LEGAL ISSUES AND RISKS ASSOCIATED WITH BUILDING INFORMATION MODELING TECHNOLOGY

BY

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LEGAL ISSUES AND RISKS ASSOCIATED WITH BUILDING INFORMATION MODELING TECHNOLOGY

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ABSTRACT

Building Information Modeling (BIM) is a tool that has already changed the ways projects are conceived, designed, communicated and constructed by integrating the fragmented Architecture, Engineering, and Construction (AEC) industry. BIM has proven to reduce risk by eliminating inefficiencies and redundancies while improving collaboration and communication which ultimately enhances the overall productivity of the project. Despite the significant benefits associated with BIM there are a host of legal issues, risks and barriers which the industry has not addressed properly. In the context of this gap, the purpose of this thesis is to introduce the subject of BIM and provide an overview of its current uses in AEC industry. A wide spectrum survey and detailed case study was conducted. BIM methods are expanding and have entered mainstream use, which requires immediate consideration to properly address the Legal Issues and Risks of BIM to support this dramatic shift in project delivery methods.

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LIST OF ABBREVIATIONS

2D	Two-dimensional
3D	Three-dimensional
A/E	Architect/Engineer
AEC	Architecture-Engineering-Construction
AGC	Associated General Contractors of America
AIA	American Institute of Architects
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BIM	Building Information Model or Building Information Modeling
CAD	Computer Aided Drafting
CATIA	Computer Aided Three Dimensional Interactive Application
CIFE	Center for Integrated Facility Engineering, Stanford University
EJCDC	Engineers Joint Contract Documents Committee
GSA	General Services Administration
HVAC	Heating, Ventilating and Air Conditioning
IAI	International Alliance for Interoperability
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
NIBS	National Institute of Building Standards
NIST	National Institute of Standards and Technology
VDC	Virtual Design and Construction

CHAPTER 1 – INTRODUCTION

1.1 INTRODUCTION TO THESIS

Building Information Modeling (BIM) is a tool that has already changed the ways projects are conceived, designed, communicated and constructed by integrating the fragmented Architecture, Engineering, and Construction (AEC) industry. BIM has proven to reduce risk by eliminating inefficiencies and redundancies while improving collaboration and communication which ultimately enhances the overall productivity of the project. Despite the significant benefits associated with BIM there are a host of legal issues and risks which the industry has not addressed properly. In the context of this gap, the purpose of this thesis is fivefold:

1) To introduce and define BIM to the AEC industry as a tool which facilitates integrated practice and reduces gross inefficiencies and redundancies.
2) To describe and illustrate the variety of ways designers and contractors are currently applying BIM tools to the construction process and address the legal issues, risks and barriers raised by the use of BIM in these contexts in conjunction with a wide spectrum survey of AEC industry members.
3) Provide detailed case study to validate the application of this integrated practice methodology. This thesis presents methodology for construction planning with BIM, a review of trade space occupation and priority, and provides an illustration of the application of this systematic approach on a Case Study project “Sprint Center Arena.”

4) Review contract terms that will assist with the implementation and management of BIM; and discuss how BIM can be addressed contractually to create effective integrated processes to maximize its benefits.

5) Challenge the AEC industry to make collaboration a top priority on future projects by adopting BIM whilst embracing the evolution into integrated practice methodology by working across traditional stakeholder boundaries since it is arguable that few design or construction teams are truly using BIM to its fullest extent today. If and when BIM is developed and utilized to its fullest extent, it will enable positive, sweeping change for the AEC industry.

1.2 BACKGROUND OF BIM

Construction projects, by definition are a unique undertaking aimed at achieving specific predefined goals and objectives that are inherent with risk during a finite time period. These risks are compounded by the project delivery methods utilized in today's markets and the ever-demanding time constraints associated with completing projects on time, under budget, while meeting contractual requirements. The future of the design and construction industry is going to be driven by the use of technology.

Industries such as aerospace and automobile manufacturing have used enterprise wide information technology to fundamentally change their ways of doing business. Similar to CATIA, three-dimensional computer-aided design system that

revolutionized airplane design, BIM radically transforms the way building designs are created, communicated and constructed. BIM is a young technology that is praised by architects for its versatility in developing design solutions and 3D visualizations. Less publicized is the use of BIM as a construction tool. Many large construction companies are experimenting with BIM to generate cost and schedule savings. BIM is expected to drive the construction industry towards a "model based" process and gradually move the industry away from a "2D Based" process.

1.3 DEFINITION AND CHARACTERISTICS OF BIM

BIM is not merely a 3D graphic representation of design intent; rather, it is a comprehensive information management tool based on the simulation of design and construction. BIM has its roots in Computer Aided Design (CAD) development from decades ago, yet still has no single, widely-accepted definition in the AEC industry. However, in the author's opinion, the most comprehensive definition of building information modeling has been defined by Associated General Contractors of America (AGC) which states "BIM is the development and use of a computer software model to simulate the construction and operation of a facility." The resulting model, a building information model, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility (Associated General Contractors of America, 2006). This "Model Based"

process where buildings will be built virtually before they get built in the field is also referred to as Virtual Design and Construction (VDC).

M. A. Mortenson Company (Mortenson) thinks of BIM as "an intelligent simulation of architecture," that must exhibit six (6) key characteristics (Campbell, 2007):

1) Digital – enabling simulation of design and construction
2) Spatial – 3D, to better represent complex construction conditions than 2D drawings
3) Measurable – data is quantifiable, dimension-able, and query-able more than visual
4) Comprehensive – encapsulating and communicating design intent, building performance, constructability, and sequential and financial aspects of means and methods
5) Accessible – data made available to the entire project team through interoperable and intuitive interface, including architects, engineers, contractors, fabricators, owners, facility maintenance, and users.
6) Durable – data that reflects as-built conditions and remains usable through all phases of a facility's life, including design and planning, fabrication and construction, and operations and maintenance

1.4 JUSTIFICATION FOR BIM

There are great opportunities for improvement in design and construction industry productivity. As measured over the past four decades, the U.S. construction

industry has failed to keep pace with steadily increasing productivity in other industrial sectors. The productivity of the construction industry, as measured by constant contract dollars of new construction work per hourly work hour, has gradually declined (with some modest exceptions) over the past 40 years at an average compound rate of -0.59%/year as shown in **Figure 1-1.** This is particularly alarming when compared to the increasing labor productivity in all non-farm industries, which have experienced an increasing productivity of 1.77%/year over the same time period. Over the past decade, this trend has slightly improved but the decline in construction labor productivity relative to the rest of the industry has continued (Teicholz, 2004).

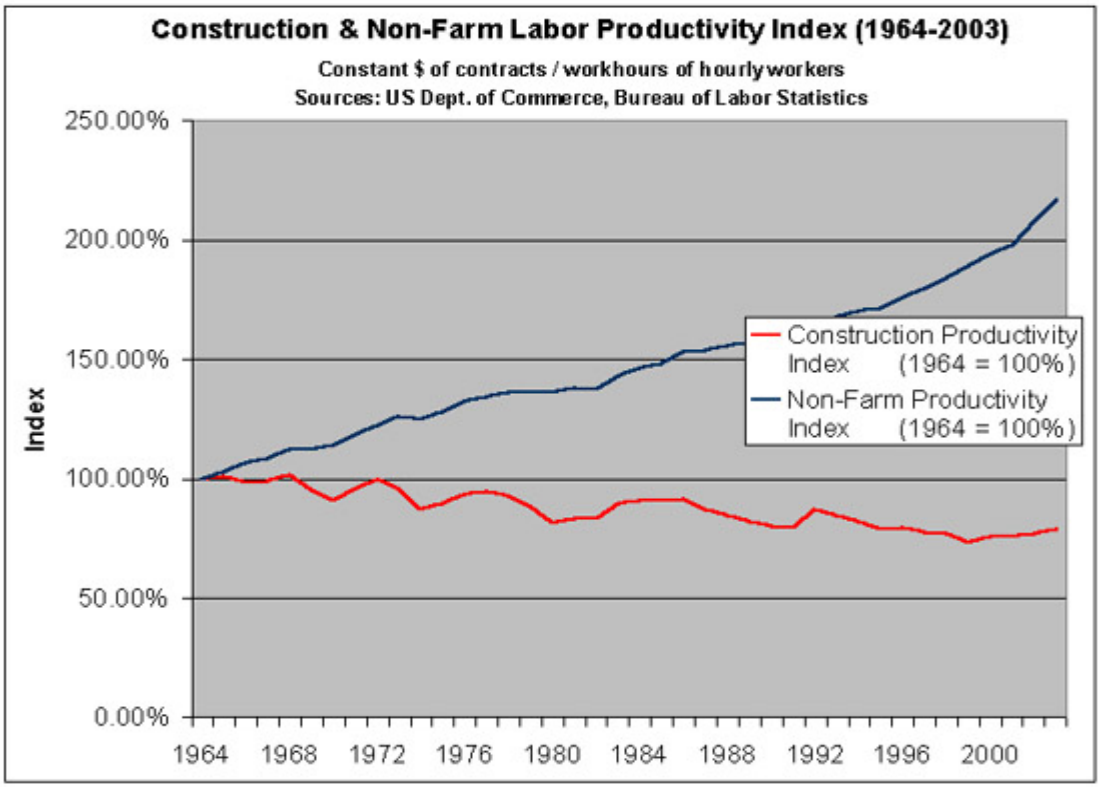


Figure 1-1. Key Productivity Trends in the Construction Industry (*Source: Teicholz)*

To further justify and support the immediate need for designers and contractors to make the dramatic shift to adopt and embrace BIM as the next information tool, a study performed for the National Institute of Standards and Technology (NIST) estimated that in 2002, $15.8 billion was lost due to "significant inefficiency and lost opportunity costs associated with interoperability," in the capital facilities industry. Moreover, building owners and operators bore the majority (2/3) of these costs. When applied to GSA's $11 billion of construction program currently in the pipeline, NIST's findings equate to $460 million of waste or rework on GSA projects. This waste and rework comes from many different sources: inaccurate as-built drawings, miscommunication among stakeholders and inefficient and inconsistent analysis of designs (e.g., spatial analysis, energy analysis, etc).

1.5 BENEFITS OF BIM

BIM technologies can aid the entire AEC industry in reducing this waste by influencing projects earlier in the project delivery phase. There are eleven (11) common "early" benefits that most contractors experience in their use of BIM and they are as follows (Associated General Contractors of America, 2006):

1) Visualization**
2) Scope Clarification*
3) Partial Trade Coordination**
4) Collision Detection / Avoidance**
5) Design Validation**
6) Construction Sequencing Planning/Phasing Plans / Site Logistics**

7) Marketing Presentations*

8) Option Analysis (Value Engineering Analysis)

9) Walk-through and Fly-throughs*

10) Virtual Mock-ups

11) Sight Line Studies*

* Indicates BIM Uses on Case Study Project: Sprint Center Arena

** Indicates BIM Uses To Be Further Examined in Chapter 4

1.6 OVERVIEW OF BIM

To better understand BIM technology a brief comparison of a "2D Based" versus a "Model Based" is necessary. The traditional 2D Based design evolved from pencils, to mylar, to overlay drafting, to the layers and levels seen in CAD programs today. These traditionally accepted "flat" media (separate nature of layers), and multiple design and consulting disciplines have contributed to the 2D "disconnected" design process currently prevalent in our industry as shown in **Figure 1-2.** The 2D process and tools available to the design team contribute to the inability to visualize, think and document in an integrated 3D world. This 2D process allows for the possibility that designs are not complete and not fully coordinated among its design disciplines. The traditional conflict resolution with 2D design process is complex, slow, expensive and error prone. This reality generates a high volume of conflicts which become claims that are a major problem in the AEC industry due to the high costs and time to resolve them. The construction industry exists within an adversarial

society and thus conflict is unavoidable but conflict can certainly be mitigated by the utilization of 3D Based process.

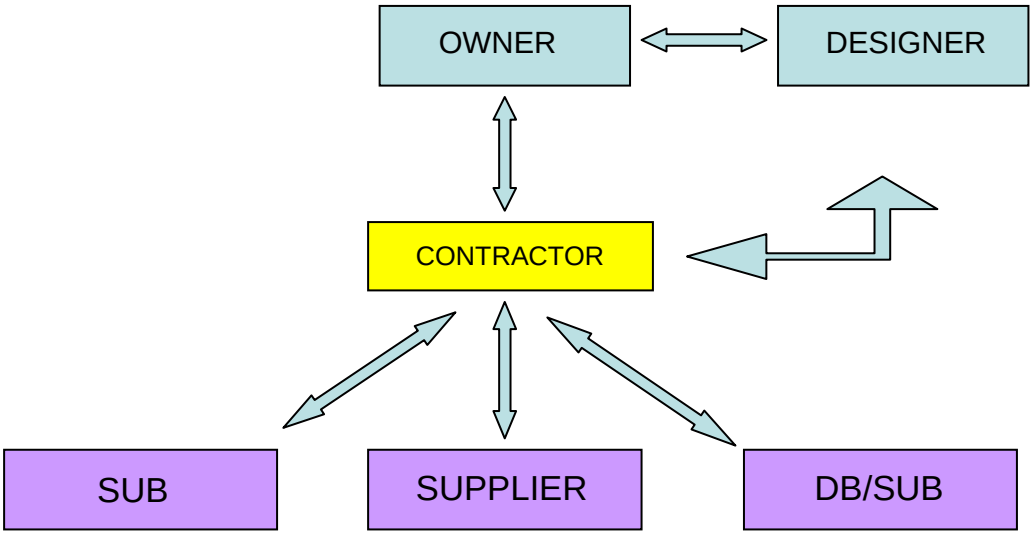


Figure 1-2. Typical Pre-History of BIM (*Source: Ashcraft*)

In a 3D Based process as shown in **Figure 1-3**, the technology and tools allow us to see, and collaborate in 3D. The information in 3D is interactive and fosters intelligence. The use of intelligence housed within a BIM allows us to see and interact differently. The benefits of BIM include improved efficiencies in the design, detailing & construction processes with reduced errors which result in less cost and fewer claims. In another words, the 3D Based process produces higher quality designs. Visualization is one of the greatest benefits of this 3D Based process. The amount of mistakes made in the field partially depends on communication between those that know what the building is supposed to look like (design team) and those actually building it (construction team).

