BUILDING INFORMATION MODELING: A FRAMEWORK FOR COLLABORATION

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Introduction

Building Information Modeling (BIM) 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 and private owners in the United States are now 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. Between 2006 and 2007, the number of licensed seats of Autodesk’s flagship BIM product, Revit, doubled from 100,000 to 200,000. Moreover, McGraw-Hill estimated that that a tipping point was reached in spring 2008, with more teams using BIM than exploring it. Pilot projects have now been completed where the entire structure was built using CNC fabrication driven from the design model. As the technical issues of standards and

1 For example, the General Services Administration, the United States Army Corps of Engineers and the United States Coast Guard all have BIM requirements.
2 ‘Building Information Modeling’, McGraw-Hill SmartMarket Report (2008) reports increasing adoption of BIM throughout all sectors of the design and construction industry, albeit at different rates for different disciplines. In the author’s personal practice, BIM has become standard practice in significant projects and commonplace in others.
4 Autodesk press releases in 2006 and 2007 reported 100,000 Revit seats sold through 8 June 2006 and over 200,000 seats sold through 4 May 2007.
6 Computationally and Numerically Controlled. This is 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 designed 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.
8 The National Institute of Building Science, through the buildingSMARTalliance, is developing a National BIM Standard (the NBIMS Project, <www.buildingsmartalliance.org/nbims>) and the buildingSMART International Alliance for Interoperability (<www.iai-international.org>) has long been working on
interoperability are addressed, the software capabilities will develop further. This explosive growth has been supported by preliminary development of BIM standards and of related issues, such as electronic data licensing and file transfer. BIM is not tomorrow’s vision; it is today’s reality.

The legal and business structures for BIM, however, lag far behind. BIM’s implications are just being realised and few solutions have been developed. Moreover, liability concerns have lead practitioners, and their lawyers, to contractually isolate the building information model – thus depriving the model of its greatest benefits.

BIM 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.

But collaboration 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.

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. This paper 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.

9 Most notably, the National BIM Standard, see note 8. Moreover, standard contractual addenda have been issued to support using BIM. See, for example, Consensus DOCS 301-2008 Building Information Modeling Addendum and AIA Document E202-2008, Building Information Modeling Protocol Exhibit.


11 The Associated General Contractors is promoting the use of BIM and has published ‘A Contractor’s Guide to Building Information Modeling, Edition One’, that is intended to show contractors ‘how to get started’ with BIM. The American Institute of Architects (AIA) Technology and Practice Committee has long supported the use of digital design tools and BIM. In April 2007, the AIA introduced its digital practice documents C106-2007 and E201-2007, see note 10.
BIM: definition and characteristics

BIM broadly encompasses a series of technologies that are transforming design and construction. In essence, BIM uses information rich databases to characterise 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 (NIBS)\(^{12}\) defines BIM 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.’

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 characteristic 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, analysed and manipulated with appropriate software.

Thirdly, the description ‘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 optimisation and the ability to ‘rehearse’ construction before ever moving labour, material, and equipment into the field.

The information maintained in a BIM also differs from the level and type of information maintained by traditional design tools. In traditional CAD, a wall or other elements is an assemblage of lines that, at most, define the geometric constraints of the wall. In BIM, the wall is an object\(^{13}\) that contains a broad

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\(^{12}\) The NIBS is responsible for the National BIM Standard, see note 8.

\(^{13}\) The terminology varies between software platforms. However, there are at least three types of objects in any program. At the highest level are classes that abstractly represent a family of objects. Walls, for example, are an abstract family. These families or classes can be subclassed into specific object types, such as a masonry wall. Subclasses inherit
array of information in addition to physical dimensions. Rather than draw lines that describe dimensions of a design, designers organise 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.

**Figure 1:** Element properties in Autodesk Revit

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 example, ‘knows’ that it is supposed to extend from the foundation up to Level 1. If either of these parameters is changed, the height of the wall will automatically adjust to match. This increases design efficiency and reduces potential for errors.

Because the BIM is a ‘computable representation’ every manifestations of the model 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.

the attributes of their family and add attributes appropriate 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 design component as desired.
In addition, the model contains data concerning the object attributes that can be extracted as 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 model, ‘and its related life-cycle information’. This indicates that the model contains the functional information necessary to evaluate the operational facility and optimise its performance for efficiency, sustainability or other criteria.

