

Building Information Modeling: Understanding and Operating in a New Paradigm

Prepared for
The Foundation of Wall and Ceiling Industry

By
Words & Images

"BIM is here to stay."
—Steve Jones, McGraw-Hill

"The real promise of BIM lies in its application across the entire project team, especially in the area of improved building performance."
—Technology Industry Analyst, Jerry Laiserin

"Get the habit of analysis—analysis will in time enable synthesis to become your habit of mind."
—Frank Lloyd Wright

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Preface

Foundation of the Wall and Ceiling Industry

In the late 1970s, there was a clear recognition among industry leaders for the need to unite and expand the educational and research activities available to contractors, manufacturers, distributors and the public, in general. At the time, there were many issues facing the industry—from a national energy crisis to injuries in the workplace, to unsafe buildings occupied by the public. In response to these issues, the Foundation of the Wall and Ceiling Industry was formed in 1977 with the following mission statement as an IRS designated non-profit 501(c)3 corporation to pursue educational and research activities benefiting the industry and the public at-large:

The Foundation's mission is to be an active, unbiased source of information and education to support the wall and ceiling industry.

To fulfill this mission, the Foundation owns and maintains the largest independent library serving the wall and ceiling industry, provides educational scholarships for those pursuing careers in engineering, construction and design, provides research support to industry inquiries and publishes research papers.

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Table of Contents

Executive Summary	7
What Is Building Information Modeling?	7
BIM Project Invitations or Survival	7
The Future of BIM	7
2020	8
Conclusion	8
An Overview	
BIM	9
The Players	9
3-D Modelers	10
Autodesk/Revit	10
Bentley	10
Vico	10
Tekla	10
Viewers/Surface Modelers	10
Google-SketchUp	10
NavisWorks	10
Analyzers	10
Energy+	10
DAYSIM	11
ApacheSIM	11
LifeCycle	11
Obstacles to BIM	11
It /s Broke	11
Training Curve	11
Cost of Software	11
What Drives the Use of BIM?	11
The Bottom Line	11
Fragmentation	11
Inefficiencies	12
Waste	12
Cost	13
A Problem Solved	13
Green Buildings	13
Energy Analyses	13
Communication	13
The Power of BIM	14
Virtual Building	14
Parametric Objects	14
Coordinated Design Model	14
2-D Documentation	15
Version Control	15
Prefabrication	15
Analysis Tools	15
Clash Detection	16
Constructability	16
Structural	16
Performance	16
Energy	17
Acoustical	17
Lighting	17
Estimating	17
Building Element Models (BEM)	18
The buildingSMART alliance	18
Industry Foundation Classes (IFC)	18

- Architects and Engineers19**
 - Design Process 19
 - Team Design 19
 - Big Room 20
 - What Ifs–Analyses 20
 - Levels of Detail 20
- General Contractors 20**
- Subcontractors 20**
 - Prefabrication 21
 - Clash Detection 21
 - Take-off and Estimating 21
- Wall and Ceiling Contractor 21**
 - Take-off and Estimating 21
 - Clash Detection 22
 - Visualization/Communication 22
 - Prefabrication 22
 - Scheduling 22
 - Sound and Light Analysis 22
 - Constructability 22
 - Information 23
 - Project Management 23
 - BIM Project Invitations 23
- Facility Managers 23**
- Risks: Legal & Contracts 23**
 - The Thorny Part 23
 - Risks in the Adoption and Use of BIM 23
 - Behavioral Risks 24
 - Technology Related Risks 24
 - Definitions 24
 - BIM – Legal Impact 24
 - Risk and Reliance 25
 - Risk Allocation 25
 - Ownership and Reliance 25
 - Current Framework/BIM Perspective 27
 - Liabilities 27
 - Risks 27
 - Rewards 28
 - Intellectual Property Rights 28
 - Suggested BIM Contract Language 28
 - ConsensusDOCS 301–BIM Addendum 28
 - General Principles 28
 - Definitions 29
 - Information Management 29
 - BIM Execution Plan 29
 - Risk Allocation 30
 - Intellectual Property Rights in Models 30
 - Conclusion 30
- The Future of BIM 31**
 - 2020 31
 - Conclusion 31

Executive Summary

WHAT IS BUILDING INFORMATION MODELING?

Building Information Modeling (BIM) allows you to fully and truly construct a building virtually, and in detail.

During the BIM-design phase you can not only select and place the materials that will make up the finished structure—including concrete slabs, rebar, steel structure, wall and ceiling components, HVAC, plumbing and electrical—but you can also test all such parts for conflicts (clash detection) to ensure everything will come together seamlessly. And all this while you can still use an “eraser,” rather than having to rework later in the field.

You can also use this 3-D building model to analyze the designed building’s energy efficiency by running “what if” scenarios to determine the best of several potential solutions. In addition, depending on the detail of the model, you can automatically take off all items contained in the model and that way produce an impressively precise estimate.

The software and database management technology exists today to accomplish exactly this. What has yet to be realized and bought in to by a large majority of our industry, however, is the degree of collaboration and coordination between the various construction disciplines that BIM calls for.

Not only the owners and architects, but engineers, contractors and, ideally, subcontractors as well, need to be involved in the project from the outset; in other words, during the design of the building. This, of course, invariably means some form of design-build rather than the currently prevailing design-bid-build process.

BIM is not just the latest release of CAD software; it is an entirely new way of looking at the design and construction of a building.

Many quarters are hailing BIM as the panacea to most, if not all, construction industry ills, solving both design and construction problems while also providing a complete as-built 3-D building model as a property management facility upon completion of the project.

Those who have already taken the BIM-leap—whether architects or contractors—report that they already see significant benefits, and savings, with BIM technology and processes; a reported reduction to near-zero job RFIs (Requests for Information) and in-the-field change orders speaks for itself.

Those who claim that BIM has yet to enter prime time also have a point in that there are still many issues to be resolved; chief among them being the question of interoperability among various BIM softwares, the learning curve involved in implementing BIM, and the necessary paradigm shift in how buildings are designed and constructed.

Although, as it stands today, the wall and ceiling industry is not greatly involved with BIM, there is no question that sooner rather than later, owners, designers and general contractors will begin to invite and bring only **BIM-enabled subcontractors** into their projects, and it would serve the wall and ceiling contractor well to become familiar with this new technology and this new way of building.

Opinions notwithstanding, BIM is moving forward. Several high-visibility projects, such as the Freedom Tower in New York City, are BIM-designed and constructed. While it may still be on the horizon for most of AWCI’s membership, BIM is approaching rapidly. This paper aims, therefore, to arm AWCI contractors with the knowledge and understanding they need to face a BIM future profitably, and with certainty.

BIM PROJECT INVITATIONS OR SURVIVAL

As BIM gains more and more traction, general contractors will increasingly look for BIM-enabled subcontractors.

Therefore, as a first step, the wall and ceiling contractor should learn all that he or she can about the technology—and the process—and decide how his or her company fits into the BIM picture.

Once he or she has become familiar with, and now can work within a BIM-framework, the next crucial step is to make this ability—this additional service—known far and wide. Advertise it, print it on your business cards and ensure all your GCs know: You are BIM-enabled.

THE FUTURE OF BIM

To quote technology industry analyst Jerry Laiserin, “The real promise of BIM lies in its application across the entire project team, especially in the area of improved building performance.”¹

To date, BIM has offered only glimpses of what 3-D modeling, and the requisite team spirit to make it work, are capable of. As more government agencies like the General Services Administration specify BIM in their contracts, as more benefits surface, and as more owners see—and share—higher profits, BIM will find full traction and will reshape the industry. It is not a question of if, it is a question of when.

BIM is not just the latest release of CAD software; it is an entirely new way of looking at the design and construction of a building.

The contractor or subcontractor who gears up now—or at the least fully informs him- or herself about what BIM can do for his or her company, or how a BIM-enabled company might better serve the industry—will soon be in high demand. Those who feel that the boat is doing just fine and should not be rocked may find themselves scrambling for BIM tools and rushing into perhaps ill-advised choices once BIM becomes a general requirement, be it for economic, green or other reasons.

The important thing to realize is that BIM, at heart, is not just software but a “human activity that ultimately involves broad process changes in construction.”²

2020

By 2020 BIM will most likely have reached all the way into the building codes structure and the permits process. “Send me the model,” may well be the immediate response to a permit request. More likely than not, the permit office now has an analyzer that will quickly (in a matter of seconds) verify that your model is to code, and you may receive your permit in days, rather than weeks, after submittal.

Lean Construction principles will have worked their way into a majority of projects, and the U.S. construction industry will, as a team-centric industry, be the most productive—and the most proud—in the world. It does not take a crystal ball, or even 20/20 vision, to see that.

CONCLUSION

Building Information Modeling has grown out of its infancy. The day the GSA required all of its contracts to be BIM-based signaled the moment.

BIM may mean many things to many people. It is a buzzword, to be sure, but it may be on or off the radar for the wall and ceiling subcontractor of today. But BIM, both as mature software and as process, has in fact arrived, and regardless of cost or learning curve, its benefits have been proven to outweigh its drawbacks.

The smart subcontractor will take heed.

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An Overview

Although the concepts and methodologies we now understand as Building Information Modeling date back as far as 30 years—and then primarily within the manufacturing and aerospace industries, BIM as a design and construction term was introduced about 15 years ago to set the then-emerging, information-rich, architectural computer-3-D modeling apart from traditional, and mainly paper-based, 2-D design and drawing.

BIM aimed to designate both a software approach and a method of designing and constructing a building by the use of highly coordinated and internally consistent computable information about the building; all the way from conceptual design, through construction, to post-construction and asset management.

A correctly assembled BIM is a reliable, digital, three-dimensional, “virtual” representation of the project to be built, for use in design decision-making, in construction document production, in construction scheduling and planning, in performance predictions and in cost estimates. Keep in mind that, as with all other computer-based applications, the quality of the output is always limited by, and does reflect, the quality of the input—you’ve no doubt heard the term “garbage in, garbage out.”

With what in essence is a three-dimensional representation of a centralized database containing all items that will comprise the actual building—including their location, dimension, relation to other items, composition, cost, as well as their ordering or manufacturing details—the owner, architect, engineer, contractor, subcontractor and manufacturer have a clear view of the project as a whole, in one up-to-date and integrated digital environment.

The model, again assuming all input is correct, will provide the builder an easily assimilated view of the entire picture, its interrelations, and of any positional conflicts and problems. And most importantly, it will also provide the information and the understanding necessary to resolve positional conflicts and other issues during the design phase, rather than later, on the building site.

These potential benefits notwithstanding, many organizations are still taking a wait-and-see attitude about BIM, waiting for the proverbial jury to return.

Needless to say, for BIM software vendors, the jury is back, and has been for a while: BIM is the answer.

This sentiment is echoed by most consultants as well, and—increasingly—by those early adopters who have

implemented BIM and its processes on their projects. These include the U.S. General Services Administration, Disney and Intel.

The consensus among those who have actually used BIM (and with that the jury is beginning to return to their seats) is that BIM saves both time and money, sees fewer conflicts and design errors—along with a drastic reduction in RFIs and change orders—and improves productivity.

