“Sexy, Young Technology Seeks Stable Project Delivery Method for Lasting Relationship…”

Building Information Modeling

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INTRODUCTION

Building Information Modeling utilizes computer technology to represent building structures and systems in terms of functional, as well as graphical attributes. Current design and construction tools are truly spectacular in their breadth and power. But the glitter of their technological wizardry can obscure the most revolutionary aspect of these tools. At their core, they are platforms for collaboration that change the nature of the design and construction process. To a greater extent than ever before, the design can incorporate contributions from multiple participants who can thereafter rely on the shared information for their unique and individual purposes.

Deep collaboration promises greatly increased efficiency and quality. But this will be a hollow promise unless the commercial and legal structures used embrace new approaches to compensation, responsibility and risk. New approaches must be developed to support these collaborative processes within a structure that maintains design integrity and discipline. With these concerns and goals in mind, this article examines the benefits and challenges of implementing Building Information Modeling.

WHAT IS BUILDING INFORMATION MODELING?

Building information modeling (BIM) broadly encompasses a series of technologies that are transforming design and construction. In essence, BIM uses information rich databases to characterize virtually all relevant aspects of a structure or system. In a BIM system, drawings, specifications, take-offs, and even construction details are not separate documents, but specific manifestations of the model. Because all aspects of a project are driven from a single database or related databases, issues of drawing coordination and conflict errors are greatly diminished. Integration of information from multiple disciplines also supports project visualization, simulation, and optimization. The model can even be used to drive computer-controlled fabrication tools, leapfrogging the tedious and error-ridden shop drawing process. Paraphrasing Dr. Pangloss, from Voltaire's *Candide*, "This is indeed the best of all possible worlds."

But will this world be realized? Building information modeling assumes centralized information that is broadly accessible. Its utility depends upon being constantly updated with new information from consultants, contractors, and vendors. Once the BIM model becomes the central design document, contractors will rely upon the model for coordination and conflict resolutions and will use the model to develop project schedules. Owners will rely on space and cost estimates. If the model is faulty, they will surely look to the designer for recompense. This creates the anomaly that the designer that initially creates the model receives little immediate benefit, but subjects itself to increased potential liability. This tension impedes BIM adoption. Unless commercial and legal structures are modified to rebalance compensation, risk, and reward, BIM cannot achieve its potential.

A FEW DEFINITIONS

The processes, issues, and benefits of BIM cannot be understood without discussion of a few key concepts.

POLYGONAL SURFACE MODELING

Polygonal surface modeling is the process of creating 3D pictures of a structure or object. The 3D surface is built from combinations of geometric objects that are coated with appropriate skins and textures. The object can be viewed from multiple angles and under different lights, and if sufficiently complex, the object becomes almost photo-realistic. By changing the "camera angle," the viewer can fly through and around the model and obtain an accurate simulation of what the structure will look like. Three-dimensional models are commonly used in design development and client communication.

The basic polygonal surface model is only a picture. For instance, a window in the model is a graphical element that does not provide any information regarding the window's characteristics, such as structural, thermal, or sound resistant attributes, nor does it have the "intelligence" to communicate with the model or other objects. Polygonal 3D models have long been used to create visualizations of a design. These models, however, differ significantly from the intelligent models used in a BIM process. Polygonal models can be thought of as expressions of a design described in other documents, whereas the BIM models are the design itself.

PARAMETRIC MODELING

Parametric modeling is the basis for BIM processes, and in contrast with the polygonal model, the parametric model is data rich. Although a parametric modeling system can create 3D visualizations, the model is not constructed from simple graphical elements. Instead, it is generated from a relational database containing information regarding the elements of a structure and their relationships. Fixed or flexible ties can be made between elements allowing the model to either maintain or adjust elements in response to changes in design. In addition, the model can be used to generate space calculations, material take-offs, energy efficiency analysis, structural details, and traditional design documents.

OBJECT-ORIENTED MODELING

Parametric modeling does not inherently require object-oriented technologies, although in many instances it will. Sometimes referred to as "intelligent objects," object-oriented designs use software objects that encapsulate information concerning each element within the software object rather than the database. Provided they conform to a common specification, objects can be created by third parties, as well as the model designer, and can appropriately interact within the model. The objects also have the ability to communicate with each other and with the model itself allowing the objects to adapt to information obtained from other objects. In effect, the model is a structure to support communication between "plug-in" objects that model the characteristics of individual building components that can be arranged to create a functional design.

Despite differences in architecture, both parametric and object oriented software share a functional, rather than graphic, approach to design, as is shown in the following example.

