Building Information Modeling: A Framework for Collaboration

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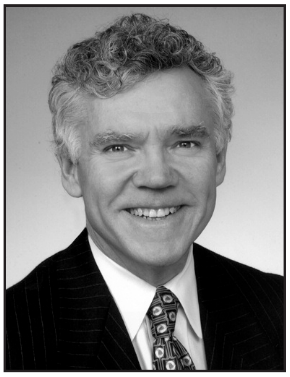

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Building information modeling technology has arrived and is being used by designers, contractors, and suppliers to reduce their costs, increase quality, and, in some instances, achieve designs that would be impossible without digital design and fabrication. Public[1] and private owners[2] now are requiring BIM, and it has been widely adopted for complex projects. Studies by Stanford University's Center for Integrated Facility Engineering report that BIM use has risen significantly and will continue to rise in the near future.[3] And between 2006 and 2007, the number of licensed seats of Autodesk's flagship BIM product, Revit, doubled from 100,000 to 200,000.[4] Moreover, McGraw-Hill estimated that a tipping point was reached in spring of 2008 where more teams are using BIM than exploring it.[5] Pilot projects now have been completed where the entire structure was built using CNC[6] fabrication driven from the design model.[7] As the technical issues of standards[8] and interoperability are addressed, the software capabilities will develop further. This explosive growth has been supported by preliminary development of BIM standards[9] and of related issues, such as electronic data licensing and file transfer.[10] BIM is not tomorrow's vision; it is today's reality.

The legal and business structures for building information modeling, however, lag far behind. BIM's implications are just being realized, and few solutions have been developed. Moreover, liability concerns have led practitioners, and their attorneys, to contractually wall off the building information model—thus depriving the model of its greatest benefits.

Building information modeling is more than a technology. Although it can be used without collaboration, such use only scratches the surface. Because the model (or models) is a central information resource, it leads naturally to intensive communication and interdependence. Building information models are platforms for collaboration.

Collaboration, however, is not a construction industry hallmark. Rather, the industry, its practices, and its contract documents assume definite and distinct roles and liabilities. The insurance products used by the construction industry mirror these lines of responsibility and liability. However, collaborative processes, and BIM specifically, foster communication, joint decision making, and interdependence that blur the distinctions between parties. Technology and business practices are in collision.

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BIM also collides with traditional professional responsibility principles. Although virtually all professional licensing regulations require that designs be prepared by a person "in responsible charge," much in a collaborative design is not supervised or directed by a single person or entity.

Change is required and change is coming.[11] This article discusses attributes of BIM that conflict with traditional notions of responsibility and proposes alternative business and legal structures that support using BIM in a collaborative environment.

Building Information Modeling: Definition and Characteristics

Building information modeling 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. It is qualitatively different from computer-assisted design and drafting (CADD) because it is not just a *depiction*, it is a *simulation* of the facility.

The National Institute of Building Sciences[12] defines building information modeling as follows:

> A Building Information Model, or BIM, utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility.[13]

Several aspects of this definition deserve discussion. Although the definition references a building information model, in current practice the design is built from a set of interrelated models that can exchange information between their differing software platforms. It is this federated set of models that comprise the complete digital information about the facility and, for the purpose of this definition, are the building information model.

The definition is also interesting for what it omits. It does not highlight three-dimensional modeling, although this is one of the most visible and immediately understood aspects of BIM. This omission is explained in the phrase "a computable representation of all the physical . . . characteristics of a facility." The computable representation is a simulation of all physical characteristics such that three-dimensional views become just one logical manifestation of the model. In BIM, three-dimensional design is an inherent feature, not an enhancement. Moreover, because it is "computational," the data can be extracted, analyzed, and manipulated with appropriate software.

The descriptor "all the physical and functional characteristics" expands BIM beyond earlier three-dimensional design tools. In BIM, the building is not just a three-dimensional picture. Instead, it is a digital simulation of the facility that can be viewed, tested, designed, constructed, and deconstructed digitally. This promotes iterative design optimization and the ability to "rehearse" construction before ever moving labor, material, and equipment into the field.

The information maintained in a BIM also differs from the level

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and type of information maintained by traditional design tools. In traditional CAD, a wall or other elements are an assemblage of lines that, at most, define the geometric constraints of the wall. In BIM, the wall is an object[14] that contains a broad array of information in addition to physical dimensions. Rather than draw lines that describe dimensions of a design, designers organize intelligent objects into a design. Figure 1 is a screen shot from Revit Architecture 2008 showing element properties of a wall type (Exterior: CMU Insulated in this example), as well as values for the specific instance in the design.

In addition to containing detailed information about the element, the building information model contains information about how the element relates to the design in general and to other objects. This parametric architecture allows the model to adjust to design changes without having to individually adjust every individual element. The CMU wall, in the prior example, "knows" that it is supposed to extend from the foundation up to Level 1. If either of those parameters is changed, the height of the wall will automatically adjust to match. This increases design efficiency and reduces the potential for errors.

Because the BIM is a "computable representation," every manifestation of the BIM is automatically current. For example, sections or elevations are just different manifestations of the BIM information. If you make a change in plan view (and, therefore, to the underlying BIM data), the elevation and section views that are built from the same BIM data will automatically reflect the changes. Without any further intervention, schedules, tables, and other related data reflect the updated information. This also increases design efficiency and makes it virtually impossible for drawings to be internally inconsistent.

In addition, the BIM contains data concerning the object attributes that can be extracted into schedules, tables, bills of materials, or other data that can be printed, evaluated, or sent to other programs for analysis. Again, because the information is based on the central model, and reflects the current design, the potential for error is reduced.

The definition continues by including, as information in the BIM, "and its related life-cycle information." This indicates that the BIM contains the functional information necessary to evaluate the operational facility and optimize its performance for efficiency, sustainability, or other criteria.

Finally, the definition states that the BIM is to be a "repository" of data for facility management. The BIM is meant to be a living document that owners can use to manage their facilities, as well as build them. BIM's potential for facility management perhaps is its most important role, but one that is just beginning to be explored.

How Is BIM Being Used?