BIM

The 3-D images of BIM are no longer surface-only shapes. They are objects.

They are objects with content. The wall contains studs at indicated intervals; it contains wallboard of a certain thickness. The concrete slab contains rebar to increase tensile strength. The windows are double-glazed (or not).

If all database fields (parameters) pertaining to a given object are correctly populated, you can find out everything you need to know about any given item, including, among other things, its position and relation to other items, its R-value, its manufacturer, its cost, its place of manufacture, its use of recycled material, and its delivery time—even its installation instructions.

You can look at a true (meaning all pertinent information is accurately entered) BIM rendering and know as much about what you are looking at as if you were looking at the real thing, in real time. And you can understand the BIM 3-D model so much better than a 2-D drawing, because you see it as it is supposed to look.

BIM has many other strengths, but this one is key: BIM truly facilitates communication and understanding.

BIM facilitates communication between the owner and the designer and between the designer and the contractor, who now sees how it all goes together, and who can be assured through clash detection that there will be no conflicts; and between the contractor and the subcontractor, who also gains a much better understanding of what, exactly, is to be done from the clear visual that BIM offers.

THE PLAYERS

The field of BIM players breaks down into makers of three distinctly different sets of tools:

- 3-D modelers.
- Viewers/Surface modelers.
- Analyzers.

The 3-D modeler is the true BIM tool, working with

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solid, parametric objects in sufficient detail to virtually construct the building.

Not all views of the project have to be in that detail, however. The financing entity may want to see what the building will “look” like—as may the owner—and for that all you need is a surface modeler—or a viewer—to which all shapes are hollow. All it knows about is surfaces, which is all it needs to recognize in order to show concepts, and detect clashes for instance, and as such is of tremendous value.

Analyzers are normally third-party software that speaks to the main BIM tool, meaning it can import and then analyze data from the 3-D modeler to determine the model’s energy efficiency or daylighting, among other things.

3-D Modelers

Although there are several additional 3-D modelers on the market, these are four of the main players at this time:

Autodesk/Revit

By all accounts this is the most widely used of the BIM tools, primarily since Autodesk’s AutoCAD has for several years now more or less ruled the auto-2-D drawing market and Revit Architecture appears to be a natural extension of that—which it actually is not.

Revit was originally a startup, acquired by Autodesk and introduced as Autodesk Revit in 2002. Revit’s platform is completely separate from AutoCAD, both as to code and file structure.

Bentley Systems

Bentley Architecture, introduced in 2004, was an evolution of its earlier platform, TriForma.

Several other Bentley modules integrate well with Bentley Architecture:

- Bentley Structural.
- Bentley Building Mechanical Systems.
- Bentley Building Electrical Systems.
- Bentley Facilities.
- Bentley Power Civil.
- Bentley Generative Components.

With these modules, Bentley addresses almost all aspects of the AEC industry.

Vico

While Vico is a new company, its BIM engine is based on the almost venerable Graphisoft ArchiCAD. Graphisoft sold ArchiCAD to a German software developer in 2007, while it at the same time spun off the

ArchiCAD-based construction suite to Vico software, a new company focusing on the design and construction industry.

The engine, ArchiCAD, has been a solid modeler since the mid-1980s, and is now a very stable platform.

Other modules in this suite include project management, Estimator, and Project Control, which is a scheduling software.

Tekla

Tekla is a Finnish software house founded in 1966 that specializes in structural steel, steel reinforcing in concrete, and precast concrete modeling. In this area, the software is capable of taking a design all the way from concept, through design and structure analysis, through detailing, all the way into production and assembly. Therefore, you can use the same model created at the outset of the project for prefabrication output.

Viewers/Surface Modelers

A viewer/surface modeler builds its model entirely on surface dimension. A box will have six sides, all of which will be incorporated as adjoining planes, but as far as the software is concerned, the box contains nothing.

Google-SketchUp

Originally, SketchUp was developed by @Last Software, and has, ever since, due to its ease of use and affordability, taken the design community by storm. Google purchased SketchUp a while back, and it appears to be a good match.

NavisWorks

This tool is a viewer of models; that is its mission. NavisWorks has developed links to virtually all BIM modelers on the market, and so can import, say, a plumber’s 3-D model along with an HVAC 3-D model for the purpose of clash detection.

Like SketchUp, NavisWorks will also allow you to rapidly put a surface modeled design together for communication purposes.

Analyzers

Analyzers are those freestanding software programs that specialize in importing BIM data from modelers for purpose of simulations and analysis. There is a wide array of these players in the field, such as these:

Energy+

EnergyPlus is now the primary software tool used for energy performance analysis of commercial buildings by the Department of Energy’s Building Technologies

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Even those trained in CAD today need to step back and realize that this is something new. This is not CAD+, or Son of CAD. BIM is its own approach and its own discipline. Any time spent now to master this approach will be time (and money) well spent.

Program. Developed in 1996 by DOE, EnergyPlus is a new generation building energy-simulation program that builds on the most popular features and capabilities of BLAST and DOE-2.

DAYSIM

DAYSIM is a daylighting analysis software that calculates the annual daylight availability in arbitrary buildings as well as the lighting energy use of automated lighting controls (occupancy sensors, photocells) compared to standard on/off switches. Among the dynamic daylight performance metrics calculated by DAYSIM are daylight autonomy and useful daylight index.

ApacheSIM

This analysis software enables you to assess every aspect of thermal performance, from annual energy consumption and carbon emissions down to individual surface temperatures. ApacheSim is at the core of the IES suite of thermal-analysis products, each of which simulates an aspect of thermal performance: solar shading and penetration (SunCast), HVAC systems and control (ApacheHVAC) and natural ventilation and mixed-mode systems (MacroFlo).

LifeCycle

NREL (National Renewable Energy Laboratory) and its partners created the U.S. Life-Cycle Inventory Database to help life-cycle assessment experts answer their questions about the environmental impact of materials used in building industry and other industries. The database provides a cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material, component or assembly. It's an online storeroom of data collected on commonly used materials, products and processes.³

Obstacles to BIM

If BIM be such an elixir for all construction-industry ills, why hasn't there been a stampede in its direction?

There is movement in its direction, to be sure, but it cannot be deemed a stampede by any stretch.

IT IS BROKE

We cannot—wash in RFIs and change orders, and with substantial contingencies budgeted as a matter of course for any given project—honestly say that the status quo is working smoothly and should be left alone to its own devices.

As Willem Kymmell puts it in "Building Information Modeling," his study of the subject, "Despite many re-

cent developments in project delivery methods, owners are often still dissatisfied with the results of the construction industry; projects still take too long and come in over budget, while the quality frequently is not up to the client's expectations."⁴

That is not a description of "all is well." More likely, it describes a situation that deserves improvement.

TRAINING CURVE

Once a designer or a contractor has bought into the concept of BIM, the next thing to face—and this is more important than the cost of needed software and hardware—is the learning curve.

Even those trained in CAD today need to step back and realize that this is something new. This is not CAD+, or Son of CAD. BIM is its own approach and its own discipline. It warrants and requires serious, and possibly lengthy, study to become proficient in the ins and outs of the tools, but any time spent now to master this approach will be time (and money) well spent.

COST OF SOFTWARE

The final obstacle to face is the actual cost of the software and necessary hardware to run it. BIM tools do not come inexpensively, and it may fall outside the budgetary realities of a smaller firm. Possibly a make-break point as far as implementing some facet of BIM with in-house software and personnel, is 100 or so employees.

Firms smaller than that can still benefit from BIM by participating in team meetings, and possibly outsource any required model construction to BIM consultants.

What Drives the Use of BIM?

THE BOTTOM LINE

The strongest driver of all, and no surprise here, is the notorious bottom line. From an owner's perspective, business as usual, in its design-bid-build mode—with its inherent inefficiencies—is simply becoming too expensive.

BIM saves him money.

FRAGMENTATION

In a typical, traditionally designed and run project, the owner retains an architect who, through conceptual schematic design, design development and contract documents, delivers to the owner an understanding of precisely what he wants the architect to build.

Once they reach an agreement and sign contracts, the architect then normally hires consultants to help

design the structural, HVAC, electrical, fire-rating and plumbing components of the job.

Now, the structural engineer is interested in the integrity of the structure. The HVAC team cares about HVAC; plumbing and electrical, same boat. They each produce a set of designs and plans depicting their own particular universes, which then have to be coordinated to avoid the most obvious conflicts.

Keep in mind that all plans at this point have to be detailed enough to serve as bid documents for sub-contractors; although the architect, perhaps to avoid liability, says conventional wisdom (so the drawings do not come back to bite them)—will insert language to the effect that the architectural drawings cannot be relied upon as to dimensional accuracy.

Still, general contractors will now bid for the job, as drawn. The general contractor in turn will send drawings out to bid by the relevant subcontractors, and based on which subs are chosen—and prices quoted—the general can then submit a final bid to the owner.

Once a general contractor has been awarded the job, but before work can begin, the winning GC may have to redraw some, or all, of the plans to reflect the actual construction process (sequence of events, avoiding conflicting subcontractors crews, etc.), which will produce general arrangement drawings.

At this point, most subcontractors and fabricators—since the dimensions and details of the bid documents, as a rule, are not guaranteed to be accurate—will then produce their own shop drawings, which must reflect accurate details of the work to be performed. These shop drawings are then sent to the architect for approval. Then the architect will typically approve them “as noted” with self-serving stamps attempting to disclaim liability should problems be encountered later.

Any errors in these shop drawings, or in the original drawing on which they are based, will invariably surface as costly conflicts and rework in the field, as when—for example—both plumbing and electrical discover that they, in fact, do not have exclusive rights to a particular duct space, which now has to be redesigned and enlarged, on the fly, to make room for both.

INEFFICIENCIES

U.S. government statistics show that between 1964 and 2000, United States manufacturing productivity doubled, while, over the same time span, the construction industry’s productivity declined by 80 percent.⁵

True, buildings have become much more complex, and rarely are any two construction projects the same or

conducted by the same players, which is hardly ever the case in auto manufacturing, for example. Nonetheless, such a drop in productivity can hardly be seen as encouraging news.

Maged Abdelsayed of Tardif, Murray & Associates, a construction company located in Quebec, Canada, compiled a revealing set of numbers to illustrate just how complex a construction project can get.

For any large-scale projects (\$10 million or above), the following numbers bear out as true (partial list):⁶

- Number of participating companies, including suppliers and sub-subcontractors = 420
- Number of participating individuals = 850
- Number of types of documents generated = 50
- Number of document pages generated = 56,000

Now, if 420 different companies are on the job, and each one is primarily looking out only to protect their own interests, wading through a small ocean of paper to make a profit, is it any wonder that efficiency is not at its peak?

This situation is not lost on owners, as observed by the representative of a large, global hospitality and lodging organization: “The culture in the A/E/C industry has for a long time been fragmented and inefficient. The industry has lacked trust and been short on strategic collaborative thinking.”⁷

WASTE

Waste on a construction site comes in many guises: lost time, for instance, due to conflicting schedules (subs getting in each other’s way—or behind schedule); wasted material (over-ordering to be safe); and lost opportunities (items that could have been prefabricated for easy install now have to be tailored on-site).

