its skills in a safe environment. Similarly, BIM will not replace the need for designers to convey their design intent, nor will it replace the dialogue of the submittal process through which subcontractors demonstrate their interpretation and understanding of the design intent.

Outside of the immediate construction effort, owners and code enforcement officials need to be afforded the ability to evaluate the cost and adequacy of the various components of a project. Again no amount of technology will replace the core responsibilities or actions of these members of the project team.

Software vendors and data warehouses must recognize the work-flow processes and responsibilities of the project team members in order to provide software and infrastructure that will adequately support the application of BIM technology. BIM technology processes must facilitate the building process and these relationships as they exist. Attempts to shift the responsibilities of the project team members into a contrived software work-flow process will ultimately obscure the goals of the project.

In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place. One in which team members are either contractually obligated or have agreed to work in a cohesive fashion and one in which they will provide each other with data that will allow its “partner” to perform its work faster, better or cheaper.

BIM technology can radically change the form of the work product of several members of the project team. It can allow projects to be built faster, with fewer surprises, and lower costs. However, the final goal of the project will remain an economically completed building ready for safe occupation and use. This goal can only be achieved if each member of the project team faithfully meets each of its traditional responsibilities.

Responsibilities That Must be Recognized and Accommodated by BIM Processes:

Submittal Process

Shop drawings, like slide rules and blueprints, may become a thing of the past, but the dialogue between designers and builders that is the basis of the submittal process must continue to be accommodated. Regardless of the medium of communication, it is necessary that the builder and designer confirm that the design intent is correctly interpreted prior to procurement of materials and performance of construction. The

Clarification of Responsibilities

safety and economy derived from this system of checks and balances is essential to the success of the project.

The submittal process, while critical to the success of a project, is often difficult to implement through traditional methods in the fast paced environment of modern construction. The dialogue is further complicated by the extensive use of performance criteria, which allow specialty contractors to bring savings and speed to the project through the application of their proprietary designs and processes. These proprietary elements must be reviewed and approved by the designer to ensure that the design intent has been properly interpreted and that the project design is modified where appropriate to incorporate them.

It is important to realize that the dialogue, not the medium of communication is the critical element of the submittal process. BIM technology allows electronic information to replace printed documents as the medium of communication. Information contained in BIM software is extracted directly to the detailing and fabrication processes without the need for further human interpretation. The speed and reduced cost of electronic communication saves the project the time and money associated with printing and shipping traditional shop drawings. These savings are easily identifiable and on large projects can be significant. Submittals can be handled electronically through review of the subcontractor's BIM, regardless of whether the design is issued in a 2D or 3D format.

The purpose of the submittal process is to check those elements of the design that require interpretation on the part of the builder prior to construction. The database qualities of BIM allow many items of a design to be explicitly defined without the use of the traditional symbols or schedules utilized in two-dimensional design drawings. This database quality of BIM could reduce the amount and content of submittals. For instance, if the builder extracts the information directly from the database created by the designer, no interpretation of the design information is required by the builder. A practical example of this is a situation in which a designer provides a BIM model with the size, grade and location of each steel beam contained within it. The information in this BIM model is then extracted by a fabricator and placed directly into the shop drawings. In this situation, no interpretation of the design has been performed by the builder and therefore a submittal showing this information to the designer would be redundant and thus not required.

The submittal process will continue to evolve as BIM technology develops and is adopted by the industry. Ultimately, the format and content of submittals is the responsibility of the entire project team. Each team member must realistically evaluate the extent of its responsibility and ensure that the interpretation of the design is adequately evaluated prior to implementation.

Changes

BIM processes must accommodate changes. Changes are part of the building process, and no amount of technology will or should prevent them. Regardless of the delivery method, the design team must be able to present the various alternative design solutions

at a schematic level in a form that can be evaluated and refined as the project moves forward. Design is an iterative process that spirals toward a final solution. It is not a straight line progression, and attempts to force it to fit a contrived work-flow to facilitate BIM implementation will obscure the ultimate goals of the project.

As discussed previously, several elements of a project are often built according to performance specifications, and implementation of these elements may require refinements of the design. Changes in financing, emerging technology, and building use will also dictate changes to the design as the project moves forward.

Design teams need a process through which to issue these changes and must be able to maintain a current set of design documents, whether paper or electronic. This set of documents must reflect the design intent at any stage of the project. Without a current set of the documents, the ultimate basis of the contracts will be in question. Without a firm basis for a contract, owners and code enforcement officials will not be able to evaluate the project's cost or suitability for occupation. Any BIM process must allow all project team members to modify and disseminate the information that they are responsible for.

Impact of 2D or 3D design on Project Responsibilities

Whether the design is issued in the form of 2D printed documents or a 3D electronic medium or in a combination of both, the responsibilities of the members of the project team remain unchanged. However, it is not necessary to go to this level in the 3D model for it to be effective. The important issue is to ensure that project team members thoroughly understand the nature, value and exactitude of the information that is being conveyed.

BIM presents the designer with the ability to precisely model every component of a design — showing every conduit, bolt, door hardware set, bent plate, and carpet pattern in a project. This is not reasonable or desirable. In order to economically construct a project and complete the design in timely fashion, the builders must be allowed the flexibility to coordinate the trades. BIM design models cannot be photorealistic representations of the completed project.

It is also important to recognize the difference between design and coordination. Creation of a coordination model does not require or supplant a design that is conveyed in 2D printed documents. When a contractor or CM creates a “coordination model,” the BIM tool is completely analogous to a light table used for overlaying mechanical and electrical drawings. Likewise a design model must not be interpreted as containing more or better quality information than the designer has included. A steel analysis model may not include the exact geometry of the project, and yet it may still be a valid representation of the required load paths. Regardless of whether the analysis model is an exact representation of the project, it is the responsibility of the design engineer to accurately convey the load carrying members of the project in a design document. Recognizing the validity and value of the information in any BIM is the responsibility of every project team member that utilizes it.

Clarification of Responsibilities

Actions/Responsibilities of Project Participants to Encourage the Use of BIM: Contractors and Construction Managers

Contractors and Construction Managers need to recognize that coordination, whether with BIM technology or a light table, is a core service rather than an added service. BIM tools that can facilitate a great deal of coordination are now available, and when applied appropriately they can reduce the cost and time of construction. The question is not whether BIM will be used on a project, but to what extent it will be used. It is known that BIM coordination improves communication, which decreases construction costs and time, thus reducing risk. Contractors and construction managers have a responsibility to evaluate the costs of various implementation processes and provide the results of this evaluation to owners and design teams in quantifiable terms.