In a traditional CAD package, the designer draws lines to illustrate the location of walls, windows, doors, or similar structures. In effect, the computer is an efficient drawing tool. In a BIM design, however, the designer selects a pre-programmed wall object that contains information about all of its relevant characteristics, not just its shape. If a window is needed, a window component is dropped onto a wall component that knows how to integrate the window into the wall and which can communicate with other components that may need to change (perhaps because of thermal differences) to accommodate the new window. Design by arranging components is sometimes referred to as designing with Legos because the design is built from a toolbox of existing elements.[1]

The difference between BIM and traditional design approaches is most striking when changes are made to the design. For example, if a steel structure is designed with traditional CAD tools, the drafted design might contain columns and beams with specific connections. If a column is removed to create a larger bay, the designer must recalculate the size of adjacent columns, resize beams, reanalyze load paths, and re-detail the connections. In object-oriented design packages, such as Tekla Structures, if a column is removed, the model will communicate with the remaining columns, adjust their size as necessary, change beam dimensions, and change the beam/column connections. Tekla currently supports conduits to an object-oriented design package (ArchiCAD® by Graphisoft®) that can either initiate the design change or can adjust its model based on the changes in the ArchiCAD® model. Thus, a change in the architectural requirements can ripple through the structural design without direct engineering involvement. The model can “design” itself based on rules embedded in the objects themselves. Similarly, changes in Autodesk’s® Revit®, result in automatic adjustments within the model to maintain relationships between components. Not only is this process efficient, it sharply reduces inconsistencies unforeseen when the design was modified.

INTEROPERABILITY

The ability of different software packages to use, edit, augment, and exchange information depends upon universal standards for describing construction elements and systems. The National Institute of Standards and Technology estimates that $15.8 billion is wasted annually due to inadequate interoperability.[2] The International Alliance for Interoperability[3] (IAI) is dedicated to facilitating interoperability by defining Industry Foundation Classes as a uniform basis for collaborative information use and exchange. IAI currently has more than 400 members in 24 countries and is the leading interoperability organization.

Other solutions are being developed to facilitate interoperability. In addition to supporting IAI standards, Autodesk’s® Revit® BIM systems are available in discipline optimized versions that use a common engine that permit tight integration between the related models.

4D, 5D, AND nD DESIGN

Parametric models can be linked to scheduling information to add a temporal dimension ("4D"). The scheduling information can be used to simulate construction sequencing and evaluate alternative approaches. The project can, in effect, be constructed in the computer before it is constructed in the field. In addition, the as-built schedule information can be used to show current construction status, and historic or posited information can be used to visualize the effect of delays in construction or other "what if" scenarios. Information concerning cost can also be linked to, or contained in the model ("5D") allowing financial, as well as constructability, analysis. And given the power of relational databases, we can anticipate the integration of more types of data as software developers push the capabilities of software and hardware.

VISION VS. CURRENT REALITY

In theory, BIM relies on a single information store that meets the needs of all participants. Changes to design, whether architectural, structural, mechanical, or electrical, all occur within the universal model. Vendor and contractor information is integrated into the model, adding detail to the design. The model then produces the field and shop level drawings and controls computerized fabrication equipment. Although this level of integration has been achieved in certain manufacturing processes, it is not the current construction reality.

In current practice, BIM is a hybrid, with several differing approaches being used. In one, a central model controls certain aspects of design, such as architectural issues, with other information or models being coordinated with the central model. For example, the TEKLA Structures object-oriented model referred to earlier integrates with the ArchiCad® model through an export/import interface. A second approach uses multiple, but tightly integrated models, such as the specialized Revit® models. In a third, multiple models and related information are visualized through in a single, "viewer" model, such as Navisworks.® Each approach seeks to tighten integration, but the single universal model and perfect interoperability are still aspirations, not achievements. Moreover, there are practical advantages to using interoperable models optimized for specific purposes or users. As the technology evolves, we will see whether these advantages outweigh the efficiencies of a universal, multiple purpose model.

The level of BIM adoption also varies. Large national and international firms are currently using or exploring BIM as well as some smaller "early adopter" firms. In many instances, the firms are responding to requests or pressure from their clients. Although these firms face the same issues as other firms, the size of the firms and their projects allows greater commitment to technology and training and provides the overhead to fund addressing the risk allocation issues.

BENEFITS OF BIM

Single Data Entry; Multiple Use

Traditional construction practices require the same information to be used by multiple organizations. Identical information may need to be entered into different programs that are designed to provide specific solutions, such as bills of materials or estimates. Information can become corrupted when translated from one format to another. Even if information is kept in compatible programs, versioning can be a nightmare. For example, the architect's consultants need to upload and maintain the basic design backgrounds they receive from the architect. These backgrounds, however, will change as the design develops and each party must take considerable care to ensure that they are working with the latest versions of the basic documents. The contractors and vendors must take the information provided by the designers, often in paper form, and enter it into their systems. As the design develops, changes in one party's documents must be transferred back to the others. Errors begin to creep into the documents because updates are incompletely or incorrectly entered, and work can be wasted because parties are working from outdated information.

By consolidating information into a single model, the likelihood of data entry, translation, or versioning errors is greatly decreased.

Consistent Design Bases

Use of a BIM model ensures that all parties working from the model share the same base. Under current practice, not all participants may be operating directly from the model. However, if the participants are using software that is compatible with the model, the base information can be moved, imported, or exported from the model.