In fact, the Construction Industry Institute reports that the construction industry generates more than twice the waste of the manufacturing industry.⁸

An accurate BIM can avoid lost time by catching and displaying scheduling conflicts before you even break ground, making it possible to address and solve these problems before any time is lost. As for material, due to the more exact material estimate provided by BIM, contractors will order what they need for the job, not more than that, and not less. Precision makes for a very lean process.

A correctly designed BIM, down to installation details of HVAC systems and even wall systems, will allow a much larger percentage of material to be prefabricated (pre-cut, pre-bent, etc.) off-site, where these

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processes can be performed more economically, and with greater precision. BIM allows for smoother and faster installation, and with the certainty, through clash detection, that there will be little or no conflict.

This adds up to greatly reduced waste, which, of course, drives straight to the bottom line.

COST

In the traditional process, today's owner is smart if he builds hefty contingencies into his projects, as the above fragmentation and resulting inefficiencies often lead to cost overruns that in turn also lead too often to "value engineering" (meaning, cut everything except the absolute essentials needed to complete the project within the available budget) or, at times, even cancellation of the project.

A survey conducted by Construction Clients Forum 1997: FMI/CMAA 2005, 2006, showed that two-thirds of owners report cost overruns.⁹

The two main factors driving up cost are unreliable estimates, which as a rule lead to expensive change orders in the field, and delays in project completion that expensively postpone deployment of the project. Other factors include redesign of conflicting plans, rework of field mistakes, and cost of litigation due, in essence, to finger-pointing.

A Problem Solved

The paradigm shift required for BIM and its process to succeed is from *fragmentation* to *teamwork*.

A BIM project more often than not involves—from the very beginning of the project—not only the owner and the architect, but also the consulting engineers, such as structural and HVAC, the general contractor, as well as subcontractors. All bring expertise to the table and are afforded input to the project, *while such input still matters*.

DPR Construction, a California-based, nationwide construction company, is aggressively pursuing BIM implementations with their projects and has already seen significant improvements in efficiency, such as their recent Camino Medical Group project, a 250,000 square-foot medical office building.

As a direct result of BIM and the collaboration and coordination inherent in the process, DPR construction achieved these impressive results:¹⁰

- Labor productivity was 15 percent to 30 percent better than industry standards.

- Less than 0.2 percent re-work was required on the HVAC system.
- There were *no change orders* related to field conflict issues.
- There were only two field issues related to RFIs.

There were no conflicts between the systems that were modeled and coordinated using BIM. Normally on comparable projects, an estimated 100 to 200 conflicts must be resolved in the field using traditional methods.

And the key? According to DPR's Atul Khanzode and Dean Reed: "Collaborate, really collaborate. A strong collaborative environment was cultivated on the Camino Medical project. The spirit and enthusiasm to drive true change, shared by all the major players, helped to overcome the lack of experience some parties had in using 3-D modeling tools and Lean construction processes. Co-locating the design and detailing teams in the Big Room, where detailers worked side by side to construct designs virtually and resolved conflicts and issues immediately, further facilitated a highly integrated project delivery. The detailers used shared resources, including a network server, printers and plotters. All construction documents were generated from this one room. Weekly meetings were held to review progress and analyze and correct clashes using the 3-D model."¹¹

GREEN BUILDINGS

Another strong driver for BIM is the current proliferation of green building. Many see BIM and green building as a marriage made in heaven, and they are not so far off.

ENERGY ANALYSES

Given a detailed BIM design model, softwares now exist that analyze correctly not only the energy impact of building orientation (north-south versus east-west, for example), but also can calculate the benefits or drawbacks of various building forms, envelope material, window types, light-fixture arrangements and so on.

An analysis might find that a tall, narrow building will outperform a shorter building with a larger footprint, and that an exterior insulation and finish system envelope will reduce energy consumption by 30 percent compared to other claddings. This allows the owner to, in effect, know—during the design phase—how green his building will be once complete.

These analyses will also help the owner determine the lifetime cost of operating the building, and will clearly show a return on investment and repayment periods, based on various designs and material.

COMMUNICATION

As stated above, we see and think in three dimensions, and one of the great drivers of BIM—especially after a

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team has gone through the entire process once—is the increased understanding that three dimensions brings to the table.

Visualizing the building in 3-D, and from all conceivable angles, removes a good deal of uncertainty. It no longer takes an expert estimator with the knack of creating 3-D buildings in his head based on 2-D drawings, to fully appreciate what he's looking at: The BIM is there, plain as day. Given that all data about the objects comprising the building are true, what you are looking at is a virtual representation of precisely what the team will build.

BIM, as a communication tool, lets the owner appreciate what his money will buy, lets the general contractor see what he will build, and it lets the subcontractor understand exactly how and where he fits in, and very often, precisely when as well.

The communication and understanding facilitated by BIM is possibly not stressed enough in the industry, but it is one of the great strengths of this new technology and process, and may well become its biggest driver.

The Power of BIM

VIRTUAL BUILDING

The key to grasping the inherent power of Building Information Modeling is that during the design phase, the architect (and the owner), along with both engineers and contractors, *actually construct the building*.

This bears repeating: *They actually construct the building.*

With input and expertise from all concerned, the project is built from the ground up in whatever detail is needed for the purpose of the model.

By collaborating at this phase, you can detect and resolve conflicts before ground is broken, or—as one AWCI member so eloquently put it—while you can still use an eraser.

What makes this possible?

Parametric Objects

A Building Information Model is constructed with *Parametric Objects*, which are software counterparts of the actual *things* used to construct the physical building, such as steel beams, concrete slabs and rebar, framing, dry-wall, ceiling grid and tile, ducts, windows and so on.

The parametric object is not only represented in three dimensions, but inherent in the object is all the information concerning it to make it “intelligent.” As an ex-

ample: A wall “knows” that it ends in an adjoining wall. Should the adjoining wall move 3 feet farther out, the initial wall will then automatically adjust its length by adding 3 feet.

Technically, parametric objects, by definition:¹²

- contain geometric information and associated data and rules;
- have non-redundant geometry, which allows for no inconsistencies;
- have parametric rules that automatically modify associated geometries when inserted into a building model or when changes are made to associated objects;
- can be defined at different levels of aggregation;
- have the ability to link to or receive, broadcast, or export sets of attributes such as structural materials, acoustic data, energy data, cost, etc., to other applications and models.

Basically, parametric means that, depending on the detail of the model, the object can be, and usually is, defined by more parameters than just width, depth and height; it also can be defined by weight, density, relation to other parametric objects, cost, manufacturer, delivery time—you name it. You can basically tell all that you know about a parametric object, which information then comes into play when used in a model.

This way, when you are constructing the building virtually, you are building it with fully defined, intelligent objects that know where they belong, how they relate to other objects and what they consist of.

COORDINATED DESIGN MODEL

A strong point of BIM is that if you need to make a change, you only have to make it once, in one place.

In a traditional environment (2-D plans and drawings), the movement of a wall—or a window or duct—may necessitate multiple updates: first in the main drawing, then of all detailed drawings affected by this change, which can sometimes run into dozens. This, of course, leads to the issues of making the change correctly in all drawings, and then ensuring that all who need these updates receive them.

The *one change* made in BIM will alter the location of the wall, and will also—and automatically—adjust all affected objects accordingly. The model is now current and all you need to do is export or print 2-D plans (as needed) from the updated model and distribute to those concerned.

This is further facilitated by the fact that, as a rule, all members of the BIM team can access the BIM

The communication and understanding facilitated by BIM is possibly not stressed enough in the industry, but it is one of the great strengths of this new technology and process, and may well become its biggest driver.

remotely, and so can print the detailed plans as needed just before beginning the work, knowing now that they are dealing with current (and fully coordinated) plans.

2-D Documentation

Although many designers now choose to model their projects in virtual space rather than drafting them in the 2-D plane, the need for 2-D documentation is still with us and will remain for some time, primarily due to regulatory and permitting agencies that will still, and for the foreseeable future, only deal in paper-based (or CAD) 2-D plans and detail.

Also, many subcontractors are not yet equipped to work directly with 3-D models and will need 2-D plans for their portion of the work.

The good BIM-news is that every BIM tool vendor on the market offers the facility to generate 2-D drawings of any area of the model, in whatever detail is required (to the extent supplied in the BIM).

Version Control

A key strength of 2-D documentation generated from a BIM 3-D model is that every team member will receive the *same version of the plans*, which, provided clash detection has been run and all clashes resolved, will give an accurate and conflict-free design you can rely on with confidence.

How often have you built according to your set of plans—which clearly show that you have the “right of way” and show absolutely no intruding electrical or HVAC items—only to discover that the HVAC plans, whether an earlier or later version than yours, install 16-inch ductwork precisely where you had planned to hang the ceiling grid?

BIM can put those days behind us.

Prefabrication

When it comes to cutting construction costs, few things, if any, come close to prefabrication.

For one, an off-site facility is *built* for manufacturing, whereas the on-site “manufacturing” area, by the nature of the beast, is always improvised to a greater or lesser degree. Also, off-site manufacturing is always more economical and will yield a higher-quality product due to closer factory control.

Further, installation of a prefabricated item, made to specs for a given place, will go much faster than building it on site. This will not only cut down the subcontractor’s time spent but also will speed up the entire project.

Also, items fabricated off-site take up no on-site space during manufacture, and so will not obstruct contractors.

Prefabrication, of course, is nothing new; structural steel, precast concrete, exterior panels and curtain walls are often prefabricated and shipped “install ready” to the job site.

It seems that BIM was designed with prefabrication in mind. Whereas prior to BIM, the designer—or more commonly the contractor or subcontractor—would develop detailed 2-D documentation for the off-site manufacturer, who in turn would convert these drawings to CNC (Computer Numerical Control) instructions for the automated machine production of the items in question—such as the dimensions of a steel girder.

If this same girder were designed in BIM in sufficient detail—which normally is the case—the BIM program, instead of generating the 2-D detailed drawing, can instead automatically generate CNC code and transmit this to the relevant prefabricator. Or better still, if the prefabricator already deploys 3-D manufacturing technology, the BIM can utilize Direct Data Exchange (DDE) and send the manufacturer or prefabricator the relevant portion of the BIM, for production.

Prefabrication has already made great inroads with HVAC systems. On the DPR Camino Medical Office Building Project, the HVAC contractor saved 33 percent of field labor hours by creating parametric and fully coordinated 3-D models and using them to prefabricate the medium- and low-pressure ducts.

And so a maxim is emerging: *The more the building can be “built” off site and then “assembled” on-site, the better the savings, both in labor and in material costs.*

Analysis Tools

While BIM tools allow you to create a 3-D model down to fabrication-level detail if you so wish, they generally do not come out of the box with analysis tools to simulate and analyze the building’s performance in various categories and under various conditions. To meet this need, a host of third-party vendors has created analysis tools that interface with and import BIM data from main modeling tools, which will then run requested simulations and analyses based on the imported data.