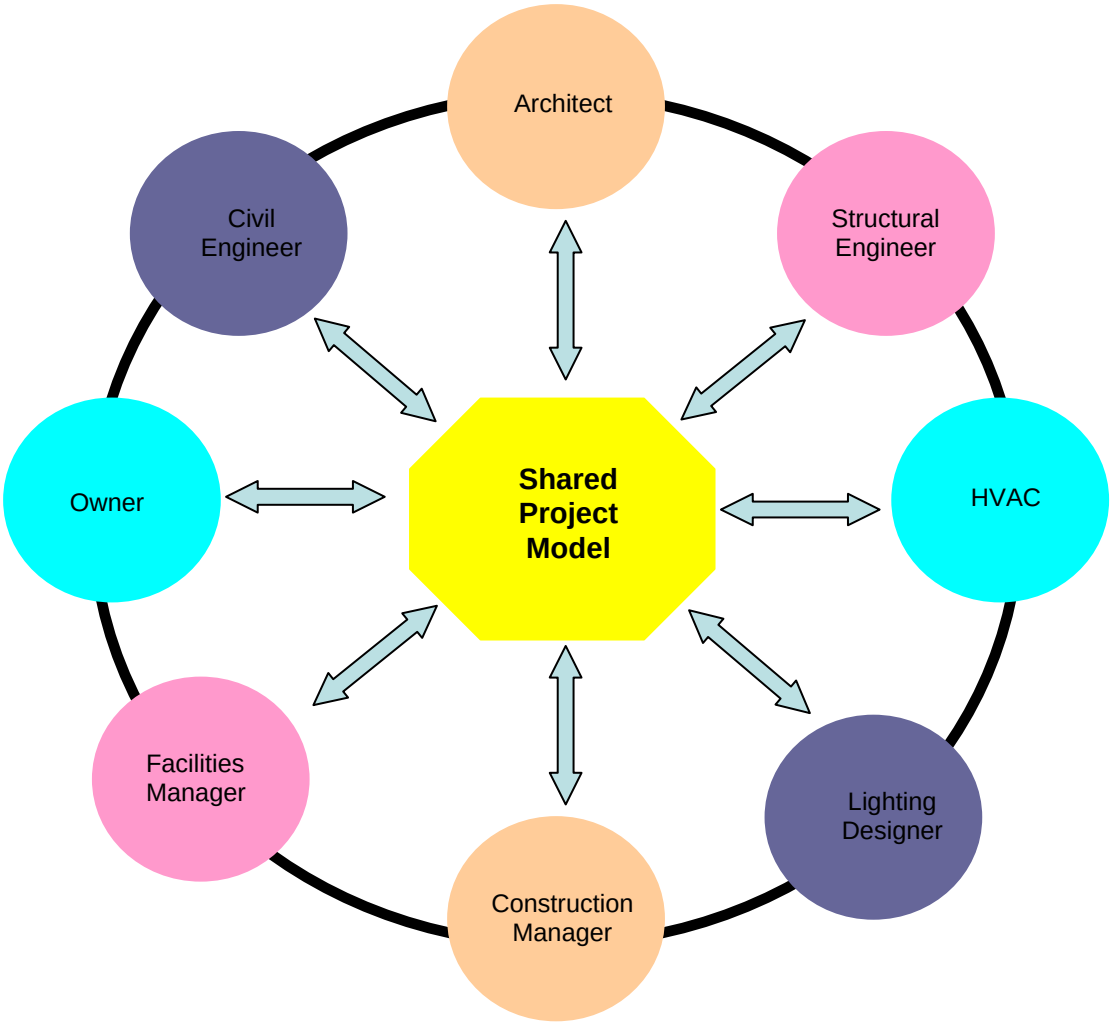


Figure 1-3. Shared Project Model Concept (*Source: Ashcraft*)

1.7 OTHER CONSIDERATIONS (4D / 5D MODELING)

In addition to the 3D Parametric Modeling (3D Model with Attributes) which not only include visual aspects of the building elements they represent, but also have the properties (or knowledge) of the solids they represent, the extended use of 3D intelligent design models leads to references to terms such as 4D (adding time to the model) and 5D (adding quantities and cost of materials). The 4D Model is the term to describe the linkage of a schedule to a model. Basically, turning on model elements

in the order in which they are built. This process is invaluable in coordinating construction sequencing activities by integrating the CPM schedule data with the model data to identify any out of sequence work. The 5D Model is the term used to describe the linkage of estimating software to a model. Essentially, element quantities are downloaded from the model database and imported directly into estimating software and cost information is applied. The simplest way is to think of the 3D Model as a "tool"; where applications of its use throughout planning, design, construction and facility operation processes are almost infinite. Thus, there are many applications of how the 3D "tool" can be used to improve all of the processes in our industry so the growing trend is to refer to all of the extended applications using the 3D tool as **"XD."**

CHAPTER 2 – LITERATURE REVIEW

2.1 INTRODUCTION

This Chapter describes the need for a new project role called a model manager whose is responsible for the integration of project information from other parties. In addition, this Chapter describes and illustrates a variety of ways designers and contractors are currently applying BIM tools to the construction process. This Chapter identifies a host of legal issues, risks, and barriers raised by the use of BIM in these contexts which the industry has not addressed properly. The aforementioned issues are categorized into three (3) major groups: Commercial Issues, Legal Concerns and Technical Issues. Finally this Chapter reviews the impact of BIM on the Spearin Doctrine.

2.2 ROLE OF THE MODEL MANAGER

The sharing and exchange of the vast amounts of electronic data associated with models by multiple parties necessitates the identification of a person or entity to act as gatekeeper for the model. Such a role is not a new concept to construction projects. Indeed, architects and general contractors have routinely acted as information gatekeepers for the project designers and contractors, respectively, and those roles have never been the source of any particular liability concern. The increased collaboration among designers, contractors, and suppliers associated with BIM, however, broadens the role of this information gatekeeper, termed the “model manager,” and makes the role a more important one.

The duties and responsibilities of the model manager are not uniformly established and agreed upon across the AEC industry. The obligations certainly vary depending upon the need of the project and the processes agreed-to by the modeling participants. The model manager may have more limited duties of simply maintaining the file transfer site and overseeing access rights. However, the model manager might also be responsible for compiling the information from smaller models of other project members and disseminating it in a useful form to all project stakeholders or even checking the correctness and accuracy of the full 3D model. Such responsibilities may be accompanied by additional liability exposure.

The role of model manager in managing the flow of information between the designer group and the contractor group appears to most in line with the industry function of a construction manager. That role will most likely carry some liability exposure. However, it is a familiar role that the construction manager tends to assume. Assuming the role of the model manager goes beyond the simple gate-keeping duties, the model manager's activities seem likely to involve the rendering of professional services governed by a standard of care that requires the model manager to use the care and skill ordinarily used by members of the profession.

Even so, several AEC industry stakeholders have the opinion that professional service firms should be in control of the information source. As integration of design and construction develops, protecting public health, safety, and welfare becomes more critical. The rationale for having a licensed professional in charge does make increasing sense. The professions, however, must become capable of monitoring and

guiding the inevitable “looping” of design and construction features so that there is conformance with the intent, design constraints, and requirements of the design.

2.3 BIM PARTIAL USES

Partial aspects of BIM have already been applied to many projects of various size, scope, type, cost, and contract delivery method. The AEC industry is currently applying BIM tools in a variety of ways, including the following applications which are discussed and illustrated below:

Design Visualization. BIM is often used by designers, and also by contractors, as a way to visualize and communicate design intentions. Historically, this use of BIM exemplifies the most common use of 3D in the AEC industry. Owners can make critical design decisions with the use of this intelligent technology to mitigate significant cost impacts to the cost of construction. As shown below in **Figure 2-1** BIM provides the visualization tools which are used to understand the complex structural components of mega projects.

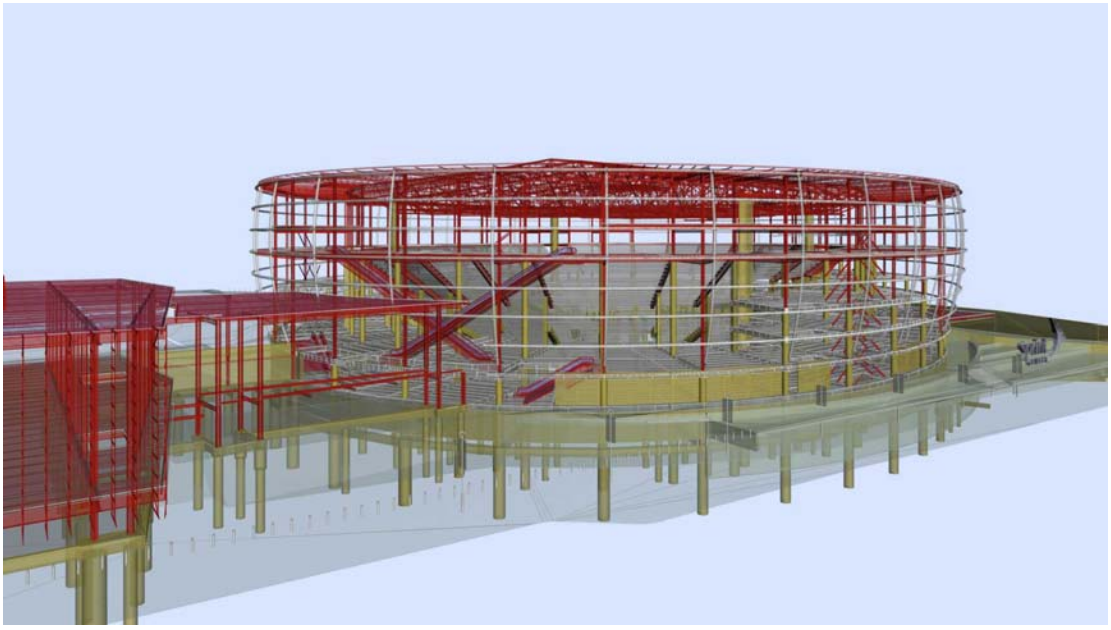


Figure 2-1. Design Visualization of Structural Components (*Mortenson 3D Image*)

Design Assistance & Constructability Review. Beyond visualization, contractors use BIM as a way to provide assistance to the design team and to provide "constructability review" in which various means and methods are analyzed and tested to ensure the design can be built in the field and meet a target schedule and cost. Often, BIM exposes errors and omissions in the design, and can assist with possible alternate solutions while preserving the original design intent.

Site Planning and Site Utilization. BIM is used not only to analyze a proposed building, but also to study known and anticipated site conditions. This includes the following elements: underground utilities (existing and proposed), site access, safety, excavations, shoring, placement of cranes (mobile and tower), and temporary parking / storage areas. As shown below in **Figure 2-2,** BIM is used to analyze and configure proposed Mobile Crane locations, entry access points,

temporary trailer locations, and laydown areas to ensure proper site utilization during the various construction phases of the project.

Figure 2-2. Site Planning and Site Utilization (*Mortenson 3D Image*)

"4D" Scheduling and Sequencing. When the 3D model is combined with the CPM schedule, it creates a "4D" model, using time as the fourth dimension. This is done to visualize the construction schedule and to optimize sequencing (phasing) on the construction site. By adding this fourth dimension, the project schedule and sequencing can be communicated clearly to the entire project team. As shown below in **Figure 2-3** BIM supports 4D analysis, where construction activities from the project schedule are simulated and studied to optimize the sequence of construction.

Figure 2-3. 4D Scheduling and Sequencing (*Mortenson 4D Image*)

"5D" Cost Estimating. BIM can also be integrated with another factor, cost, to generate a "5D" simulation. This BIM is used to facilitate a quantity survey of building materials and components, and these quantities are linked directly to cost databases. With this information, building design is modified in real time to determine various cost implications.

Integration of Subcontractor and Supplier Models. The majority of detailed data that is incorporated into BIM comes from subcontractors, suppliers, and vendors who traditionally would supply "shop drawings" that detail precisely how they would execute the design intent in fabrication and installation. Today with the use of BIM, there is rarely One Model. Typically multiple models are produced by several specialty contractors. As mentioned previously, the Model Manager would be

responsible to provide a platform to combine multiple models produced in different design packages into one file, to be viewed as one **composite model**. This is where the early initial benefits of visualization, conflict detection, and specific trades' scope isolation and analysis are found.

Systems Coordination. After all building systems are detailed in 3D and incorporated into BIM, these systems are then coordinated. All equipment, fixtures, pipes, ducts, conduits, structural members, and other building components are checked through "clash detection" tools to discover and resolve conflicts before systems are installed in the field. Some early cases have shown an 80% reduction in field-related questions and conflicts due to this specific use of BIM. As shown in **Figure 2-4** all mechanical, electrical, plumbing, fire protection, structural, and architectural systems are coordinated before they are fabricated and installed in field.

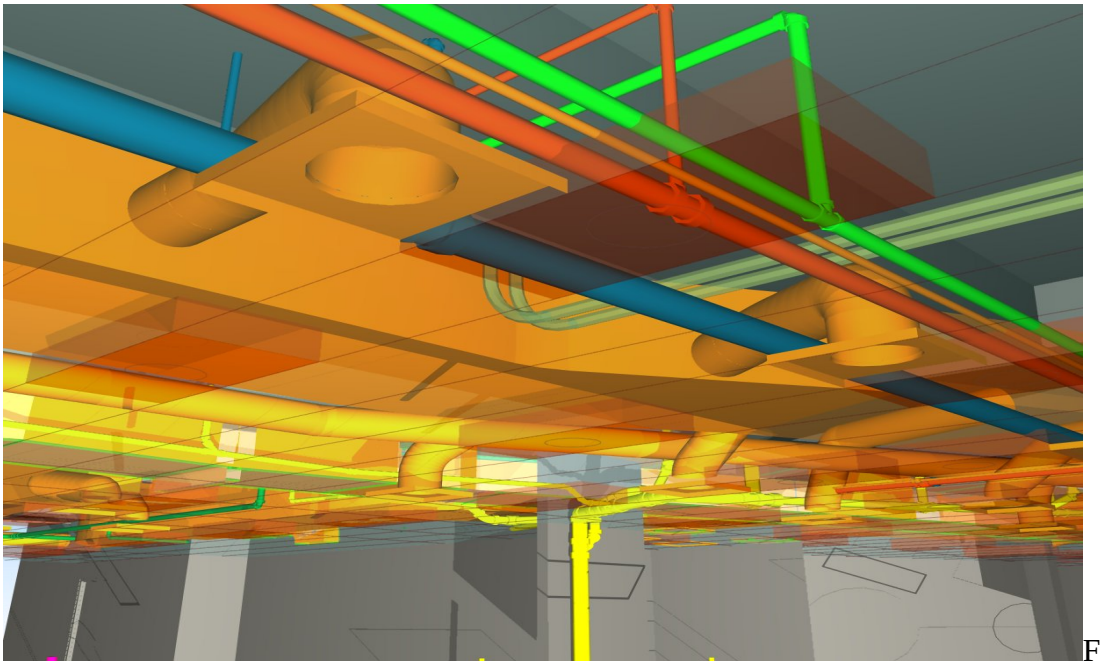
 F

Figure 2-4. Systems Coordination (*Mortenson 3D Image*)

Layout and Fieldwork. Once the design is fully coordinated, the BIM is then used to assist in the layout of materials and systems in the field. This includes the creation of "lift drawings," 2D extractions in plan and section which describes the work in detail, and integrated with pertinent quality and safety information.

Prefabrication and Preassembly. BIM is also used to assist in the prefabrication of building systems, enabling faster field assembly of the building components. This is a result of the integration of many other uses described within. The offsite fabrication increases productivity as the majority of the components are built under a controlled environment and as a result reduces the number of skilled and un-skilled workers needed on-site which mitigates congestion in the field.

Operations and Maintenance. When BIM is updated during the construction of the facility, it creates a true "as-built" record of construction conditions. If implemented fully, BIM becomes a complete and living record to support the facilities management. In addition, Owners who use real estate as part of their business models will experience benefits from BIM such as marketing tools, etc.

2.4 BARRIERS TO BIM

Despite the significant benefits associated with BIM there are a host of legal issues, risks, and barriers which the industry has not addressed properly. The foundations of our legal systems are essentially individual and primarily focus on individual rights and responsibilities. In contrast, BIM is essentially collaborative. As a result, 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. Below is a compiled detailed list of legal issues, risks and barriers raised by the use of BIM in the above contexts. The aforementioned issues have been categorized into three (3) major groups: Commercial Issues, Legal Concerns and Technical Issues (Ashcraft, 2006).

2.4.1 Commercial Issues

Immediate Benefits Do Not Accrue to the Key Adopter (Designer). The benefits of BIM for contractors were previously addressed in Chapter 1. The benefits an owner accumulates from BIM can be easily recognized. The use of a virtual model allows for design optimization, fewer design errors, fewer construction errors, and fewer coordination issues which ultimately results in fewer conflicts and claims. Upon completion of the project, the Owner can also use the as-built model for the management and operation of the facility.

However, for the design professionals, the economic advantages of BIM are less immediate. BIM actually creates significant practical obstacles to the deign professional as further expanded later in this chapter. In short, the designers must adopt new technology, train their employees, and champion the use of BIM to be competitive in their respective design discipline. Basically, if there are no economic benefits (i.e. guarantee of additional fees) the designers have little incentive to fully adopt BIM processes since this process can increase the designer's potential liability. Just because there is a wealth of information easily extractable from the virtual model, this does not necessarily mean that design professionals will be compensated

for this information. The design professionals are currently experiencing asymmetrical rewards for BIM (excessive risk with no reward).