As the leaders of construction coordination, contractors and construction managers have a responsibility to encourage and facilitate the sharing and distribution of BIM technology on a project. They must also understand and convey the nature of the information that is being shared. Appropriate contract language that will foster the open sharing of BIM information must be developed. The contract language cannot alter the relationships of the project team members or change their responsibilities beyond their ability or what they are licensed to perform.

As an example, if a designer approves an electronic file prepared by a detailer, and this file contains a dimensional inaccuracy, the designer must be protected to the same extent that it would be had the approval document been a printed drawing. Similarly in the case where a designer provides an analysis model or three-dimensional facade rendering to supplement the design documents, and the designer has stated that the analysis or rendering model shall not be considered to accurately show all aspects of the geometry (presumably the designer has issued and identified a separate document for specification of geometry) the designer shall not be liable if a detailer ignores the warning and bases the geometry on the supplemental model or rendering. The 3D information is valuable and should be shared with the team, but its use and accuracy must be carefully defined.

Design Teams

Design teams must recognize the benefits of sharing all available electronic information with the entire project team. Structural analysis models, for instance, have value to other team members, so delivery of these models should be part of the design contract. Along with the responsibility of sharing information, the designer has the obligation to convey the quality of the information that is provided. If the geometry or the load cases in a design model are not completely accurate, this needs to be made known and documented. In addition, the source of the correct information in the design documents needs to be established.

Design teams must also honestly evaluate the submittal process and work with the rest of the project team to develop the best process for the project. Together the team must find appropriate ways to facilitate communication without unduly burdening any single member with additional liability. Requiring printed shop drawings or resisting the requests of the team to distribute electronic files, simply because that is the way

business has traditionally been conducted, is not helpful to the project or the growth of the industry.

Public Agencies

Public agencies, like design teams must recognize the industry's movement toward electronic information and evaluate what information is truly needed to perform code enforcement checks and permitting. They must ensure that project design and construction are compatible with community safety and facilitate community development. They must be open when appropriate to adopt new formats for demonstration of a project's compliance with specified standards.

Owners & Program Managers

Owners that recognize the value of BIM must accept the responsibility of the costs associated with it. While the use of BIM coordination does not constitute an added service, it does represent added value or better service. Owners also need to recognize that additional deliverables (such as final as-built models) do constitute added services, and pay for these as warranted.

Subcontractors

Subcontractors are responsible for fully conveying their interpretation of the design intent to the Design Team. They also must coordinate their work with that of other subcontractors by sharing the electronic information they have developed in file formats that can be used and combined with the work of others. They must encourage their software vendors to develop file formats that can be readily exchanged between the various trade subcontractors. Subcontractors also must ensure that all parties understand what they will supply as part of their contract and what will constitute additional work.

Software Providers and Data Warehouses

To date, BIM technology has been developed to facilitate specific processes and activities related to a project. At the core, BIM software is a database. Its application to a process requires that the database be initially populated and then maintained as the project progresses. The amount of redundant effort required to develop and maintain the various databases of the many subcontractors that employ BIM technology represents the greatest source of waste and error associated with BIM implementation. In order to facilitate the full integration of BIM technology, software vendors must develop ways for the various members of the project team to input and maintain the data relating to the specific aspects of the project within their responsibility. In short, interoperability is essential, and must be accommodated by the software industry.

Software providers must also understand the process of design and construction, and fit their software to these work-flows. BIM software must be capable of modification as design progresses, so that the increasing levels of detail characteristic of the various design stages—from schematic design to construction documents—can be included in the BIM at the appropriate point in the design process. The software must also be able to accommodate changes.

Clarification of Responsibilities

BIM Adaptation:

BIM is a tool that will help the project team to communicate the needs of the project more quickly and accurately than through current practices. However, the tool cannot perform without the cooperation of the entire team. Each member must contribute its information to the BIM for the betterment of the project, and understand the quality of the information that is included in the BIM.

Current practice is evolving such that the contractors and construction managers are taking a lead role in coordination modeling. This makes sense, as they have the most immediate need and can reap the highest return for being able to virtually assemble and view the various components of the project prior to construction in the field. Each project is unique, and the implementation of BIM should be tailored to the needs of the project. We must remember that BIM is only a tool. BIM will not create, correct nor prevent errors. BIM will help find and more fully expose errors earlier in the construction process when the project team members work responsibly together.

Legal Environment and Contract Documents

The emergence of BIM as a vehicle for dramatic change in design and construction occurs in a legal environment that has not fully come to grips with all the risk management implications of the underlying technology of electronic representation, or transmission of documents of any type. Some concerns are obvious—what are the liabilities associated with participating and collaborating in the model? As the use of BIM expands, other concerns are only beginning to be recognized.

But even as lawyers spot the legal issues, how best to resolve those issues remains an open question. Some fear that an excess of concern over all the potential questions of liability, risk allocation, shifting and sharing associated with BIM might inhibit many from experimenting with it, and in the process deny owners, designers and constructors the opportunity to sort through the issues as they experiment in the laboratory of the real world.

This guide will not attempt to answer all the legal questions presented by BIM, but rather will discuss some of the concerns contractors should at a minimum understand and if possible address as they climb the BIM learning curve. While the risks presented by BIM may be different in some respects, it does not automatically follow that a contractor's risk should be greater.

First, contractors should do their best to reach an understanding with all parties about the ability and right to rely upon the model. Disclaimers of reliance that some have sought to apply to design documents in electronic format should be discarded.

Second, the same risk allocation principles that apply to traditional two-dimensional design should apply to a BIM model. Even with a BIM approach, the architect/engineer remains responsible for project design. A contractor's involvement in, and corresponding liability for, design should not extend beyond that typically associated with constructability issues, construction means and methods, and shop drawings. Thus, for example, the fact that the shop drawings are added into a model should not change the risks for the information being added. The crucial questions for the contractor are: what are the deliverables and who is responsible for them?

Third, when a model is used, strict rules are applied to police the model, so that access rights are reasonably restricted, the ability to change the model is strictly limited to those who are responsible for changes to that portion of the model, outdated versions of the model can be destroyed, and a precise audit trail can be maintained for the various iterations of the model. Anyone who has been involved in a project where one of the participants was working off an obsolete version of the drawings knows that the 2D world has problems of its own. In fact, adherence to 2D drawings as the "gold standard" of design is built on a faulty premise. The problems long inherent in the use of 2D drawings make clear that regarding them as sacrosanct is a mistake.