Tools exist for areas such as these:

- Clash Detection Analysis
- Energy (Performance) Analysis
- Structural Analysis

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- Estimating/Cost Analysis
- Acoustic Analysis
- Lighting Analysis
- Building Form Analysis
- Water Harvesting Analysis
- Renewable Energy Analysis

The common strength of these tools is the ability to run “what if” scenarios to determine the optimum course of action. What if we used 50 percent fewer windows on the eastern face of the building? How would that impact energy use or lighting needs? The BIM designer would reduce the window-count by half and then run the test analysis again. This way the most efficient building, or the building that most closely meets the owner’s needs, can be designed with the certainty that it will perform just so in the real world as well.

Clash Detection

The analysis that may eventually put aspirin and TUMS® out of business is the Clash Detection Analysis.

A *hard clash* is where objects in the design occupy (or try to) the very same space; a soft clash is where objects in the design are placed so close to each other that there is no room for construction or access, or so close that building codes are violated.

Traditionally, in the 2-D drawing environment, clashes are detected by the manual process of overlaying individual system drawings on a light table, and visually “eyeing” the clashes. In a CAD environment, the same principle applies, whereby the designer can synchronize and overlay several CAD drawings and, again visually, identify potential or actual conflicts.

In the not very common BIM scenario where all participating team members are using the same software platform and, in effect, working on one single large BIM 3-D model covering all disciplines, the clash will not be permitted by the BIM tool itself, which will raise appropriate flags if an object’s space is encroached upon by another.

The norm, however, is that different disciplines of the design and construction team will do their work on different software platforms. The structural team may be using Tekla, the architectural model may be built using Revit, the electrical contractor may use Bentley, and the HVAC engineers may deploy Graphisoft. These applications do not speak directly to each other and so cannot alert one another that clashes occur.

In this scenario, there are software solutions like NavisWorks that can import the 3-D models from diverse

platforms and combine them into a single model, primarily for the very purpose of clash detection.

Once the structural, architectural, electrical and HVAC models are combined into one, NavisWorks will highlight hard and soft clashes for team resolution, which means the HVAC engineer may go back and do some re-routing, and then reload the corrected model for another clash detection run.

You repeat this process until NavisWorks gives the green light: no conflicts or clashes, which means that if this version of the designs is the one to be built, there will be no costly and time-consuming conflicts to resolve in the field at time of construction.

It is not surprising that Clash Detection Analysis is one of the most popular BIM applications today, and the one that quickly tends to have a high rate return for the user’s investment.

Constructability

Can you build this thing? That is something the general contractor needs to determine with some certainty.

The BIM 3-D model itself will give the experienced contractor most of the certainty he needs. Additionally, once the model is created in requisite detail, including sequencing for various zones of the project, analyses can be run against the model to validate feasibility and to highlight areas of potential problems.

Structural

Structural engineers need to verify that the columns, beams, slabs, etc., of the building will hold up under expected loads. Most architectural BIM tools do not represent such structural elements in sufficient detail today to afford an actual structural analysis.

To solve this issue software vendors have created modeling tools that provide the structural objects and relationships (connections and connection releases, etc.) called for by the engineers in order to analyze the structure properly under various loads.

These products maybe freestanding applications that mirror, but are not incorporated into, the core BIM software.

Performance

An owner may need to determine, before breaking ground, exactly how his project will perform. He may, for example, need to know the energy consumption of the building, which—especially over the life of the building— translates into cost; or he needs to determine the acoustic or lighting performance of the building in pursuit of a LEED (Leadership in

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Energy and Environmental Design) Green Building certification.

Energy

Once the model is complete, or even during early stages of design, you can link the BIM 3-D model to energy analysis tools to determine energy use in its current iteration.

As the model develops into further detail, several what-if scenarios can be created for the model such as re-orienting the building five degrees in either direction and then re-running the analysis to compare the results.

Other “what if” scenarios may include varying the size of HVAC systems and anticipated heat generation within the building (type of lighting, occupancy rate per room, etc.).

Since energy costs, measured per square foot, contribute to the annual operational cost, investment in energy-saving features such as a using material with a higher R-value may return their investment in five or six years. If the owner plans to retain and operate the building upon completion, he may very well opt for better insulation or operable windows. The available analyses make deciding the best path to follow easy and unequivocal.

Speculative projects built for immediate turnover upon completion rarely focus on energy issues to this degree, unless LEED certification is being pursued as part of a building marketing strategy.

Acoustical

Analysis packages can run reverberation time acoustical analyses for various scenarios, allowing the designer to test for and decide on the appropriately STC (Sound Transmission Class) rated building material, especially in areas where noise pollution may be an issue, or, again, where LEED certification may be sought.

Lighting

Similarly, an analysis package can simulate the lighting levels for a building as designed, taking into account the number of windows or reflective surfaces within the building.

When the designer analyzes lighting, he or she is mostly interested in daylight and in determining how much of it enters the building, and how deep into the building it will provide workable light-levels for employees. Efficient and comfortable lighting is a LEED certification criterion as well, and is mostly addressed when the owners are green-aware. Of course, high-

efficiency fixtures, although more expensive, draw less energy for the same illumination, and may also be evaluated by applications.

Estimating

While you can view estimating as just another analysis tool, this is a subject near and dear to all contractors and subcontractors, and BIM brings good news to this field.

An accurately built model—made in sufficient detail to incorporate individual, suppliable objects—can, as part of the parametric data for each object, include a link to a costing database—whether to a local file, updated as needed or to a supplier’s database for up-to-date pricing at any time.

Given a complete model, it “knows” exactly how many of which items it consists of, and the take-off becomes nothing more than selecting the right menu item and clicking the mouse.

A quantity take-off generated by a computer from a construction model is much more reliable than one generated by traditional methods, which rely on the estimator marking the paper drawing with a felt pen (to indicate items already taken off) or, if using CAD, with textures to show the item has been counted.

When one makes mistakes in traditional quantity take-offs, they are usually in this area: one misses something, or something is taken off twice. The computer, on the other hand, using the 3-D model, does not make such counting errors.

If viewed only as an estimating tool, which is faster: taking-off traditionally from a 2-D drawing, or building a BIM 3-D model from which to run a takeoff? Most likely the former, but don’t forget that estimating is only one of the model’s many uses; it is now available for all other benefits as well.

Automatic quantity takeoff based on the 3-D model does, naturally, not replace estimating as such. What you get from the model is the complete shopping list in accurate quantities and with accurate pricing (though, keep in mind the garbage-in/garbage-out principle). With this in hand, you will still need an experienced estimator to view the 3-D model in some detail—specifically in areas of staging, possible congestion on the site, need for scaffolding or other material that may or may not be modeled in the BIM tool, etc.—who then, based on his own understanding of the project and knowledge about costs, can make a realistic, accurate estimate.

Once the model is complete, or even during early stages of design, you can link the BIM 3-D model to energy analysis tools to determine energy use in its current iteration

Building Element Models (BEM)

To help speed design, many BIM design tools provide pre-defined libraries of both fixed geometry and parametric objects. These are typically generic as to size and function and based on customary construction practices. Objects from such libraries serve their most useful function early in design when the final parameters may not yet be known—to then be refined as the design progresses.

As final dimensions and other parameters become known, the designer can either copy and modify a library object, or design one from scratch.

Building Element Models are BIM representations of physical products such as doors, windows, fixtures and high-level assemblies of walls, roofs, ceilings and floors consisting of a combination of parametric objects and the detail needed for the current project. Some design tools may include BEMs as part of their libraries.

More importantly, however, manufacturers of building materials have begun to recognize the importance of BIM, and some are now listing their product information in an optional BEM format, providing fully parametric objects with geometric connectivity for softwares such as Revit, ADT and to some degree Bentley and ArchiCAD.

As BIM gains industry-wide traction, more and more manufacturers will no doubt BIM-enable their catalogues to interface with all major BIM tools. Down the road, when an open interface standard—most likely IFC (Industry Foundation Classes — *see discussion under “Interoperability” below*) has been agreed to and endorsed by all BIM players, all construction supply manufacturers will most likely display their wares in such format.

The buildingSMART alliance

The buildingSMART alliance was created to spearhead technical, political and financial support for advanced digital technology in the real property industry—from concept, design and construction through operations and management.

The buildingSMART alliance operates within the independent nonprofit National Institute of Building Sciences. This public/private initiative expands on goals of the North American Chapter of the International Alliance for Interoperability, whose Industry Foundation Classes have initiated open standards for national and international links among industry players. It provides developers and users of building

information models the digital tools that are increasingly helping to share highly accurate information throughout a facility’s life cycle.

In contrast with centuries-old ways of documenting facilities with two-dimensional drawings plus specifications—a process recently automated with Computer Aided Design (CAD)—new digital technology brings together owners, operators, designers, constructors, regulators and other stakeholders around a single BIM, a unified tool that offers unprecedented accuracy, speed and economy. The closely related concept of open standards that let all users communicate quickly and efficiently, nationally and internationally, led to the creation of the International Alliance for Interoperability and the coinage “buildingSMART.”¹³

This is the organization that will make interoperability possible. The proposed open standard is called IFC.

INDUSTRY FOUNDATION CLASSES (IFC)

The Industry Foundation Classes were developed to create a large set of consistent data representations of building information for exchange between AEC software applications, such as BIM modeling tools,¹⁴ and were designed to address all building information, over the whole building lifecycle, from feasibility and planning, through design (including analysis and simulation), construction, to occupancy and operation (Khemlani 2004).¹⁵

Industry Foundation Classes, as an effort to accomplish open data-exchange between BIM platforms, is run and coordinated by the buildingSMART alliance, whose vision is the sharing of information between project team members and across the software applications that they commonly use for design, construction, procurement, maintenance and operations.

The buildingSMART alliance sees data interoperability as a key enabler to achieving the goal of true BIM efficiency, and is therefore working on developing a common data schema that makes it possible to hold and exchange relevant data between different software applications. This data schema comprises interdisciplinary building information as used throughout its lifecycle.

The name of this format is Industry Foundation Classes; it is registered by International Organization for Standardization as ISO/PAS 16739 and is currently in the process of becoming an official International Standard ISO/IS 16739.

Software applications store the building information in a native and proprietary format. In order to make this valuable information available to other project

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Spending as much time—within reason, of course—as the architect needs and wants, BIM will enable him or her to play around with various designs, approaches or materials, and actually see (and allowing the owner to see) not only what the design will look like, but also how it will perform as a building.

participants, their software applications either all have to understand the native formats of the other applications, or preferably, they support IFC as the open format for building information models. Industry Foundation Classes can be used to exchange and share BIM data between applications developed by different software vendors without the necessity to support numerous native formats. As it is an open format, it does not belong to a single software vendor and is therefore neutral and independent of a particular vendor's schedule and development direction. One could say that Industry Foundation Classes is *open BIM as opposed to proprietary BIM*.

Software applications correctly implementing IFC are said to be IFC compliant, as they allow one to read and/or write *.ifc files. It is important to understand that every implementation of an IFC exchange should follow a so-called Exchange Requirement. An Exchange Requirement documents which information needs to be present in an exchange/sharing of data at a certain stage in a project. It is not specific enough to ask for an IFC file, which basically can be compared to asking for an Excel spreadsheet without specifying which data you expect to be present in that spreadsheet.