Absence of Standard BIM Contract Documents. The lack of standard contract documents which address BIM ultimately hinders its development. Standard contract documents perform three key functions: (1) provide framework for practice; (2) establish consensus allocation of risks and an integrated relationship between risks assumed, dispute resolution, and insurance; and (3) reduce effort involved in documenting the roles and responsibilities of the participants on the project.

While professional liability insurance does not hinder a collaborative BIM environment, industry standard agreements appear to do so. Current contractual forms clearly separate, define, and allocate responsibilities and risks among contracting parties. These agreements are based on a legal system that differentiates between design, as a professional service, and construction work, as a contractual and warranty obligation. Standard contracts envision the encapsulation of design information into instruments of service which are given to the client for use by the contractor. It is the client that stands behind the adequacy of the documents.

Increasingly information is exchanged electronically, but the separation of design and construction continues. Even during the digital transfer of design information, the "hard copy" is denoted as the controlling information. In a "shared information and shared risk" situation, this current practice is seen as inefficient and dysfunctional. With integrated practice focused on the use of a building information model by a collaborative team, the ability to rely on the information contained in the

database is pivotal. Without agreements on the sharing of information and the ability to rely on the shared database, integrated practice founders.

As integrated practice evolves, contracts will also need to evolve in order to recognize allocated and shared responsibility for the generation of design information, authorize justifiable reliance on the information, assign the duty of updating and archiving the database, and provide compensation for the services, risks, efficiencies, and savings created. Many of the basic roles and responsibilities on a project change under BIM. Contracts that establish a consensus allocation of risks and provide a framework for practice will take time to develop. Unfortunately, it is the authors understanding, through informal discussions with the legal sector of the industry that standard AIA documents reflecting BIM approach are unlikely to be developed in the immediate future. EJCDC is also unlikely to develop BIM standard documents in the near future. It will be years after that when contractual rights and responsibilities are construed by our legal system.

Insurance. The law cannot keep pace with technological advances. Presently, design firms, contractors, clients, and insurers have a shared understanding of where the responsibility of one party ends and that of another begins. “Bright line” separations are helpful in determining liability. Since insurance tracks legal liability, it too is dependent on a clear separation of responsibility and, therefore, liability. A collaborative system presents legal ambiguities. Without a clear delineation of responsibility, insurers will be hesitant to assume such imprecise exposures.

Inertia. The reality still remains that the AEC industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. The use of BIM in the design and construction industry will lead to a revolution in project delivery methods. However, this revolution cannot be achieved unless the project has a fully collaborative project team. To ensure this team structure, the parties must be required to do so as a result of their contractual obligations. Meaning, the theory of full collaboration generally envisions the entire project team: owner, architect, engineers, consultants, contractors / construction managers, and specialty contractors being fully involved from the project's inception. In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. All parties must work in a cohesive fashion and provide one another with data that will allow its "partner" to perform its work faster, better and less expensive. BIM technology will allow projects to be built faster with fewer surprises and ultimately lower costs. This goal can only be achieved if each member accepts this new technology and approach and faithfully works together in a collaborative manner.

Need for a New Business Model. Presently in the U.S., the design and construction industry is not set up to fully use the advantages of BIM. The only exception may be integrated design-build entities. Elsewhere in the world there are examples of project alliances among disparate design firms and construction entities with shared exposures and benefits. In the U.S., however, business relationships that would allow interlocking risk allocation and performance incentives are undeveloped.

Such collaboration is not easily achieved by firms with differing cultures and economic interests. Until this occurs, design firms will continue to receive a benefit that is disproportionately minor compared to their investment and risks.

2.4.2 Legal Concerns

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

As stated in the introduction, BIM is a tool. Recent advancements in technology have made BIM available and relevant to the work of all members of a project team. The uses of BIM will inevitably change the ways projects are conceived, designed, communicated and constructed. However, the core responsibilities of the members of the project team will not change.

Whether the design is issued in the form of 2D printed documents or a 3D electronic medium or in combination of both, the responsibilities of the members of the project team remain unchanged. It is very important to recognize the difference between design and coordination. Creation of a composite (coordination) model does not require or supplant a design that is conveyed in 2D printed documents. When a

contractor or construction manager creates a “coordination” model, the BIM tool is completely similar to a light table used in the past to overlay mechanical and electrical drawings. Recognizing the validity and value of the information in any BIM is the responsibility of every project team member that utilizes it.

Contractors and construction managers need to understand that coordination, whether through BIM technology or a light table, is their core service to the project. It is a fact, based on results from Sprint Center Arena case study, BIM coordination improved communication, which decreased construction cost and time, thus reduced overall risk. As the leaders of construction coordination, contractors and construction managers have the responsibility to encourage and facilitate the sharing and distribution of BIM technology on a project. Appropriate contract language will guide the open sharing of information between team members. In addition, the design teams must also recognize the benefits of sharing all available electronic information with the entire project team. Subcontractors are still responsible for fully conveying their interpretation of the design intent to the design team. They also must coordinate their work with that of other subcontractors by sharing electronic information they have developed in file formats that can be used and combined with the work of others.

Standard of Care. Design professional liability is almost always based on the standard of care. A basic understanding of the standard of care is helpful at this point in time. A typical standard of care clause is as follows: “The Design Professional’s services shall be performed in a manner consistent with that degree of

skill and care ordinarily exercised by practicing Design Professionals performing similar services in the same locality, and under the same similar circumstances and conditions" (Yoakum, 2006). 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. Clearly, the design professional's agreement should explicitly permit reliance without detailed checking, but the ability to rely on another's work may be limited by professional registration statutes and ethics. This may lead to using risk transfer devices, such as limitations of liability or indemnity agreements, as methods to rebalance design professional liability.

The difference between professional and software liabilities is also problematic. When the software is faulty, there is little opportunity to recoup the loss from the software vendor due to very limited warranties and broad consequential damages waivers. Similar to other risk control mechanisms, the party who gains the most from the BIM approach should control the risk; therefore this risk must be allocated to the owner through its agreement with the design professional.

Privity and Third-Party Reliance. The extent to which third parties may rely upon a designer's work is a highly contested subject across the country. The use of a collaborative model lessens the likelihood that the designers' defenses of lack of privity will be successful.

The model designer must be aware that there are other parties relying on the accuracy of the model. Basically, it is foreseeable that the main purpose of the model is to provide information for contractors' and subcontractors' use. Under the

RESTATEMENT (SECOND) OF TORTS, which is followed in most jurisdictions, a person negligently providing information is liable if it is intended that the plaintiff be able to rely on the information. Liability under the RESTATEMENT only requires that there be intent to influence and reach a group or class of persons (Ashcraft, 2006). For this reason, contractors' and subcontractors' relying on the model will likely be able to bring an action against the designer for damages caused by negligent errors. Therefore, considerations must be given to requiring a waiver of consequential damages as a pre-condition to using the model or otherwise limiting damages due to model errors.

Provisions used by design firms that treat electronic data as inferior representations of controlling "hard copies" no longer make sense. The idea of obtaining waivers or limitations of liability to control allegations of detrimental reliance is counter to the BIM process. Disclaimers may be ineffective since reliance is implicit. With BIM, there must be a free exchange of data and the ability to rely on such data when incorporated into the final model. Harm can still occur, however, and whichever party is seen as controlling the information may be seen as the source of the harm. If the model becomes a tool to assist the client in operating or modifying the facility, the question of the rights of the client to use all the information in an unregulated way also becomes paramount.

Economic Loss Doctrine. The economic loss doctrine is another highly contested defense to contractors' actions against design professionals (Ashcraft, 2006). Simply stated, the doctrine holds that purely economic losses cannot be

recovered through a negligence cause of action. As with the privity and third-party reliance defenses, the utility of the defense varies among jurisdictions and is dependent upon specific facts. However, the use of a collaborative model will be a factor tending to support a contractor's claim that it should be able to recoup its economic losses.

Distributed Design (Professional Responsibility). For the protection of public health and safety, it seems logical that a licensed design professional always be in charge of the creation and modification of the data that forms a digital model. However, that is not presently required and perhaps may not be the final outcome. Design elements are increasingly delegated to unregulated parties such as contractors, fabricators, and manufacturers. With BIM, parties supplying design information are not, by contract, under the responsible charge of a prime design professional. BIM may lead to increased decision making not by design firms using professional judgment, but rather by construction entities or by a computer program working on preset rules created by independent organizations not subject to registration laws.

Intellectual Property. The ownership of the intellectual property generated in the BIM process has not been addressed. In the shared design philosophy intrinsic in BIM, there are layers of intellectual property provided by design participants and others that are incorporated into the final model. With the project stakeholders all being able to share project information and add details to the project model, the copyright bright line will be blurred, which can lead to disputes over who owns the copyright should any of the design elements attempt to be used on future projects. To

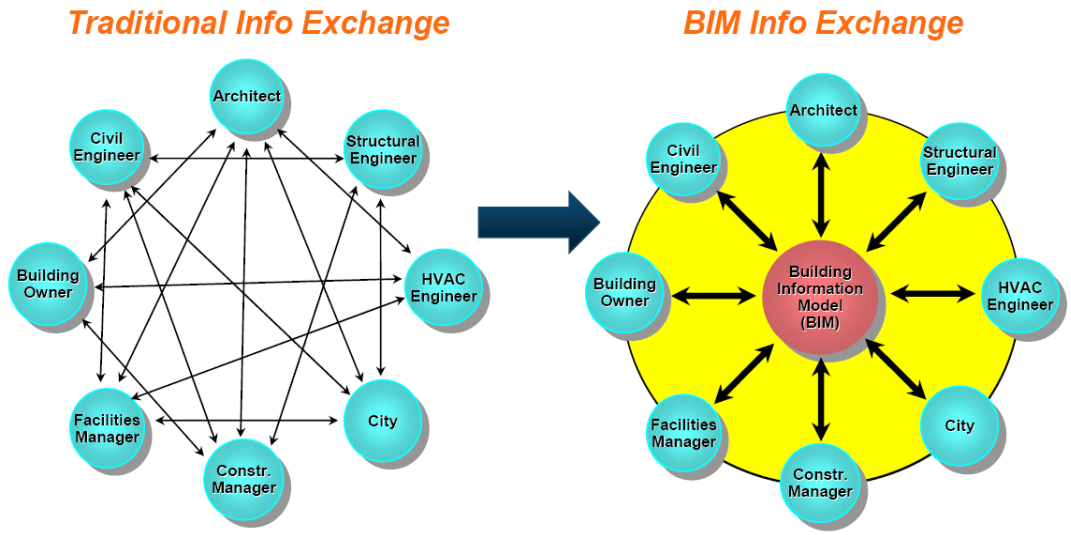
further complicate this issue, there may be inadvertent sharing of proprietary information, trade secrets, or patented processes. Confidentiality as well as ownership rights may be compromised.

2.4.3 Technical Issues

Universal Model or Multiple Models. In theory, BIM relies on a single information store that meets the needs of all project participants. Changes to design, whether architectural, structural, mechanical, or electrical all occur within the model. Contractor and supplier information is integrated into the model, adding more detail to the design. That model then produces the field and shop level drawings. This level of integration has been achieved in certain manufacturing processes, but is not the current construction reality.

Meaning, there is rarely one model. In fact, on the Case Study Project (Sprint Center Arena) there were multiple models produced by several specialty contractors, such as the steel fabricator, precast supplier, mechanical, plumbing, electrical and fire protection contractors. Mortenson, the construction manager at risk, on the Sprint Center Arena purchased specific 3D Interoperability Software (Navisworks) which provided the platform to combine multiple models produced in different design packages into one file, to be viewed as one **composite model**. This is where the early initial benefits of visualization and conflict detection can be found. As discussed below, significant effort is being made to tighten the integration between BIM software and to support interoperability, but the single model and perfect interoperability is still a dream not reality.

Interoperability. The processes and issues with BIM cannot be fully understood without discussion of the concept of interoperability. According to a survey by the Structural Engineering Institute of ACSE and the Structural Engineers Association of Texas, the biggest complaint is poor interoperability of different vendors' parametric modeling (BIM) software. Interoperability is the ability to manage and communicate electronic product and project data among collaborating firms. The ability of different software packages to use, edit, augment, and exchange information depends upon universal standards for describing construction elements and systems. According to The National Institute of Standards and Technology estimates that $15.8 billion is wasted annually due to inadequate interoperability (Gallaher and O'Connor, 2004). As shown in **Figure 2-5** the concept of BIM interoperability and integrated process for information exchange across the AEC industry is a key approach to reduce the waste currently experienced in the U.S. Construction Industry.



Source: International Alliance for Interoperability, 2007 and McGraw Hill

Figure 2-5. BIM, Interoperability and Integrated Processes (*Source: Young*)

The International Alliance for Interoperability (IAI) is dedicated to facilitating interoperability by defining Industry Foundation Classes as a uniform basis for collaborative information use and exchange. There are at least ten (10) initiatives (either ongoing or in start-up mode) which focus on BIM and various interoperability and industry process issues (Hagan, 2006):

- National BIM Standard
- National Institute of Building Sciences (NIBS) International Alliance for Interoperability—North America (IAI-NA) and its buildingSMART initiative
- GSA requirements for Industry Foundation Class (IFC)-based BIM submissions for design starts in Fiscal Year 2006
- Virtual Builders Roundtable
- NIBS Facility Maintenance and Operations Committee

- National Institute of Standards and Technology (NIST) effort on the Capital Facilities Information Handover Guide
- FIATECH Capital Projects Technology Roadmap
- Federal Facilities Council (FFC) Emerging Technologies Committee focus on BIM and Interoperability
- AIA TAP's own focus on three inevitable technologies: BIM, interoperability, and collaboration
- Construction Users Roundtable focus on A/E productivity

Elaboration on each of these efforts and their success rate may be studied in the future. However, they all seem to have similar objectives and goals about BIM and the future of the AEC industry. There also seems to be a united opinion among these same members with the concerns over BIM platforms not speaking to each other which have been recently heightened by the rigorous new BIM requirements set forth by the United States Army Corps of Engineers (USACE). In short, the USACE is mandating Bentley sole usage, which is not currently compatible with Autodesk systems.

Model Hosting and Archiving. An Agreement should be reached at the inception of the project who will host the model. The parties may elect to use an outside vender as a model host during construction and post construction activities. The agreement needs to include responsibility for model use and access, record keeping, protecting the model, warranty, and preserving the model for use in later litigation. It may also require archiving the model at periodic intervals, or milestones,

to demonstrate the model's state at a particular point in time. There are a host of other BIM risks associated with technology that must be considered and addressed within the contractual framework of the Agreement. These other BIM considerations are as follows: replacement functions, system crash, computer viruses, and data access.

Training. There are additional issues that design professionals should be aware of before converting their systems to BIM. Below are some of the more important issues as identified by H. Edward Goldberg, Principal of HEGRA, at the AIA's National Convention.

- Steep learning curve – These software packages are complicated and require a great deal of time to master. It is best to train small groups of employees at a time, rather than to attempt to convert an entire company at once.
- Few advanced users – Most advanced users appear to be younger architects that lack extensive design experience, while older architects have extensive design experience, but lack the required technological ability to use BIM software. A solution may be to establish a mentor program where an advanced BIM user is paired with a senior designer lacking software experience, creating a two-way learning experience.
- Duplication of content – If a component has been accidentally duplicated (i.e., a window on top of a window) and this is not

corrected before the job is sent out to bid, this can affect the contractor's price.

- Details done in 2D – Details must still be done in 2D and are not necessarily linked to the virtual model.

2.5 LEGAL IMPACT OF BIM

One of the fundamental functions of any construction contract is to allocate responsibility for design and construction among the various contracting parties. Conflict occurs when these responsibilities are not clearly defined. Issues of who is entitled to rely on design documents, or whether a particular activity is design or construction means and methods, come to the forefront.