Single Data Entry; Multiple Uses

Traditional construction practices require the same information to be used multiple times by multiple organizations. Identical information is entered into different programs that provide specific solutions, such as structural analysis, code compliance, material quantities, or cost estimates. Every repetition is an opportunity for inconsistency and error. Moreover, even if information is digitally translated from one program to another, translation can alter or corrupt the data. Versioning can be a nightmare, even with compatible programs. Drawing backgrounds is a recurring example of this problem. 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 each is 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. Figure 2 shows an example of structural design information in the Revit structural design model and in ETABS, a structural analysis program.

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

Design Efficiency

Although the greatest efficiencies are obtained when BIM is used collaboratively, BIM design can aid a traditional design process. BIM software can reduce the cost of preparing 2D drawings in a conventional project, especially when designs are changing rapidly.[15] For example, in Revit®, any change in plan view automatically updates any section affected by the change. In Tekla Structures, changes in dimension or geometry automatically update details and related features. Moreover, using data-rich elements instead of drawn objects accelerates creation of contract drawings.

Consistent Design Bases

BIM modeling 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. Moreover, periodic imports into 3D visualization software, such as NavisWorks's Jetstream®, quickly expose inconsistencies.

3D Modeling and Conflict Resolution

The BIM model can render the design in three dimensions and does not require separate software to explore the model visually. This allows better exploration of space, visualization of light studies, and improved communication and understanding of design concepts within the team and with project stakeholders.

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 later will design key systems, such as HVAC or life safety equipment, that are not reflected in the design drawings. Even in a complete design-bid-build project, construction details and layouts may require information regarding the actual equipment that will be installed.

This information deficit typically is addressed by warning the contractor that the design is "diagrammatic" and that coordination will be required. Traditionally, the contractor coordinates physical drawings of different systems by overlaying them on light tables to determine if the various systems actually can be constructed in the allowed

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space. Alternatively, drawings for each discipline are merged and printed as color-coded composite drawings. 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. Light table resolution, however, is inherently a two-dimensional process applied to a three-dimensional problem. It is notoriously difficult and fraught with error, and thus conflicts are a primary source 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.[16] In a complex project, the savings derived from coordination can completely offset the model's cost.

Take-offs and Estimating

The model contains information, or can link to information, necessary to generate bills of materials, size and area estimates, productivity, materials cost, and related estimating information. It avoids the processing of material take-offs manually, thus reducing error and misunderstanding. Moreover, the linked cost information evolves in step with the design changes. The estimating advantages are so significant that some contractors will create models on 2D-designed projects to use the model's estimating capabilities.

Shop and Fabrication Drawing

In some instances, the models can provide construction details and fabrication information. This reduces costs by reducing the detailing effort and increases fabrication accuracy. In addition, because conflicts are resolved through the model, there is greater confidence that prefabricated material will fit when delivered. This allows more construction work to be performed offsite in optimal factory conditions. Subcontractors in the steel and MEP trades regularly use models to fabricate their products.

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 how changes affect key attributes, such as energy use, enhances the model's usefulness as a thinking tool. However, the software interface 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.[17] This may lead to using freeform design tools initially, with the results being loaded into the BIM system for refinement.[18]

Energy Optimization

Building information modeling systems such as Autodesk's® Revit® can provide information for energy analysis. They can be used to evaluate lighting design and options, and, in conjunction with their material take-off capabilities, they can generate documentation necessary for LEED™ certification.[19]

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 also can 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 also can be used to evaluate 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 workflow, 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. In addition, the model can be updated with as-built information, allowing accurate fabrication of custom components, such as building facades.

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 remodeling, additions, and maintenance.

Functional 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.[20]

Building information modeling is the most powerful tool yet conceived for integrating design, construction, and management of facilities. It allows designers to explore alternative concepts and iteratively optimize their designs. Contractors can use the model to rehearse construction, prepare cost data, coordinate drawings, and prepare shop and fabrication drawings. Owners can use the data to manage maintenance and facility renovation. Together, the parties can use building information modeling as a basis for collaboration.

Commercial Barriers to Building Information Modeling

Despite BIM's advantages, its adoption faces significant barriers.

Discussions of BIM generally focus on the technology. 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 early adopters are left attempting to integrate the new technologies into conventional practices.[21]

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

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

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decreased, and delivery times shortened.

For designers, however, BIM's economic benefits are less apparent. 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 promote efficiency and improved quality. However, unless the designer shares in the economic benefits, the owner, not the designer, reaps the immediate rewards. Yet it is the designer, not the owner, who 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 BIM's use. They need to restructure their workflows and reinvent the design process. If they do not share in the 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 adopting BIM. This concern is echoed in comments from the American Institute of Architects' 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.[22]

Although designers should logically benefit from BIM, new business models have developed slowly. The Australian alliance model is promising because it allocates risks and rewards among all parties. In the United States, however, few projects are 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, compensation, dispute resolution, and insurance. Custom agreements, unless crafted by seasoned practitioners, often are unbalanced and overlook key issues. Third, standard documents reduce the effort involved in documenting the roles and responsibilities on a project. Designers want to design structures, not structure contracts. Finally, crafting custom documents increases the transaction costs, and thus reduces the profitability of every transaction. Unfortunately, the current standard contract documents are just beginning to address BIM use.

For example, regarding electronic information transfer, 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.[23]

After many years, the AIA introduced the "separate written agreements" envisioned by the 1997 documents, the Digital Data Licensing Agreement[24] and the Digital Data Protocol Exhibit.[25] These documents reflect a major shift from using transfer documents to encapsulate liability to a more open and balanced approach.[26] They do not, however, attempt to address BIM's many legal implications, and AIA Document A201-1997, General Conditions of the Contract for Construction, does not discuss electronic documents, except to state that electronic documents provided by the architect are "instruments of service."[27] The Associated General Contractors also will address this area and it is expected that, by the summer of 2008, the AGC will have released its Building Information Modeling Addendum. However, the current drafts do not pretend they are full-fledged BIM contract documents.[28] The contract committees rightly believe that business practices must evolve further before contracts can be drafted to document the BIM process.[29]

Legal Concerns Inherent with BIM

The legal issues associated with BIM arise either from the technology itself or from the way the technology is used. BIM can be used solely to produce better-quality design documents without any intent to share information or to use the more extensive functionality that BIM allows. Used in this limited fashion, BIM is simply CAD on steroids. However, BIM also can serve as a collaborative framework. Used in this fashion, BIM serves as a catalyst to change the relationships between the parties and eventually the fabric of their agreements. Collaboration through BIM is a profound change that creates great opportunities, but it also creates new issues that need to be addressed and resolved.