Exchange Requirements are grouped into something called an "IFC View," i.e., a particular subset of IFC dedicated to a set exchange purpose. Most currently available IFC compliant software has implemented the IFC coordination view, but there are other IFC view definitions, e.g. the IFC structural analysis view. Within each of these views, there can be several exchange requirements (i.e., for different domains in coordination view etc.)¹⁶

Architects and Engineers

Designers and their allied engineers are right behind the owners in seeing the advantages and benefits of BIM.

Not only will BIM allow the designers to try, and test, various conceptual design approaches, but once the concept has been settled on—and bought into by the owner—the architect can now construct the building virtually, and in such detail as needed to answer their or the owner's questions in areas of:

- Optimum building orientation
- Optimum building material
- Energy efficiency
- Green requirements
- Construction cost
- Construction schedule

- Operating costs

By providing clear insight into these issues, before ground is broken, BIM affords the design team a high degree of certainty and of "know before you go." And when you minimize later conflicts, you also minimize errors and omissions, and the risk of liability.

DESIGN PROCESS

Architects are artists at heart.

And as artists, they like to conceptualize. They like to assess different aesthetic approaches; or they like to design something with unorthodox materials, perhaps even based on untried-as-yet shapes or layouts (think Sydney Opera House or the Walt Disney Concert Hall in Los Angeles).

The 2-D drawing world does not lend itself to conceptualizing; it soon grows too costly, especially if the design is out of the ordinary, for how best do you communicate it to the potential owners? Often, in order to get the design across, the architect will then resort to actual three-dimensional mock-ups of the project—expensive at best, cost-prohibitive at worst.

And how many concepts would the architect like to try? How many 3-D mock-ups can the firm, or the owner, afford?

At the conceptual stage, the architect should have the freest reins possible, those with the fewest cost- and time-constraints. And this is what the BIM not only promises but delivers to the designer.

Spending as much time—within reason, of course—as the architect needs and wants, BIM will enable him or her to play around with various designs, approaches or materials, and actually see (and allowing the owner to see) not only what the design will look like, but also how it will perform as a building.

Basically, at this stage, BIM gives the architect much sought after (and dreamed of) freedom to create.

Team Design

Once the building concept has been agreed upon by designer and owner, the wise architect now invites as many of the players as he or she can contractually involve; at minimum the consulting engineers, the general contractor, specialty contractors (HVAC, plumbing) and as many other subcontractors as possible.

With the conceptual questions settled, this team will then knuckle down to build the actual—buildable—structure in virtual 3-D space.

Make no mistake, the architect does take the lead in this, but he or she will work very closely with the engineers (civil, structural, etc.) who will not only have input to give in the overall design but will also extract applicable portions of the design (such as structure) for detailed analyses in their own systems.

The architect, at the team design phase, is also wise to welcome points and suggestions provided by both the general contractor (who *knows* what it takes to build the thing) and the subcontractors present, who will also speak from a very practical angle when they suggest that what the architect just proposed might in fact not work or will generate conflicts farther down the line.

Big Room

The process should take place in an i-Room (information room) or *Big Room* (another word for the same thing)—a room large enough to house the entire team and all the necessary computers and display screens for everyone to follow the process in detail.

This is stressed repeatedly in BIM reviews and literature: Get the team together in one spot. The design is, in essence, a collaborative team design under the conductorship of the architect.

What Ifs—Analyses

In team mode, or perhaps in separate sessions, you can pose many “what-ifs.”

In the traditional 2-D environment, “what-ifs” usually lead to conjecture rather than answers, and conjecture may be a very flimsy foundation upon which to erect a twelve-story hospital. BIM affords you the opportunity not only to ask “What if we did so and so?,” but also the power to answer such questions.

Usually, “what if” questions centers on efficiency. *Would cooling costs be reduced if we used operable windows? Or By how much would ICF reduce the heating bill?; and What would be the payback period of using ICF rather than traditional cladding?* Here is where BIM excels.

Given a design, the architect can run—or have an energy consultant run—an initial energy analysis as a benchmark. The architect can then substitute the conventional cladding with ICF (and its higher R-value) and then re-run the energy analysis. Based on the result, he or she can then calculate HVAC cost savings (both by needing a lesser capacity system and in lowered electrical costs) and so determine the ROI of the added ICF cost.

By similar “what ifs” and analyses, the design team

can also calculate various environmental impacts of design choices, and so arrive at the optimum building, one that meets the owner’s needs in the most energy-efficient and environment-friendly way possible.

Level of Detail

A reminder here about garbage in/garbage out, or, in this case, accurate level of detail.

To simulate and analyze the impact of, say, masonry versus EIFS, the BIM 3-D model has to know the R-value and other relevant properties of each. It is therefore incumbent upon the designer to create the model in sufficient detail to facilitate such analyses.

The only way to determine the level of detail needed in a model is to specify its use. For what purpose are you creating the model?

If it is purely conceptual/aesthetic, the model needs to know nothing of R-values or acoustics, but it must show the physical components of the building in 3-D and visually (and more for communication purposes than anything else). But there ends the need for detail.

At the other end of the scale of detail—if the BIM 3-D model will be used for application-to-application transmission of manufacturing-specific data (as for prefabrication)—the data in the model have to be very precise and in such detail that the machinery that will manufacture the items can act on the information received from the BIM 3-D model and build it with precision (this is known as DDE, or Direct Digital Exchange of CNC, or Computer Numerical Control, and requires BIM data at least as precise as a high quality shop drawing).

General Contractors

Entering the nuts and bolts world, the general contractor is, as a rule, third man in.

And this is where the RFIs and change orders normally occur. With BIM, you can avoid those problems up front, while an eraser can still be of use. For it is the contractor who, with a critical and experienced eye, looks at the model and points and says, “There, right there. Won’t work. You’ll have a crane there while pouring the slab.” And the designer will look at him, and the engineers will look at him and then at the model and suddenly nod, and any subcontractor present will nod, too, and then the designer, finally, as well; and so, then and there, they can arrive at a working alternative and incorporate that into the design.

BIM affords you the opportunity not only to ask “What if we did so and so?,” but also the power to answer such questions.

Subcontractors

Although the subcontractor, by contractual necessity, is usually the last man to the BIM table, and sometimes doesn't even make it there, BIM provides him or her many, and quite specific, advantages.

PREFABRICATION

Subcontractors such as HVAC and plumbing—which as a rule have off-site “shops” of varying degrees of sophistication—quickly see the benefit of BIM and the shop drawing/prefabrication detail model, which in essence can communicate via DDE and deliver CNC data to the shop manufacturing machines, which in turn can produce the assemblies necessary for the job.

More and more design teams now include HVAC and plumbing contractors for that very reason.

CLASH DETECTION

Another factor that has called HVAC and plumbing to the BIM table is that they are the trades that most commonly “clash” in the field, both fighting for scarce and prime real estate between slab and suspended ceiling—the HVAC intake duct insisting on occupying the same space as the plumber's major waste line—and so easily see the great benefit of the clash detection, and resolution, provided by BIM.

It is also important to remember that it is only with the confidence that there will be no clashes on site, once assembly begins, that the HVAC and plumbing contractor can prefabricate many of his assemblies off site.

Ideally, the main design model will also include all HVAC and plumbing details, but what normally happens is that the HVAC and plumbing contractors design their systems using their own software, and then feed the results to a surface modeler such as NavisWorks, which is well set up to run clash detection analyses.

TAKE-OFF AND ESTIMATING

Same as for the general contractor, the subcontractor will benefit greatly from accurate take-off quantities and a good construction-sequencing view to determine how crowded the site will be when they arrive. Armed with this information, the experienced estimator will, and does, work up an accurate quote without having to look around corners and second-guess the architect as to what he or she really intended.

Wall and Ceiling Contractors

So far, the wall and ceiling contractor has not been a frequent guest at the BIM table. This is not to say that he should not be there.

For one, any work done for the Government Services Administration will require a BIM 3-D model for their space and facility management, and so is a requisite for any contractor bidding GSA work.

For another, although the benefits may not be as apparent as with HVAC and plumbing (Clash Detection and Prefabrication), there are still benefits to be derived from early wall and ceiling contractor involvement in the process, and their deployment of BIM technology.

TAKE-OFF AND ESTIMATING

As with other subcontractors, an accurately detailed BIM 3-D model will give you not only the location and interrelation of each wall-and-ceiling item, but also the “recipe” of what exactly comprises each component for an accurate take-off quantity.

Given this a clear view of the construction sequencing, the BIM 3-D model will then afford the estimator a firm basis for a good bid.

Pat Arrington of Commercial Enterprises, Inc. in New Mexico is investigating BIM primarily from that angle: “Using BIM, if the process is followed, there is going to be very little chance of not having the right components covered in your estimates.

“I think that the virtual graphics of BIM will allow perhaps even a neophyte, or at least a less experienced person, to understand the complexity of a job and to put all requisite components together.

“Years back, we were only covering up framing. Today we have firewalls, sound walls, smoke walls and positive-pressure walls to seal and keep out contaminants from another source—even negative pressure walls, things we did not have before. Our trade has become a lot more complicated. If you throw LEED and green building into the mix as well, you will almost need BIM to visualize the project and make sure all the pieces are included.”

As an aside Arrington adds, “We also have millions of dollars in negotiated work with the GSA, which requires BIM as part of the contract to aid facility management. I believe that the big school districts are now also beginning to ask for BIM for the same reason.”

Although the subcontractor, by contractual necessity, is usually the last man to the BIM table, and sometimes doesn't even make it there, BIM provides him or her many, and quite specific, advantages.

CLASH DETECTION

BIM's ability to detect hard clashes (two objects occupying the same space) and soft clashes (two object impractically close to each other, perhaps also in violation of code) in the model lets the contractor trust the plans and affords him the luxury of going ahead without fear of having to re-do work.

Bruce Miller, owner of Denver Drywall Company in Colorado, has been around that block a few times: "It often happens that the plans you're looking at allow you to frame the ceiling, only to then find out that on another set of plans, right in the middle of that same ceiling there is a can-light; and low and behold, in exactly the same place, on a third set of plans, there is also a sprinkler head.

"That's where I see us benefiting from BIM: We will be able to trust the design to the point where we no longer have to include the re-work margin in our bids."

Steve Spence of DPR Construction, Inc., a general contractor and construction manager with 10 offices across the United States, is a superintendent with 15 years of drywall contracting experience and an early implementer of BIM. Spence agrees with Miller: "Knowing that the HVAC duct is not going to run through your firewall is a great benefit to the wall and ceiling contractor. He can proceed with confidence."

VISUALIZATION/COMMUNICATION

BIM's inherent 3-D rendering of the project, and in detail, promotes communication and understanding of what the project is all about. And the more complex or sophisticated the work is that the wall and ceiling contractor is to perform, the more important grows this feature.

Miller says, "I believe that the sophistication of the drywall company is going to determine the degree to which they'll benefit from BIM.