The use of BIM as a project delivery method (or at least part of a project delivery method) raises unique opportunities and risks associated with design and construction operations. Perhaps the greatest source of legal concern is the fear that arises from the degree of collaboration that BIM enables from its project participants. The true concern among the AEC industry comes from the belief that BIM will result in the blurring of these fundamental roles and responsibilities. A basic understanding of the Spearin Doctrine is helpful at this point in time.

2.5.1 Spearin Doctrine

The *Spearin* doctrine protects contractors and is generally used as a defense to an owner's claim of defective and non-conforming work (Clark, 2005). It holds that if a contractor builds a structure according to the owner's plans and specifications, and the structure does not function as intended, the contractor is not responsible.

When defects in the plans and specifications are the cause of the problem, *Spearin* properly shifts the responsibility to the owner's architect or engineer. This is often referred to as "the owner's implied warranty" of the adequacy of the plans and specifications.

The original *Spearin* case, *United States v. Spearin* (1918), 248 U.S. 132, gave rise to the *Spearin* doctrine. In *Spearin* the contractor relocated a 6-foot sewer as part of a larger overall construction project. The contractor built the sewer according to the government's plans and specifications. About a year after this relocation, the sewer failed, and the contractor's work-site was flooded. The paramount question raised by this case was who was liable for these damages.

An investigation found that an adjoining 7-foot sewer was partially dammed so as to divert more water to the relocated 6-foot sewer, resulting in the 6-foot sewer becoming overstressed to the point of failure. The government's plans did not show the obstruction in the 7-foot sewer. The contractor refused to continue work until the government assumed responsibility for the damage. The government terminated the contractor, and the contractor then sued. The United States Supreme Court found in favor of the Contractor, stating what has come to be known as the *Spearin* doctrine: "If the contractor is bound to build according to plans and specifications prepared by the owner, the contractor will not be responsible for the consequences of defects in the plans and specifications" (United States v. Spearin, 1918).

Courts throughout the country have followed *Spearin* as a defense to an owner's claim of defective and non-conforming work. The implied warranty set forth

in the Spearin case was twofold: first, that the information contained in the plans and specifications would be accurate, and second, that the plans and specifications, if followed, would be adequate to accomplish the purpose of the project. Most importantly, the Spearin case also held that the responsibility of the owner is not overcome by the usual clauses contained in construction contracts requiring the contractor to visit the site, to check the plans, to inform himself of the requirements of the work, or to assume responsibility for the work until completion and acceptance. Simply put, contractual language obligating the contractor to examine the site did not impose upon the contractor the further duty of making a diligent inquiry into local conditions to confirm whether the owner's representations in the plans and specifications were accurate. The contractor was also not obligated to second-guess the adequacy of the plans and specifications to accomplish the purpose of the project. The Supreme Court emphasized that the owner's warranties were implied by law, and that they did not need to be expressly stated in the contract documents.

2.5.2 BIM Impact on Spearin Doctrine and Means & Methods

There are two major legal questions that need to be further investigated as a result of the collaboration process enabled by BIM. First, from the contractor's point of view, does the step-change in collaboration among its stakeholders during the design phase of the project deprive the contractor from the protection from responsibility for design error provided by the Spearin Doctrine? Secondly, from the designer's point of view, does the collaboration enabled by BIM during the design

phase erode designer's traditional protection from responsibility for contractor means-and-methods?

The answer to these key legal questions remains in the construction contract itself. Meaning, as long as the parties' roles are appropriately defined and as long as the appropriate control is exercised over the collaborative process the use of BIM does not necessarily alter the traditional allocation of responsibility among its project stakeholders. It is important to emphasize that there is no new legal issue here. Instead, the hypothetical merely involves the application of long standing legal principles to a new context.

2.5.3 Final Thoughts

The *Spearin* doctrine remains a powerful tool for contractors when faced with problems resulting from defective drawings and specifications. Applied in its basic form, the *Spearin* doctrine frees contractors from having to double-check the designers' work (models), and enables contractors to concentrate solely on the construction's means and methods (models). Owners who wish to avoid the application of the *Spearin* doctrine need to think ahead and include very clear statements as to the risks that the contractor is accepting. All parties involved in a construction project need to study the contract language carefully to be sure they understand exactly what the contract says about liability for plans and specifications that don't reflect reality or that won't work as intended.

CHAPTER 3 – METHOD: SURVEY

3.1 INTRODUCTION

This chapter describes a survey, to track the legal issues and risks associated with BIM technology and attempts to analyze and evaluate trends in its use. The purpose of this survey is to begin to gather information about BIM awareness, experience, and innovative best practices in the design and construction industry. It is the author's opinion that use of BIM methods is expanding and has now entered mainstream use, which dictates the immediate requirement to properly address the legal aspects of BIM to support this dramatic shift in project delivery methods.

3.2 SURVEY APPROACH

As supported by the survey responses several adopting companies have placed significant effort into implementing BIM programs across all phases of the design and construction process and many report reaping benefits from this concerted effort. Many user companies report that they are shifting toward broad BIM implementation and an overall organizational transformation based on its use. At this point in time, these users report value in qualitative terms as few measure value quantitatively.

This study analyzes data from surveys and an interview conducted in 2008 on the legal issues and risks associated with BIM technology in the AEC industry. In an effort to get true and accurate feedback from respected AEC industry members who specialize in BIM and/or practice in these areas a large sample size of 85 surveys were strategically distributed via electronic delivery. The survey sample pool included firms which were identified as progressive that may already be working with

BIM in some capacity. Industry sectors such as academia, construction, design, owners and legal were targeted. Unfortunately, only nine responses were received to the 2008 survey. Fortunately, this small sample size does represent a broad mix of geographic locations, business sizes, technical disciplines, project types, and industry sectors. The raw data suggests that BIM use is significant, expanding quickly and is here to stay.

3.3 SURVEY OVERVIEW

Survey respondents report increased sophistication in the use of the methods in their operations and many are reporting specific benefits in the areas of improved participant engagement, reduced risk and project contingency, improved latency, and cost and schedule conformance. While value of their work in practice is rarely measured quantitatively, the majority of users report qualitative value across all phases of the design and construction process. A growing proportion of early adopters report plans to transform their organizational strategy, and, in addition, more early adopters are now shifting from individual pilot projects to broad scale use of the methods than in the previous year of the survey. The majority of veteran users now plan such organizational transformations, and, indeed, are attempting integration and automation phase implementation of BIM in a sign of ever-increasing sophistication of use.

Complete adoption is not universal as shown by the relatively small sample size of respondents. However, all of the survey respondents say that they have used BIM on past projects and are using BIM on their current projects. Thus, it is assumed

the majority of non-respondents may lack the following: need, request by owners, and qualified providers as the most common reasons for not implementing the technology. Perhaps if these same non-respondents would use the technology, they could improve their process efficiency since the sweeping majority of current respondents seem to derive value in the use of BIM for precisely this reason. Therefore, the gap of process efficiency is widening exponentially between the users and non-users and shortly this gap will be exposed by the future awards of upcoming projects.

3.4 NOTES ON SURVEY METHODS

This thesis highlights the results from a single annual survey that began in 2008. The 2008 survey is considered an alpha version and some changes should be contemplated and made to the beta version based on the valuable experience gained on this initial survey.

In particular, several new questions should be added in the beta version to address non-users in order to mitigate incidences of non-response while improving clarity and/or providing information seen lacking in the 2008 version. A significant change between the two versions should be contemplated with a particular modification in the treatment of respondents who have minimal experience and/or having no projects using BIM methods at the time they took the survey. These non-users should be diverted past all detailed or direct-experience related questions. Instead, they should be asked why they do not use BIM and for what reasons they might begin doing so. From this change the author assumes it would reduce the incidence of respondents failing to formally respond. In the 2008 alpha version, users

were not diverted in this manner. The author feels this modification will allow the survey to gather better insight into the perspective of the significant numbers of non-user respondents.

Another modification that should be evaluated was the survey method itself. Meaning, most AEC industry members are extremely busy with work and other pressing commitments. Therefore, the time required to respond meaningfully by answering questions (long hand) is not the most time efficient method for conducting surveys. The trend recently has shifted to on-line surveys. A company such a Survey Monkey has thousands of customers in over 40 countries and there is a good chance that several AEC industry members have already used this type of service. Survey Monkey is flexible and scalable enough to meet the needs of a wide range of people: whether you are managing HR for a multi-national organization, or simply trying to gather feedback for a survey. SurveyMonkey provides the tools necessary to create your own surveys, and above all, it enables you to get it done quickly and easily. It most likely took approximately one (1) hour to complete the BIM Survey that was distributed. With a service such as SurveyMonkey, there would be a significant increase in time savings by each respondent, thus creating a greater response rate.

The 2008 data is based on a combination of an electronic survey which is shown in **Appendix A** and an individual follow-up interview with an Owners' representative who volunteered to be contacted. At the end of the survey there were a total of nine respondents to the survey and one follow-up interview conducted. The raw survey data is included in **Appendix B**, and the raw interview results are shown

in **Appendix C**. It is worth noting that this thesis includes a relatively small population of respondents for the 2008 survey. Because of this small sample size, data based on percentages of total respondents to the 2008 version are too sensitive to fluctuation and thus deemed unreliable. As a result of the small sample size, each question was summarized and analyzed within individual tables in the next section based on the actual responses received. The expectation for the future beta survey should be a larger sample size, so data averages based on percentages of total respondents would prove to be more reliable and represent the AEC industry as a whole.

3.5 FINDINGS

This section reports the findings of the 2008 BIM survey and evaluates these findings. As previously noted survey respondents represent all parts of the AEC industry. Survey respondents in 2008 provided a broad and representative cross-section of all parties in the AEC industry, as shown in **Table 3-1.** The only exception was the lack of responses from owners. Respondents operate throughout the United States and frequently provide services in multiple phases of the design and construction process. Table 3-1 demonstrates the relative number of respondents specializing in the various roles and services that make up the process of design, construction and operation of buildings. Such broad involvement provides a balanced insight into all phases of the design and construction processes.

TABLE 3-1
BIM Survey Response Chart

			Industry Sector Responses			
BIM Survey Respondents			**Academia**	**Construction**	**Design**	**Legal**
University of Kansas			x			
HarenLaughlin Construction				x		
Skanska				x		
The Fagan Company				x		
Foley				x		
Puma Steel				x		
Ellerbe Becket					x	
FLAD Architects					x	
Hurtado						x
	Sub-Total By Sector		1	5	2	1
	Total Respondents					9

3.5.1 Survey Summaries & Analysis

As previously discussed, due to the relatively small response sample size, each BIM survey question will be review and summarized in the below tables.

TABLE 3-2	
Industry Sector Responses to BIM Survey Question #1	
Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?	
Academia	BIM is a modeling software system that in addition to supporting graphical entities it includes a relationship between those entities and all corresponding attribute data.
Construction	BIM is the incorporation of three dimensions into design. This incorporation gives the builder the ability to order material more accurately, construct without conflicts, or the ability to find conflicts in the design stage in lieu of during construction which leads to changes orders, delays and additional costs.
	My definition is closely linked to the GSA's definition paraphrased as "a data model not only used to document building design but also to simulate construction and operation." The key to this is data, not just 3D CAD. As a company we have 50+ projects in which we have used some degree of 3D CAD to BIM. Right now I am specifically involved in four.

	BIM from the modeling perspective is drawing Virtual data rich models which use object drawing practices as opposed to vector based practices. (object = Pump, W10X30, Door / Vector = Line, Circle, 3D Surface). These elements contain data rich information that can be used for purposes such as estimating pricing, extracting material quantities, engineering calculations, manufacturer's specifications to fabrication from automated plasma cutters and even man hour calculations for fabrication and installation. These models have the capability to contain vast amounts of information as opposed to just lines, arc and surfaces to represent geometry of such items. BIM models are also promoted to encourage the project team members to add the variety of different 3D content in order to coordinate a Virtual Building Model first and resolve interferences that otherwise would be more costly to resolve on the job site between the disciplines. For example HVAC duct hitting steel beams.
	In my opinion BIM would be fully coordinated model completed prior to construction. I have experienced this on one project which was the Sprint Center and I am currently involved in 2 other projects that it is being used.
	The modeling of intelligent three dimensional building components resulting in a database available for many enhanced design, coordination, and construction processes. We use it on every job to detail and ultimately fabricate structural steel.
Design	Worked on construction administration for architect on Sprint Center project. Contractor and "main" subs created a 3D model and worked with them in interpretations and questions generated from their modeling of the project. Since; have worked on a smaller ($11M) project designed and carried through CD phase in Revit (a BIM software tool) including some hands on work with the software in creation of construction document level "drawings." All other consultants on this project are working in this software.
	Description: 3D (or 4D) Representation of a building frame, shell, finishes and/or systems used to streamline and facilitate the design, construction and operation of the building. Experience: (1) Exporting structural steel framing model to design clash detection model (2) Exchanging data with steel fabricators.
Legal	Parametric computer-generated building modeling utilizing intelligent design elements for design, cost and scheduling development. Wrote Consensus Docs 2007 and commented on BIM Addendum, write contracts for construction using BIM.
Summary / Analysis	Based on the above responses, it is apparent that the entire AEC industry is at least familiar with the term BIM. BIM has now

	entered mainstream use in our industry and is not just used on large complex projects. BIM is ready to become the standard protocol for project delivery methods regardless of project size and scale.

TABLE 3-3	
Industry Sector Responses to BIM Survey Question #2	
When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?	
Academia	It seems to me that the best use of BIM is when the decision is made early in the project life. I also know that some construction companies make BIM models in the planning phase of the construction project. For BIM to be successful, it needs to save time and money and not "cost" anyone. If no one wants to "pay" the costs, build the model and sell the knowledge gained by it. For example if there is an interference between the structural and HVAC ducts, approach both organizations, tell them there is a problem and charge them for it. Rather unconventional project management but it would probably encourage both organizations to build their respective models so the comparisons can be made. I suspect the biggest obstacle for implementation of BIM is fear of the unknown and the change that it requires.
Construction	The decision to use BIM is in the concept stage of a project before drawings have begun. Since the owner will be the major benefactor of a BIM project the initial cost should be borne by the owner/developer. This cost will come back to the owner/developer in the form of lower construction costs and faster building delivery. It is our opinion that the principle problem is finding design firms with BIM knowledge.
	Earlier the better. When choosing a designer, the owner should specify BIM. Generally the owner should bear the cost. However for d/b projects it has traditionally been up to us (the contractor). Successful implementation to me would be a process where the owner understands the potential for design/construction and operation and specifies it for the project, including ground rules for collaboration and minimum standards. Short of that the biggest obstacle is the conversion cost of 2D to 3D.
	The earlier the decision is made the more beneficial the process is in order to reduce unforeseen project cost escalations and the sooner the project team has an understanding of project. I believe all the trades should be drawing with intelligent objects and should all bear the costs, share the risks and reap the benefits.

	In our region (midwest) the paradigm shift of breaking away from traditional methods of doing business is the largest obstacle. The skeptical architectural and general contracting communities that are not embracing this transition are hindering the progress and movement into this era and way of doing business. Both communities also have a vested interest in protecting their positions such as owner's reps and in keeping a tiered business model which they are comfortable with, understand and is traditional.
	The decision to use BIM should be done during the design phase. The costs should be the owner or the designer. I believe with increase in change orders on projects today, an owner would save a substantial amount of money due to a fully coordinated building model. I believe the biggest obstacle is to get everyone on board. The model is ineffective unless all disciplines participate fully.
	It has to be decided at the very beginning. Cost (if any) depends on delivery system, but should be passed to contractor and ultimately the owner since they see the most benefit. Legality of who owns and is responsible for the model at which phase and contractors fully utilizing the model.
Design	At the very beginning; it should be determined if the design team will use BIM, and what consultants. If the contractor is part of the process at that point, they should also understand if the design team is using BIM, will they also go that route – to what extent will they want to use "the model" – and what level of accuracy they expect. Not sure what "costs" you are referring to – up to a point there should be no "cost" as the use of BIM is for the benefit of all project participants. So; depending on what are identified as "cost" I guess that would start to determine who should pay. We have made the decision to implement Revit on all of our new projects going forward. Obstacles include availability of consultants who understand and utilize the software (but they are catching up - some are ahead of us). Getting staff trained and up to an appropriate level of proficiency is one of the biggest obstacles – it is an ongoing process. We don't have enough experience with how contractors will use the model to see what impact that may have; but there is some trepidation about how much liability may transfer to the architect if the contractor chooses to just "use" our model.
	The decision to use BIM should be made early in the design

	process. I'm not convinced BIM should cost more to the owner. Internally to the team, savings in some areas should cover increased cost in others. Principal obstacle is probably challenges with interoperability.
Legal	At project inception; owner bears cost of producing project model – each modeler bears cost of hardware, software and interoperability of contributions to model; lack of software interoperability.
Summary / Analysis	There is a consensus among the respondents that the decision to implement BIM needs to be made at the project inception. It is also evident that the project team must define early on what level of accuracy the model will be used on the project. There appears to be mixed opinions on who should bear the costs. Based on the author's experience and research it can be concluded that the Owner should bear the cost of producing the model while each modeler (designer, contractor, subcontractor, and fabricator) should bear the costs of the hardware, software and training. The author also echo's the opinion that the lack of software interoperability is the principle obstacle to the advancement of the BIM project delivery method.