The issue of "ownership of the model" can be worked out through the contract, just as ownership of design documents is now addressed in AGC's standard form documents. The issue of ownership of the model becomes much more complex when the final

Risk Management

“model” is actually a gathering of the input of a single model or of many models through the use of software that allows such a roll-up process. Many parties will have contributed to the “model” in a fully modeled project and the issues of design input versus design responsibility will need to be sorted out. In addition, the licensing and royalty requirements of potentially “selfish” members of the Building Team need to be discouraged in standard form documents. Owners need to be particularly aware of the implications of such issues and are expected to play an important role in addressing them.

Other issues that should be understood and considered:

- Methods for maintaining version control of electronic documents, including a depository of record copies of transmitted and received electronic documents.
- Specific privacy and security requirements.
- Storage and retrieval requirements for electronic documents and data.
- The parties should review contract provisions in the design and construction agreements that address the line and flow of communications among the project parties. This allows them to assess whether such provisions need modification in appropriate, limited circumstances to permit direct communications among parties not in contractual privity, such as the principal design professional and a specialty contractor performing a portion of the design. In such circumstances, contemporaneous notification of such communications or exchanges should be given to the parties otherwise in the line of communications.
- Contractual reporting requirements for known or observed errors or omissions in contract documents should be reviewed, to ascertain whether they are adequate and consistent given the potentially increased pace of electronic document exchanges.
- Confidentiality provisions should be reviewed for consistency with similar requirements in exchange agreements.

Finally, as the use of BIM becomes more and more commonplace, standards will be developed as to who is responsible for inputting what information into a model. Currently, the National Institute of Building Sciences (“NIBS”) is engaging in such an effort.

BIM and other collaborative technology will compel owners, constructors and designers to interact differently than they have traditionally. As those relationships change, so too will the contractual language that defines them. However, the current uncertainties that accompany the changes brought on by BIM need not inhibit the constructor from experimenting with and ultimately embracing the future of construction. The traditional tri-party approach to design and construction will, over time, be replaced by “Integrated Practice” and collaboration.

Insurance

Any convergence of the design and construction processes signals the need for contractors to review not only their overall risk profiles, but also their risk-financing programs. BIM presents many of the same risk management questions contractors already face as they increasingly provide preconstruction services that require them

to analyze, price, and suggest modifications to the architect's design prior to its completion. Therefore, it is strongly advised that any contractor looking to participate in the BIM process consult with an insurance advisor to examine any potential increase in risk as well as the appropriateness of its current insurance coverage.

For example, the Commercial General Liability (CGL) policy should be examined. Unless so endorsed, the industry standard Insurance Services Organization (ISO) CGL policy does not contain an exclusion pertaining to the rendering of design and/or professional services. However, many insurers will add such exclusionary language by endorsement. The optimal situation for a contractor that undertakes design-build projects is to have a CGL policy with no professional services exclusion. The next-best option is to have the CGL policy endorsed with ISO form CG 22 80. This endorsement excludes coverage for claims arising out of the rendering of design services as a standalone service, but will provide coverage where the contractor also builds the project, i.e., design-build. Bear in mind that the CGL policy will respond only to claims for third-party Bodily Injury (BI) and/or Property Damage (PD) arising out of a design error.

Claims arising out of services provided as part of the BIM process may only be passive in nature. That is, they could involve pure economic loss when there is a design error that needs to be corrected, but BI or PD as defined in the CGL policy has not occurred. Thus, as neither BI nor PD has occurred the CGL policy will provide no coverage for the purely economic loss. As a result of this potential coverage gap, it is recommended that the contractor who becomes involved in any level of the design process consider the purchase of Professional Liability (PL) insurance. Here again, the counsel of a savvy construction insurance professional is critical as not all PL policies are alike. For example, some PL insurers may exclude and/or not specifically address coverage for claims arising from such services as value engineering and constructability review. Frankly, these are services that any contractor may currently be providing without having become involved in the BIM process.

A thorough review of the contractor's involvement or intended involvement in the design process should be undertaken to assess the potential exposures presented. Contract documents should be reviewed in conjunction with legal counsel and modified as appropriate, and available insurance protection should be discussed with your insurance advisor (including, but not limited to, Commercial General Liability and Professional Liability insurance policies), prior to entering the realm of potential design risk.

Beyond the design/professional services liability issues that may arise from participation in the BIM process, or that may exist with current project delivery methodologies, the contractor may very well have exposure to other electronic data/technology issues such as: project management software, project web-hosting/web-sharing, transmittal of electronic viruses, or intellectual property ownership/infringement, to name but a few. These potential exposures should also be discussed with both legal and insurance advisors to address both the contractual and risk-financing options of these and other technology and/or intellectual property related exposures.

Risk Management

Exposures Checklist

If you answer yes to one or more of the following provisions of services, it is recommended that you discuss these exposures with both your legal and insurance advisors. Making these advisors aware of such exposures will allow for an appropriate dialogue to address the contractual and risk-transfer/risk-financing options available for such exposures.

Does our company provide (or may it become involved with):

- Value Engineering and/or Constructability Review?
- Conversion of 2-D design documents to 3-D design documents?
- Building Information Modeling (BIM)?
- Design of specific project systems and/or full project design, whether performed in-house or subcontracted to others?
- Revisions or modifications to construction documents with or without design firm review and approval?
- Provision and/or development of Project Management Software?
- Project Web-Hosting and/or Web-Sharing systems?
- Transmittal of Project data/information using electronic transmission devices/systems?
- Ownership of design and/or intellectual property rights?

Surety Bonding Industry

The utilization of BIM technology by the construction industry will be an “evolving” underwriting process for the surety industry. At this date, BIM technology is such a new concept to the surety industry that no clear industry opinion has emerged and individual sureties likely are still formulating their own positions. This is especially true since little guidance in the form of industry standards exists concerning the proper utilization and application of BIM technology on construction projects. Some contractors, as early adopters, are utilizing BIM technology internally. Such internal use by contractors likely does not bring any additional burden to the surety, as its use is not made part of the contract documents at this time. However, where contractors utilize BIM technology as part of their contractual performance requirements for a project, certain surety issues may arise, particularly in the absence of a clear contractual delineation among the project parties for design, coordination and communication responsibilities.

AGC of America will continue to monitor the utilization of and developments surrounding BIM technology as more contractors seek to use or are required to use such technology on future construction projects. This discussion will focus on only the broadest surety implications of BIM technology utilized in three methods of project delivery: Design-Build, Design-Bid (or negotiate)-Build and Construction Management “at Risk”. Please keep in mind, however, that much about the legal and risk implications of BIM technology is unknown at present.