3D Modeling

The BIM model can render the design three-dimensionally and does not require separate software to explore the model visually. Besides design studies, the 3D model can be used for conflict resolution and constructability reviews.

Take-offs and Estimating

The model contains information necessary to generate bills of materials, size and area estimates, and related estimating information. It avoids the manual process of material take-offs with less risk of error and misunderstanding.

Shop and Fabrication Drawing

In some instances, the models are capable of providing construction details and fabrication information. This reduces costs by reducing the detailing effort and increases accuracy of fabrication.

CONFLICT IDENTIFICATION AND RESOLUTION

On complex projects, conflict identification and resolution is an extraordinarily expensive and difficult task. In many instances, designers do not have the time or budget to fully explore and resolve conflict issues. In other instances, full coordination cannot be accomplished during the design phase because the contractor will later design key systems, such as HVAC or life safety equipment. Even in a complete design-bid-build project, construction details and layouts may require information regarding the actual equipment that will be installed.

The lack of information is typically addressed by warning the contractor that the design is “diagrammatic” and that coordination will be required. Traditionally, the coordination process will move forward with the contractor creating physical drawings of different systems that are overlain on light tables to determine if the various systems can actually be constructed in the allowed space. Conflicts that are identified are brought to the designer’s attention through the request for information process, where solutions can be developed and clarifications issued. But light table resolution is inherently a two dimensional process applied to a three dimensional problem, is notoriously difficult, and fraught with error. For these reasons, conflicts are one of the primary sources of contractor claims.

Building information modeling greatly reduces conflict issues by integrating all the key systems into the model. Design BIM systems can detect internal conflicts and model viewing systems, such as NavisWorks®, can detect and highlight conflicts between the models and other information imported into the viewer. The solution can then be checked to ensure that it resolves the problem and to determine if it creates other, unintended, consequences.[4]

VISUALIZATION OF ALTERNATIVE SOLUTIONS AND OPTIONS

Because it is inherently a 3D process, models are excellent methods for evaluating alternative approaches. Moreover, the ability to evaluate the effect of changes, such as energy use, increases the utility of the model as a thinking tool. However, the structure of the model can interfere with the creative process. In a study of one system, users noted that it was not “sketchy,” and therefore impeded the initial creative process.[5] This may lead to using freeform design tools at the inception of design with the results being loaded into the BIM system for refinement.[6]

ENERGY OPTIMIZATION

Building information modeling systems, such as Autodesk’s® Revit®, are capable of providing information for energy analysis. They can be used to evaluate lighting design and options, are in conjunction with their material take-off capabilities, and can generate documentation necessary for LEED™ certification.[7]

CONSTRUCTABILITY REVIEWS AND 4D SIMULATIONS

Using the model, the contractor can visualize the entire structure, gaining a greater understanding of the challenges involved in its construction. By integrating 4D capabilities, the contractor can also simulate the construction process, which significantly increases the contractor's ability to evaluate and optimize the construction sequence. The interaction between scheduling software and the model can also be used to evaluate the effect of construction delays and errors.

Reduced Fabrication Costs and Errors

The ability to use information in the model to directly create fabrication drawings avoids a problematic and difficult step in the construction process. In a traditional work flow, the fabricators must review the plans and specifications, prepare fabrication drawings, compare them to other fabrication and design drawings, have them reviewed by the design team, and eventually release the drawings for fabrication. Errors can occur at any stage. By using the data in the model, dimensional errors, conflicts, and integration errors can be avoided or significantly reduced.

Facilities Management

If the model is properly maintained during construction, it becomes a tool that can be used by the owner to manage and operate the structure or facility. Modifications and upgrades can be evaluated for cost effectiveness. Data contained in the model can be used for managing maintenance.

Emergency Simulations

The 3D and conflict checking mechanisms can be used to simulate and evaluate emergency response and evacuation. For example, NavisWorks® was used at the Letterman Digital Arts Center to assure that fire response vehicles could navigate the parking structures.

BARRIERS TO BIM

With its many advantages, why hasn't BIM become the norm?

Commercial Issues

Discussions of BIM generally focus on the technology of BIM. Although this is a fascinating subject, the key question is how BIM alters current commercial models. Rather than view BIM as a technology, it should be analyzed as a project delivery method, with new risks, rewards, and relationships. Unfortunately, new business models have not yet surfaced and designers are left with attempting to integrate the new technologies into conventional practices.[8]

Immediate Benefits Do Not Accrue to the Key Adopter (Designer)

The benefits an owner accrues from BIM are easily seen. The use of a flexible model allows design optimization, fewer construction errors, fewer design coordination issues, and, thus, fewer claims. The owner can also use the model for management and operation of the facility. Contractors also benefit through less coordination and engineering effort and reduced fabrication costs.