"We make a lot of panels, floor panels, wall panels—some structural, some space dividers—and roof trusses, and here is where I believe BIM is going to help us, because we will be able to see the building clearly and precisely, where and how the panels and trusses are to be installed."

PREFABRICATION

At this point the only area of prefabrication that appears practicable for the wall and ceiling contractor lies in the area of exterior panels, which can be sized in BIM and then custom-ordered via DDE and CNC from the provider.

Arrington has worked with prefabricated exterior

wall panels in the past and reports that it works fine, though he still prefers the leeway of un-cut panels for trickier installations.

He does not, however, see a benefit in pre-cut ceiling tiles or pre-cut [wallboard]: "You'll spend more time hunting and pecking for the different pieces than it takes to cut them as you go.

"Also, with [wallboard] it would be impracticable for the manufacturer to attempt to pre-cut; it would not be cost effective. And again, finding the right pieces for the right spots would take longer than simply cutting them on site."

Spence agrees: "I don't see a benefit in pre-cut tiles or [wallboard]. That is better handled on site. But we are looking at ordering pre-cut studs. Once we have determined the tolerances in the concrete and in the decks, we can order a pre-cut length of stud that will meet them, and this can result in huge labor and material savings."

SCHEDULING

Although Lee Zaretsky of Ronsco, Inc. in New York is not pursuing BIM at the moment, he knows it will soon be relevant even for the mid-size interior wall and ceiling contractor, especially in the area of scheduling. He sees the 4-D (3-D plus the time element) capability of BIM as a great benefit.

SOUND AND LIGHT ANALYSIS

According to Gail H. Johnson of Acousti Engineering in Florida, his company is not actively pursuing BIM at this time either, but again, he sees the benefits of it, especially in the area of acoustical analysis.

"Every space," Johnson points out, "has to take into consideration reverberation and acoustics, and in order to accurately evaluate that, you need to know precisely what the walls are made of, what the ceiling is made of, what the floors are made of, what surface material and type of finish you are using.

"With the BIM 3-D model built to this level of detail, you will be able to evaluate this information. Also, your surface material will affect illumination, and so, again, you need a full set of data in the model for a good analysis."

CONSTRUCTABILITY

Can the wall be built as intended? Is it too close to the beam? Will it be to code? These are questions best asked at the BIM design table, not in the field.

Spence sees constructability as a key issue for the wall and ceiling contractor: "Our drywall guys are actually

“

That's where I see us benefiting from BIM: We will be able to trust the design to the point where we no longer have to include the re-work margin in our bids.

”

working with the BIM guys right now, catching things like this, and it is working very well.

“They are sorting out the chicken-or-egg issues of which goes in first, the duct or the firewall, and these are good things to have resolved before you arrive on site.”

INFORMATION

Another perhaps not-so-apparent benefit of BIM to the wall and ceiling contractor is the greater understanding of the project as a whole that he or she will gain by having access to all the information about the project.



As a superintendent on a non-BIM job, I receive questions about drywall four or five times a day and requests for more specific information about precisely where and how. These can all be answered by access to the BIM 3-D model that will show all the rough openings, all the outlets, all those things that are typically missing from a set of drawings.



“As a superintendent on a non-BIM job,” Spence says, “I receive questions about drywall four or five times a day and requests for more specific information about precisely where and how. These can all be answered by access to the BIM 3-D model that will show all the rough openings, all the outlets, all those things that are typically missing from a set of drawings.”

“Easy access to information, for me, is huge. If all these things are figured out ahead of time, one will save a lot of time in the field.”

PROJECT MANAGEMENT

One bonus feature that a BIM 3-D model can provide the wall and ceiling contractor is an accurate measure of productivity.

Says Spence: “The model will allow you to track things. You can get your entire material list from the model, even by area if you like, and then you can use the model to track your progress as the drywall goes up.”

“To me, that is another huge plus, because this has always been a tough thing to manage as a drywall contractor: Where, exactly, do we stand?”

“The only thing I see that stands between the drywall contractor and the benefits of BIM and its process is a reluctance to change. Once we surmount that, we’ll see for ourselves that BIM makes a lot of sense.”

BIM PROJECT INVITATIONS

As BIM gains more and more traction, general contractors will increasingly look for BIM-enabled subcontractors.

Therefore, as a first step, the wall and ceiling contractor should learn all that he or she can about the technology—and the process—and decide how his or her company fits into the BIM picture.

Once he or she has become familiar with BIM and now can work within a BIM-framework, the next crucial step is to make this ability—this additional service—known far and wide. Advertise it, print it on your business cards, and ensure all your GCs know that you are BIM-enabled.

It will open doors.

Facility Managers

One of the boons of the detailed BIM 3-D model is that at the end of the job, if constructed as per the model, which is often verified during construction by laser scans, you now have an accurate *as-built* model that will include most, if not all, of the data a facility manager needs to take over and operate the building, including energy and other performance data.

This is one of the main reasons that the GSA today will not award a non-BIM contract; they require a full BIM as-built model at the end of the job for their facility management.

Some see this as a gentle way for the government to ease the construction industry into the use of BIM, focusing on an easy-to-implement aspect of the technology, and that is probably not so far off the mark.

Risks: Legal & Contracts

THE THORNY PART

So far everything looks good. You are developing BIMs. Teams are eager to apply the Three Cs—to communicate, collaborate and coordinate—and to get the proverbial show on the road.

But not so fast. Your lawyer just called. There is some contract language to consider.

RISKS IN THE ADOPTION AND USE OF BIM

The risks involved in adopting building information modeling come under two major headings: There are risks associated with the behaviors of the parties involved in a BIM project and with the technology itself.

You can alleviate or clarify the majority of both types of risks by good contractual language at the outset of the project. Such language is, in fact, critical to the success of a BIM project, as is the adoption of behaviors that support BIM and encourage a truly project-centric approach.

These soft risks are often the most difficult to spot

and are virtually impossible to quantify. They are, however, critical aspects of the implementation of BIM on a project.

Behavioral Risks

Among the behavioral risks of BIM, the assumption that all the parties will engage in collaborative behavior is central to the process; in fact, as discussed above, BIM requires collaborative use in order to achieve and maintain any level of efficiency at all. This means that the parties to a BIM process should move from traditional risk avoidance and transfer philosophies to one of risk acceptance and of true risk management. Those parties who do not make that transition effectively will impact not only their own performance but also the performance of all the other parties connected with a BIM project.

Technology Related Risks

Within the technology-related risks, three general areas of issues predominate:

- First and foremost, the question of reliance must be properly addressed. In other words, to what extent are the parties involved able to rely on the accuracy and currency of the model? If the model is merely illustrative of design intent or used solely as a marketing tool with no design accuracy, then it is essentially useless for construction purposes, and the project is, for all practical purposes, a simple 2-D (traditional) project from the contractor's perspective.
- Second, the question of maintenance is also critical. The project contract documents must clearly state who is responsible for what provisions of administering, updating, maintaining, distributing and archiving the model. A model that is accurate for only a few days or weeks becomes increasingly useless (if not outright dangerous) unless it is updated and maintained properly during the construction process.
- Third, the matter of ownership must be settled. Simply put, if the model is collaboratively built, who owns it? Was it the intention of the parties to sell and surrender their proprietary information to the ultimate owner of the model? Were they compensated adequately for that? If not, what exactly is the ownership of the model, and to what extent can the participants use the same information in subsequent jobs?

Definitions

In this discussion of risk, these definitions apply:

2-D. Traditional flat paper designs and plans (even those using Mylar overlays).

3-D. Virtual visualizations of the building using computer modeling software. While physical models and mock-ups are technically 3-D artifacts, they are not included within that definition for the purposes of this discussion. In general usage, the term 3-D has come to mean computerized modeling as opposed to physical models.

4-D. A 3-D model that also includes a time element drawn from (or, ideally, incorporating) the construction schedule. Allows a time-related step-through of the construction process, and provides access to critical sequencing information. There is, also, the concept of 5-D, which is a 4-D model that incorporates material quantities (and, potentially, labor and costs as well).

"BIM" – Building Information Modeling. A computer aided or generated 3-dimensional virtual model of the building/installation.

Collision or Conflict Detection. The ability of a model to detect, flag and display any conflicts in the construction drawings (or, with 4-D models, in the construction sequencing).

Model. The output of a BIM process, the deliverable derived from BIM software (as distinct from and not including physical models or mock-ups).

BIM-LEGAL IMPACT

While BIM affects a wide variety of processes, it does not directly impact all aspects of construction. Activities such as contract negotiations, the submittal process and most portions of the RFI process are largely intact in a BIM construction project, and while the items under discussion in those areas may change, the discussions themselves will be largely recognizable to practitioners of traditional non-BIM construction.

BIM, however, will alter the methods, if not the substance, of many other construction activities. In particular, the architect's communication of design intent is substantively changed when BIM is used, as are the plans, designs and specifications for the project. Parties working collaboratively may owe legal duties to each other even without express written contracts with each other.

Once you apply BIM as a tool, you also dramatically alter trade coordination and sequencing. The ultimate goal, obviously, is to improve those processes and to increase both the efficiency and the effectiveness of them.

A great many activities peripheral to construction

BIM requires collaborative use in order to achieve and maintain any level of efficiency at all. This means that the parties to a BIM process should move from traditional risk avoidance and transfer philosophies to one of risk acceptance and of true risk management.

Once you have addressed the aspects BIM use, you must also consider the issues of ownership and reliance, for these, too, are critical matters, and should be clearly and directly addressed in the contract documents.

are also impacted by BIM, in particular the area of construction insurance. Unanswered to date is the question of whether participation by a contractor in a BIM construction project is a “professional” activity or service. And, if so, would an error in the BIM activities of a contractor be covered under their Commercial General Liability (CGL) policy? Or, if not, would it be better to seek to modify the exclusions that apply in the CGL, or would you more properly cover this under an Errors & Omissions (E&O) or a contingent design liability policy?

Similarly, how would the contractor’s or subcontractor’s contribution to the BIM differ from the contractor’s or subcontractor’s shop drawing or field installation drawing? How would it fundamentally differ from a materials submittal? Has the contractor or subcontractor assumed the risk of the design?

RISK AND RELIANCE

The issues surrounding BIM are mostly concerned with one or both of these two issues. The first of these concerns proper risk allocation for the BIM activities; the second concerns reliance on the model.

The wall and ceiling contractor will need to clearly address and resolve both of these areas in the contract documents.

Risk Allocation

As to the first issue, a number of factors will influence the outcome of the risk allocation discussion. You can simply and directly address most, if not all, of these issues in the contract. A few, such as those listed below, are not contractual issues per se, but will still have an impact on risk allocation and should be carefully considered:

- BIM assumes collaborative behavior; efficient use of BIM requires such behavior.
- Is the owner willing to allow BIM to “scramble the risk allocation egg” and blur the traditional discussions of liability for design and for construction means and methods?
- Why is BIM being applied to this project?
 - Is this truly a construction tool or is it primarily a marketing issue? Does the owner truly understand the up-front costs of BIM, and that the potential savings are downstream?
- Will this be a conversion from 2-D to BIM, or was it developed in either 3-D or 4-D initially?
- Do the BIM activities trigger questions about “professional services?”
 - What about any needed value engineering and/or constructability review?
 - What is the process for revision or modifications of the construction documents (with or

without design firm review and approval)?