TABLE 3-4	
Industry Sector Responses to BIM Survey Question #3	
Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?	
Academia	None, other than in the educational environment
Construction	The construction industry made this move due to demand for a competitive edge. The aerospace industry has used BIM for decades. Only companies that are willing to "jump into" BIM will gain the largest projects and increase bottom line profits. We are currently entering into our first BIM project.
	3D is much better for visualizing the project. We read drawings but we all think in 3D anyway. I personally have been involved with 10, Skanska 50+.
	For those that have made the transition, they have seen the benefits and understand the processes. The more projects that they have completed the more experienced they have and see the benefits. I've been doing BIM since 1987. Too many to count.
	The 3D process allows interferences to be identified a lot easier and it is a great tool for building owner who may know how to run a business but can't read blueprints. The 3D models are great tools for marketing. I have completed one project with BIM and involved with two others right now.
	Coordination and the use of CNC data. Probably around 50.
Design	"Clash detection" seems to be one of the biggest sources of problems, change orders and claims and the 3D based process at least holds the promise of reducing this element. From a design perspective it allows the architect to develop the design in 3D and at the same time develop the background detail that identifies scope, etc. - this holds promise of a richer development of project information at an earlier point in the process. Two – see above.
	I haven't witnessed the construction industry fully embracing 3D. I see more activity in the design industry and most of that is for design coordination, not construction. I have used BIM on two projects.
Legal	3-D modeling permits more advanced clash detection, reduces errors due to changes, permits life cycle and environmental analysis; 5
Summary / Analysis	Based on the above survey responses along and the author's personal experience and research, it can be concluded that the AEC industry has shifted to the "3D" based modeling process due to Owners' demands for shorter schedules, tighter budgets, and

	complex designs which leave little room for error and delay. Owners' principle concerns are cost overruns and delays which often plagued complex large projects. Recently, BIM has also been helping Owners with the operations and maintenance of their facility once the project is built.

TABLE 3-5	
Industry Sector Responses to BIM Survey Question #4	
Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?	
Academia	If done right one gets a complete drawing and database. Not sure what the risks are. I can only think of advantages.
Construction	Since we have just begun to work with BIM it would be unfair at this time to comment on this question. I will comment on one item and that is the design firm is "learning by design". In all fairness we are also.
	Common advantages: more comprehensive design validation or design coordination verification (finding problems in the design phase); coordination of MEP trades is much faster and more comprehensive; and the link to operation and maintenance data for long term O&M. Common disadvantages: Not enough buy-in from Sr. Management, subs and or the owner. With regard to the subs, if they don't have the capability we have supplemented them with outside vendors. We have overcome some of the disadvantages of legacy views with examples of BIM in action on other projects and created peer pressure.
	Benefits: Savings in Estimating time, construction coordination, shop fabrication, field labor, less rework, lower labor rates due to less experts needed in the field for problem solving. Other benefits include automated reports for change orders, digital RFIs, better installation planning which also creates safer working conditions, more fabrication done in the shop as opposed to the field, (more efficient in the shop). Schedules tied to BIM models. Owners and architects have clearer understanding of conditions and interferences when models are used. Risks: There is an investment to be made in order to make the transition which includes software, hardware, personnel, training and programming. Control Risk: Our Company was solid and could make the investment / also understood the importance of training.
	The biggest advantages are explicit detailed drawings for the field and allows for more shop fabrication. The critical risks associated were time frame to complete the model, finding qualified CAD operators and finally if one discipline has a mistake it can

	adversely affect every discipline that is following them.
	(A) Accuracy and coordination speed of delivery, CNC and purchasing data transfer. (B) Legal liability, tracking of changes, accuracy of transferred models/level of detail and associated rework.
Design	During construction the contractor was able to determine where clashes were going to occur "in the model" instead of "in the field". This allowed for development of responses and solutions before they cost money (in many instances) – which was a big advantage. Not sure if I can speak for the firm; I have found Revit to be somewhat laborious to use in the final stages of development of the last details to complete the CD's. This takes some getting used to and sometimes an early modeling decision comes back as a problem near the end. It is mostly a function of the level of education and experience the user has – as an architect and as a Revit user. These sorts of things are to be expected in any industry wide roll-out of a new tool that is catching hold as fast as BIM. I expect the most critical risk will arise from the interface of the design team (who has created a model); with the construction team (who would like to use it) – and an understanding of what level of accuracy and correctness is to be expected from one party of the other (when they typically don't have a straightforward contractual relationship).
	Advantages are time savings and improved quality. Disadvantages are software limitation and lack of buy-in from other parties. We control risk by working within our limits
Legal	Superior clash detection and more cost effective clash resolution; 1) Interoperability errors – particularly in round tripping of data; 2) Difficulty depicting as built structures pre-existing to which new work will attach 3) Architect fears of change and loss of design control
Summary / Analysis	Again, there appears to be a consensus among the respondents that "clash detection" ranks the highest of the benefits (advantages) to BIM. The respondents identified several drawbacks to this technology. However, it appears that the major disadvantages are as follows: interoperability, steep learning curve for all project participants and the blurring of traditional lines between the designer and contractor. The author concurs with the later drawbacks and also believes that the AEC industry as a whole is fearful of change and therefore will ultimately wait for Owners to mandate BIM uses prior to making the transition. Based on the varied responses it doesn't appear that the AEC

	industry has employed a formalized risk control mechanism for this new technology.

TABLE 3-6	
Industry Sector Responses to BIM Survey Question #5	
What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?	
Academia	Revit. As with any software application, there is an upfront effort to make sure all software shares data. Talk to the software developer and use the same package they are testing with. A little investment up front saves $$ and time in the future.
Construction	We currently do not use any in house.
	We primarily use Navisworks as a collaboration tool. Since we do not author our own work we do not have a standard authoring platform. However we do have experience with Revit, Archicad, Bentley, Catia, ADT. Compatibility issues do arise, however depending on the data we need certain file exports work better than others. With regard to the having the data in the model in the first place, it is best to work with the designers and ask them for the data to be included. Even then we need to experiment with export file formats to make sure we get what we need.
	AutoCAD 2002, 2006, 2007, 2008, 2009, Building Systems, AutoCAD MEP 2008, 2009, Revit Arch, Revit MEP, Quickpen, East Coast, CAD Duct, CAD CAM, EST MECH, EST DUCT, CAD MEP, CAD MECH, Hydra CAD, FREEDOM, NAVIS, No compatibility problems Hired competent candidates
	We are currently using CAD MECH it is marketed by TSI and runs on top of auto cad therefore it is autocad based and can be utilized by anyone with Auto Cad.
	We use SDS/2 steel detailing software by Design Data. We have imported models from RAM, ETABS, and Revit structure. We have exported to AutoCAD and Navisworks, but have not successfully exported to Revit. Settings and file formats are critical.
Design	Revit Not that I am aware of; but we might have. When new versions come out, that will be an issue as to when you switch over to the new version – same thing happened in AutoCAD. Don't know.

	Don't really know what risks you are asking about, so can't really address this one.
	We use RAM Structural System linked with our CAD drawings via RAM CAD Studio. We collaborate with fabricators/detailers using SDS/2 and have the viewer from SD2/2 in house.
Legal	Have worked with Revit and Bently; Yes!; money and patch writing; slowly developing contract risk shifting language – insurers now provide expanded "valuable papers" coverage.
Summary / Analysis	Based on the above survey responses along with the author's research it is apparent that the AEC industry has not adopted a uniform platform and/or software program. This lack of uniformity leads to the previously identified issues of interoperability and information management. This conundrum reminds the author of the "race" between VHS and Beta. BIM relies heavily on software vendors that are competing for market share with their BIM products and are therefore not particularly eager to make their products compatible. It can be concluded that until one software system takes the lion share of the market, the problems with functionality will exist and will ultimately hamper the broad implementation of BIM.

TABLE 3-7	
Industry Sector Responses to BIM Survey Question #6	
BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?	
Academia	Interesting question. I think that it will. Mainly, it will be the tool for all members to communicate with one another. We can all play in our own sandbox but everyone will be watching and observing. I think the owner will eventually win with a less expensive, but better, project.
Construction	YES. We are in the very beginning and we can already see advantages of BIM for construction and design.
	There is a difference on a BIM project with regard to construction. With regard to responsibilities changing, I think the roles of BIM technicians, or VDC Managers, or project engineers are evolving. There is a new vocabulary and a new set of processes that we have employed. Based on ability and the size of the project team, we have decided on who will use this data. The other traditional roles of PM and Supt have not changed that much, however it has made the construction process easier to visualize and solve problems.
	No
	No response.
	Yes, when things go wrong someone will be blamed. Each entity will either need accept responsibility for the data and be compensated appropriately or limit their liability.
Design	I don't think the "core" responsibilities of the project team will change because of BIM; necessarily. It may be that use of the tool redefines the roles of project team members and certainly different project delivery methods such as "design- build" would change those core responsibilities.
	I think the core responsibilities are essentially the same but will expand to be directly linked with fabrication and construction (current link is indirect).
Legal	Yes – group responsibility and buy in for design development is critical.
Summary / Analysis	Again, there appears to be a consensus among the respondents that "core" responsibilities of the project team will NOT change because of BIM. Meaning, the designers are still responsible for the design of the project and the contractors are still responsible for the construction of the project. However, the AEC industry must acknowledge and recognize there is a new project position

	(role) evolving called Model Managers. This position is critical to the BIM process to ensure the responsibility boundaries are not blurred between the work of the designer and contractor.

TABLE 3-8	
Industry Sector Responses to BIM Survey Question #7	
In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?	
Academia	Not sure I should answer this one.
Construction	Design and construction have to be in sync with each other. We are currently working with Timberline Estimating software to incorporate BIM. This will be used to speed estimates and increase accuracy. The builder has to have in house software that can communicate with the design team software.
	The integrated project delivery form of agreement is a great document to help align the project parties. Outside of a formal agreement to "get along" and share the risks and rewards, voluntary culture change doesn't happen that often.
	First, it should be written into the contract and specifications. Next I would pre-qualify the subs to verify that they have the capability or will be delivering as expected.
	No response.
	Design-build is the best delivery method to get everyone on the same team under one contract and working collaboratively toward a common goal.
Design	A. An enlightened educated client who sees the advantages of the new approaches to work on projects. B. Bringing the major players on board early; and nearly at the same time. CM people need to be on board early in the design process to provide cost and level of needed information feedback to the design team. At some point, CM people might take over some of the details of the model to get it into a format that they need for bidding and use by their subs down the line. C. All the firms involved must be committed to project success, and the people must be trusting of each other – part of the same team and not an adversarial relationship.
	The ultimate practice is by utilizing lean construction methodologies – contractual arrangements that structure teams that are motivated to collaborate (not de-motivated). Regardless, all parties must be trained and equipped and fairly compensated.
Legal	Beat the project architect with the nearest blunt object until they remember to breathe (just kidding) – assign a model (master – responsible for edits to master model and getting updates to team; early structural, MEP and skin model impact.
Summary / Analysis	The AEC industry exists within an adversarial society where conflict is prevalent. Hence, the bright lines of responsibility

	between designers and contractors. The BIM process, by nature, promotes collaboration and integrated project delivery methods. Regardless of the obvious benefits associated with BIM, voluntary change will not occur. Therefore, the most efficient way to align project participant is to incorporate BIM requirements into the formal agreement. Owners must take control of this requirement.

TABLE 3-9	
Industry Sector Responses to BIM Survey Question #8	
Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?	
Academia	No Experience in this.
Construction	At this time we have not seen any differences in contractual language. I went to a BIM seminar on Legal Aspects of BIM and this is new to everyone.
	To my knowledge we have not signed any parallel agreements with regard to BIM, only the IPD agreement from the AIA. However each of our subs must comply with a 3D MEP spec which we have authored. We have signed indemnification agreements in order to get drawing files and or model files.
	I've been on projects where it was a secondary consideration and additional scopes were written in and additional compensation for BIM-MEP coordinator.
	I have yet to see any construction agreements that address BIM. I think the design firms are worried about responsibility at this point and feel the models need to be generated by the contractors but they don't want to dictate any certain methods.
	Yes, typically custom parallel agreements or blanket disclaimers provided at the time of transfer.
Design	Not to my knowledge.
	No
Legal	Yes – most contracts have zero process ("prepare BIM model;" a single line in a 1000 pg. contract). Worked on US Army Corps of Engineers BIM Addendum and only form out there that gets into subcontractor terms right now
Summary / Analysis	Based on the above responses from the respondents, it is obvious that BIM is still in its infancy stage as it relates to contractual obligations. Although some sophisticated Owners (i.e. U.S. Army Corp of Engineers) with vision have introduced custom contracts with BIM Addendums, currently the AIA and EJCDC have not published any BIM contract language to date. The new 2007 AIA edition introduced for the first time a document called E201 "Digital Data Protocol Exhibit" which is primarily geared towards CAD files and the like, not BIM, and it only addresses transfer, not process and the like.

TABLE 3-10	
Industry Sector Responses to BIM Survey Question #9	
Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?	
Academia	Not Sure.
Construction	I have seen changes in the last 30 years of being in this business. 30 years ago the designers/architects took more responsibility for their drawings. During the last 10 years the trend has been to shift more "design" responsibility to the general contractor. BIM, I feel, will return that responsibility back to the designers. I also see more design/build projects with our firm. With this, it puts the general contractor in the seat to direct the designers on how to design the project and with what materials.
	I do not think there is a change. The requirement for design docs has not changed; a model is a means to an end in most cases. Documents are still produced from the model. For construction models however, ones that we prepare, we make the statement in our agreements that the information contained here in is subject to the original design and is for coordination purposes only.
	No.
	No I think the ultimate responsibility is with the designer the contractor only coordinates the work. Anything that works in a scaled model has to work in the real world. The only difference with BIM is we first provide a trial run electronically.
	It can, but in many cases no. It primarily adds to the methods of delivering the same data.
Design	It may, depending on how the different team members expect to use information in the model; when they want to access it, and what level of completion and correctness they expect it to contain.
	Yes, but I think many in the industry exaggerates the change. In risk, our documents are historically verified and re-created by fabricators and constructors, but now they are used directly.
Legal	If contractors contribute to model they should get contractors professional liability coverage.
Summary / Analysis	The use of Building Information Modeling (BIM) as a project delivery system – or at least part of a project delivery system – raises unique opportunities and risks associated with design and construction operations. By taking the necessary steps to address these issues early, particularly at contract formation, the parties may be able to mitigate the impact of the new risks BIM creates while enabling a project to benefit from its technical advantages. BIM does not necessarily change the traditional allocations of risk

	and responsibility among the contracting parties. However, the roles and responsibilities assigned to the parties should be expressly defined in the context of what is expected from each party while using BIM as a project delivery system.