For designers, however, the economic advantages of BIM are less tangible. Properly implemented, BIM design systems do increase efficiency by reducing duplicative and potentially inconsistent data entry. Multiple use of consistent data and the ability to quickly explore design alternatives also promotes efficiency and improved quality. But unless the designer shares in the economic benefits, the owner, not the designer, reaps the immediate benefits. Yet it is the designer, not the owner, that must adopt and invest in the new technology.

The asymmetrical rewards of BIM are a significant practical obstacle because design professionals are the linchpins of BIM. Design professionals must adopt the technology, install the software, train their employees, and champion the use of BIM. They need to restructure their workflows and begin to reinvent the design process. If they do not reap economic benefits, designers will have little incentive to adopt BIM processes. In fact, because BIM can increase the designer's potential liability, there is a significant disincentive to adopt BIM. This concern is echoed in comments from The American Institute of Architects' (AIA) Technology Advisory Group, which stated in a recent monograph:

> *We fear there will be a tendency, driven by valid concerns about liability and insurability, to prevent such use of the architect's design data. We believe this is the wrong answer and would jeopardize the future of architectural practice as we know it. If the architecture firm is not willing to deliver the potential value of the digital building model, the owner will seek delivery methods, probably contractor-led, that will deliver that value. The role of the architect will be diminished.*
>
> *We believe, rather, that the architecture firms' role and compensation should be enhanced by these technology developments. Obstacles to a free flow of data among the project participants should be overcome so that the architecture firm can deliver the full value of its work to the client and be rewarded commensurately.*[9]

Although designers should logically benefit from BIM, new business models have developed slowly. In Australia, projects have proceeded on an alliance model, where an attempt is made to share the risks and rewards among all parties. In the U.S., there is a paucity of projects operating under new paradigms.

Absence of Standard BIM Contract Documents

Lack of standard contract documents also hinders development of BIM. Standard contract documents perform four key functions. First, they validate a business model by providing a recommended framework for practice. As noted above, a consensus business model for BIM has not emerged. Second, standard documents establish a consensus allocation of risks and an integrated relationship between the risks assumed, dispute resolution, and insurance. Custom agreements, unless crafted by seasoned practitioners, often overlook key issues. Third, standard documents reduce the effort involved in documenting the roles and responsibilities on a project. Designers want to design, not craft custom construction agreements. Finally, crafting custom documents increases the transaction costs, and thus reduces the profitability of every transaction. Unfortunately, the current standard contract documents provide little guidance to the BIM practitioner.

For example, with regard to the transfer of electronic information, the AIA contract language consists of the following:

> *1.3.2.4 Prior to the Architect providing to the Owner any Instruments of Service in electronic form or the Owner providing to the Architect any electronic data for incorporation into the Instruments of Service, the Owner and the Architect shall by separate written agreement set forth the specific conditions governing the format of such Instruments of Service or electronic data, including any special limitations or licenses not otherwise provided in this Agreement.*[10]

As of this time, there are no exemplars of the “separate written agreement.”

AIA Document A201-1997, *General Conditions of the Contract for Construction*, omits discussion of electronic documents entirely, except to state that electronic documents provided by the architect are “instruments of service.”[11]

The documents published by the Engineers Joint Contract Documents Committee (EJCDC) take a very conservative approach toward electronic information. They disallow any reliance on the electronic information and place the risk of errors and discrepancies on the receiving party. This approach may be appropriate to the transfer of CAD files, but is totally inconsistent with a collaborative (BIM) approach.

> *3.06 Electronic Data*
>
> *A. Unless otherwise stated in the Supplementary Conditions, copies of data furnished by Owner or Engineer to Contractor or Contractor to Owner or Engineer that may be relied upon are limited to the printed copies (also known as hard copies). Files in electronic media format of text, data, graphics, or other types are furnished only for the convenience of the receiving party. Any conclusion or information obtained or derived from such electronic files will be at the user's sole risk. If there is a discrepancy between the electronic files and the hard copies, the hard copies govern.*
>
> *B. Because data stored in electronic media format can deteriorate or be modified inadvertently or otherwise without authorization of the data's creator, the party receiving electronic files agrees that it will perform acceptance tests or procedures within 60 days, after which the receiving party shall be deemed to have accepted the data thus transferred. Any*

errors detected within the 60-day acceptance period will be corrected by the transferring party.

C. When transferring documents in electronic media format, the transferring party makes no representations as to long term compatibility, usability, or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by the data's creator.[12]

The author was recently told, during informal discussions with personnel involved with the AIA and EJCDC documents, that attachments for the AIA documents may be developed to handle the transfer of electronic information, but that documents reflecting a new BIM approach are unlikely to be developed in the immediate future. EJCDC is also unlikely to develop BIM documents in the short term. In both instances, the committees rightly believe that business practices must evolve further before contracts can be drafted to document the BIM process.[15]

LEGAL CONCERNS

Our legal systems are essentially individual, focusing on individual rights and responsibilities. We expend great effort to determine where the responsibility of one party ends and the responsibility of another begins. Many of the most fiercely fought battles in construction law focus on the dividing line between entities. Privity of contract, the economic loss doctrine, means and methods, and third party reliance are all issues where drawing lines between parties is essential to determining responsibility and liability. Insurance, because it tracks legal liability, is also focused on individual responsibilities.