Finally, the definition states that the model is to be a ‘repository’ of data for facility management. The model 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 is perhaps its most important role, but it is a role that is just beginning to be explored.

How is BIM being used?

Single data entry; multiple use

Traditional construction practices require the same information to be used multiple times by multiple organisations. 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. And keeping track of different versions can be a nightmare, even with compatible programs. Drawing backgrounds are a recurring example of this problem. The design consultants working alongside the architect 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. Figure 2, on the following page, 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 version 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. 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 the creation of contract drawings.

Figure 2: Structure design in Revit and ETABS

![Structure design in Revit and ETABS](image)

Courtesy of Walter P Moore

**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 visualisation software, such as NavisWorks’s Jetstream®, quickly exposes 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, visualisation 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.

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14 In discussion with myself, design firms with significant BIM experience have reported 50% reduction in time to produce drawings, compared with conventional 2D CAD drawings.
phase because the contractor will later design key systems, such as HVAC or life safety equipment that is 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 is typically 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 can actually be constructed in the allowed 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. But light table resolution is inherently a two dimensional process applied to a three dimensional problem. It is notoriously difficult and fraught with error. For these reasons, conflicts are a primary source of contractor claims.

BIM 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. In a complex project, the savings derived from coordination can completely offset the model’s cost.

**Figure 3:** Clash detection in NavisWorks Jetstream

![Clash detection in NavisWorks Jetstream](image)

*Courtesy of University of California, San Francisco*

**Take-offs and estimating**

The model contains information, or can link to information, necessary to generate bills of quantity, size and area estimates, productivity, materials cost, and related estimating information. It avoids processing material take-offs

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15 NavisWorks® was used to model LucasFilm’s Digital Arts Center; it identified several significant conflicts before construction commenced and was used to check field construction, again identifying mislocated elements and penetrations.
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 drawings**

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 off-site in optimal factory conditions. Subcontractors in the steel and mechanical, electrical and plumbing trades, regularly use models to fabricate their products.

**Visualisation 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 ‘sketch’, and therefore impeded the initial creative process. This may lead to using freeform design tools initially, with the results being loaded into the BIM system for refinement.

**Energy optimisation**

BIM 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, can generate the documentation necessary for LEED™ certification.

**Constructability reviews and 4D simulations**

Using the model, the contractor can visualise 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 optimise the construction sequence. The interaction between scheduling software and the model can also be used to evaluate the effect of construction delays and errors.

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17 Supporting graphic creativity is already being addressed by the primary software houses, for example, Autodesk’s Architectural Desktop® and Google’s Sketch Up®.
**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 ensure that fire response vehicles could navigate the parking structures.

BIM is the most powerful tool yet conceived for integrating design, construction and management of facilities. It allows designers to explore alternative concepts and iteratively optimise 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. And together, the parties can use BIM as a basis for collaboration.

**Commercial barriers to BIM**

Despite BIM’s advantages, its adoption faces significant barriers. Discussion of BIM generally focuses 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 analysed as a project delivery method, with new risks, rewards, and relationships. Unfortunately, new business models have not yet surfaced and early users are left attempting to integrate the new technologies into conventional practices.\(^\text{19}\)

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\(^{19}\) 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
Immediate benefits do not accrue to the key adopter (the designer)

The benefits an owner accrues from BIM are easily seen. Using a flexible model allows design optimisation, 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. Quality is increased, cost decreased and delivery times are shortened.

For designers, however, BIM’s economic benefits are less apparent. Properly implemented, BIM design systems do increase efficiency by reducing duplicate 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, 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 (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 jeopardise 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.’

Although designers should logically benefit from BIM, new business models have developed slowly. The Australian alliance model is promising because it

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20 Intelligent Building Models and Downstream Use (Comments of the Technology in Architectural Practice Advisory Group submitted for the 2007 revisions to the AIA’s documents B141 (Standard Form of Agreement Between Owner and Architect without a Predefined Scope of Architect’s Services) and A201 (General Conditions of Contract for Construction), American Institute of Architects 2005).
allocates risks and rewards among all parties. In the United States, however, few projects are operating under new paradigms.