Data Translation/Interoperability

As noted previously, there rarely will be a single BIM on a complex project. The architect may have its design model, the structural engineer its analysis model, the contractor its construction model, and the fabricator its shop drawing or fabrication model. In theory, these models will communicate seamlessly. However, under current technology, this is an aspiration, not a reality.

In current practice, there are differences in capability between BIM software. Information must be translated or must fit into the standards for IFC classes. Translators may not transfer all information from one model to another. In addition, some translators cannot "round trip," i.e., move data from one platform to another and then return it to the original platform after it has been modified or augmented. IFC classes do not exist for all data types, and there can be data loss if the host application supports functionality not modeled in the IFC class. The net result is that differences can be created during translation that

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cause model inconsistencies and errors.

Software is not perfect, and residual flaws will remain despite strenuous debugging. Luckily, these bugs are most often annoying, but not harmful. Sometimes, however, that is not the case. In *M. A. Mortenson Co., Inc. v. Timberline Software Corp.*,[30] a contractor's bid was $1,950,000 too low because of a software error. In affirming the software vendor's motion for summary judgment, the Washington Supreme Court held that the software warranty contained in the instruction manual was incorporated into the purchase contract and that its limitation to the purchase price was valid and not unconscionable.[31] Thus, if errors in BIM software cause economic loss to the user, the injured party has no realistic remedy. However, the user's liability to other parties is not similarly limited, causing a liability gap if the errors cause deficiencies in plans or other deliverables.

Data Misuse

Models can be created for several uses. However, a perfectly adequate model may cause difficulties if used for a different purpose than intended. Currency, adequacy, and tolerances are three issues that need to be addressed when information in one model is used for another.

It seems obvious to state that a model needs to be up-to-date. Still, a structural analysis model may not need to be absolutely synchronized with the architectural model to determine whether a structure is sound. However, the structural fabrication model that can be derived from the structural model must be synchronized with the architectural model or dimensional conflicts will exist. Similarly, the detail required in a model depends upon its intended use. The end user of information must understand what information the offered model contains—and does not contain. Finally, even if the model is current and adequate, the tolerances required may differ between disciplines. The tolerances assumed for structural steel, for example, may differ from the tolerances assumed by a window wall manufacturer. If the tolerances are different, the window wall may not fit when the structural steel is attached. In addition, when performing conflict checking, the models may need to include space around modeled elements to accommodate tolerances or additional material, such as fireproofing.

Intellectual Property

Many of the intellectual property issues are similar to those that existed before BIM. However, they are amplified by the amount of information contained in the BIM and its ease of transfer.

At the most fundamental level, who owns the information in the BIM? If the BIM is a collaborative work, then ownership may not be vested in a single party. If ownership issues are significant, they should be determined by contract. If information is confidential, then care must be taken to limit the distribution of information and have appropriate confidentiality agreements. Confidentiality issues can arise subtly when the embedded information is confidential, although the overall design is not inherently confidential. The upshot is that who owns the model, who owns information in the model, and who has access to the model all should be considered when the BIM procedures are developed.

Loss of Data

Building information models, like all digital data, are susceptible to data loss. If a party is hosting the information, it must take adequate steps to protect, and insure, against data loss or face possible liability for the ensuing losses.

Legal Status of the Model

Appendix A to the American Institute of Steel Construction's Manual of Practice states that the model is the contract document. Although this may be appropriate for steel fabricators and erectors, it is not yet appropriate in all contexts.

As noted previously, current practice uses a series of interlocking BIMs to communicate the design and construction intent for a project. In many instances, the complete design is only visualized when imported into a viewing program such as NavisWorks JetStream. Moreover, most BIMs do not contain all of the construction details required for a project. Thus, the contract documents will include some 2D information that is added to the information in the BIM. Finally, many permitting agencies are not yet ready to review digital information and require traditional submissions. Then there is the pesky problem of how to stamp the BIM. In practice, these issues are currently resolved by using a printed submission as the contract document, even if the communication flow has been digital.

If the BIM is not the contract document, what is its legal status? There are several options being followed. The first is that it is a "co-contract document" that is used between the parties but is not submitted to permitting agencies. In this case, the contracts need to state how inconsistencies will be handled. Another option is to use the BIM as an "inferential document." Under this option, the BIM provides visualization of the design intent inferable from the contract documents. Finally, the BIM can be used as an "accommodation document" that can be used, but not relied upon, by the recipients. This last approach is similar to the CAD transfer liability waivers that designers use when providing CAD documents to contractors. However, limiting reliance undermines the BIM's utility.

Standard of Care

When CAD was introduced, it was viewed as a tool for very large companies and very large projects. Now it is the standard, and, within a few years, BIM will be standard. This will change the standard of care with regard to design, especially in complex projects. Physical conflicts are an obvious example. If we can avoid virtually all conflicts by using a detailed model, we can expect the standard to say that we should. Resolving conflicts in the field or through postdesign coordination drawings will not be acceptable.

Design Delegation

Design delegation creates issues with licensing and responsible charge. BIM designs, especially when based on object technologies, can contain embedded information provided by manufacturers and subcontractors. In addition, some BIM software can react to changes in the model. Structural design software, for example, can change details in response to changes in the design. In neither of these cases will the architect or engineer of record have created the information or probably have checked the information before it is incorporated in the model.

A recent case decided in a different context highlights the licensing issue. In *Frankfort Digital Servs. v. Kistler*,[32] an individual used bankruptcy software to prepare his Chapter 7 bankruptcy. The software, which was not designed by a lawyer, was an "expert system" that pro-

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vided advice about filing options and "knew the law" as respects various jurisdictions. A series of adversary proceedings were initiated against the software provider, and using California law, the Ninth Circuit held:

> Frankfort's system touted its offering of legal advice and projected an aura of expertise concerning bankruptcy petitions; and, in that context, it offered personalized—albeit automated—counsel. Cf. Landlords Prof'l Servs., 215 Cal. App. 3d at 1609. We find that because this was the conduct of a non-attorney, it constituted the unauthorized practice of law.[33]

Design and detailing software also "knows" about the construction regulations, such as building codes. Moreover, they contain the specialized knowledge of engineering principles that is beyond the ken of laymen. From a legal perspective, there is little difference between Frankfort's bankruptcy software and advanced BIM tools.