- Is the entire project BIM or only portions of it (i.e., structural, mechanical, etc.)

- Which contractors will be involved with the BIM?
 - Some partial uses of BIM include the following:
 - Project visualization, walk-through and fly-through capability, virtual modeling and sight line studies, etc.
 - Scope clarification, partial trade coordination, collision detection/avoidance, construction sequencing/planning/phasing
 - Value engineering analysis, design validation, option analysis and selection and engineering analysis
 - Marketing presentations

You should consider all of these issues, and, if needed, clearly incorporate them into the contract documents.

Ownership and Reliance

Once you have addressed the aspects BIM use, you must also consider the issues of ownership and reliance, for these, too, are critical matters, and should be clearly and directly addressed in the contract documents.

Ownership. Ownership issues to consider include the following:

- Who will own the model?
 - How is the cost of the model being spread, shared or allocated?
 - Who has the right to use the model?
 - What are the approved purposes for which the model may be used?
 - Who is the “designer,” and who is the “host” organization (if different)?
 - What parts of BIM constitute or are incorporated into the “design?”
 - What standard of care applies to the creation and updating of the model?
 - Is privity of contract (or lack thereof) a problem?
 - Who owns the copyright to which part of the design and the database?
 - Who controls the process of creating and updating the model?

Reliance. As noted above, the second issue deals with the matter of reliance. Some of the questions to consider are these:

- How will BIM be used on the project, and by whom?

- Who will be responsible for BIM errors?
- Is there any “limitation of liability” in the contract?
- When is the design in its final form at various stages?
- How should the parties deal with “evolving technologies” or large changes in the software or capabilities affecting the model?
- How will the parties resolve conflicts between different models?
- Does the contract contain a waiver of consequential damages arising from use of the BIM process?
- Who is/will be responsible or liable for translation errors between differing BIM platforms?
- Are non-BIM contractors or suppliers third-party beneficiaries of the BIM process or its outputs? If so, to what extent?

Recommendations. Incorporating the relevant items below into the contract documents or other relevant enforceable provisions of the project should help to clarify the above issues and assist in smoothing out the use of BIM on a job.

Wherever possible, the terms and conditions incorporating these issues should be fairly and openly negotiated among the stakeholders:

- Define the model as a contract document, and make it a contract deliverable.
- Appropriately compensate the model creators for preparing and sharing the model.
- Provide that parties sharing the model are not responsible for changes or additions made by downstream users.
- Establish a process to preserve read-only copies of the model, especially when it is to be shared among multiple users.
- Determine what level of detail will be included in the model.
- Define which party has the responsibility for clarifying and interpreting each aspect of the model.
- Determine who is responsible for errors in the model at each phase of its creation and of its use.
- Determine who has version control and who is responsible for archiving the model, and who has control over changes to the model.
- Define clearly the extent to which the contractors or subcontractors should rely on the model as a valid design communication.
- Establish clearly who has rights as a third party beneficiary of the BIM process.
- Establish clear terms dealing with consequential damages (if any) or with liquidated damages arising from BIM use.
- Develop an access protocol that allows free and easy access to the model but that does not supersede

ownership rights.

- Choose whether to require a single software platform for use of the model, or whether to allow stakeholders to use the model on differing platforms.
- Identify who is “responsible for administering the model and providing the technical resources to enable connectivity, host the files, manage access and assure security.
 - Determine who pays for the software required if a change is needed (both initially and subsequently).
 - How will different BIM tools talk with each other?
 - Determine who pays for translation if multiple software platforms will be used.
 - Determine who is responsible for network security at the host and at the user level.
 - Determine whether transfers of data will occur via a network or by physical media transfers (“sneaker-net”).
 - Determine who is responsible for prevention of information theft, and what protocols will be used to secure the information.
 - Determine whether to use a third-party host for the model, or whether using the network of a stakeholder is preferable.
 - Make electronic “snapshots” of the model at key milestones, and preserve the electronic information at each major milestone event.
- Identify who is responsible for deciding what information is permitted into the model, and pre-determine a mechanism clarifying how conflicting information will be reconciled.
- Determine whether the project will maintain printed design documents as the official contract documents for archival purposes and regulatory review.

Regardless of the above, some of the risk allocation principles that apply to traditional 2-D design and construction will still apply under a BIM project. For example, the architect and engineer remain responsible for project design. A contractor’s involvement in, and corresponding liability for, design should not extend beyond those that are customarily associated with a collaborative construction project.

In addition, it is critical that the difference between BIM and Integrated Project Delivery (IPD) be fully disclosed and recognized. IPD is a method of project delivery that may or may not include BIM, and BIM can certainly function well without an IPD approach. Together they can form a powerful mechanism, either for successful project delivery or for abject failure. The successes or failures of these tools will depend to large extent on whether the contract documents clearly define what the contract deliverables are and

It is critical that the difference between BIM and Integrated Project Delivery (IPD) be fully disclosed and recognized. IPD is a method of project delivery that may or may not include BIM, and BIM can certainly function well without an IPD approach. Together they can form a powerful mechanism, either for successful project delivery or for abject failure.

There is no pragmatic difference between relying on an outdated set of plans and an outdated BIM model. The inherent assumption that BIM will somehow pierce through this matter is simply wrong.

how well they succeed in determining accountability and scheduling for those items.

Finally, it is important to note that BIM is not a panacea for the ills of traditional construction methods and “normal” project delivery. BIM can be as flawed and dangerous a process as any flawed 2-D project. There is no pragmatic difference between relying on an outdated set of plans and an outdated BIM model. The inherent assumption that BIM will somehow pierce through this matter is simply wrong. BIM, in fact, may require even a higher diligence due to its very complexity and power. Addressing the issues presented above, preferably in the contract documents, will do much to mitigate these potential problems and help ensure a smoother and more profitable project.

CURRENT FRAMEWORK/BIM PERSPECTIVE

Nowadays it seems construction and litigation have become synonymous. Today’s projects are large and often complex, and the opportunities for miscommunications and disagreements stemming from errors and omissions during the design phase of the project abound. Some prudent designers and contractors factor in a percentage for legal costs in their bids, which tells a sad tale.

This also indicates that in the current legal and contract environment, communication suffers, for litigation happens when there is not enough communication and collaboration among the project team members.¹⁷

Today there is normally one contract between the owner and the architect for the project design and subsequent provision of construction documents; in other words, 2-D drawings for the general contractor to take off and bid, and a separate contract between the owner and the contractor who is to build the job based on the architectural drawings.

Often as not, the first time the contractor hears about the project is when he bids it; he rarely has any input in the design. Likewise, the first time the subcontractor hears about the project is when he bids it, and he has less rarely had any design input.

William A. Lichtig, a California attorney specializing in construction contracts, offers this sobering view:

“Over the past 100 years, the design and construction industry has become increasingly fragmented. Each specialized participant now tends to work in an isolated silo, with no real integration of the participants’ collective wisdom. As construction practitioners, we are familiar with the most common industry responses during the past 30 years. Post-design constructability

reviews and value engineering exercises, together with ‘partnering’ and contractual efforts to shift risk, have been the most prevalent. However, these ‘solutions’ do not attack the problem at its root cause; rather than working to avoid the problem, providing higher value and less waste, these attempts merely try to mitigate the negative impact of the problems.”¹⁸

Liabilities

In this environment, it is normally the designer’s or architect’s responsibility to generate construction documents and specifications of sufficient detail to facilitate construction bids. But due to potential liability, the architect may choose to include fewer details in the drawings—shifting the burden to the contractor, who now must verify and certify that details and dimensions are true and correct—or he may choose to insert language to the effect that the drawings cannot be relied upon for dimensional accuracy.¹⁹

The subcontractor, in turn, is called to provide detailed shop drawings of precisely what work he will perform, thus assuming responsibility—and, of course, liability—for their correctness as to dimension and placement, and so getting both the general contractor and the architect “off the hook.”

It is a game of avoiding liability, and liability—like many other things—tends to roll downhill.

BIM Perspective. Refreshingly, in Australia and some European countries, the construction industry is using contracts between the project team members that disallow litigation except in cases involving criminal or other extreme actions.²⁰

And here it bears repeating: Litigation happens when there is not enough communication and collaboration among the project team members.²¹

Trust. BIM will only succeed to the degree that communication, collaboration and coordination are promoted and practiced, with a healthy helping of a fourth factor: trust.

The BIM team must be based on mutual trust, and the contracts between them need to assign shared liability equitably among them—more as a precaution than as teeth—because most issues that lead to legal action in today’s world can be resolved by communication, either during the design phase or on site.

Risks

As mentioned, the main risk-holder, by the nature of the beast, is always the owner. He stands to gain the most but also to lose the most if things go wrong.

To guard against potential losses, his contract with both the architect and contractor will contain language that limits risk by assigning liability to the architect and contractor. Any contract drafted by the owner's attorney will naturally do its utmost to reflect the interests of the owner and will only concern itself with the interests of other participants if forced to do so.

The same holds true for the general contractor vis-à-vis the subcontractor.

BIM Perspective. The ideal legal framework for the BIM project should distribute the risk equally among the members of the team best able to manage that risk, including, of course, the owner.

Rewards

Today, the financial rewards for a successful project invariably line the pocket of the main risk-taker: again, the owner.

You will sometimes find an incentive clause for the general contractor to reward him if the job is brought in on time and under budget, balanced by a liquidated damages clause should he not. Subcontractors, however, rarely see financial benefits beyond contractual compensation for a well done job brought in on schedule.

BIM Perspective. In the ideal legal framework for BIM, "It would be wise for the industry to develop a contracting method whereby all participants on the project team would share the benefits from the improvements resulting from the BIM management techniques, thus placing the contract in the position to provide the incentive for collaboration and risk reduction."²²

If the team shares the risk, it would simply stand to reason that all members of the team would also share the rewards.

Intellectual Property Rights

When it comes to the collaborative world of BIM, current legal views highlight the need to protect the intellectual property offered by each member of the team as they share expertise—which some may deem trade secrets.

BIM Perspective. It is only right that hard-earned experience and industry-knowledge should be viewed as an asset—it is definitely of value to the team. As such, shared expertise should be legally protected as the intellectual property of the person sharing, for the rest of the team to use on a non-exclusive basis, and only for the duration of a particular project.

SUGGESTED BIM CONTRACT LANGUAGE

As BIM proliferates in the construction industry, lawyers have begun to sharpen their pencils, and new contracts, or contract-addenda, have begun to appear to address the legal issues pertaining to BIM.

The Army Corps of Engineers has suggested BIM contract language for use in its many projects,²³ as has the American Institute of Architects (AIA) with its proposed E202 BIM Protocol.

The AIA protocol says, "Written by practitioners from across the industry, E202–2008 is easy to read and delivers what the industry needs: a practical tool for using BIM across the project.