**Absence of standard contract documents**

The lack of standard contract documents also hinders the 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. Secondly, standard documents establish a consensus allocation of risks and an integrated relationship between the risks assumed, compensation, dispute resolution and insurance. Bespoke agreements, unless crafted by seasoned practitioners, are often unbalanced and overlook key issues. Thirdly, standard contracts reduce the effort involved in documenting the roles and responsibilities on a project. Designers want to design structures, not structure contracts. Finally, drafting bespoke documents increases the transaction costs and thus reduces the profitability of every transaction. Unfortunately, the current standard contract documents are just beginning to address the use of BIM.

For example, regarding electronic information transfer, the AIA contract language in the owner-architect agreement states:

‘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.’21

In 2007, the AIA introduced the ‘separate written agreements’ envisaged by the 1997 documents: the Digital Data Licensing Agreement22 and the Digital Data Protocol Exhibit.23 These documents reflect a major shift from using transfer documents to insulate the creator from liability24 to a more open and

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21 AIA document B141-1997, Standard Form of Agreement Between Owner and Architect without a Predefined Scope of Architect’s Services, §1.3.2.4.
24 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 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. For example, EJCDC C-700, §3.06, states:

‘3.06 Electronic Data
A. Unless otherwise stated in the Supplementary Conditions, the data furnished by Owner or Engineer to Contractor, or by 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.'
balanced approach. Essentially, the Licensing Agreement establishes the licenses and permitted uses of the documents. Under this document, the user is licensed to use and rely on the electronic document if used for the project and only indemnifies the creator from liability caused by unauthorised use. The Protocol Exhibit expands upon the Licensing Agreement by creating a Project Protocol Table that allows the parties to specify the data format, the transmission method and the permitted use of almost every common construction document. They AIA documents have recently been joined by ConsensusDOCS, which has published an Electronic Communications Protocol Addendum that differs in mechanics and emphasis, but shares the AIA documents’ support for open communication protocols.\(^{25}\)

Although these communication protocols are a distinct improvement, they do not attempt to address BIM’s many legal implications. As of this date, the core contract documents, such as AIA document A-201-1997, General Conditions of the Contract for Construction, are silent regarding electronic documents, except to state that electronic documents provided by the architect are ‘instruments of service,’\(^{26}\) and do not discuss BIM at all. To fill this gap, both the AIA and ConsensusDOCS have published supplementary documents that are intended to amend the existing contract documents.

The ConsensusDOCS and the AIA BIM documents are quite different. Under the ConsensusDOCS Building Information Modeling Addendum, the owner appoints (and pays for) an Information Manager who is responsible for managing the model(s).\(^{27}\) The project participants then meet to develop a BIM Execution Plan that will be executed by the parties. In addition, the document provides a liability waiver relating to use of the model information and provide licensing to use the intellectual property. The AIA Building Information Protocol, takes a very different approach.\(^{28}\) It separates the process of using BIM from the substance of the models. In the process portion of the document, the Protocol defines the process and responsibilities for model management, the model standard, model ownership, model archiving and conflict coordination. The most significant aspect of the document,

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\(^{27}\) ConsensusDOCS 301 (2008).

\(^{28}\) ‘Building Information Modeling Protocol Exhibit,’ AIA document E202 (2008). The E202 is available with Model Element Tables matching traditional AIA phase definitions, the newer Integrated Project Delivery phase definitions, or with blank phase definitions that can be defined by the user(s).
however, is its handling of the model’s substance. The Protocol defines five Levels of Detail (LOD 100 – LOD 500) for the modeled elements. Using a Model Element Table (completed by the parties) it specifies who (Model Element Author) is responsible for developing the element and the Level of Development at each phase of design and construction. The individual elements are defined using the Uniformat codes used for building specification, cost estimating and cost analysis. This allows the model information to directly relate to the cost estimating and specifications systems used by contractors.

**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 the former limited fashion, BIM is simply CAD on steroids. But BIM can also serve as a collaborative framework. Used in this way, 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 also creates new issues that need to be addressed and resolved.