There is a difference in use, however. In most instances, BIM design software is used by licensed professionals, rather than a lay individual, as in *Frankfort*. But this only raises a new issue. In virtually all jurisdictions, the design professionals of record must be in "responsible charge" of the design.[34] Responsible charge is generally met by either performing the work or having the work performed under the architect's or engineer's supervision. In this instance, however, work performed automatically by the software has clearly not been supervised by the architect or engineer of record. Moreover, the software or embedded object is probably *not* prepared by an appropriately licensed professional. Thus, design work provided by a subcontractor and embedded in the BIM may, or may not, have been prepared by a licensed professional.

Architecture and engineering practice will continue to evolve and use increasingly powerful design tools. However, as the above discussion demonstrates, the legal and regulatory structures have not adjusted to this change in practice.

Information Ownership and Preservation

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 backup strategies, there are risks involved with hosting data, and even small data losses 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[35] 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.

Data preservation 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.[36] 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. An advantage 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.

Issues Arising from How BIM Is Used—BIM as a Collaborative Framework

Our legal systems are essentially individualistic, 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.[37] 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. BIM as a collaborative framework layers additional issues onto those inherent in the technology.

Risk Allocation

Using BIM substantially alters the relationships between parties and blends their roles and responsibilities. Our legal framework, however, assumes a less collaborative environment with a 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 other means. Several key risk allocation issues are discussed below.

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

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to using risk transfer devices, such as limitations of liability or indemnity agreements, as methods to rebalance design professional liability.

Privity and Third-Party Reliance

The extent to which third parties may rely upon a designer's work is hotly contested across the United States. Two defenses often interposed are that there is a lack of privity and that the designer's services are not for plaintiff's benefit. The efficacy of these defenses varies widely between jurisdictions. However, using a collaborative model lessens the likelihood that the defenses will be successful anywhere.

Restatement (Second) of Torts section 552 sets the requirements for a negligent misrepresentation claim.

> (1) One who, in the course of his business, profession or employment, or in any other transaction in which he has a pecuniary interest, supplies false information for the guidance of others in their business transactions, is subject to liability for pecuniary loss caused to them by their justifiable reliance upon the information, if he fails to exercise reasonable care or competence in obtaining or communicating the information.
>
> (2) Except as stated in Subsection (3), the liability stated in Subsection (1) is limited to loss suffered:
>
> (a) by the person or one of a limited group of persons for whose benefit and guidance he intends to supply the information or knows that the recipient intends to supply it; and
>
> (b) through reliance upon it in a transaction that he intends the information to influence or knows that the recipient so intends or in a substantially similar transaction.
>
> (3) The liability of one who is under a public duty to give the information extends to loss suffered by any of the class of persons for whose benefit the duty is created, in any of the transactions in which it is intended to protect them.

In a collaborative project, the designer is aware that other parties are relying on the model's accuracy. It is a short step from foreseeability to knowing that the model is intended to provide information for the contractors' and subcontractors' benefit. Liability under the *Restatement* only requires that there be intent to influence and reach a group or class of persons.[38] 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.

Economic Loss Doctrine

The economic loss doctrine is another hotly contested defense in construction cases. Simply stated, the doctrine holds that purely economic losses cannot be recovered through a negligence cause of action.[39] As with the privity and third-party reliance defenses, the utility of the defense varies among jurisdictions and is dependent upon specific facts. Note, however, that the *Restatement* provision discussed above specifically addresses *pecuniary* losses. Where the parties intend to jointly rely on BIM information, it will be difficult to apply the economic loss damage.

Delegated and Distributed Design

These liability issues highlight concerns that arise from the distribution and delegation of design. Although design delegation issues can exist with or without collaborative use of BIM, they are clearly much more significant when more parties are involved and are involved more deeply. In looking at this issue, it is useful to focus on three questions that highlight the change between traditional and BIM processes: 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. Design elements 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.

Project design needs to be clearly expressed. 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.[40]

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. However, in a multidimensional 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 semipermanent 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"

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building elements. Most disputes regarding design deficiencies, however, have little to do with these design elements.[41] Instead, they arise from deficiencies in details, inadequate coordination, deviations in submittals, excessive changes, and failure 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 raise several significant questions:

- How will the contributions of various "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 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 reusing 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.

The model also may contain confidential or trade secret information. For example, a model for a manufacturing plant may disclose what a company is planning to build and the processes it will use. If information is broadly circulated in a collaborative team, how will this information be protected legally and practically?

Spearin ***Warranties***

In 1918, the U.S. Supreme Court introduced the *Spearin* doctrine, which allocated liability for defects that occurred during the construction process.[42] The *Spearin* court found that "the one who provides the plans and specification for a construction project warrants that those plans and specifications are free from defect."[43] A contractor that adheres to the project's design specifications cannot be held liable for defects arising from the specifications, and can sue for financial costs accrued for fixing the defected condition.[44] Thus, in the design-bid-build process, an implied warranty exists when the contractor is required to use a precise, detailed method in executing the contract.

The *Spearin* doctrine has had mixed results where the contractor has participated in preparing the design or the specifications. When contracts combine design and performance specifications, the courts still have allowed contractors to use an implied warranty theory if design specifications authored by someone else "are defective to the degree that adherence to them results in an article that fails to satisfy a stated performance specification."[45] However, in cases where the contractor could apprehend the potential for defect, the courts have found that the contractor assumed the risk of defect, and that no implied warranty exists.[46]

Where the contractor contributed pertinent information in designing a project, an implied warranty may not exist.[47] In *Austin Co. v. United States*, a contractor entered into a contract to design, manufacture, test, and deliver an innovative, novel digital data recording system.[48] The contract already contained some detailed specifications as to the method of constructing the system, but the contractor determined that the contract would be impossible to perform using those specifications.[49] The contractor modified the design, but still was unable to successfully execute the contract.[50] The court denied the contractor the defense of impossibility, finding that because the contractor had integrated his own design into that of the original contract, he warranted his ability to successfully perform those substituted specifications.[51]

Although no cases currently exist that specifically discuss how *Spearin* warranties are affected by BIM collaboration, it seems clear from analogous cases that extensive contractor and subcontractor involvement may sharply curtail implied warranties.