TABLE 3-11	
Industry Sector Responses to BIM Survey Question #10	
Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?	
Academia	a) Absolutely. b) Not qualified to answer this one. C) From what I hear, BIM will bring in the job faster and lower cost. See GM article in ENR. Not sure when it was published. Probably 12 – 24 months ago.
Construction	Yes to all. The last questions as far as cost, it should be worth no more in front end costs.
	BIM does hold great promise, possibly the most promise of any change in the past 20 years or longer. Paying for it is another matter, and we have had some success where we can make those decisions. The cost varies however as a rule of thumb .5% is a good number.
	Yes I do believe that BIM is/will be the next new process in design and construction. Our firm has paid a premium by investing in the tools, development and training. Not sure on the percentage question.
	I believe this is the future and there is no way to avoid it. I don't feel that the cost would apply to my line of work.
	We do pay a premium, but it is typically to reduce schedule, not risk. No question it is the future, though not even close to fully utilized. If properly used it is easily worth a 30% premium to the design fees (2-3% of project).
Design	It is part of a package of "tools" that can work toward these goals. The use of a "model" does not guarantee success – but it is a better tool than the ones available to the project teams in the past. Additional factors of equal importance are a collaborative and open atmosphere among all project team member firms and individuals; a project schedule that reflects the time requirements for creating the model to a proper level of completion at the various project stages; and project staff from all member firms with the proper level of general experience and understanding of the BIM software being utilized. We have "bitten the bullet" and jumped into the use of BIM. If a premium is being paid, we are absorbing it since I don't think we are asking for higher fees as a result of our decision to use Revit.

	Why should it necessarily cost more for the project if there is a tool that provides a savings in time and problems down the road? This is how contractors think. (*Just kidding – we are trying to figure out a rationale for charging a higher fee for using BIM; just haven't come up with a strategy yet).*
	It does hold promise, but the value is just as much if not more about relationships/project management than it is about technology. We would invest in BIM. We have not put a value on BIM.
Legal	Yes – but my firm doesn't actually model – we wrote contracts for people who do. People either get this and are willing to invest or they are stuck in 2D CADD land in my experience.
Summary / Analysis	Again, there appears to be a consensus among the respondents that BIM holds the most promise to save time and money, while reducing conflicts (claims) and increasing overall project quality. The respondents have varying opinions regarding costs for BIM implementation. The author's opinion is that all the design disciplines should be drawing with intelligent objects and should all bear the costs. However, the designers should receive financial rewards for producing a 3D model for the project. This would certainly provide the designers the incentive necessary to generate 3D models for every project. Peer pressures in the industry and business development requirements have already pushed most design firms into absorbing the costs for implementing BIM. In the future, responsibilities need to be redefined and financial rewards and risk allocated so that there is a stronger alignment of the interests of all project participants.

TABLE 3-12	
Industry Sector Responses to BIM Survey Question #11	
The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?	
Academia	The industry is the big dog in building development field. Support the leaders. When they come in with the lowest bids, the rest of the industry will follow suit or drop out. Probably the best thing to do is sponsor seminars illustrating case studies and information.
Construction	I believe that general contractors need to demand this from the designers that they hire when the general contractor or construction manager hires or recommends a designer to an owner.
	One of our clients said that they can't control labor costs, or material costs, nor land costs so their only solution is to make it functional faster. This is a great intro for BIM with regard to delivery faster and better design and ultimately constructed facilities.
	Write it into the contracts and specifications.
	I have seen the increase in efficiency due to BIM. The biggest problem right now is qualified 3D designers who also understand constructability. There needs to be a large push to train operators for the many different types of software being developed but it is important that the designer understands how the job needs to be built when detailing the project.
	Today most large designers are being forced to react by contractors and owners. The change is significant and inevitable, so designers really need to become educated and prepare for the time and money investment to their firm.
Design	Working closely together on the design and construction side makes the most difference I think. Sharing information in an open and non-confrontational environment is most effective, and when coupled with use of effective tools like BIM, this is compounded benefit. The biggest obstacle to all of this is the legal issues that pervade our industry and the prevailing attitudes of self-preservation and protection rather than open honest communication.
	(1) Demand/promote interoperability * (2) Draft sample contracts and financial models * (3) Educate clients and each other *

	*Achieved through collaboration of industry group organizations and national and local levels.
Legal	Force software companies to use IFC platforms to permit robust interoperability; show larger developers pretty models and get them excited about energy analysis- life cycle O and M saving also have governments allow (or require) BIM model for permitting.
Summary / Analysis	The issue with interoperability must be solved swiftly to reach an all-encompassing open-standard process for BIM. As previously discussed, several groups have attempted to make interoperability seamless. The NIBS has released guidelines on implementing BIM as well as on coordinating such open standard. Based on the author's research it appears that IFC platforms are the best answer to solve these challenges. Finally, owners must take the leadership role in the general construction industry to promote a true interoperable solution. Again, in the author's opinion, the answer does not reside with an owner forcing AEC firms to buy software applications, whether or not it fits their work process. The most influential organization to encourage the use of BIM is the U.S. General Services Administration (GSA). The GSA began its National 3D-4D BIM program in 2003 and now requires (since 2007) the use of BIM on all new projects.

TABLE 3-13	
Industry Sector Responses to BIM Survey Question #12	
Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?	
Academia	Yes if I can contribute.
Construction	Yes.
	Happy to help if I can.
	Yes, Very interested.
	Yes I would.
	Sure.
Design	Probably not, this is about as deep as I can go on this.
	Yes but keep in mind that my experience is limited.
Legal	Sure.
Summary / Analysis	There appears to be a consensus among the respondents that my survey questions reached their plateau of BIM knowledge and experience. This reinforces the author's belief that his experience and detailed research has brought himself to the cutting edge of BIM technology and its processes.

3.5.2 Interview Analysis

As previously discussed, due to the relatively small response sample size and the lack of responses from owners, a follow-up interview was scheduled and conducted with an owners' representative who has previous experience not only with BIM technology but more importantly has vast experience with large scale complex projects.

Based on the feedback received from the interviewee, BIM benefits such as saving time and money along with improved quality of finished product are again echoed. However, this interview introduced a new viewpoint from the owner's perspective which validated that compensation is still one of the primary obstacles that prohibits swift adoption of BIM as a project delivery method.

CHAPTER 4 – CASE STUDY: SPRINT CENTER ARENA

4.1 INTRODUCTION

The objective of this Chapter is to describe the BIM implementation and application on the Sprint Center Arena Project during July 2005 to October 2007. To compete with an ever demanding sports market the City of Kansas City, Missouri decided to construct a new arena in its downtown business district (the "Arena"). This Arena is designed to NHL and NBA specifications. The Arena has a seating capacity of approximately 18,000 to 20,000 for NHL and NBA type events. The Arena's completion date was in conjunction with and in support of the City's KC Live Entertainment District, the H&R Block Headquarters building and other projects in the vicinity. The Arena was expected to be one of the focal points and anchors the new downtown entertainment district. On the Sprint Center Arena Project, Mortenson, was acting as the Construction Manager at Risk and the Architect was the Downtown Arena Design Team (DADT) which was formed by HOK Sport, Ellerbe Becket, 360 Architecture and Rafael Architects. The Design Team was selected based on Pre-Qualifications based on the size, type and complexity of this type of project.

4.2 BIM APPLICATIONS

Early on in the project, Mortenson decided to build a 3D/4D model of the project to visually support this complex building structure. Mortenson created a comprehensive 3D model of the whole existing and proposed structural conditions of the project. Mortenson developed this geometric 3D model using 2D CAD drawings

supplied by the design team. A 2D conversion is the process of taking the traditional CAD files (such as .dwg) and using the attributes necessary to add the third dimension that allows the 2D Design to begin taking its 3D form. There are several software programs available to perform this conversion. Mortenson then created corresponding 4D models by linking the overall construction schedule to these 3D parametric models. By combining project scope and schedule information which would usually be represented in various different information sources, 3D/4D models serve as an instrumental construction planning, coordination and communication tool.

Mortenson is an expert in using innovative construction technologies and processes to reduce the time and cost of construction as demonstrated by the Case Study Project: Sprint Center Arena. Mortenson has developed in-house processes to improve the cost, quality, and schedule of complex projects. Mortenson industry leading expertise can be further understood from the below BIM processes utilized during the preconstruction and construction phases on the Sprint Center Arena.

4.2.1 Visualization

The construction industry is burdened with inefficiencies and redundancies, and in recent years, productivity has measurably declined relative to other industries as previously discussed in Chapter 1. Frequently, the lack of productivity has been associated with rework, poor planning and injuries. Mortenson has addressed these issues through the innovative application of BIM technology. With this powerful visualization technology, you can view the project from multiple vantage points, and zoom in and out as if traveling through the building.

The model has 3D visualization capabilities. The 3D model used on The Sprint Center Arena project allowed the design and construction teams to clearly understand and communicate complex design features to the entire project team. By using the model, Mortenson was able to visualize the entire structure, gaining a greater understanding of the challenges involved in its construction. Specifically, the exterior enclosure (envelop) of The Sprint Center Arena was designed as panelized glass curtain wall systems, a total of 2,214 individual units, supported by structural tube steel. This complex design represented the single biggest project challenge. Therefore, the structural and enclosure components of this design feature was modeled as shown in **Figure 4-1 and Figure 4-2** respectively, for the Sprint Center Arena Project.

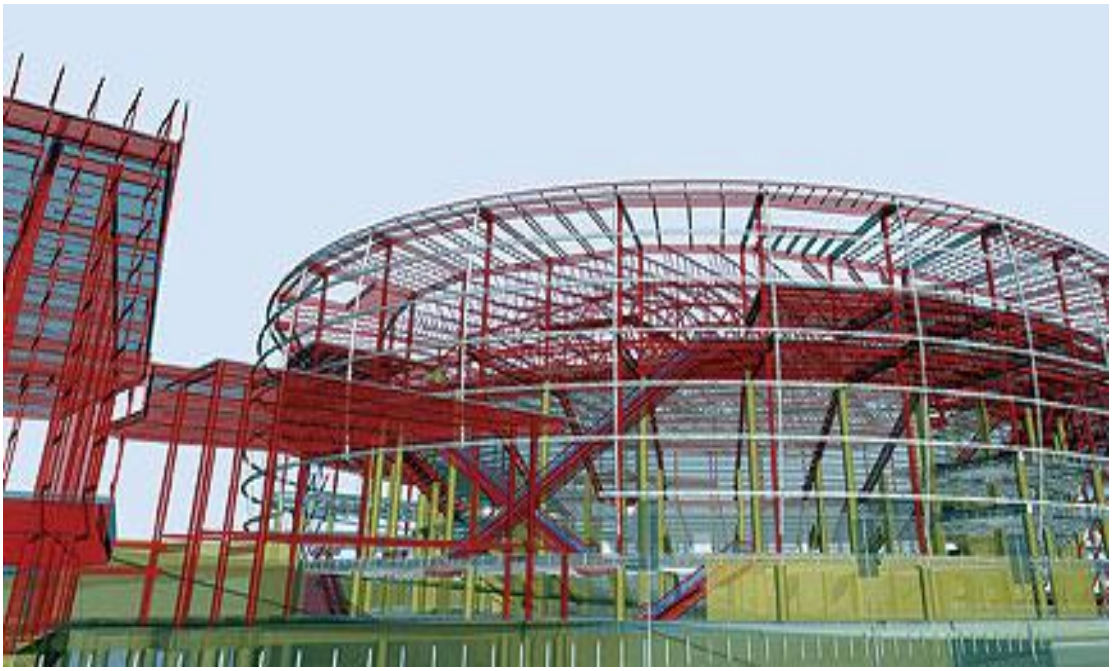


Figure 4-1. Design Visualization of Structural Components (*Mortenson 3D Image*)

Figure 4-2. Design Visualization of Enclosure Components (*Mortenson 3D Image*)

4.2.2 Partial Trade Coordination

Mortenson performs the 2D conversion (2D Design into 3D) in-house with Design Phase Coordinators (Model Managers). At this point in time it has already been established how the 3D model will be used. Meaning the below tasks were addressed in the design phase of the project:

- Determine level of detail necessary (not all architectural elements are modeled)
- Establish roles (which subcontractors are required to deliver 3D models)
- Mortenson assumes the role to assemble the "composite" model
- Establish exchange methods of files and formats (shared folders on FTP site)
- Implement regularly scheduled coordination meetings

4.2.3 Collision Detection / Avoidance

On the Sprint Center Arena project, all disciplines (structural, mechanical, electrical, plumbing/piping, fire protection and HVAC) were modeled by each respective subcontractor as a requirement set forth in their contractual obligations. These subcontractors were given a certain timeframe to start the 3D modeling process. Again, it is critical to integrate the 3D modeling effort with the overall CPM schedule to ensure this process supports the field operations. Mortenson Design Phase Coordinator is responsible for clash detection and information gathering/exchange based on the models supplied by the respective subcontractors. All disciplines must be coordinated against one another (i.e. MEP vs. Struct/Arch and Plumbing vs. Ductwork). This process greatly reduces conflict issues by integrating all the key systems into a single "composite" model. Mortenson used the software system NavisWorks to automatically detect and highlight conflict issues for resolution. For simplicity a single area (Club Level West) of the Sprint Center Arena will be examined to review the coordination procedure.

During weekly coordination meetings as shown in **Figure 4-3 and Figure 4-4** 3D clash issues were reviewed in detail by location, description and status. In order to resolve clashes, a clash detection resolution priority was established. Meaning, coordination of priorities in conjunction to the relationships of disciplines that are most to least affected relative to one another. In other words, Architecture and Structural should be coordinated first and take precedence over all other disciplines. The least to most flexible (MEP) disciplines are as follows: Plumbing, Mechanical,

Electrical and Fire Protection. Based on the above precedence, clashes should be resolved accordingly. Most changes will have minimum cost impacts due to early detection and avoidance.