**Data translation / interoperability**

As noted previously, there will rarely 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. But 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 Industry Foundation Classes (IFC). Translators may not transfer all information from one model to another. In addition, some translators can not ‘round trip’, that is 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

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29 The Model Element Table is based on the Model Progression Matrix developed by AIA California Council and can be downloaded at www.ipd-ca.net/Model%20Progression%20Spec%20V%2008-08-20.xls


31 The Industry Foundation Classes specification is a neutral data format to describe, exchange and share information typically used within the building and facility management industry sector. The IFC specification is developed and maintained by buildingSMART International, bSI, (formally known as International Alliance for Interoperability, IAI) <www.ifcwiki.org/index.php/Main_Page>
can be created during the translation process that can cause model inconsistencies and errors.

Software is not perfect and residual flaws will remain, despite strenuous debugging efforts. Luckily, these bugs are most often annoying but not harmful. Sometimes, however, that is not the case. In *M A Mortenson Company Inc v Timberline Software Corporation*, 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. Thus, if errors in BIM software cause economic loss to the user, the injured party has no realistic remedy. But 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 a variety of uses. But 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. However, a structural analysis model may not need to be absolutely synchronised with the architectural model to determine whether a structure is sound. But the structural fabrication model that can be derived from the structural model must be synchronised 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.

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At the most fundamental level, who owns the information in the BIM? If the model 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 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 models to communicate the design and construction intent for a project. In many instances, the complete design is only visualised when imported into a viewing program, such as NavisWorks JetStream. Moreover, most models 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 model. 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 model. 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 model 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 model as an ‘inferential document’. Under this option, the model provides visualisation of the design intent inferable from the contract documents. Finally, the model 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. But limiting reliance undermines the model’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 post-design 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 Services v Kistler, 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 provided 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 personalised – albeit automated – counsel. … We find that because this was the conduct of a non-attorney, it constituted the unauthorized practice of law.’34

Design and detailing software also ‘knows’ about the construction regulations, such as building codes. Moreover, they contain the specialised 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 the Frankfort case. But this only raises a new issue.

In virtually all jurisdictions, the design professionals of record must be in ‘responsible charge’ of the design.35 Responsible charge is generally achieved

34 Frankfort Digital Services v Kistler 477 F.3d 1117 (9th Cir 2007), at 1126.
35 In California, for example, architects must be in ‘responsible control’ (Cal Bus & Prof, §5531.5) and engineers must be in ‘responsible charge’ (Cal Bus & Prof, §6703). These requirements reverberate through many other statutes and regulations.
by either performing the work or having the work performed under the architect’s or engineer’s supervision. But in this instance, 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. And 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. But 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 back-up 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 and the designer’s commercial general liability policy will not respond to purely economic losses. The difficulty in characterising 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. 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 recognise 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

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

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.

**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.\(^3\) Privity of contract, the economic loss
document, 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 issue 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.

\(^3\) Although there are many notable examples, it is interesting that one of the Supreme
Court’s earliest construction decisions, *US v Spearin*, 248 US 132 (1918) concerned
where to place the boundary between the owner’s responsibility and the responsibility of
the contractor.
This may lead 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 U.S. Two defenses often interposed are: 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 defences will be successful anywhere.

Restatement of Torts (Second) section 552 states 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. For this reason, contractors and subcontractors relying on the model are likely to be able to bring an action against the designer for damages caused by negligent errors.

39 See comment h to Subsection (2) of Restatement of Torts (Second), §552.
**Economic loss doctrine**

The economic loss doctrine is another hotly contested defence in construction cases. Simply stated, the doctrine holds that purely economic losses cannot be recovered through a negligence cause of action.\(^{40}\) As with the privity and third-party reliance defences, the utility of the defence 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. They 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. 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

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address two issues: first, the contracts between the parties should define the
design deliverables in content, time, and type of electronic media used.
Secondly, 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.41

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 disputes regarding design
deficiencies, however, have little to do with these design elements.42 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 raises several
significant questions:

- How will the various designers’ contributions be unwound to
determine responsibility?

41 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.

42 In over 20 years of representing designers, the author has only once defended a designer
sued because the design was ‘ugly’.
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 ‘designer’s’?