Insurance

If BIM is used solely to prepare better contract documents, there are few insurance concerns. However, as a collaborative framework, it does create possible issues.

Many professional liability policies have exclusions for "means and methods" and for joint venture liability. The "means and meth-

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ods" exclusions are designed to eliminate coverage for construction activities. In a collaborative setting, the designers may assist in developing sequences and construction procedures that at least skirt this exclusion. Sharing risk and reward, a hallmark of integrated project delivery, is also a joint venture characteristic and may lead insurers to deny or limit liability if joint venture liability is alleged.

Contractors also face insurance issues. Most standard commercial general liability policies exclude professional services and do not cover pure economic losses. As contractors become more deeply embedded in the design process, they must consider whether they should obtain contractor's professional liability coverage. Contractors also must recognize that their standard coverage provides little protection from economic claims based on their negligence.

Hosting data can create additional insurance issues. Essentially, data loss more closely relates to valuable papers coverage than traditional construction coverage. Moreover, if the parties are developing custom software for others' use, there are product risks involved that may not be covered by their customary policies. The insurance industry is aware of these issues and may see a market in providing coverage for collaborative projects. But currently, the parties must work with their brokers to ensure that the tasks they are undertaking on today's projects are adequately covered by their policies.

Technical Issues

Standards and Interoperability

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. Still, 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 that specific purpose. Thus, there often are 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.[52] While the preference to use familiar software is understandable, using 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 International Alliance for Interoperability (IAI)[53] has developed, and is continuing to develop, standardized descriptions through the Industry Foundation Classes (IFC) and IFC/xml common model.[54] 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. In addition to IFC compatibility, BIM software often is designed to interact with related software, such as structural or energy analysis programs. 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.

Archiving

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 and, if carefully preserved, can last 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."[55]

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.[56] If data are 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?

Integrated Project Delivery: The Way Forward

Building information modeling does not require a collaborative process. Designers can use the existing software to prepare traditional plans and specifications without providing the digital model to the contractor, its subcontractors and suppliers, or even to the owner itself. Contractors can create models for estimating, fabricating, or construction simulation without ever sharing the information. However, doing so wastes the power of building information modeling as a collaborative framework and discards the cost and quality advantages of single entry, multiple uses. This interrelationship between BIM and integrated project delivery was reflected in the AIA/AIACC *Guide*:

> **A Note on Building Information Modeling**
> It is understood that integrated project delivery and building information modeling (BIM) are different concepts—the first is a process and the second a tool. Certainly integrated projects are done without BIM and BIM is used in non-integrated

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processes. However, the full potential benefits of both IPD and BIM are achieved only when they are used together. Thus, the IPD phase descriptions included here assume the use of BIM.[57]

Moreover, an insular approach ignores current best practices favoring integrated project delivery with building information modeling at its core. To use BIM effectively, one must understand the trend to collaborative processes.

CURT White Papers

The construction industry has long been plagued by fragmented and fractious project delivery processes. Competitive low-bid procurement, guaranteed maximum price, and similar contract structures have fostered an individualistic, zero-sum approach to construction. These processes, in conjunction with other influences, have resulted in declining productivity. CURT, the Construction Users Roundtable, has concluded that wholesale industry change is necessary to achieve successful projects.[58]

In response to these productivity concerns, the Construction Users Roundtable issued a 2004 report implementing a CURT policy favoring integrated project delivery methodologies.[59] The report proposed four elements of a new policy framework.

> **Owner Leadership:** Owners, as the integrating influence in the building process, must engage in and demand that collaborative teams openly share information and use appropriate technology. CURT should establish policy and procedures to implement change in the AEC industry and encourage other building owner organizations to join the effort.
>
> **Integrated Project Structure:** The building process cannot be optimized without full collaboration among all members of the design/build/own project. CURT and other owner organizations should establish policies that support such collaboration.
>
> **Open Information Sharing:** Project collaboration must be characterized by open, timely, and reliable information sharing. CURT should advocate the establishment of procedures and protocols to achieve this end.
>
> **Virtual Building Models:** Effectively designed and deployed information technology will support full collaboration and information sharing and will lead to more effective design/build/manage process. CURT should endorse establishing technology-based lifecycles that optimize the creation, interaction, and transport of digital information throughout the building process.

CURT's vision of an integrated project built around virtual building information models was sharpened in a later report on implementing the optimized building process.

> **Technology/Building Information Modeling**
>
> Desire for re-use of project information beyond the building design created by architects and engineers will drive market adoption of building information models. Standards will be established for how building information models are developed with regard to content and modeling methods to produce information supporting downstream BIM automation services that are aligned with the owner's business objectives. Ultimately, for BIM to succeed, owners must acknowledge that all risk comes from them and ultimately returns to them.
>
> Owners must set the tone for the project by requiring their design and construction teams to use the latest technologies. Including these requirements in requests for proposals is one simple step that owners can start using. Further, the owner should use the technology as well.
>
> Owners should support industry initiatives to create standards where they are needed. Owners should also increase their awareness of the technology tools their consultants and contractors are using on their projects. Owners must recognize that the choice of technology solutions will affect their projects, not just during the development phase, but also after the project is completed and operating.[60]
>
> **Information Sharing**
>
> An essential element woven throughout the vision of transformation to an optimized model is the ability for all parties to communicate freely. Current practices of silence for fear of liability must be eliminated and a new process where decisions are made at the highest and most appropriate level of competency must be established to leverage team knowledge. . . . This issue most certainly is the greatest obstacle to transformation and the realization of the optimized project. Owners must demand this openness and transparency from the team entity of which they are a part.[61]

CURT's message is quite clear. Projects should capitalize on the competencies of all project participants and should promote open communication using the best technologies available. Building information models should be at the core of the process. However, CURT does not explain how this radical transformation should occur, or how to resolve the boundary problem.