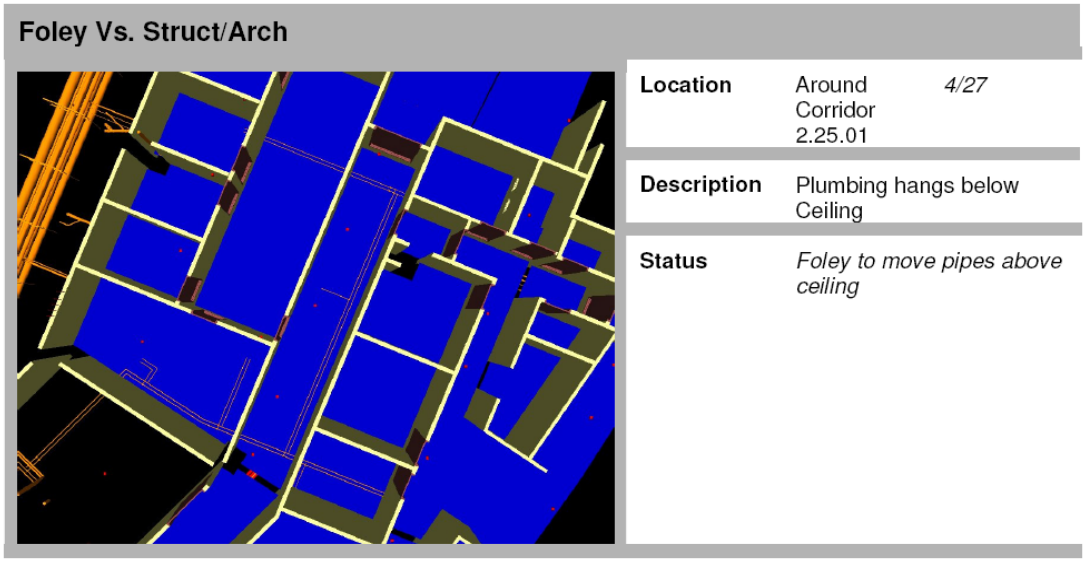


Figure 4-3. Clash Detection - MEP vs. Architectural (*Mortenson 3D Image*)

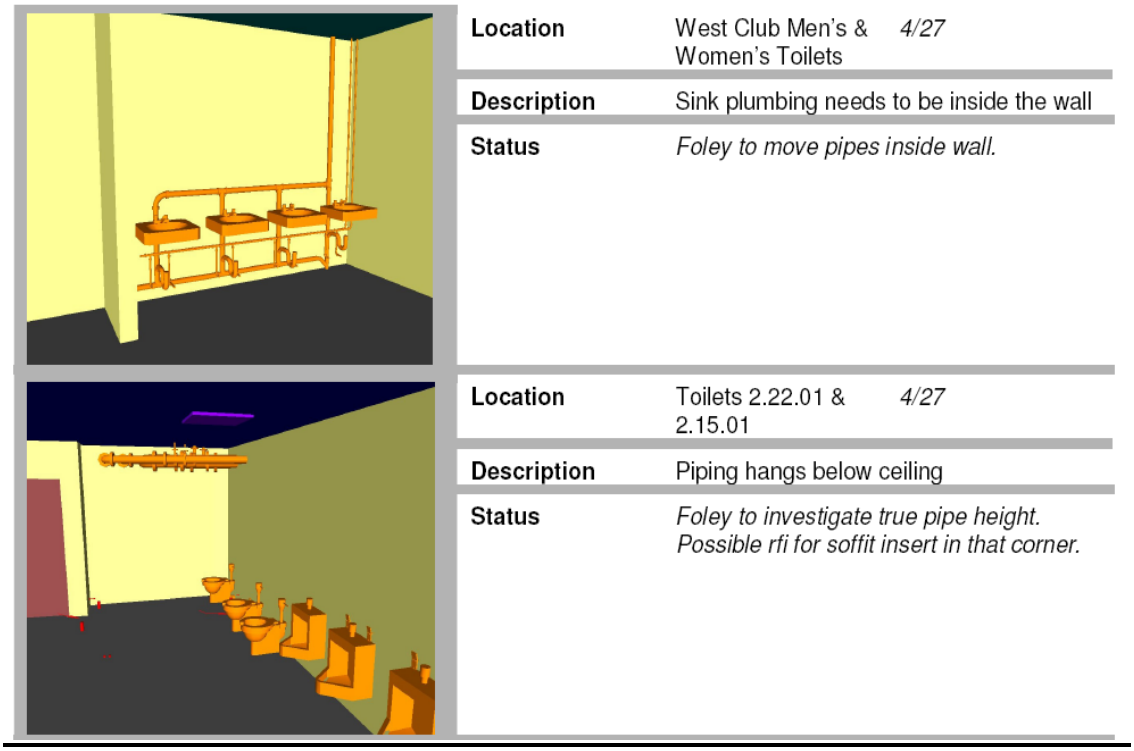


Figure 4-4. Clash Detection - MEP vs. Architectural (*Mortenson 3D Image*)

4.2.4 Design Validation

This task is performed by Mortenson during the preconstruction (design development) phase of the project. Essentially this task is similar to the 2D based process of using light tables (2D overlay coordination) to identify major conflicts or errors with structural elements and mechanical, electrical and plumbing (MEP) systems for constructability issues. Typically, "Design Validation" is categorized as a preliminary design review of structural and MEP Systems. More specifically, risers, mains, routing, and stacking priorities are reviewed in detail. In addition, major mechanical elements such as ductwork are reviewed against structural and architectural disciplines. These activities are predecessors to sleeve coordination activities. Sleeve locations are critical for the coordination of the structural and MEP

disciplines. This entire process is performed by seasoned MEP coordinators whom are familiar with typical design coordination issues based on several years of experience in the industry.

4.2.5 Construction Sequencing Planning / Phasing / Site Logistics

In addition to the 3D parametric modeling (3D model with attributes) which not only include visual aspects of the building elements they represent, but also have the properties (or knowledge) of the solids they represent, the extended use of 3D intelligent design models lead to references to terms such as 4D (adding time to the model). The 4D Model is the term to describe the linkage of a schedule to a model. Basically, turning on model elements in the order in which they are built. This process is invaluable in coordinating construction sequencing activities by integrating the CPM schedule data with the model data to identify any out of sequence work.

The simplest way is to think of the 3D Model as a "tool"; then applications of its use throughout planning, design, construction and facility operation processes are almost infinite. Thus, there are many applications of how the 3D "tool" can be used to improve all of the processes in our industry so the growing trend is to refer to all of the extended applications using the 3D tool as **"XD."** The below **Figure 4-5** illustrates Mortenson application of BIM to generate 4D Site Logistics Plans for Sprint Center Arena Project to improve the construction planning and coordination process.

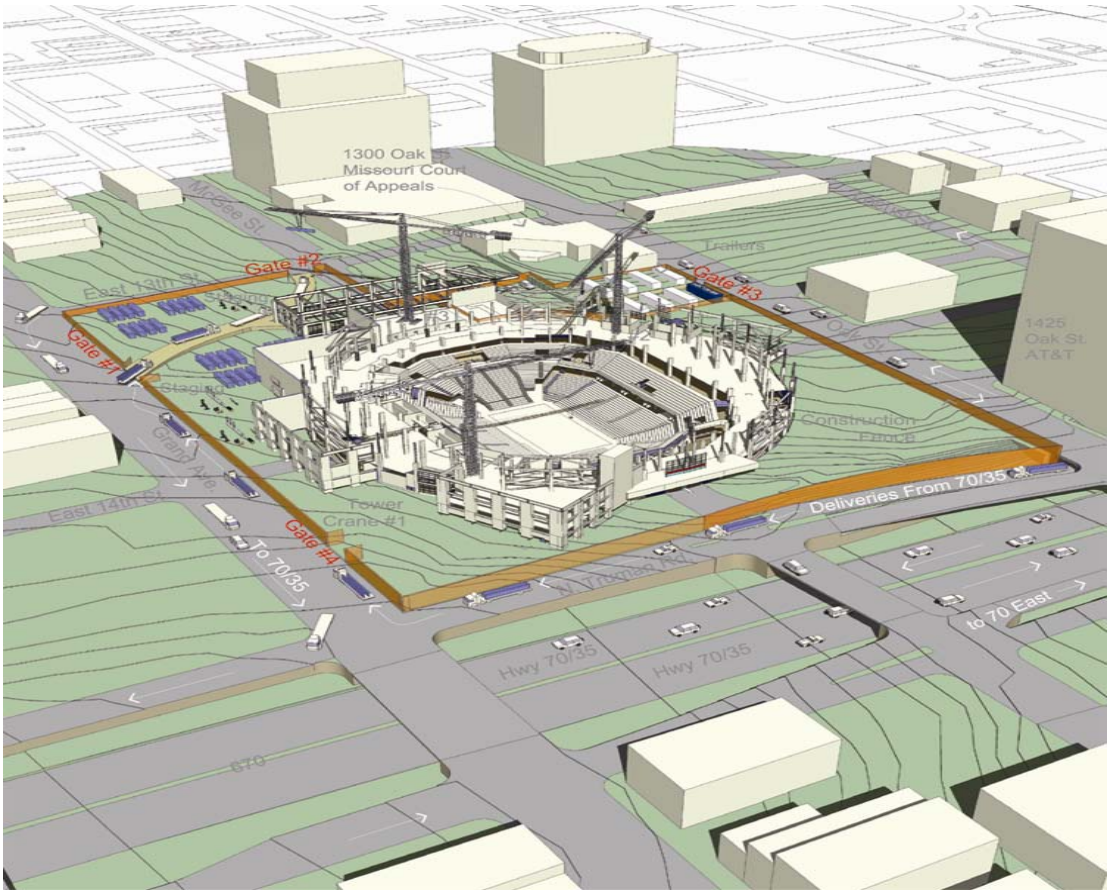


Figure 4-5. 4D Site Logistics Plan for Sprint Center Arena (*Mortenson 4D Image*)

4.3 SUMMARY OF LESSONS LEARNED

The case study project "Sprint Center Arena" validates the benefits of using 3D enabled collaborative construction as a tool to operate more efficiently and in more expeditious ways. However, this modeling effort was not accomplished without several obstacles. This section will provide a summary of main problems encountered during the implementation of the BIM processes and review the lessons learned from this type of project delivery method.

4.3.1 Model Manager

One of the problems that Mortenson encountered early on in the BIM effort was the challenge of finding an experienced 3D computer modeler who not only understood the computer software but also was knowledgeable in the aspects of design and construction. Typically, most 3D computer modelers come with design backgrounds but lack construction field experience and "street-sense".

Another issue that was discovered early on in the design phase was the requirement for a 3D computer modeler "model manager" that was knowledgeable in BIM Implementation Guidelines. One cannot express how important it is to establish 3D modeling guidelines and protocols. This includes not only acquisition of 2D design data provided by others but also the acquisition and integration of the schedule data. As previously discussed, the model manager has a new critical role in the design and construction process and must assume the managing responsibilities of digital information to ensure there is not blurring of design responsibility between the design team and contractor. Strict adherences to the established 3D modeling guidelines and protocols must be followed. Recall, the model host assumes the risk of verification of data provided by others and the liability for transmission to others of incorrect/inaccurate information.

4.3.2 Contract Terms

Unfortunately, the agreement between the Owner and Architect did not require that the Architect (DADT) and its design consultants provide a complete 3D model. Meaning, the design team was not contractually obligated to design the

project in 3D. By developing and coordinating a complete 3D model, the design team could have discovered and resolved uncoordinated or incomplete design issues early and resolve conflicts before they were discovered in the field.

In order to achieve the benefits from BIM, Mortenson was forced to build a 3D Model from the design team's 2D digital data. This task became monumental and required the model manager to take several months to essentially create the project 3D model. Again, if only a portion of the project is completed in 3D then only that portion can benefit from the BIM tools. This work by the model manager was redundant, time consuming and unnecessarily expensive. This effort proved to take longer than previously anticipated. The model manager discovered several conflicts between the 2D hard documents and the 2D digital data which required several hundred requests for information (RFIs) to address these errors and omissions. This process highlights the industries disconnect between 2D hard documents and 2D digital data. Design firms have instituted boilerplate disclaimers (i.e. electronic data transfer agreements) which simply state that the 2D hard documents govern the 2D digital data. These standard disclaimers are inherently in opposition to the widespread application of BIM technology to the building process. To overcome these standard disclaimers on the Sprint Center Project, Mortenson model manager was required to verify all 2D digital data provided by the design team and its consultants.

Mortenson's subcontract agreement required that every critical subcontractor model their own scope of work on the Sprint Center Project. In addition, each

subcontractor was required to comply with a 3D MEP specification exhibit which was authored by Mortenson. However, the Agreement failed to explicitly define the open file format for digital data received by the subcontractors. This contractual requirement would have addressed the plethora of proprietary CAD and other file formats used in design and construction. Instead, Mortenson was forced to take additional liability and incur extra costs to ensure the BIM processes were implemented and not simply abandoned due to early interoperability challenges.

4.3.3 Compatibility of BIM Programs

Early on experience at the Sprint Center Area resulted in a harsh realization that there are several limitations in the use and implementation of this technology. One critical limitation which was experienced at Sprint Center Arena dealt with the sharing of data; which requires full compatibility of hardware and software and a coordination of the persons entering data into the systems. Several challenges were discovered when integrating all of the key systems into a single "composite" model. The lack of uniformity among BIM technologies and the information they are capable of incorporating resulted in the single largest challenge to this BIM approach.

Mortenson on the Sprint Center Arena purchased specific 3D Interoperability Software (Navisworks) which provided the platform to combine multiple models produced in different design packages into one file, to be viewed as one composite model. Mortenson primarily uses Navisworks as the collaboration tool. To overcome the challenges of integrating digital data in countless proprietary file formats, the AEC industry must embrace the (IAI) effort of "The Building Smart." A key

component of “Building Smart” is the development and use of Industry Foundation Classes (IFC), an open source file format.

To gain a brief understanding and appreciation for the plethora of popular BIM systems below is a list of systems offered by the leading suppliers of BIM technology:

- Autodesk Architectural Desktop (ADT)
- Autodesk REVIT
- Bentley Systems
- Graphisoft ArchiCAD
- Nemetschek

With the absence of a single model, software vendors aspiring to gain market share have forged ahead with competing BIM systems that differ from each other in material detail. Design and construction professionals willing to pursue open standards in the AEC industry are faced with the choice of pursuing either IFC or X3D paths. This choice could prove to be very risky since their selection could be the system that might be abandoned amid the market race.

4.3.4 CPM Schedule Integration

As discussed above, the 3D model on the Sprint Center Arena Project required our model manager to take several months to create. This time consuming effort was not truly a collaborative environment therefore not all the benefits of BIM were realized by the project participants. This effort actually delayed the early 3D coordination efforts with the critical subcontractors since the 3D model needed to be

created first prior to this phase. The desired BIM design process occurs during the Schematic Design Phase of the project in lieu of the Construction Document Phase which increases its ability to impact change with minimal costs for design changes. Another drawback from a scheduling standpoint was that the 3D coordination process was not integrated into the CPM schedule on the Sprint Center Arena Project. In order to properly track and monitor the progress of the 3D coordination effort, it must be integrated into the CPM schedule as separate work activities. These 3D coordination activities need to be predecessors to the construction activities (i.e. MEP Rough-in). This schedule integration will ensure that the 3D coordination activities are completed on time and in the proper sequence to support field operations.

It should also be noted that there are several major 3D coordination tasks that need to be completed early in the design phase of the project to support successful 3D coordination schedule integration. The aforementioned activities are as follows:

- 2D Overlay Coordination – identify major conflicts of systems
- Sleeve Location Coordination – determine conflicts with structure
- 3D Layout Coordination
    - Modeling – layout and design based on accurate design models
    - Begin 3D Coordination – clash detection process
    - Sign-off – completion of 3D coordination process, trades sign-off on composite drawings which are used in the field

Successful implementation of the above 3D processes can be contributed to the following factors:

- 3D expectations are explicitly defined in subcontractor bid packages
- Early buy-out of critical subcontractors
- 3D/4D coordination activities fully integrated into the CPM schedule
- 3D coordinator included in project overhead from project inception

CHAPTER 5 – RESULTS

5.1 INTRODUCTION

Demands from Owners for more efficiency in creating capital improvements, condensed delivery times, fewer disputes, and reductions in waste and unproductive expenditures has propelled the AEC industry entities to create effective processes. Through the widespread application of BIM, it is possible that the industry can reverse its decade's long pattern of anemic productivity. This Chapter will present how BIM can be integrated into the design and construction process and introduce a systematic approach for the industry to achieve improvement by creating a collaborative commercial and legal environment most conducive to the broad adoption and growth of BIM technology.

5.2 DEVELOP APPROPRIATE BUSINESS MODEL

As explained in the previous chapters, there are several issues and practical considerations which have slowed the broad adoption of BIM. As noted, BIM is not just technology it is a project delivery method. The following pressing issues must be considered in developing BIM and its new project delivery method. These key issues must be addressed in the Owner-Design agreement and the project agreement signed between the Owner-Contractor which is ultimately signed by all project participants through flow down clauses.

Compensation. The use of BIM provides opportunities for increased service and quality to the Owner. BIM provides unprecedented opportunity to provide enhanced scope of service for design professionals. BIM has reduced ambiguities

and inconsistencies among the design information provide by the design teams which results in projects built in less time with fewer conflicts and claims. Unfortunately, this author understands that there has been little financial benefit provided to the design professionals. BIM requires a significant investment by design firms that are willing to change their existing procedures and enhance their services. Owner's must take responsibility and provide the designer with a portion of benefits related to increased efficiency and lower project costs by adjusting existing design fee structures. BIM lends itself to performance-based bonuses based on actual construction costs versus budgeted construction costs. Meaning, there must be shared benefits for the project participant based on project success. In variably, value based fees would certainly encourage the wide spread adoption and growth of BIM technology among the remaining non-users.