In contrast, BIM is essentially collaborative. It is most effective when the key participants are jointly involved in developing and augmenting the central model. Although roles remain, the transitions between participants are less abrupt and less easily defined. Thus, there is a tension between the need to tightly define responsibilities and limit reliance on others and the need to promote collaboration and encourage reliance on information embedded in the model, regardless of how it was developed.

Risk Allocation

The use of BIM substantially alters the relationships between parties and blends their roles and responsibilities. Our legal framework, however, assumes a less collaborative environment with clearer delineation of responsibility. As we move forward with BIM projects, risks will need to be allocated rationally, based on the benefits a party will be receiving from BIM, the ability of the party to control the risks, and the ability to absorb the risks through insurance or some other means. Several key risk allocation issue are discussed below.

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[15] AISC is somewhat further along regarding BIM contract practice, primarily because they have a narrower focus than the design professional associations.

Standard of Care

Design professional liability is almost always based on the standard of care. Tort liability is directly linked to the standard of care and contracts often reference it as the liability standard. Because roles are changing, clearly defined standards will not exist. A key question will be the extent to which the design professional can rely upon information provided by other participants and, to some extent, by the software itself. Clearly, the design professional's agreement should explicitly permit reliance without detailed checking of the software or others contributions, but the ability to rely on another's work may be limited by professional registration statutes and ethics. This may lead to using risk transfer devices, such as limitations of liability or indemnity agreements, as methods to rebalance design professional liability.

The difference between professional and software liabilities is also problematic. If software is faulty, there will be little opportunity to recoup the loss from the software vendor. First, it may be very difficult to assign liability to a software error. In many instances, it is the interaction of software components that results in error, not an inherent flaw in either. Because BIM, especially with object-oriented design, will be accomplished with data objects written by differing vendors and operating through differing software, determining fault may be nearly impossible. Second, most software vendors use very limited warranties and broad consequential damage waivers. If an error arises because of a software fault, the injured party will likely look to other participants to absorb the shortfall, including the designers. Because the owner gains most from the BIM approach, this risk should appropriately be allocated to the owner through its agreement with the design professional.

Privity and Third-Party Reliance

The extent to which third parties may rely upon a designer's work is hotly contested across the U.S. Two defenses are usually interposed to protect the designer: lack of privity or that the plaintiff is not an intended beneficiary of the designer's services. The efficacy of these defenses varies widely between jurisdictions. However, the use of a collaborative model lessens the likelihood that the defenses will be successful.

The model designer will be aware that there are other parties relying on the accuracy of the model. It is a short step from foreseeability to knowing that a purpose of the model is to provide information for contractors' and subcontractors' use. Under the Restatement (Second) of Torts, which is followed in most jurisdictions, a person negligently providing information is liable if it is intended that the plaintiff be able to rely on the information.[13] Liability under the Restatement only requires that there be intent to influence and reach a group or class of persons.[14] For this reason, contractors and subcontractors relying on the model will likely be able to bring an action against the designer for damages caused by negligent errors. Thus, in setting up a BIM project, consideration should be given to requiring a waiver of consequential damages as a pre-condition to using the model or otherwise limiting damages due to model errors.

Economic Loss Doctrine

The economic loss doctrine is another hotly contested defense to contractors' actions against design professionals. Simply stated, the doctrine holds that purely economic losses cannot be recovered through a negligence cause of action.[15] As with the privity and third-party reliance defenses, the utility of the defense varies among jurisdictions and is dependent upon specific facts. However, the use of a collaborative model will be a factor tending to support a contractor's claim that it should be able to recoup its economic losses.

DISTRIBUTED DESIGN

These liability issues highlight concerns that arise from the distribution of design. In looking at this isue, it is useful to focus on three questions that highlight the change between traditional and BIM processes. The are: what is the design, who is the designer, and who is in "responsible charge?"

What Is the Design?

The new design processes will be fluid and collaborative. Elements of the design, such as object properties, will be created by vendors or software manufacturers, not licensed design professionals. The design may be self-modifying, and to that extent, partially self-designed. The design deliverable may be a computer model or simulation, not paper drawings, and may be distributed between computer systems operated by different participants. The complete design may exist in a space defined by the Internet, not plotting paper's narrow confines. The design will be flexible, but elusive.

The parties will still need a clear definition of the project design. Contractors need to know what they are bidding on. They need to be able to compare revised design elements to earlier versions to determine if there are changes in scope. Owners need to determine whether they have received a project that complies with the design. Inspectors must be able to compare physical construction to an objective design standard. Designers need assurance that their services are complete and, if problems later occur, that their designs can be compared against the constructed condition. Building officials and inspectors need a definite "something" to review, not a moving target.

The design fluidity allowed by new technologies competes with the precision required for contract enforcement. Contract definitions of design should address the following issues:

The contracts between the parties should define the design deliverables in content, time, and type of electronic media used.