Industry Responses

In June of 2007, the American Institute of Architects California Counsel issued *Integrated Project Delivery: A Working Definition*.[62] This document sets forth the fundamental assumptions and framework for a fully integrated project. Summarized in the graphic[63] below, it defines a highly collaborative process where all key participants are involved throughout the project lifecycle and contribute on a "best person" and "best for project basis." These concepts were further elaborated in the joint AIA/AIACC *Integrated Project Delivery: A Guide*[64] and have now been embodied in form integrated project agreements using Single Purpose Entity[65] and Owner-Architect[66]/Owner-Contractor[67] approaches.

The Associated General Contractors and others have recently released their ConsensusDocs Series 300 integrated project delivery agreement, which is based on the earlier Lean Construction Institute agreement.[68] It is a collaborative, multiparty agreement (owner/contractor/architect).

Contractual Frameworks for BIM

Many of the legal issues related to collaboration are caused by duties and obligations that transcend boundaries. When assessing contractual frameworks, it is useful to compare how they address (or ignore) boundary issues.

Status Quo

Building information modeling will be used regardless of business models. As stated to the author by a partner in a major international

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architectural firm: "We are using it. We will use it. Owners should just demand it." BIM can overcome the liability concerns and, in the hands of experienced users, reduces risk even if responsibility increases. If BIM reduces drawing errors and miscommunications between the parties, the frequency and severity of loss will be lessened even if the pool of potential relying parties is expanded.[69] However, little is done to address boundaries because they are simply ignored.

Design/Build

Design/build solves the boundary problem by increasing the boundary's perimeter until it absorbs the key participants. Thus, information sharing and reliance issues are resolved by joining the provider to the relying party. For this strategy to be fully effective, the key participants must be identified and included in the design/build team. This is automatically accomplished if the designers are employed by the design/build firm. It is more challenging if the designers or key systems providers are subcontractors to the design/build firm. In this instance, the additional parties can become part of the "virtual" design/build team if their liability is limited and their compensation, at least in part, is performance based.

Single Purpose Entities

Single purpose entities (SPE) also solve the boundary problem by bringing all parties within the boundary. The SPE is a limited liability enterprise (corporation, LLC, LLP, etc.) created to design, construct, and possibly own and operate a facility. The key participants sponsor the SPE and achieve gain by optimizing the SPE's success. The SPE contracts with the sponsors for the services required to construct the facility, with the specifics of scope, responsibility, and liability determined on a project-specific basis. The parties within the boundary must release each other from most potential liabilities or agree that any "in boundary" claims will be paid only by project insurance.

Single purpose entities are common in off-balance-sheet asset-financed projects (project finance). Under a classic project finance structure, nonrecourse loans are used to design and construct a revenue-generating asset that is owned by the SPE. The asset, and any guaranteed income streams, secures the loans. As might be expected, there also are many variations with limited recourse, limited sponsor guarantees, and similar features. However, the fundamental economic principle of the SPE is that the sponsor's return is based on creating value in it.

Unfortunately, SPEs burden the project with the additional costs of creating the SPE and managing its operations, precluding SPEs for smaller projects. Research on project finance shows that most projects exceed $100 million and a significant percentage exceed $500 million.[70] Furthermore, because the created value may be locked into the SPE for some time, the structure may not meet the parties' liquidity requirements.

Interlocking Risk Allocation

Interlocking risk allocations leave boundaries in place but lessen their importance. Under this approach, the key participants jointly negotiate specific limitations to their individual liabilities using releases, indemnifications, and limitations of liability. The interlocking risk allocations lessen the liability fears that accompany free flow of information.

Interlocking risk allocation has three potential drawbacks. First, there is a risk that the provisions will be inadequately drafted or incomplete. Second, some jurisdictions have restrictions on liability limitations or indemnification that could undermine this approach. Finally, although the risk allocations lessen disincentives, they do not create any additional incentive to collaborate. To enhance their success, interlocking allocation should be balanced by performance incentives.

Relation-Based Contracting (NEC3, Lean Construction)

The New Engineering Contract (NEC3) is a contract system currently used in the United Kingdom that is based on a collaborative management approach.[71] The guiding principles of NEC3 are:

> The two principles on which the ECC [Engineering and Construction Contract] are based and which impact upon the objective of stimulating good management are:
>
> o foresight applied collaboratively mitigates problems and shrinks risk, and
>
> o clear division of function and responsibility helps accountability and motivates people to play their part.
>
> A secondary but important theme is that people will be motivated to play their part in collaborative management if it is in their commercial and professional interest to do so. Reliance need not be placed upon exhortation, either within the contract or outside it.[72]

Lean Construction seeks to apply the Toyota management principles to the construction industry.[73] This includes recasting Toyota's just-in-time project delivery methodology into the concept of Last Planner, where project management becomes a workflow conversation from one precedent activity to the next. The Lean Construction approach has been applied in the Sutter Health system, where it was distilled into Five Big Ideas.[74]

> o Collaborate; really collaborate, throughout design, planning, and execution;
>
> o Increase relatedness among all project participants;
>
> o Projects are networks of commitments;
>
> o Optimize the projects not the pieces; and
>
> o Tightly couple action with learning.

Relational contracting is based on early and deep collaboration between all members of the design and construction process. Although BIM is not required to accomplish these ends, it supports relational contracting at a fundamental level. However, neither of these approaches directly addresses the liabilities inherent with increased collaboration. They assume that more collaboration results in less risk, therefore less loss.

Alliancing

The alliance approach to contracting has been successfully used for oil exploration, the delivery of infrastructure, and at least one significant structure.[75] A recent definition of alliancing is:

> A project alliance is a commercial/legal framework between a department, agency or government-backed enterprise (GBE) as "owner-participant" and one or more private sector parties as "service provider" or "non-owner participants" (NOPs) for delivery of one or more capital works projects, characterized by:

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o collective sharing of (nearly) all project risks;
o no fault, no blame and no dispute between the alliance participants (except in very limited cases of default);
o payment of NOPs for their services under a "3-limb" compensation model comprising:
- reimbursement of NOPs' project costs on 100 per cent open book basis;
- a fee to cover corporate overheads and normal profit; and
- a gainshare/painshare regime where the rewards of outstanding performance and the pain of poor performance are shared equitably among all alliance participants;
o unanimous principle-based decision-making on all key project issues; and
o an integrated project team selected on the basis of best person for each position.[76]

Initially developed for risky projects,[77] alliancing has attributes that are attractive in a broader setting. Three alliancing features work particularly well with building information modeling.