Utilization of BIM technology on projects requires a clear understanding of each party’s responsibilities. The parties will need to define and address the data standards

and protocols, the preparation of the model, and the distribution of information from the model. In this regard, a contractor and its surety who are evaluating BIM should consider how the contractor's organization can best manage the risks associated with utilizing this new project tool. If BIM technology is clearly defined contractually, it should decrease conflicts and make the design and construction process more efficient. As a result, the surety industry should embrace its utilization.

Summary

The major objective of the “The Contractors’ Guide to BIM” Edition One was to generally introduce the subject and provide an outline of the “how-to” for getting started. Regardless of the extent to which you decide to participate in BIM, simply getting started and understanding the topic will keep you in touch with a subject that is probably the most revolutionizing tool to come into the design and construction industry in recent times.

As this guide identifies, BIM is a tool that enables our industry to more efficiently operate in new and increasingly expeditious ways. Initially, BIM and 3D models have primarily helped eliminate design conflicts with far more efficient coordination. Expanding beyond this premise to some other specific practices, contemplate the future with BIM in regard to:

- Project scheduling and the concept of 4D, in which time considerations are inserted into the modeling process. With manpower loading inserted into the scheduling portion of the model, the project team will be able, on a long-term, look-ahead basis, to observe and plan to the detail on a daily (perhaps eventually even hourly) basis. Manpower can be best concentrated in a constrained area, thus providing resolution to increased field production. Imagine drilling down into the 3D model and actually being able to realize that your schedule exposes the conflict of an erroneously planned overabundance of manpower in a constricted area. By identifying such a conflict early, redirection and rescheduling of manpower will allow for fewer field conflicts and increased production.
- Estimating and quantification when 5D concepts are incorporated with the BIM process. As the 3D model is developed, a materials quantity report is instantaneously available. Further, depending on the sophistication of the software, pricing information could also be instantaneously generated. As good contractors know, the human element and judgment process for estimating will never be replaced by software. But given the capability of instantaneous estimate reports, as long as they are properly monitored, the project team will be able to “tweak” the design in real time to match the project budget, thus eliminating the need for complex value engineering after a design develops to more complete stages.
- The speed of shop drawing development and the associated coordination between all trades. Simply put, with 3D, it is realistic to envision that shop drawings could be developed simultaneously as the design unfolds. Thus, the “issued for construction” model is just that—eliminating the need for approvals and submittal “turnarounds,” as that process will already have been accomplished during the design period.
- Requests for Information (RFIs) will be significantly reduced during field construction due to the enhanced coordination and conflict reduction with the use of 3D.
- Accurate as-built drawings are available immediately at the close of construction with the use of BIM and a 3D model. The 3D model, as it is updated throughout the project duration, actually represents in electronic format the physical design and construction of the project throughout all trades. Imagine the future capabilities for the owner in maintaining and revising its structure or facility when inheriting a 3D model as its as-builts.

- The use of BIM and 3D modeling allows for the optimization of lean construction techniques and principles. Modeling allows one to precisely plan and coordinate the design and execution of the project, leading to the potential for increased prefabrication, the minimization of waste in both the shop and the field, the reduction of field interferences and collisions, and a general increase in productivity at all stages of the project.

And the list goes on and on when our creative thinking allows us to imagine the possibilities with BIM.

As the use of BIM accelerates within the design and construction industry, it will lead to a revolution in project delivery. Many are already referring to this revolution as leading to the fully collaborative project team. The theory of full collaboration generally envisions the entire project team: Owner, Architect, Engineers, Consultants, GC/CM and Specialty Contractors being involved from the project's inception by "sitting together at one table" in developing the project design. Essentially the team constructs the project electronically in 3D with the use of BIM. This full collaboration allows for increased speed of project delivery, enhanced economics for the project, and true lean construction all at levels—never yet experienced in our industry.

The Construction Users Round Table (CURT), an organization of international owners from a variety of industries, is addressing the future of the design and construction industry from their perspective. Their research and committee work on collaboration is summarized within their White Paper publications¹. Owners are under increasing pressure to more efficiently and expeditiously deliver projects due to more intense worldwide competition, which varies by each of their respective industries. Increased or full collaboration fulfills the owners' new and futuristic objectives in delivering projects.

We must face the fact that our design and construction industry has historically reacted rather slowly to change, especially revolutionary change. The use of BIM, for those who react quickly, will propel them beyond their competition in monumental proportions. Fortunately, as contractors, any magnitude of the use of BIM will improve the way we conduct our business. Additionally, contractors do not need to wait until other specific areas of our industry adapt the use of BIM. Many of the specialty contractors with whom GC/CMs subcontract are well established in 3D coordination. With the recent developments in BIM, the software tools are now available for the GC/CM's coordination of the overall project with 3D models, thus allowing incorporation of these related efforts of specialty contractors.

This is one of the major reasons why this "Contractors' Guide to BIM" Edition One specifically addresses the use of BIM by contractors when receiving the project design in a 3D format or when receiving a 2D representation of design for conversion to a 3D model. Simply put, we as contractors can only move further ahead just by coordinating

¹ The two most recent CURT White Papers relating to Collaboration are "Collaboration, Integrated Information and the Project Life Cycle in Building, Design, Construction and Operation (WP-1202) August 2004" and "Optimizing the Construction Process: An Implementation Strategy (WP-1003) July 2006".

Summary

a project in 3D versus utilizing existing 2D methods. Reducing field corrections and re-fabrication alone provides tremendous labor production increases and resultant cost savings.

Just as the technology and software of BIM expands and improves, this “Contractors’ Guide to BIM” is expected to evolve through future editions to keep AGC member contractors on the cutting edge of this industry revolution. With this guide, you now have a “roadmap” to begin your company’s industry participation with BIM and 3D models. You control the options and decisions regarding the extent to which your firm will get started and participate with BIM and 3D models. But more than anything make those decisions and...

GET STARTED USING BIM!

3D Parametric Modeling (3D Model with Attributes)

Model elements not only include visual aspects of the building elements they represent, but also have the properties (or knowledge) of the solids they represent.

4D Model

Term used to describe the linkage of a schedule to a model—essentially turning on model elements in the order in which they are built.

5D Model

Term used to describe the linkage of estimating software to a model—element quantities are downloaded from the model database and imported directly into estimating software.