The contract documents should determine whether incorporated submittals, such as objects provided by vendors, are part of the designer's deliverables and which party takes responsibility for incorporation and coordination.

Once a design definition is adopted, it will be important for the parties, and particularly the designer, to adhere to the definition during project development.[16]

The design should be preserved in “snapshots” at major design milestones. In some cases, this may be accomplished by printing and saving these milestone documents. But in a multi-dimensional electronic design maintained in a diffused Internet relationship, the total design package may not be encompassed by printed documents. It may be possible, however, to temporarily freeze this digital design world and save it, complete with linked documents and locations on semi-permanent media, such as CD-ROMs. Revit®, for example, can preserve snapshots as “Design Alternatives.”

The definition must consider the needs of inspectors and building officials to have a stable document to review or to compare against the actual construction.

Who Is the Designer?

Not only is the concept of “the design” becoming less clear, the identity of the “designer” is becoming equally vague.

In the grand sense, we will always know the designer. The prime design professional will maintain responsibility for systems design, the overall layout of design elements, the flow through the structure, and “artistic” building elements. Most of the disputes regarding design deficiencies, however, have little to do with these aspects of design.[17] Most design disputes arise from deficiencies in details, inadequate coordination, deviations in submittals, excessive changes, and failure of the design to meet budgetary or functional program requirements.

In a collaborative setting, the design details that create disputes may well be provided by subcontractors or vendors through submittals or object specifications. To this extent, those subcontractors and vendors become the “designer.” The distribution and “hiding” of the design process raises several significant questions:

- How will the various contributions of “designers” be unwound to determine responsibility?
- Will parties accessing the shared model be able to legally rely upon the contributions of others? Is privity an issue?
- If the software can communicate between objects and cause them to adjust their properties, does the software become a “designer” as well?
- Do the standards committees that develop interoperability protocols and object specifications become project “designers?”
- What are the responsibilities of these secondary “designers?”
- To what extent can the design professional rely upon the products of these “designers?”
- If these “designers” do have responsibility, do they have insurance for design

risks? Do we need new insurance products better tailored to collaborative projects?

In the immediate future, owners and building officials will look to the architect and engineers of record as the project's designers. But, in a practical sense, these parties cannot check and be responsible for all of the work of the many "designers" distributed throughout a collaborative design process. Just as tomorrow's designs will be distributed, so should design responsibility. In developing contract documents, careful thought should be given to integrating appropriate limitations of liability and waivers.

Who Is in Responsible Charge?

The professional registration statutes generally require that a licensed professional be in "responsible charge" of all work performed by a design firm. This work must either be performed or supervised by the responsible professional. The contract documents are sealed by the responsible professional to signify compliance with this requirement and acceptance of this responsibility. If design responsibility is distributed, however, is this even possible? How can a professional supervise design contributions by firms that are not under the professional's control? How can a design professional supervise changes to structural detailing that are performed by the software itself? In the short run, building officials are likely to accept sealed drawings without considering what portion of the content has been created under the responsible charge of the signing professional. But in the long run, the professional registration statutes must be modified to reflect the actual practices, and realities, of digital design.

Intellectual Property

Given that the intelligent model is an inherently collaborative work, to what extent can anyone claim ownership of the intellectual property? In select instances, the designer's intellectual property rights have been used to preserve the integrity of the design itself. More commonly, the intellectual property rights are used to enforce payment obligations or to prevent reuse of the design without compensation. Because the client will ordinarily have access to the model as it is being developed, care must be taken to ensure that the intellectual property rights are not lost because of the open and collaborative nature of model development.

Information Ownership and Preservation

The existence of a dynamic model creates challenging issues regarding ownership and preservation. The model is immensely valuable, but can be fragile. Computer software is susceptible to power interruptions, viruses, and physical damage. Although these dangers can be reduced by appropriate back-up strategies, there are risks involved with hosting data, and even small losses of data can require significant effort to recover or replace. If a failure occurs, what insurance, if any, will respond to the economic losses? A design firm can purchase "valuable papers" coverage that provides catastrophic loss protection, but this will not necessarily cover losses to other collaborative users. Coverage under the designer's professional liability policy is problematic and the designer's commercial general liability policy will not respond to purely economic losses. The difficulty in characterizing and insuring against this type of loss underscores the necessity of comprehensive risk allocation and waivers among all model users.

Preservation of data can be challenging as well. We have recently seen extraordinary judgments and sanctions levied against corporations that did not appropriately preserve relevant electronic evidence. The duty to preserve evidence arises when litigation can be reasonably anticipated.[18] On a construction project, however, claims are a normal aspect of project closeout, with only *some* claims proceeding to litigation. Unfortunately, when they arise, claims that are eventually resolved by the parties look strikingly similar to claims that result in litigation. After litigation commences, the likelihood of litigation will look "reasonably anticipatable" in hindsight.