First, in an alliance, the parties agree that they will not sue each other, except for willful default. Sharing information cannot lead to liability. The liability concerns that impede BIM adoption do not apply in an alliance project.

Second, because a portion of compensation is tied to a successful outcome, there is an incentive to collaborate. In this context, BIM is an ideal platform for interactively sharing information, ideas, and solutions.

During early project development, the parties develop a target cost estimate that is used to calculate a target outturn cost (TOC). The amount of each party's compensation depends on whether the actual outturn cost (AOC) matches, exceeds, or is less than the TOC. In all cases, the nonowner participants are guaranteed their direct project costs plus project-specific overhead. Thus, if the AOC exceeds the TOC, the nonowner participants forfeit any profit or company overhead (painshare). If the AOC equals the TOC, the nonowner participants also receive their corporate overhead and "usual" profit. If the AOC is less than the TOC, then the nonowner participants also receive a portion of the difference (gainshare). Thus, there is a positive incentive for nonowner participants to assist each other. Contractors and vendors will want to participate in the design process to root out any source of error and suggest better, alternative methods of construction. Similarly, designers have an incentive to provide the model to contractors to allow accurate take-offs and construction simulations because they will increase project efficiency, as a whole. When compensation is tied to success, decisions are made on a "best for project" basis. Similarly, if issues arise during project execution, it will be in everyone's best interest to seek the optimal solution for the project.

Finally, under a "best person" philosophy, design can be delegated through the model, or by using interacting models, to the person, whether designer, subcontractor, fabricator, or supplier, with the greatest knowledge and skill.

These attributes are tailor-made for BIM. By limiting liability and tying compensation to firm success, alliancing makes boundaries irrelevant. BIM is also tailor-made for alliancing. Because it is fundamentally collaborative, BIM provides a structure for "best for project" decision making.

The Promise of BIM

Building information modeling promises exponential improvements in construction quality and efficiency. But current business and contract models do not encourage its use and actively inhibit the collaboration at its core. To bring BIM into the mainstream, we need to recraft business models and contract relationships to reward "best for project" decision making and to equitably allocate responsibility among all construction participants.

Endnotes

1. For example, the General Services Administration, the U.S. Army Corps of Engineers, and the U.S. Coast Guard all have BIM requirements.

2. During the last six months, the author has been involved in developing project documents for six hospitals and several major tenant improvement projects. All of these projects are being implemented in BIM.

3. Brian Gilligan & John Kunz, *VDC Use in 2007: Significant Value, Dramatic Growth, and Apparent Business Opportunity*, Center for Integrated Facility Engineering, Report TR171 (2007).

4. Autodesk press releases in 2006 and 2007 reported 100,000 Revit seats sold through June 8, 2006, and over 200,000 seats sold through May 4, 2007.

5. *Interoperability in the Construction Industry*, McGraw Hill SmartMarket Report (2007), at 11.

6. Computationally and numerically controlled—a manufacturing process where the fabrication of components is done by machines responding to computer directives, not human operation. Modern machining is often CNC because of its accuracy and repeatability. It also allows creation of complex and curved shapes that would be very difficult to duplicate with manually controlled tools.

7. An example is the Camera Obscura, Phase II at Mitchell Park by SHoP Architects. The structure was CNC manufactured from the design model and then "installed" by the contractor. The "installers" did not use plans; rather, they had instructions, much as might be in a kit, explaining where parts went and how to connect them. www.shoparc.com.

8. The National Institute of Building Science is currently developing a National Building Information Modeling Standard (www.nibs.org/newstory1.html), and the International Alliance for Interoperability (www.iai-international.org) has long been working on standards for data exchange between modeling software.

9. Most notably, the National Institute of Building Science's National Building Information Modeling Standard V. 1.0, www.facilityinformationcouncil.org/bim/publications.php. As this article is being written, ConsensusDocs is circulating a draft BIM specification that should be issued in 2008.

10. *See*, *e.g.*, American Institute of Architects standard documents C-106, Digital Data Licensing, and E-201, Digital Data Protocol; and the ConsensusDocs Document 200.2, Electronic Communications Protocol Addendum.

11. AGC is promoting the use of building information modeling and has published *A Contractor's Guide to Building Information Modeling, Edition One*, which is intended to show contractors "how to get started" with BIM. AIA's Technology and Practice Committee has long supported the use of digital design tools and building information modeling. In April of 2007, AIA introduced its digital practice documents C106 2007, Digital Data Licensing Agreement, and E201 2007, Digital Data Protocol Exhibit.

12. National Institute of Building Sciences is responsible for the National Building Information Modeling Standard (NBIMS).

13. www.nibs.org/newsstory1.html.

14. Terminology varies between software platforms. However, there are at least three types of objects in any program. Class objects have properties appropriate to everything in that family. Walls, for example, are a family. Subclasses are specific types in a family, for example, an eight-foot masonry wall. Subclasses inherit the attributes of their family and add attributes appropriate

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to the subclass. Classes and subclasses are essentially descriptions, not the object itself. Instances are the individual examples of a subclass in the design. This hierarchy makes it possible for designers to quickly create new component types by subclassing an existing component type, adding or modifying attributes, and then creating as many instances of the newly designed component as desired.

15. In discussion with the author, design firms with significant BIM experience have reported a 50 percent reduction in time to produce drawings as compared to conventional 2D CAD drawings.

16. 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.

17. L. Khemlani, *Autodesk Revit: Implementation in Practice*, ARCWIZ, 2004.

18. Supporting graphic creativity is already being addressed by the primary software houses. For example, Autodesk's Architectural Desktop® and Google's Sketch Up®.

19. Building Information Modeling for Sustainable Design, Autodesk® 2005.

20. Mieczyslaw Boryslawski, *Building Owners Driving BIM: The "Letterman Digital Arts Center" Story,* AECBYTES, Sept. 30, 2006.

21. 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.

22. 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.