BIM

Building Information Modeling is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a Building Information Model, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.

BIM Software Packages Categories

- Analysis Software—complete engineering analyses (examples include: Risa 3D, RAM, STAAD, and ETABS);
- Design Software—produce coordinated construction drawings (examples include: Autodesk's Revit and Architectural Desktop, and Bentley's MicroStation or V8);
- Coordination Software—host and/or merge Design and Detailing Models (examples include: Navisworks, Tekla Structure, and Graphisoft);
- Detailing Software—produce shop drawings and control fabrication processes (examples include: Xsteel, SDS/2, QuickPen, and CADPIPE);
- Rendering Software—provide a three-dimensional interactive rendering of the project (examples include: Sketchup, and PowerPoint)

Construction Coordination

The process of ensuring that the various elements of a building are constructed in a sequence that allows the various elements of the building to be.

Coordination Model

A Building Information Model that is developed from a completed design. The creation of the model is an interpretation of a design as opposed to the creation of a design.

Design Coordination

The process of ensuring that the various elements of the design (architectural, structural, electrical, etc.) fit together and complement one another.

Appendix A: Glossary

Interoperability (as it relates to BIM)

The ability of data rich models to share valuable data, either through import or export.

Obstacles to standard implementation of BIM technology

Necessity to concurrently perform the activities of design and construction; divergent protocols of data input and extraction; the lack of an appropriate software platform to catalog all aspects of the project; and the lack of sufficient infrastructure to provide access to the model by all members of the project team.

Appendix B: "Example BIM Tools"

(as of 2006)

Software - 3D Modeling (or 2D to 3D Conversion)

Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
Revit Building	AutoDesk	Creating and reviewing 3D models	<p>Autodesk® Revit® technology is Autodesk's platform for building information modeling. Built on the Revit platform, Autodesk® Revit® Building software is a complete, discipline-specific building design and documentation system supporting all phases of design and construction documentation. From conceptual studies through the most detailed construction drawings and schedules, Revit-based applications help provide immediate competitive advantage, deliver better coordination and quality, and can contribute to higher profitability for architects and the rest of the building team.</p> <p>At the heart of the Revit platform is the Revit parametric change engine, which automatically coordinates changes made anywhere—in model views or drawing sheets, schedules, sections, plans...you name it.</p> <p>Compatible with 2-D drawings</p>	<p>Various</p> <p>http://usa.autodesk.com/adsk/servlet/inde x?siteID=123112 &id=2435651</p>	<p>System Requirements: Microsoft® Windows® XP (Professional, Home, Tablet PC Edition) or Microsoft® Windows® 2000 SP4 (or later) Intel® Pentium® 4 1.4 GHz or equivalent AMD® Athlon® processor 1 GB RAM with 1 GB free disk space 1024 x 768 monitor and display adapter capable of 24-bit color Internet connection for license registration Microsoft Internet Explorer 6.0</p> <p>System Recommendations: Microsoft Windows XP Professional SP2 (or later) Processor: Intel Pentium 4 2.8 GHz or equivalent AMD Athlon processor RAM: 2 GB with Two-button mouse with scroll wheel</p>	~\$4,000 To \$6,000 Per Seat plus Subscription
Virtual Construction	Graphisoft	3D Modeling/Virtual Building	<p>The Virtual Construction™ suite of technologies employs 3D modeling to virtually construct your project. This process identifies constructability issues during design and/or preconstruction. The 3D model is further utilized to extract accurate estimating quantities and to analyze alternative construction sequences. Finally, design (3D), schedule (4D), and cost (5D) are all interlinked, so a change to any of the three automatically updates the other two.</p> <p>Graphisoft's construction tools include Change Manager. This solution automates revision of drawing changes and allows members of a project team to easily identify, communicate and manage those changes so they have minimum impact on time, cost and schedule.</p> <p>5D Construction Management</p>	<p>Various based on region</p> <p>http://www.graphisoft.com/products/where_to_buy/</p>		~\$8,000 Per Seat
Bentley Architecture	Bentley	Architecture Design	<p>Bentley is committed to delivering complete BIM solutions that support the whole project delivery process for the entire lifecycle of facilities. Built on a single platform while supporting industry standards, these solutions focus on design rather than drafting, integrate design with engineering, facilitate multi-disciplinary collaboration, and allow distributed teams to "build as one" within a managed information environment.</p> <p>Bentley Architecture, an advanced Building Information Modeling (BIM) application, virtually creates 3D prototypes of buildings, thereby providing significant business-critical benefits for architectural design and A/E/EA firms of all sizes. Able to deliver better buildings on time and on budget, they can substantially improve client services, reduce costs, and increase revenue.</p> <p>Prerequisites: MicroStation V8 (08.01.02.15 or higher) and MicroStation TriForma (08.01.01.30 or higher)</p> <p>Supports DGN File Formats</p>	<p>Bentley Architecture</p> <p>http://www.bentley.com/BentleyWebSite/Tools/sales_contact.aspx</p>	<p>Intel-compatible Pentium PCs running Microsoft Windows 2000, Microsoft Windows NT or Microsoft Windows XP Memory: Minimum 256 MB Hard disk: 200 MB minimum free Input device: mouse or digitizing tablet (tablet on Windows requires WINTAB driver or Bentley's Windows Digitizer Tablet Interface) Output Device: Majority of industry-standard devices supported; works with Windows-supported printers Video: Supported graphics cards (256 or more color card recommended for rendering); 16-bit color minimum for QuickVision GL; dual screen graphics supported for Windows NT4; multi-monitor configurations supported with Windows XP and Windows 2000</p>	<p>Contact Bentley sales for a customized quote: http://www.bentley.com/BentleyWebSite/Tools/sales_contact.aspx</p>

Appendix B: "Example BIM Tools"

(as of 2006)

Software - 3D Modeling (or 2D to 3D Conversion)

Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
Architect	VectorWorks	2D and 3D Production Management	For more than twenty years, VectorWorks Architect has provided building information modeling (BIM) capabilities that offer a true increase in productivity. With BIM, your 2D drawings, 3D drawings and project data are linked into a simple, yet powerful design environment. VectorWorks BIM technology allows you to design in 2D and 3D simultaneously. Changes made in one view are automatically updated in the other. And, because your drawings are linked, a change in one can automatically ripple through the entire drawing set, saving you time and reducing drawing errors. Plus, you can integrate information into your design to automatically generate schedules, as well as track materials and costs. And, you can export this information to use downstream in other costing and database programs.	VectorWorks http://www.nemetschek.net/sales/index.php	Macintosh Operating System: Mac OS X 10.3.9 or later Other Software: QuickTime 6 or higher Processor: PowerPC G3 or newer Other Hardware: CD-ROM drive Screen Resolution: 1024 x 768 (XGA) Display color depth: 16 bit Windows Operating System: Windows 2000 SP4 or later; Windows XP Other Software: QuickTime 6.5.2 or 7.0.2 Processor: Pentium or newer Other Hardware: CD-ROM drive Screen Resolution: 1024 x 768 (XGA) Display color depth: 16 bit	~\$1,400 Per Seat