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 may also 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 Supreme Court introduced the Spearin doctrine, which allocated liability for defects that occurred during the construction process. 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.” A contractor who 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. 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 have still 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’. 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.

Where the contractor contributed pertinent information in designing a project, an implied warranty may not exist. In *Austin v United States*, a contractor entered into a contract to design, manufacture, test and deliver an innovative, novel digital data recording system. 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. The contractor modified the design, but was still unable to successfully execute the contract. The court denied the contractor

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43 United States v Spearin (1918) 248 US 132.
48 Austin Co, 314 F.2d, page 520.
49 Austin Co, note 47, page 519.
50 Austin Co, note 47, page 519.
51 Austin Co, note 47I, page 519.
the defence 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.52

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 methods’ 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. And contractors must also recognise that their standard policies provide little protection from economic claims based on their negligent performance.

Hosting data can create additional insurance issues. Essentially, data loss more closely relates to valuable papers coverages than traditional construction policies. Moreover, if the parties are developing custom software for others’ use, there are product risks involved that may not be covered by their usual 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 assure 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

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52 Austin Co, note 471, page 520.
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 realised.

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 are often multiple models existing on a single project that are optimised 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, 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 customise 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, standardised descriptions through the Industry Foundation Classes (IFC) and IFC/xml common model. 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 capitalise 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 is often 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.

53 Additional information concerning the IAI and IFC foundation classes can be found at <www.iai-international.org>
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.’

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. 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?

Integrated project delivery: the way forward

BIM 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 sub-contractors 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 BIM as a collaborative framework and discards the cost and quality advantages of single entry, multiple use. This interrelationship between BIM and Integrated Project Delivery (IPD) 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 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.’

54 M Wein being quoted by Norsam Technologies, the archival vendor for The Rosetta Project.
55 <www.rosettaproject.org/about-us/rosetta-disk/technolog>
Moreover, an insular approach ignores current best practices favouring integrated project delivery with BIM 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. The Construction Users Roundtable (CURT) has concluded that wholesale industry change is necessary to achieve successful projects.57

In response to these productivity concerns, CURT issued a 2004 report implementing a CURT policy favouring IPD methodologies.58 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 organisations to join the effort.

**Integrated Project Structure:** The building process cannot be optimised without full collaboration among all members of the design/build/own project. CURT and other owner organisations should establish policies that support such collaboration.

**Open Information Sharing:** Project collaboration must be characterised 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 optimise 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 optimised building process.

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Technology/BIM

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 recognise 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.59

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.60

CURT’s message is quite clear. Projects should be capitalised 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. But CURT does not explain how this radical transformation should occur, nor 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’.61 This document sets forth the fundamental assumptions and framework for a fully integrated project.

60  CURT Report 2004, note 57.
Summarised in the graphic 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, and have now been embodied in form integrated project agreements using Single Purpose Entity and Owner-Architect/Owner-Contractor 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. It is a collaborative, multi-party agreement (owner/contractor/architect).

Contractual frameworks

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

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

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62 Reproduced with permission of the American Institute of Architects California Counsel.
63 <www.aia.org/ipdg>
67 <www.consensusdocs.org>
will be lessened even if the pool of potential relying parties is expanded. 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, limited liability company, limited liability partnership, for example) created to design, construct and possibly own and operate a facility. The key participants sponsor the SPE and achieve gain by optimising 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.

SPEs are common in off balance sheet asset financed projects (project finance). Under a classic project finance structure, non-recourse loans are used to design and construct a revenue generating asset that is owned by the SPE. The asset, and any guaranteed income streams, secure the loans. As might be expected, there are also numerous 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 the SPE.

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. Furthermore, because the created value may be locked into the SPE for some time, the structure may not meet the parties’ liquidity requirements.

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68 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.

**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 published in the UK that is based on a collaborative management approach.70

The two principles on which the Engineering and Construction Contract (ECC) are based and which impact upon the objective of stimulating good management are:

- foresight applied collaboratively mitigates problems and shrinks risk, and
- 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.