23. AIA Document B141-1997, § 1.3.2.4.

24. AIA Document C106-2007.

25. AIA Document E201-1997.

26. In contrast, 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. *See* EJCDC C-700, § 3.06.

27. AIA Document A201-1997, § 1.6.1.

28. The California Council of the AIA is working on recommendations for Integrated Project Delivery that may include recommendations for a fully integrated BIM project, but although some contract language may be included in the recommendations, a complete contract set is unlikely. The National Institute of Building Sciences is developing BIM standards but is not attempting to create model contract documents.

29. AISC is somewhat further along regarding BIM contract practice, primarily because it has a narrower focus than the design professional associations.

30. 140 Wn. 2d 568; 998 P.2d 305 (2000).

31. *Id.* at 584–88.

32. 477 F.3d 1117 (9th Cir. 2007).

33. *Id.* at 1126.

34. In California, for example, architects must be in "responsible control" (CAL. BUS. & PROF. CODE § 5531.5) and engineers must be in "responsible charge" (CAL. BUS. & PROF. CODE § 6703). These requirements reverberated through many other statutes and regulations.

35. At least one insurer of design professionals is currently considering a "technology rider" to expand professional liability coverage to include some information technology risks.

36. *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*).

37. Although there are many notable examples, it is interesting that one of the Supreme Court's earliest construction decisions, *U.S. v. Spearin,* 248 U.S. 132 (1918), concerned where to place the boundary between the owner's responsibility and the responsibility of the contractor.

38. *See* comment h to subsection (2) of RESTATEMENT (SECOND) OF TORTS, § 552.

39. Further exposition on the economic loss rule can be found in papers published in 25:4 CONSTR. LAW. (2005) under *Taking the Measure of the Economic Loss Rule*. *See also* Andrus, Gessford & Joce, *The Economic Loss Doctrine in Construction Cases: Are the Odds for Design Professionals Better in Vegas?* J. ACCL, Winter 2008, at 53.

40. 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 they will 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.

41. In over twenty years of representing designers, the author has only once defended a designer sued because the design was "ugly."

42. United States v. Spearin, 248 U.S. 132 (1918).

43. Kevin C. Golden & James W. Thomas, *The* Spearin *Doctrine: The False Dichotomy Between Design and Performance Specifications*, 25 PUB. CONT. L.J. 47, 48 n.2 (1995) (quoting Thomas L. Patten, *The Implied Warranty That Attaches to Government Furnished Design Specifications*, 31 FED. B. J. 291, 292 (1972)).

44. Hercules Inc. v. United States, 24 F.3d 188, 197 (Fed. Cir. 1994).

45. R.J. Crowley, Inc. v. United States, 1990 U.S. App. LEXIS 21618 (Fed. Cir. 1990).

46. Blake Constr. Co. v. United States, 987 F.2d 743, 746 (Fed. Cir. 1993); Austin Co. v. United States, 314 F.2d 518, 519 (Ct. Cl. 1963); T. L. James & Co. v. Traylor Bros., 294 F.3d 743, 751 (5th Cir. 2002)**;** Martin K. Eby v. , 436 F. Supp. 2d at 1310.

47. *Austin Co.*, 314 F.2d at 520.

48. *Id.* at 519.

49. *Id.*

50. *Id.*

51. *Id.* at 520.

52. Federal Reserve Building, San Francisco. Articles describing the project are available on the web at www.architechmag.com/articles/detail.aspx?contentID=5154#trades and www.aia.org/SiteObjects/files/morphosis.pdf.

53. The International Alliance for Interoperability is the organization developing worldwide standards for exchange of building modeling information. Rather than develop software-specific conduits, the IAI publishes standards for data structures that model the key attributes of building elements and systems. These data structures can then be read and manipulated by Industry Foundation Class (IFC) compliant building information modeling software. More information regarding the IAI and the IFC concepts can be obtained from www.iai-international.org. In the United States, the IAI is represented by the Facility Information Council of the National Institute of Building Sciences, which publishes the National Building Information Modeling Standard. (www.facilityinformationcouncil.org/bim/publications.php).

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

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

56. www.rosettaproject.org/about-us/rosetta-disk/technology.

57. *Integrated Project Delivery: A Guide*, explanatory note at 20, AIA/AIACC 2007.

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58. The Construction Users Roundtable, *Optimizing the Construction Process: An Implementation Strategy*, WP-1003 (July 2006), at 4.

59. The Construction Users Roundtable, *Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation*, WP-1202 (August 2004).

60. *Optimizing the Construction Process*, *supra* note 58, at 14.

61. *Id.*

62. www.ipd-ca.net/images/Integrated%20Project%20Delivery%20Definition.pdf.

63. Reproduced with permission of AIACC.

64. www.aia.org/ipdg.

65. Standard Form Single Purpose Entity Agreement for Integrated Project Delivery, AIA C195 (2008).

66. Standard Form of Agreement Between Owner and Architect for Integrated Project Delivery, AIA B195 (2008).

67. Standard Form of Agreement Between Owner and Contractor for Integrated Project Delivery, AIA A195 (2008).

68. www.consensusdocs.org.

69. Risk management can take alternate routes. A person can choose to insulate him- or herself from liability by contract, thus reducing the risk of being successfully sued. In the alternate, the person can embrace the risk, manage it, and avoid the failure that would give rise to the lawsuit. Although both are rational, they represent very different approaches to risk management.

70. BENJAMIN C. ESTY, MODERN PROJECT FINANCE (2004), Exhibit 2-9, at 38.

71. www.neccontract.com.

72. Guidance Notes for the NEC Engineering and Construction Contract.

73. www.leanconstruction.org.

74. WILLIAM A. LICHTIG, TEN KEY DECISIONS TO A SUCCESSFUL CONSTRUCTION PROJECT, paper delivered at the American Bar Association Forum on the Construction Industry Fall Meeting, Sept. 2005.

75. Australian National Museum.

76. GOVERNMENT OF VICTORIA, PROJECT ALLIANCING PRACTITIONER'S GUIDE 2 (2006).

77. The alliancing delivery system was developed for oil exploration in the North Sea. At the time of these projects, it wasn't clear they could be accomplished and at what costs. Alliancing guaranteed recovery of costs and created incentives to collectively manage uncertainty and risk, thus eliminating the fear that causes participants to focus on their narrow self-interests.

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