Even assuming that the design professional could recognize *when* information needed to be preserved, it is unclear *how* that should be accomplished. One of the advantages of a dynamic model is that it can and does evolve. This inherently involves replacing information with newer information and overwriting or discarding the obsolete data. Although systems can track revisions, they may not be able to accurately roll back every change made to the system. Moreover, the model differs from traditional paper documents (or even electronic word processing files) in that there is no single paper representation of the model, and critical information is contained in the relationships between information. The model, and not its manifestations, needs to be preserved.

Archiving also raises technical and practical issues. Although it is possible to save the model onto electronic media, this does not guarantee that the saved model will be usable. Properly prepared paper has an archival life of 100 years. In many instances, if carefully preserved, paper often lasts longer. We have limited experience with the long-term reliability of digital systems. We are aware that most magnetic media have limited lifespans. CDs and DVDs can last considerably longer, but that may be irrelevant. When the author began practicing law in 1979, word processing departments used eight-inch floppies and magcards. It would be hard to find any hardware that could read these formats, let alone run the software necessary to access and read the Displaywrite files. As succinctly stated by one commentator, "…the truth is that our digital storage media have a shorter lifespan than an old man with a good memory."[19]

Technology obsolescence issues led The Rosetta Project to micro-etch *analog* information onto nickel disks rather than entrust the world's languages to the fickleness of digital technologies.[20] If data is archived on currently popular media, with currently popular software, it may be difficult or impossible to restore or view the data when needed. How long do we need to maintain models and how should this be accomplished?

TECHNICAL ISSUES

Interoperability Standards

In its purest form, a BIM project would use a single data model for all purposes. Each participant would access the model, adding content that could be accessed immediately by all others. Exploration, analysis, and evaluation would take place within the model with information being exported as contract drawings, fabrication drawings, bills of materials, or other information. But there are several reasons why this goal is only partially realized.

Not every participant uses the same software and not all software is appropriate for all projects or tasks. Designing a software framework that can handle any conceivable project is a daunting task and can result in an overly complex program. In many instances, modeling software was developed to address issues affecting specific trades, such as piping, ductwork, or structural detailing. Not surprisingly, software developed for a specific purpose has advantages when used for the specific purpose. Thus, there are often multiple models existing on a single project that are optimized to a specific task. In a recent project in San Francisco, the subcontractor responsible for a complex structural steel sunscreen used the designer's 3D model to establish design intent and provide baseline data, but entered the information into a second model to generate shop and fabrication drawings. While the preference to use familiar software is understandable, the existence of multiple models undermines the efficacy of the BIM process.

There are three current approaches to the multiple model problem. First, BIM models are becoming more powerful and capable of handling larger portions of the project. Additional software modules can be added to frameworks to customize the framework for specific uses. Second, standards can be adopted to provide common definitions for the software emulating specific construction elements and systems. The IAI has developed, and is continuing to develop, standardized descriptions through the Industry Foundation Classes (IFC) and IFC/xml common model.[21] Many of the primary BIM software packages are IFC compatible. Under the IAI vision, information in any compatible program can be saved as an .ifc file and then opened and edited in another compatible program. Information is universal with specific tools being used to manipulate the common information. The third approach, used by Autodesk's® Revit®, seeks to capitalize on the advantages of "purpose built" modeling systems and lessen the difficulties caused by multiple models by using adjacent models constructed on a common framework that are separate, but closely linked. Although this approach is very effective if a common engine is used, it can be problematic when merging models built on engines from different software houses.

From the participants' viewpoint, the plurality of solutions makes it more difficult to develop a BIM project. Although all of the solutions may work, as long as participants are committed to different systems, integration will be challenging.

KEY ISSUES WITH BIM

WHAT IS THE APPROPRIATE BUSINESS MODEL?

The prior discussions highlight individual issues that have slowed the adoption of BIM. As noted, BIM is best viewed as a project delivery method, not a technology. From this viewpoint, the most pressing issues are compensation and risk allocation, not the technical details. The following represents key issues that should be considered in developing this new project delivery method. These should be reflected in the owner-designer agreement and in a project agreement signed by all participants. This project agreement could also address other issues, such as partnering or dispute resolution, although only the BIM provisions are discussed here.

COMPENSATION

BIM requires investment by design firms. Enhanced quality, service differentiation, and client satisfaction are important rewards. But there has been little direct financial incentive to adopt BIM because compensation has not increased to cover the additional effort and potential liability. If owners want designers to adopt this project delivery method, they should provide the designer with a portion of the benefits related to increased efficiency and lowered contracting costs. This could be an enhanced design fee, an “information management fee,” or a performance-based bonus. The performance bonus could factor actual construction costs, the ability to meet or exceed design targets (such as energy usage), or maintenance and life-cycle costs.