Software - Training

Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
Revit	Autodesk	Software Fundamentals and Advanced Training	<p>Tutorials A complete set of self-paced training exercises is available to help you become more productive using Autodesk® Revit® Building.</p> <p>Revit Classroom Training Autodesk offers Autodesk Revit Fundamentals and Autodesk Revit Advanced training courses from our offices in Waltham, Massachusetts and San Rafael, California.</p> <p>How-to Articles Through step-by-step lessons written by recognized experts in their fields, Autodesk how-to articles and tutorials can help you master the techniques you need to become more productive with Autodesk products and solutions.</p> <p>API Training and Consulting for Developers Visit the Autodesk Developer Center for the latest courses and schedules of hands-on API training. Also, get information about Autodesk API consulting services.</p>	Autodesk	Tutorials, Classroom Training, and How-to Articles Prerequisites: Implementation of Revit	~\$1,000

Appendix B: "Example BIM Tools"

(as of 2006)

Software - Training						
Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
Virtual Construction	Graphisoft	Transition Services	<p>To both ease the transition to the new technology and to provide additional customer support during peak loads, Graphisoft Construction Services will utilize this product line under the direction of the Customer's project team. Services include:</p> <ul style="list-style-type: none"> Construction Modeling Constructability Analysis Estimating Support 4D Sequencing Support Production and Procurement Planning Support Site Planning Support 5D Construction Simulation Presentation 	Graphisoft	<p>Services Include: Construction Modeling Constructability Analysis Estimating Support 4D Sequencing Support Site Planning Support 5D Construction Simulation Presentation</p> <p>Prerequisites: Implementation of Virtual Construction Suite</p>	Varies based on need
Bentley Architecture	Bentley	Bentley Training Programs	<p>Classroom Learning Led by experienced Bentley instructors, classroom learning is offered through scheduled courses at Bentley training facilities or as account-specific training in your office or nearby training facility convenient to your work location.</p> <p>Distance Learning Live, instructor-led distance learning is taught by experienced Bentley instructors via the Internet. Distance learning is available through scheduled courses or as account-specific courses tailored to your workflow.</p> <p>OnDemand eLearning OnDemand eLearning delivers professional training to every desk through recorded interactive courses and lectures. Hundreds of hours of OnDemand eLearning courses are available to Bentley LEARN and Enterprise Training Subscription users.</p>	Bentley	<p>Programs for every user, goal or budget Bentley Institute offers a variety of training programs that make it easy for any individual or organization to get professional training. Organizations can increase return on investment and train more people through the annual training subscription programs, Bentley LEARN and Enterprise Training Subscriptions.</p> <p>Prerequisites: Implementation of Bentley solution</p>	Varies based on need
Various	Kristine Fallon Associates, Inc.	BIM Training and Transition	<p>KFA has developed training curricula and conducted training in multiple BIM products. KFA was principal author of Autodesk Revit Building 8 training curriculum and materials. KFA restructured the training curriculum for Autodesk Revit Building Essentials from a five-day to a three-day program and the Advanced curriculum from a three-day to a two-day program. As part of the documentation review, KFA verified all model sets used in each unit of the programs were complete and had the necessary building components and families for students to create models. The conventional training manuals were also reformatted and adapted for modified online versions of both training programs.</p> <p>The ERDC Computer-Aided Design and Drafting/Geographic Information Systems Technology Center for Facilities, Infrastructure, and Environment (CADD/GIS Center) provides the expertise, standards, and onsite implementation support to execute BIM technology in the Federal design arena. The CADD/GIS Center is well-acquainted with the unique requirements of the Federal user, including long-term management, operation, and maintenance of facilities in the Federal environment and the impact of the President's current Management Agenda.</p>	KFA	<p>KFA has followed the evolution of intelligent building modeling technology for over a decade, developing academic programs using advanced modeling products, producing a Triforma white paper for Bentley Systems, evaluating the maturity and scalability of BIM systems for the Spallation Neutron Source project at Oak Ridge National Lab and assisting Revit Technology in market research and feature prioritization prior to their initial product release.</p>	Varies based on need
Various	ERDC	BIM Training and Support	<p>The ERDC Computer-Aided Design and Drafting/Geographic Information Systems Technology Center for Facilities, Infrastructure, and Environment (CADD/GIS Center) provides the expertise, standards, and onsite implementation support to execute BIM technology in the Federal design arena. The CADD/GIS Center is well-acquainted with the unique requirements of the Federal user, including long-term management, operation, and maintenance of facilities in the Federal environment and the impact of the President's current Management Agenda.</p>	U.S. Army Engineer Research and Development Center	<p>The Center offers training and implementation support for this software to the Federal user community. Must be part of the Federal User community.</p>	Varies based on need

Appendix B: "Example BIM Tools"

(as of 2006)

Software - Training						
Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
Various	Gehyr Technologies	Digital Technology Integration	GT brings fifteen years' experience applying advanced digital technologies to complex building projects undertaken by Gehyr Partners and other leading architecture and engineering companies. Our clients and partners are firms and building teams interested in moving beyond the limits of drafting and paper driven project management and into 21st century, digitally enabled design and construction practices.	Gehyr Technologies	Gehyr Technologies ("GT") is a building design and construction technology company that provides integrated, digitally driven construction practice tools and methodologies to companies and their projects.	Varies based on need