Lean Construction seeks to apply the Toyota management principles to the construction industry.71 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.72

- Collaborate; really collaborate, throughout design, planning, and execution;
- Increase relatedness among all project participants;

70 NEC3 Engineering and Construction Contract (ECC) (Thomas Telford Ltd)
<www.neccontract.com>
71 <www.leanconstruction.org>
72 William A Lichtig, ‘Ten key decisions to a successful construction project’ (paper delivered at the American Bar Association, Forum on the Construction Fall Meet, September 2005).
Projects are networks of commitments;
Optimise the projects not the pieces; and
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.73 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, characterised by:

- collective sharing of (nearly) all project risks;
- no fault, no blame and no dispute between the alliance participants (except in very limited cases of default);
- payment of NOPs for their services under a “3-limb” compensation model comprising:
  - reimbursement of NOPs’ project costs on 100% 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 or poor performance are shared equitably among all alliance participants;
- unanimous principle-based decision-making on all key project issues; and
- an integrated project team selected on the basis of best person for each position.74

Initially developed for risky projects,75 alliancing has attributes that are attractive in a broader setting. Three alliancing features work particularly well with BIM.

73 Australian National Museum.
75 The Alliancing delivery system was developed for oil exploration in the North Sea. At the time of these projects, it was not clear that they could be accomplished and at what cost. Alliancing guaranteed recovery of costs and created incentives to collectively
First, in an Alliance, the parties agree that they will not sue each other, except for wilful default. Sharing information can not 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 non-owner participants are guaranteed their direct project costs plus project specific overhead. Thus, if the AOC exceeds the TOC, the non-owner participants forfeit any profit or company overhead (painshare). If the AOC equals the TOC, the non-owner participants also receive their corporate overhead and ‘usual’ profit. If the AOC is less than the TOC, then the non-owner participants also receive a portion of the difference (gainshare).

Thus, there is a positive incentive for non-owner 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 the 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.

**Integrated Project Delivery**

Collaborative project approaches are beginning to appear in the United States under the general term Integrated Project Delivery (IPD). Unlike Alliancing, which has generally been used for major civil and industrial infrastructure, IPD in the United States has been primarily used for complex vertical structures, such as hospitals. IPD is a radical departure from traditional prescriptive and adversarial contract approaches and offers the potential for increased project value and greater reward for all participants.
Most of the existing IPD projects have been performed using bespoke agreements.\(^76\) Two of the primary publishers of standard agreements, the American Institute of Architects and ConsensusDOCS have also issued contracts for use in integrated projects although their approaches vary significantly.

ConsensusDOCS has issued a multi-party agreement that, depending upon the internal options chosen, can support a collaborative project.\(^77\)

The AIA has issued two very different contract sets. The most innovative uses a special purpose limited liability company that is owned by the project owner, architect and contractor.\(^78\) The special purpose entity contracts with the architect and the contractor to design and construct the project subject to its direction with incentives and risks based on project performance. This approach is flexible, but complex and, depending upon where the project is located, can create corporate governance and licensing issues. The AIA’s alternative approach\(^79\) is more traditional. The contractor and architect separately contract with the owner under terms that encourage collaboration but still adhere to traditional compensation models, risk allocation, and project management roles.

Although the custom and standard form IPD approaches vary significantly,\(^80\) they all assume early involvement by key construction as well as design personnel. Moreover, they assume a high level of information exchange that is consistent with and supported by BIM. This leads recursively to BIM being best supported by collaborative project delivery methods that themselves are best executed using BIM.

\(^76\) Sutter Health in California has undertaken a broad range of hospital and healthcare projects using its proprietary contract form. Variants of this form have been used for hospital and research laboratory projects in Missouri and Wisconsin. The author’s practice has used an approach that was initially developed for Autodesk projects in California and Massachusetts that were closely modeled on IPD principles. This approach has also been used on hospital projects.


\(^80\) The key IPD elements are 1) early involvement of key participants; 2) designing to budget rather than designing to the programme; 3) joint project management; 4) economic risk and reward shared based on project outcome; and 5) waiver of claims to reduce internal conflict and defensiveness. These elements are not completely embraced in the current standard form agreements.
Conclusion

BIM 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.

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‘The object of the Society
is to promote the study and understanding of
construction law amongst all those involved
in the construction industry’

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