RISK ALLOCATION AND RELIANCE

As discussed above, collaborative design increases the number of parties relying upon the design. The potential liability increases proportionately. Because the owner and contractors are the parties that immediately benefit from the model, their ability to benefit *and* claim damages against the designer should be limited. A project-wide agreement should be reached that appropriately limits, or waives, consequential damages due to errors in the model. Execution of the project agreement should be a pre-condition to model access. Similarly, because the model can be used to evaluate constructability, limitations should be placed on the designer’s liability for constructability or means and methods of construction. The agreement should also specify the extent to which the designer can rely upon information incorporated into the model, but provided by others.

DESIGN OWNERSHIP AND ACCESS

Ownership of the model should be clearly defined and the project agreement should provide that the availability of the model does not waive any ownership rights. If the designer cedes ownership of the model, there should be an alternative method for guaranteeing payment. On a traditional project, the designer can withhold contract documents if not paid. If the model has been open to all parties, withholding the design is not an effective option.

INSURANCE

The model must be protected by insurance that covers the economic losses to the parties if the model is lost or damaged. If the designer is hosting the model, it should have insurance covering this activity in addition to its professional liability insurance. In addition, the insurance must clearly cover the collaborative aspects of the project. This may lead to insuring projects, not participants.

INTELLECTUAL PROPERTY

There are two separate intellectual property issues. First, who owns the design for the purpose of re-use or continuation (in the event the designer is terminated). If the model is developed for a repetitive type of project, such as a store chain or a restaurant franchise, then a licensing fee may be appropriate. Second, if the model incorporates proprietary information, such as process information in an industrial facility, the parties should be required to maintain confidentiality of the information. It may also be necessary to limit access to more sensitive portions of the project.

MODEL HOSTING

An agreement should be reached regarding who will host the model. This will include responsibility for managing access, protecting the model, and preserving the model for use in later litigation. It may also require archiving the model at periodic intervals, or milestones, to demonstrate the model's stats at a particular point in time.

SUMMARY

Building information modeling is a key advance in building technology, but its promise will not be achieved without adopting structural changes to existing project delivery methods. The key issues are compensation, risk allocation, and control of the model. If these issues can be satisfactorily addressed, BIM should become a dominant design methodology.

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[1] BIM systems also allow the designers to customize existing elements, or create new elements, that can then be incorporated into the design.
[2] M. Gallaher, et al., Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, NIST GCR 04-867, August 2004.
[3] www.iai-international.org.
[4] NavisWorks® was used to model LucasFilm's Digital Arts Center and identified several significant conflicts before construction commenced and was used to check field construction, again identifying mislocated elements and penetrations.
[5] L. Khemlani, Autodesk Revit: Implementation in Practice, Arcwiz, 2004.
[6] Supporting graphic creativity is already being addressed by the primary software houses. For example, Autodesk's Architectural Deskstop® and Graphisoft's Sketch Up®.
[7] Building Information Modeling for Sustainable Design, Autodesk® 2005.
[8] Design-Build avoids the tension between collaboration and separateness by reducing the number of principal participants. Thus, many of the commercial and legal issues related to implementing BIM are obviated in the Design-Build project delivery system or its variants. However, Design-Build is not

appropriate on all projects and is not permitted on others, such as some public agency projects. And in any event, Design-Build does not address all of the issues relating to implementing BIM processes.

[9] Intelligent Building Models and Downstream Use, Comments of the Technology in Architectural Practice Advisory Group submitted for the 2007 revisions to AIA Documents B141 and A201, AIA 2005.

[10] AIA Document B141-1997, §1.3.2.4.

[11] AIA Document A201-1997, §1.6.1.

[12] EJCDC Document C-700, §3.06.

[13] RESTATEMENT (SECOND) OF TORTS, §552, Information Negligently Supplied for the Guidance of Others; *Bily v. Arthur Young*, 3 Cal.4th 370; 834 P.2d 745; 11 Cal.Rptr.2d 51 (1992).

[14] See, comment h to Subsection (2) of RESTATEMENT (SECOND) OF TORTS, §552.

[15] Further exposition on the economic loss rule can be found in papers published in *The Construction Lawyer*, Vol. 25, No. 4 (2005) under "Taking the Measure of the Economic Loss Rule."

[16] We have all experienced clients that will execute contract documents with detailed provisions governing change, notice, and dispute resolution and then ignore these provisions during contract performance. Or the same clients or create entirely new mechanisms that deviate significantly from the systems provided in the contract. In this fashion, we must expect deviation from whatever prospective systems we and our clients develop. Technology may change, but people do not.

[17] In over 20 years of representing designers, the author has only once defended a designer sued because the design was "ugly."

[18] *See, Zubulake v. UBS*, 220 F.R.D. 212 (S.D.N.Y. 2003) ("*Zubulake IV*") and *Zubulake v. UBS*, 229 F.R.D. 422 (S.D.N.Y. 2004) ("*Zubulake V*").

[19] M. Wein being quoted by Norsam Technologies, the archival vendor for The Rosetta Project.

[20] www.rosettaproject.org/about-us/rosetta-disk/technology.

[21] Additional information concerning the IAI and IFC foundation classes can be found at www.iai-international.org.