"E202–2008 is a hands-on working tool for all project participants that tackles head-on the following questions:

- Who is responsible for each element of the model and to what level of development?
- What are authorized uses for the model?
- To what extent can users rely on the model?
- Who will manage the model?
- Who owns the model?"²⁴

CONSENSUSDOCS 301 - BIM ADDENDUM

ConsensusDOCS,²⁵ viewed as a good source for construction contract language, also recently announced a proposed BIM addendum, which, with ample input from the construction industry appears well thought-out and to cover most of the questions listed above as well as other legal issues arising with the BIM process.

This document consists of six main sections: General Principles, Definitions, Information Management, BIM Execution Plan, Risk Allocation and Intellectual Property Rights in Models.

General Principles

Among other things, the first section of the addendum clarifies that the addendum does not alter the existing contractual relationship between the parties, nor does it shift risk other than as specified by the addendum itself and its attachments. Also, while a contractor may contribute information to the BIM 3-D model, this shall not be viewed as a design service; the owner and architect are still held responsible for the "buildability" of the design.

This section also states that the addendum requires a "flow-down" provision, meaning that the addendum shall apply to any downstream subcontractors or subconsultants as well.

When it comes to the collaborative world of BIM, current legal views highlight the need to protect the intellectual property offered by each member of the team as they share expertise—which some may deem trade secrets.

Finally, this section also states: “In the event of an inconsistency between this Addendum and the Governing Contract, this Addendum shall take precedence.”²⁶

Definitions

This section clarifies all terms necessary to make the addendum legally viable. It approaches (by definition) the various complexities of the BIM 3-D model as follows:

Model. 2.14 Model means a three-dimensional representation in electronic format of building elements representing solid objects with true-to-scale spatial relationships and dimensions. A Model may include additional information or data.²⁷

Design Model. 2.6 Design Model means a Model of those aspects of the project that (a) are to be modeled as specified in the BIM Execution Plan prepared pursuant to this addendum and (b) have reached the stage of completion that would customarily be expressed by an architect/engineer in two-dimensional construction documents. This shall not include Models such as analytical evaluations, preliminary designs, studies or renderings. A Model prepared by an architect/engineer that has not reached the stage of completion specified in this definition is referred to as a Model.²⁸

Construction Model. 2.2 Construction Model means a Model that (a) consists of those aspects of the Project that are to be modeled as specified in the BIM Execution Plan prepared pursuant to this addendum; (b) utilizes data imported from a Design Model or, if none, from a designer’s construction documents; and (c) contains the equivalent of shop drawings and other information useful for construction.²⁹

This definition prescribes shop-drawing precision for the Construction Model, which—by general BIM expert opinion—is normally viewed as one step less detailed than shop drawings.

Federated Model. 2.8 Federated Model means a Model consisting of linked but distinct component Models, drawings derived from the Models, texts and other data sources that do not lose their identity or integrity by being so linked, so that a change to one component Model in a Federated Model does not create a change in another component Model in that Federated Model.³⁰

The *Federated Model* applies when various team members, either by necessity or choice, deploy separate BIM platforms to perform their work, resulting in separate models that can then be linked or incorpo-

rated into one overall model, which the BIM addendum refers to as:

Full Design Model. 2.9 Full Design Model means a Model consisting of coordinated structural, architectural, MEP and other Design Models designated in the BIM Execution Plan to be produced by the design team.³¹

The *Full Design Model* will be needed for such analyses as clash detection.

Project Model. 2.15 Project Model means a Model consisting of the federation of a Full Design Model and one or more Construction Models designated in the BIM Execution Plan to be produced by project participants.³²

The *Project Model* can perhaps best be viewed as the shop drawing equivalent, physically built in sufficient detail to allow conflict-free construction.

Information Management

This section outlines who will have the right to build, view and alter the models. It also details steps one should take to ensure the security and safety of the model, which is becoming more and more valuable as it grows, and needs diligent backup with off-site storage of back-up media.

BIM Execution Plan

The opening paragraph spells it out:

“4.1 As soon as is practicable, but in no event later than thirty (30) days after the latter of the execution of the contract between the owner and the architect/engineer or execution of the contract between the owner and the contractor or construction manager, all project participants shall meet, confer and use their best efforts to agree upon the terms of, or modifications to, a BIM Execution Plan. When agreed upon, the BIM Execution Plan and any modifications shall become an amendment to this addendum. As soon as is practicable, but in no event later than thirty (30) days after the execution of a contract with any other project participants, all project participants shall meet, confer and use their best efforts to agree upon any necessary modifications to a BIM Execution Plan.”³³

It is the BIM team that develops the BIM Execution Plan, which, once agreed upon, becomes an amendment to the BIM addendum.

The plan specifies which models (and to what detail) are to be produced by the team; outlines a delivery schedule for these models; establishes procedures and

It is the BIM team that develops the BIM Execution Plan, which, once agreed upon, becomes an amendment to the BIM addendum.

protocols for the team; and addresses dimensional accuracy of the models.

It further establishes coordination methods, file format and structures for the models; addresses interoperability issues, and other administrative measures to ensure that the team can and will operate successfully.

Risk Allocation

Again, the opening paragraph sets the tone for the section:

“5.1 Each party shall be responsible for any contribution that it makes to a Model or that arises from that party’s access to that Model. Such responsibility includes any contribution or access to a Model by a project participant in privity* with that party and of a lower tier than that party. Nothing in this paragraph shall expand the scope of any representation stated in the BIM Execution Plan pursuant to Section 4.3.11. [pertaining to representations of dimensional accuracy].”³⁴

* A relationship recognized by law

Note, however, that by the addendum, each party is in fact waiving claims against the other parties by reason of the collaboration on the model:

“5.2 With respect to the issue of a waiver of consequential damages:

“(a) The Governing Contract shall govern the issue of any waiver of consequential damages arising from a contribution; and

“(b) Each party waives claims against the other parties to the Governing Contract for consequential damages arising out of or relating to the use of or access to a Model, including but not limited to damages for loss of use of the project, rental expenses, loss of income or profit, costs of financing, loss of business, principal office overhead and expenses, loss of reputation or insolvency.”³⁵

Intellectual Property Rights in Models

This, the last section of the BIM addendum, addresses the issue of what team member owns what part of the collaborated model.

The opening two paragraphs clearly state the intent (the contributing team member confirms that he owns the information shared, and that he only shares it on a non-exclusive, for-this-project-only basis):

“6.1 Each party warrants to the other parties to the Governing Contract that either (a) that party is the

owner of all copyrights in all of that party’s contributions, or (b) that party is licensed or otherwise authorized by the holders of copyrights of expression contained in the contribution to make such contribution under the terms of this addendum. Subject to waiver of subrogation* clauses, if any, contained in the Governing Contract, each party agrees to indemnify and hold such other parties harmless for claims of third parties arising out of, or relating to, claims or demands relating to infringement or alleged infringement of expression contained in that party’s contribution. Nothing in this addendum is intended to limit, transfer or otherwise affect any of the intellectual property rights that a party may have with respect to any contribution, except for the licenses or permissions expressly granted by this addendum or the Governing Contract.”

* The substitution of one person or group by another concerning a debt or claim, accompanied by the transfer of any associated rights and duties.

“6.2 Subject to the provisions of Section 6.1, each party grants to the other party or parties to the Governing Contract (a) a limited, non-exclusive license to reproduce, distribute, display or otherwise use that party’s contributions for purposes of this project only; (b) a limited, non-exclusive sublicense to reproduce, distribute, display, or otherwise use, for purposes of this project only, the contributions of those other project participants who have granted that party an identical license or sublicense; (c) the right to grant an identical sublicense to any other project participants with which the licensee has an affiliated contract in which this addendum is incorporated by reference; and (d) a limited, non-exclusive license to reproduce, distribute, display or otherwise use any Model containing such contributions, or any other Model with which the Model containing such contributions is federated or otherwise related, in each case for the sole purpose of carrying out the project participants’ respective duties and obligations relating to this project. This limited license shall include any archival purposes permitted hereunder or in the Governing Contract, but does not allow the licensee to reproduce, distribute, display or otherwise reuse all or part of any other party’s contributions except as permitted herein or in the Governing Contract. This limited, non-exclusive license is in addition to any other licenses or usage rights that also may be granted under the Governing Contract.”

Conclusion

The ConsensusDOCS 301 BIM Addendum was developed through a collaborative effort of entities representing a wide cross-section of the construction industry—including COAA (Construction Owners As-

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sociation of America) and the AGC (Associated General Contractors of America).

This collaboration has resulted in a well-thought-out document that answers most questions (and should still most fears) when it comes to the BIM process.

The only area conspicuous in its absence is that of rewards. Risk, and the sharing of it, is handled well and in a brotherly fashion, but nothing is yet said about rewards and the sharing of them.

Perhaps they can be written into the BIM Execution Plan—the project members do have the latitude to do so; even so, it would be nice to see an incentive system of shared rewards included in the next iteration of the ConsensusDOCS 301 BIM Addendum.

The Future of BIM

To quote technology industry analyst Jerry Laiserin: “The real promise of BIM lies in its application across the entire project team, especially in the area of improved building performance.”³⁶

To date, BIM has only offered glimpses of what 3-D modeling, and the requisite team spirit to make it work, are capable of. As more government agencies, like the GSA, specify BIM in their contracts, as more benefits surface, and as more owners see—and share—higher profits, BIM will find full traction and will reshape the industry. It is not a question of if, it is a question of when.

The contractor or subcontractor that gears up now—or at the least fully informs himself or herself about what BIM can do for his or her company, or how a BIM-enabled company might better serve the industry—will soon be in high demand. Those who feel that the boat is doing just fine and should not be rocked may find themselves scrambling for BIM tools and rushing into perhaps ill-advised choices once BIM becomes a general requirement, be it for economic, green or other reasons.

The important thing to realize is that BIM, at heart, is not just software, but a human activity that ultimately involves broad process changes in construction.³⁷

2020

By the year 2020 BIM will most likely have reached all the way into the building codes structure and the permits process. “Send me the model” may well be the immediate response to a permit request. More likely than not, the permit office now has an analyzer that will quickly (in a matter of seconds) verify that your

model is to code, and you may receive your permit in minutes, rather than weeks, after submittal.

Lean Construction principles will have worked their way into a majority of projects, and the U.S. construction industry will, as a team-centric industry, be the most productive—and the most proud—in the world. It does not take a crystal ball, or even 20/20 vision, to see that.

CONCLUSION

Building Information Modeling has grown out of its infancy. The day the GSA required all of its contracts to be BIM-based signaled the moment.

BIM may mean many things to many people, it is a buzzword, to be sure; it may be on or off the radar for the wall and ceiling subcontractor of today. But BIM, both as mature software and as process, has in fact arrived, and regardless of cost or learning curve, many teams have already proven that its benefits outweigh its drawbacks.

The smart wall and ceiling subcontractor will take heed.

The important thing to realize is that BIM, at heart, is not just software, but a human activity that ultimately involves broad process changes in construction.

Endnotes

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- ²² Ibid. (p.17).
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- ²⁴ <http://www.aiacontractdocuments.org/bim/>
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