Software - Interoperability

Product Name	Manufacturer	BIM Use	Manufacturer's Description	Supplier	Hardware Requirements	Approx. Cost
JetStream v5	Navisworks	Combining and reviewing 3D models	<p>Powerful and flexible yet affordable and easy to use, JetStream v5 saves time and reduces the risk of problems onsite, thus saving money. JetStream v5 gives access for all stakeholders to work effectively together on a project employing 3D design models on the desktop or over the Web, and regardless of size or file format.</p> <p>BIM compliant, a solution for Virtual Construction and an aid to LEAN construction techniques, JetStream v5 has become an integral part of many major companies' review processes.</p> <p>Our product is used in diverse markets including Engineering, Construction, Oil & Gas, Petrochemicals, Energy, Shipbuilding, Automotive, and Utilities, and offers proven benefits in saving time and money throughout the project lifecycle for both engineering and procurement contractors as well as owner operators, and for CAD and non-CAD user alike.</p> <p>Our fifth major release, JetStream v5, is scalable and easy to deploy and administer; fitting into existing processes and linking to third party software and databases.</p>	<p>Various</p> <p>http://www.navisworks.com/resellers/</p>	<p>Minimum specification for NavisWorks would be:</p> <p>Pentium II processor (or equivalent) 64MB RAM Windows 95 or above</p> <p>Recommended specification for NavisWorks would be:</p> <p>Pentium III processor (or equivalent) Hardware-accelerated OpenGL graphics card 128MB RAM Windows NT 4 or above</p>	~\$8,000 Per Seat
JetStream v5 Roamer	Navisworks	Combine Designs into one model	<p>Roamer can be used to navigate and explore the design free from the limitation of pre-programmed animation and without specialist skills or hardware. Fully compatible with the all major 3D design* and laser scan formats, Roamer can quickly open and combine competing 3D files to create a single virtual model for review of geometry, object information and linked ODBC databases. Textures, materials and lights can also be viewed from .nwd files or, when used with the Presenter plug-in, other compatible formats. Stereo viewing support, collision detection, gravity and a third person view improve the reality of the Roamer experience.</p> <p>Allows collaboration using 3D design models regardless of format.</p>	<p>Various</p> <p>http://www.navisworks.com/resellers/</p>	<p>Minimum specification for NavisWorks would be:</p> <p>Pentium II processor (or equivalent) 64MB RAM Windows 95 or above</p> <p>Recommended specification for NavisWorks would be:</p> <p>Pentium III processor (or equivalent) Hardware-accelerated OpenGL graphics card 128MB RAM Windows NT 4 or above</p>	Component of JetStream plug-in architecture

**For custom Interoperability options, please see the consulting section below.

Notes:

1. Products presented are not in any specific order
2. Costs are typical and may vary based on configuration or other requirements

Appendix B: "Example BIM Tools"

(as of 2006)

Software - Change Management						
Product Name	Manufacturer	BIM Use	Description	Supplier	Hardware Requirements	Approx. Cost
JetStream v5 Clash Detective & TimeLiner	Navisworks	Report indifferences in 3D project models and track project status	<p>Key Attributes of JetStream v5 Clash Detective</p> <ul style="list-style-type: none"> • Check for intersecting, distance between & duplicate geometry. • Workflow planning based on time & space co-ordination. • SwitchBack to 3D design software for fault finding & fixing. • Full audit trail of detected clashes. • Extensive interference management & reporting capabilities. • Clash test XML import / export. • Point / Line Based Clashing. <p>Key Attributes of JetStream v5 TimeLiner</p> <ul style="list-style-type: none"> • Improve site planning & enables "what-if" scenarios for visual risk management. • Integrates with existing tools such as Primavera, MS Project & Asta Powerproject • Time-based work-flow planning when linked with Clash Detective 	<p>Various</p> <p>http://www.navisworks.com/resellers/resellers.php</p>	JetStream v5 Roamer is required for use of these plugins	<p>Both included with JetStream Roamer v5 Pro which is ~\$8,000 Per Seat</p> <p>Sold separately: Clash Detective: ~\$4,000 per seat</p> <p>TimeLiner: ~\$1,500</p> <p>**Indicated cost for budgetary purposes only.</p>
Change Manager	Graphisoft	Identify, communicate and manage changes	<p>Graphisoft Change Manager features include:</p> <ul style="list-style-type: none"> • Easily define document sets & analyze changes. • Assign changed documents to project team members. • Review changes on a document-by-document basis: <ul style="list-style-type: none"> ▪ Adjustable contrast with color-coded identification of new, deleted, and changed entities. ▪ Slider: overlay of new and old documents with a slider control to shift the display. ▪ Shift: mouse control that shifts the position of the new document relative to the old to make it easy to understand the changes. • Cloud annotation with logging. • Project Log: Stores the list of changed documents, action assignments, change descriptions, and action completions for each document set. • Ignore Change: Stylistic changes such as fonts and repetitive changes such as revision numbers on title blocks can be identified once and ignored in all future documents. • AutoCAD® Release 14 DWG format and above. 	<p>Graphisoft</p> <p>http://www.graphisoft.com/products/construction/products_and_services/change_manager/contact.html</p>		<p>~\$895 + VAT</p> <p>Volume discounts available</p>
Software - Consulting						
Product Name	Manufacturer	BIM Use	Description	Supplier	Hardware Requirements	Approx. Cost
Revit	AutoDesk		Autodesk Consulting also provides consulting offerings for project assessments, process audits, and a range of implementation services. Custom consulting offerings are also available to meet your specific needs.	Various	Prerequisites: Implementation of Revit	Varies based on need
Various	Gehry Technologies	Digital Technology Integration	GT brings fifteen years' experience applying advanced digital technologies to complex building projects undertaken by Gehry Partners and other leading architecture and engineering companies. Our clients and partners are firms and building teams interested in moving beyond the limits of drafting and paper-driven project management and into 21st century, digitally enabled design and construction practices.	Gehry Technologies	Gehry Technologies ("GT") is a building design and construction technology company that provides integrated, digitally driven construction practice tools and methodologies to companies and their projects.	Varies based on need

Appendix B: "Example BIM Tools"

(as of 2006)

Hardware Options					
Product Name	Manufacturer	Performance	Base Description	Product Information & Functionality	Approx. Cost
Dell (www.dell.com)					
Dimension 1100	Dell	Low End	<p>Processor: Intel® Celeron® D Processor up to 330 (2.66GHz, 533MHz FSB, 256KB L2 cache).</p> <p>Operating System:</p> <ul style="list-style-type: none"> • Genuine Windows® XP Home Edition • Genuine Windows® XP Media Center Edition 2005 <p>Memory: Up to 1GB (dual channel) Shared! DDR SDRAM at 400MHz for superior performance (Note: 400MHz memory performs at 333 MHz with 533 FSB processors).</p> <p>Storage: Ultra ATA Hard drives up to 160 GB2 to meet your storage needs.</p>	<p>Essential Productivity at an Affordable Price</p> <p style="text-align: center;">Basic</p>	<p>Starting base at ~\$350</p> <p>Fully loaded at ~\$1,000</p> <p>(Price may change as product is customized)</p>
Optiplex GX620	Dell	Mid Range	<p>Processor:</p> <p>Intel® Pentium® D Dual Core with up to 2MB L2 cache, Intel Pentium® 4 HT & XD Security up to 2MB L2 cache, or Intel Celeron® D Processor</p> <p>Operating System:</p> <ul style="list-style-type: none"> • Genuine Windows® XP Professional • Genuine Windows® XP Home Edition • Windows Vista™ capable <p>Memory:</p> <p>Up to 4GB1 of 533MHz Dual Channel Shared2 DDR2 SDRAM</p>	<p>Maximum performance and scalability that meets your most demanding needs today and provides investment protection for the future. The GX620 also shares a common image and BIOS with the GX520, providing unsurpassed choice while minimizing ownership costs.</p>	<p>Starting base at ~\$1,100</p> <p>Fully loaded at ~\$2,250</p> <p>(Price may change as product is customized)</p>
Precision 690	Dell	High End	<p>Processor:</p> <p>64-bit Dual-Core Intel® Xeon® Processors (Up to 3.73 GHz, 2x2MB L2 Cache, 1066MHz FSB) or (Up to 3.0 GHz, 4MB L2 Cache, 1333MHz FSB)</p> <p>Operating System:</p> <ul style="list-style-type: none"> *Genuine Windows® XP Professional *Genuine Windows® XP Professional x64 Edition *Windows Vista™ -capable! *Red Hat® Enterprise Linux WS v.4 (EM64T) <p>Memory:</p> <p>Up to 64GB3 quad-channel4 architecture DDR2 Fully-Buffered DIMM 533 and 667 MHz ECC memory</p> <p>Storage:</p> <p>Up to 2TB8 of SATA integrated storage or up to 1.2TB8 of integrated SAS storage, both with integrated support for RAID 0 and 1; up to 1.7TB8 of storage with 500GB8 SATA boot drive plus 4 SAS drives, Optional PERC 5/i PCI-e RAID card supports RAID 0, 1, 5,</p>	<p>The Dell Precision 690 is an ultra-high-performance workstation that maximizes performance and scalability in an innovative, new, customer-driven chassis design. The 690 offers up to two 64-bit Dual-Core Intel® Xeon® 5000 and 5100 series processors, up to 64GB1 of memory in four fully-buffered DIMM channels (with an optional memory riser card) and a wide range of high-performance OpenGL graphics cards. The Dell Precision 690 is designed for the most business-critical, computer-intensive and graphically demanding workstation environments.</p>	<p>Starting base at ~\$2,358</p> <p>Fully loaded at ~\$8,500</p> <p>(Price may change as product is customized)</p>

Appendix B: "Example BIM Tools"

(as of 2006)

Hardware Options					
Product Name	Manufacturer	Performance	Base Description	Product Information & Functionality	Approx. Cost
Gateway [www.gateway.com]					
E-1500D SB	Gateway	Low End	<p>Intel® Celeron® D Processor 346 (3.06GHz, 533MHz FSB, 256K L2 cache)</p> <p>Genuine Microsoft® Windows® XP Professional Edition (SP2)</p> <p>ATI® Xpress 200 Chipset</p> <p>512MB DDR2 PC4200 533MHz SDRAM (2-DIMM)</p> <p>80GB Ultra ATA100 7200rpm hard drive w/ 2MB cache</p>	<p>When it comes to affordable computing solutions, why compromise on performance? That's why the Gateway® E-1500 SB Desktop is an invaluable business asset for organizations keeping an eye on the bottom line.</p>	<p>Starting base at ~\$645</p> <p>Fully loaded at ~\$1,165</p> <p>(Price may change as product is customized)</p>
E-6610 Series	Gateway	High End	<p>Intel® Core™2 Duo E6300 (1.86GHz 1066MHz FSB 2MB cache, non-HT)</p> <p>Genuine Microsoft® Windows® XP Professional Edition (SP2)</p> <p>Intel® 975X Chipset with DDR2 and Intel® Core™ Duo support</p> <p>1024MB PC5300 Dual-Channel DDR2 667MHz SDRAM (2-512MB modules)</p> <p>160GB Serial ATA II/300 7200RPM w/Raid 0 (2-80GB Hard Drives - Striping)</p>	<p>The Gateway® E-6610 Desktop is designed for optimal performance with workstation-class configurability. Benefit from the top-notch level of performance and features, including the latest Intel® 975X chipset, OpenGL graphics, ultrahigh-speed hard drives, ECC or non-ECC memory and RAID options. Complementing these high-end features is BTX Technology with ultra-quiet dual-fan cooling for improved reliability.</p>	<p>Starting base at ~\$1,350</p> <p>Fully loaded at ~\$3,530</p> <p>(Price may change as product is customized)</p>
Hewlett-Packard [www.hp.com]					
Dx2200	Hewlett-Packard	Low End	<p>Operating systems installed Genuine Windows® XP Home SP2</p> <p>Processor type* Intel® Celeron® D 326</p> <p>Processor features 2.53GHz, 256-KB L2 Advanced Transfer Cache, 533MHz Front Side Bus</p> <p>Memory 256MB PC2-5300 (DDR-667)</p> <p>Hard drive, internal 80GB SATA Hard Drive (7200 rpm) 3.0 GBps</p>	<p>The HP Compaq dx2200 combines essential business features and proven technology for a PC that is ideal for mainstream business applications and environments.</p>	<p>Starting base at ~\$349</p> <p>Fully loaded at ~\$850</p> <p>(Price may change as product is customized)</p>
Dc7600	Hewlett-Packard	High End	<p>Operating systems installed Genuine Windows® XP Professional</p> <p>Processor type* Intel® Pentium® 4 Processor 640</p> <p>Processor features 3.2 GHz, 2-MB L2 Cache, 800-MHz front side bus</p> <p>Memory 512 MB (533 MHz)DDR2 (2x256)</p> <p>Hard drive, internal 80GB 3.0Gb/s Hard Drive (7200 rpm)</p>	<p>The innovative design of the HP Compaq dc7600 Convertible Minitorner provides increased expandability, flexibility, convenience, and savings. With easy conversion from a minitorner to a desktop, the CMT offers maximum expandability and performance options. Security, stability, and manageability features add IT peace of mind.</p>	<p>Starting base at ~\$849</p> <p>Fully loaded at ~\$1,500</p> <p>(Price may change as product is customized)</p>

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