Risk Allocation and Reliance. Although BIM provides tremendous opportunities and benefits for the AEC industry it does come with new risks. Collaborative design environments with BIM are inherently in opposition to the existing case law which is based on individual rights and responsibilities. As discussed previously, information coming from many sources results in difficulty identifying responsibility. This reality requires the agreement to address who will host the model and ultimately assumes this increased risk. In addition, the project-wide agreement must interlock risk allocation among the contracting parties. Meaning, design and construction services should be priced accordingly to reflect the exposure retained by each project participant. There seems to be a concern among

the AEC industry that with the electronic sharing of information, the ability of contractors to claim detrimental reliance on the design has increased. Case law may be moving from the Spearin Doctrine in which the client provides an implied warranty of the suitability of the documents for construction but the design firm only has to meet a professional standard of care. Now, a new paradigm seems to be allowing contractors to claim they are intended beneficiaries of the design information and therefore have an absolute right to rely on its accuracy. Much of this trend is tied to the use of electronic information, and BIM may accelerate this trend. Based on the latter, the project-wide agreement must address liability limitations, indemnity, liquidated and consequential damages raised due to errors in the model. The agreement must explicitly address to what extent the design professional can rely on information incorporated into the model, which is provided by others.

5.3 DEVELOP BIM CONTRACT AND SPECIFICATION LANGUAGE

From a legal liability point of view (including both liability among the contracting parties and liability to third parties) BIM introduces uncharted waters, and only limited guidance can be taken from legal precedent. By taking steps to address these issues early, particularly at contract formation, the parties may be able to minimize the impact of the new risks BIM creates while enabling a project to benefit from its technical advantages. The purpose of this section is not to address all the varying scenarios that may arise from using BIM; rather, it raises several of the pertinent legal issues that should be evaluated on projects where BIM may be used.

The roles and responsibilities assigned to the parties need not be substantively different than they traditionally have been. They should, however, be **expressly** defined in the context of what is expected in using BIM to develop the model for the project. The development of and adherence to procedures for using BIM models that will protect the agreed upon roles defined by the parties are the crucial steps to maintaining an appropriate allocation of risk. As in any design and construction process, BIM simply requires a clear understanding of each party's role in the process.

Each contracting party needs to have control over its own model, allowing it to be shared for comments, conflict-checking, and problem-solving without changes or updates being made by other parties. To reiterate, design decisions should be made by the design team; means-and-methods should be developed by contractors. The process should be directed by a single, central model manager for the project, who grants access to the parties and maintains the availability, security, and version control of the data.

The following questions should be asked and if possible, expressly addressed in the Owner-Design agreement and the project agreement signed between the Owner-Contractor. In a general sense, these questions are not unique to projects using BIM, but they are particularly important to them (Larson and Golden, 2008):

- What models are to be developed?
- What party will develop and manage a model?

- What will be the content for each model? This may require some significant scope definition.
- Who will manage the overall modeling process, including integration of several models or data from several models? Will control or management of the model change during the design and construction process? Who will be contributing to the model or models, and does that party have direct access to the model(s)?
- How will data be stored?
- A definition should be developed as to what constitutes design versus non-design information.
- What models are for other parties' use?
- How, and when, can a model be relied upon?
- How complete must the model be, and by when?
- What work is to be "designed" by the contractor? Is there a performance specification? Is some portion of the work design build?
- If design recommendations are made by the contractor and incorporated into the model by the design professional, who is ultimately liable for the design?
- How do collaborative designs alter responsibility for design?
- Can pieces of a collaborative design be distinguished as the responsibilities of different parties?
- By what process will models be shared and made available?

- What parties can modify which models?
- What happens if there is a problem with the BIM software that causes a defect or delay in design or construction? Does the software producer have potential liability?
- Should the modeling process be incorporated into the schedule as an activity or series of activities? If not, what are the milestones for deliverables that will be incorporated into the model?
- Are digital models contract documents? If so, to what end?

The above questions should not be considered an exhaustive list but will provide some guidance when drafting the various design and construction contracts whilst establishing BIM modeling protocol and specifications.

5.4 IMPLEMENT INTEGRATED PROJECT DELIVERY TOOLS

As previously discussed, there are a host of possible owners and project team goals and objectives for the use of BIM with a variety of BIM systems in use today. There is also a wide range of capabilities amongst the AEC industry participants as it relates to BIM and its project delivery methods. According to the above list of questions, it is conceivable that it would be very challenging for Standard Form Agreements to address many of the BIM specific contract terms and protocols. According to the author's knowledge, no Standard Form Agreements by AIA or EJCDC have been published to date with BIM specific contract language.

With the above said, the author understands that industry efforts are underway to create standard contract language related to the use of BIM. The new

ConsensusDOCS group introduced the first standard integrated project delivery contract. The ConsensusDOCS 300, Standard Form of Tri-Party Agreement for Collaborative Project Delivery, provides the contractual framework for a truly collaborative interaction between a client, designer, and contractor. The parties sign the agreement at the inception of the project, binding them to collaborate in planning, design, development, and construction. This lean construction approach is also known as alliancing or relational contracting. This innovative agreement creates a core team to make project decisions. The author also discovered that ConsensusDOCS published its ConsensusDOCS 301, BIM Addendum on June 30, 2008. The ConsensusDOCS 301, BIM Addendum is the first and only industry standard document which addresses technology and legal implications of moving from a 2D world to a 3D world. The release of this standard document marks a significant step forward in utilizing BIM as a collaborative tool.

Recently, the leading design organization AIA and its component, the AIA California Council, published Integrated Project Delivery: A Guide to help define the concept of integrated or relational contracting for project delivery. This Integrated Project Delivery Guide is offered as a tool to assist owners, designers and builders to move toward integrated models and improved design, construction and operations processes (AIA, 2007). The goal of the Guide is to identify the characteristics of IPD and to provide specific information and guidance on how to utilize IPD methods to achieve enhanced design, construction and operations processes. The material in the Guide extends beyond a mere definition of integrated project delivery by examining

how responsibilities are redefined and financial rewards and risk are reallocated as the design and construction processes blend. Most importantly, it assumes that the use of building information modeling for design and construction is fundamental and looks beyond the technology to the refabrication of the process and the restructuring of the form and relationship of the participants.

These transformative tools were produced separately by the construction side of the industry and the leading design organization for building projects. This innovative collaborative approach to design and construction fosters greater alignment of the interest of all project participants with the overall success of the project. The use of BIM requires greater collaboration among its project participants, to fully utilize the attributes of the technology both of these tools will serve as catalysts for refabricating the design and construction processes.

5.5 PURCHASE APPROPRIATE INSURANCE

There are significant general and professional liability exposures that the AEC industry as a whole (or the law) will have to deal with when implementing BIM and its integrated processes. The insurance industry already struggles with the difference between professional services and means and methods. As previously discussed, BIM and its project delivery methods only further blur the lines between designer and contractor. The reality exists today that professional services and means and methods are becoming more integrated and harder to separate. BIM essentially accelerates this trend. A basic understanding of the difference between General Liability Policies and Professional Liability Policies is helpful at this point in time.

Commonly, the contractor is required to carry Comprehensive General Liability (CGL) insurance. Generally, CGL policies are intended to cover unusual, unexpected losses and exclude liability arising from professional services. Commonly, the designer is required to carry Professional Liability insurance. Professional Liability coverage provides protection against claims that the policyholder becomes legally obligated to pay as a result of an error or omission in his/her professional work. Also known as E&O insurance, this type of liability insurance is critical to design firms. Errors and Omissions insurance helps address claims of professional liability in the delivery of technical services by design professionals. A Professional Liability policy is not intended to cover liability arising from means and methods.

The insurance coverage must mesh in the integrated world of BIM to ensure proper project coverage and avoid claim disputes between policies. The solution to this problem is as follows (O'Connor, 2008):

- Change how bodily injury and property damage is insured for both General Liability and Professional Liability.
- Require the insurer for both General Liability and Professional Liability to agree to a mixed claim endorsement or agreement.
- Develop Professional Liability BIM endorsement which provides a broader coverage for professional services, i.e. technical consulting.

In addition to the above coverage's the model itself must be protected by insurance that covers the economic losses to the parties if the model is lost or

damaged by viruses. Whichever party has assumed or is assigned the risk of model hosting, it should procure insurance covering this activity in addition to the ones noted above.

CHAPTER 6 – CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

The production of cost-efficient, deadline-specific projects that meet regulatory requirements and expected quality levels has always been an aspiration of the AEC industry. Now, because of technological advances, this goal may be more easily attained through an integrated practice methodology. Integrated practice, in which the bright line between design and construction is blurred, is facilitated through the use of BIM technology. The use of BIM could mean fundamental changes in the project delivery process, opening up new opportunities for service and reducing exposure to communication and documentation problems that now lead to so many claims. Unfortunately, the AEC industry may not truly achieve this high standard for several years as it tends to react at a slow pace to fully adapt to and exploit information technology.

6.2 CONCLUSIONS

Complex construction projects are initiated in dynamic environments resulting in circumstances of high uncertainty and risk, which are compounded by demanding time constraints. As a result the majority of construction projects fail to achieve their objectives and goals (i.e. productivity, performance, quality, safety and budget). Rather than view BIM as a technology, it should be analyzed as a project delivery method, with new risks, rewards, and relationships. Unfortunately, new business models have not yet surfaced.

6.3 IMPROVED SURVEY METHODOLOGIES

Based on typical survey sampling standards, the overall return rate received of ten (10) percent is average considering the total number of surveys sent (85) and surveys received (9). As previously discussed in Chapter 3, the 2008 survey should be considered an alpha version and some changes should be contemplated and made to a future beta version based on the valuable experience gained on this initial survey.

First, several new questions should be added in the beta version to address non-users and/or inexperienced users in order to mitigate incidences of non-response while improving clarity and/or providing information seen lacking in the 2008 version. These non-users should be diverted past all detailed or direct-experience related questions. Instead, they should be asked why they do not use BIM and for what reasons they might begin doing so.

Another modification that should be evaluated was the survey method itself. The response rate reflects the difficulty in completing the BIM survey itself. The effort required to answer the questions long hand in lieu of responding with one word responses with an on-line survey service, most likely turned off several respondents. Meaning, the author purposely asked several challenging questions with multi-part questions. In addition, the questions were difficult to answer since they were intentionally written to avoid simple one (1) word responses. The survey also produced several cursory answers in numerous places where a respondent could have spent several minutes to respond meaningfully.

Based on the response rate, the challenging questions and survey method was a detractor for several survey takers and so they simply elected not to complete the survey which resulted in fewer responses. A future beta version must consider reformulating the survey to make it less difficult and time consuming to respond to.

6.4 RECOMMENDATIONS FOR IMPLEMENTATION

The greatest stakeholders in the design and construction industry are the owners. Currently, the owners are poorly served by the fundamental inefficiencies inherent in the industry. There is no one solution, but productivity gains in other industries in the last 15 years have been driven by technology. There are still tremendous inefficiencies in the design and construction process. BIM must be incorporated into the building process to combat the previously discussed inefficiencies and to communicate effectively between project participants. Although BIM offers significant benefits to owner, contractors and the design team it brings new "risk" elements into agreements between the parties. To effectively deal with BIM and the project delivery methods it supports, a change in risk allocation and mechanisms of risk allocation must be employed.

Since it is not a question of if, but simply when, the promise of BIM technology become too great to be ignored, projects that participant in BIM today need to adopt an analytical process that allows its participants to determine the risks that need to be addressed. Project risk management in the context of BIM is the systematic process of identifying, analyzing, and responding to BIM risks for the protection of your company's assets. It includes maximizing the results of positive

events and minimizing the consequences of adverse events to the project objectives. BIM risks include factors that can negatively impact schedule or budget, cause damage to property or injury to persons, create friction in customer relationships, or damage your company's reputation.

This section will outline the following three (3) major processes as they directly relate to BIM risks in construction industry:

- **Risk Identification** – anticipate and/or identify risks associated with BIM.
- **Risk Analysis** – perform a qualitative analysis of BIM risks and prioritize their effects while measuring the probability and consequences and estimate their implications for project objectives.
- **Risk Response Planning and Control** – developing procedures to enhance opportunities and reduce threats while managing changes in BIM risks throughout the life of the project.

Risk Identification. The first step in risk identification is to define project and strategic goals and objectives. Risk identification involves determining which risks associated with BIM might affect the project objectives and documenting their characteristics. Risk identification is accomplished by stepping back and considering the potential consequences of each option available "cause and effects". New technology means new problems. Many problems will not become immediately apparent with BIM therefore the project team must rely on present knowledge of systems and system failures. A generic BIM checklist should be developed and

utilized for similar types of projects based on historical data and lessons learned. However, it must be noted that the aforementioned checklist is not all inclusive therefore should be only used as a guideline. The goal is to generate a comprehensive (exhaustive) list of BIM risks which will be addressed later during the risk analysis process.

Risk Analysis. After this exhaustive list is prepared, the management team must prioritize the issues. This prioritization is accomplished by analyzing the BIM risks, considering likelihood (frequency) and impact (severity), including financial and reputational consequences, as a basis for determining how each BIM risk should be managed. Although there is limited information to evaluate the risk of BIM, time and experience are the best indicators in evaluating risk in any process. This task is difficult since we are trying to analyze a process without history or a roadmap.

Risk Response Planning and Control. The management team must now select the appropriate risk response action to control the risks of BIM: **retention**, **transfer** or **avoidance**. Managing BIM risks means minimizing (regardless of whose risk it is), covering, and sharing of risks meaning, an equitable sharing of risks among the various project participants. Although BIM risks can be entirely avoided (avoidance), the following primarily deals with the concepts of accepting, reducing or sharing of risks since BIM has entered mainstream and is clearly here to stay. BIM risk allocation and liability sharing must be addressed early in the construction progress so all parties involved can have a better understanding of the realities of the risk responsibility, assumption and allocation. The legal system has already allocated

most construction risks between the designer, owner, and contractor. However, re-evaluation of existing construction agreements is necessary to incorporate BIM and its new approach to project delivery methods. Traditional approach to risks does not consider the aspect of new technology and the need to take control or to play a significant role with its use. Contracts contain many clauses that must be closely reviewed to determine what risks are being transferred.

6.5 RECOMMENDATIONS FOR FURTHER RESEARCH

As has been explained in the previous chapters, the purpose of this thesis was to introduce the subject of BIM, provide an overview of its current uses in AEC industry, identify and address the various legal issues, risks and barriers which the industry has not addressed properly. A wide range survey and detailed case study was conducted to gauge the current status of the AEC industry as it relates to the Legal Issues and Risks associated with BIM. The use of BIM could mean fundamental changes in future project delivery methods.

Apart from the previously discussed beta version survey, a number of other issues may be studied in the future. First, investigate and analyze the results of success on real life projects where the U.S. Army Corps of Engineers mandated for Bentley Systems as the sole BIM platform to address interoperability concerns with BIM systems and technology. In addition, this research should include the success of the rigorous U.S. Army Corps of Engineers requirement for building teams to develop detailed BIM implementation plans and evaluate the success rate of requiring the

design teams to include 3D details in BIM which structural engineers chorus as unrealistic.

Additional research needs to be conducted to further analyze the benefits and drawbacks of using an in-house model manager in lieu of third party professional consultants. Currently, there is a division amongst AEC industry leaders who should take charge of the BIM process and be in control of the information source. In order to validate either theory, further research into real life projects dealing with both approaches is necessary.

Finally, remaining research is needed when future Standard Form of Agreements and contractual language directly relating to BIM are released by AIA and EJCDC. These contract documents will ultimately dictate which project participant bears the greatest risk. Currently there is no case law (legal precedent) dealing with BIM, therefore when groundbreaking judicial rulings related to BIM technology are ruled on these same rulings must be evaluated analyzed in depth to align BIM and the project delivery methods it supports with legislation.

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APPENDIX A

LEGAL ASPECT OF BIM SURVEY

Attn: Design, Construction, and Related Industry Members
Date: April 28, 2008
Re: Legal Aspects of Building Information Modeling (BIM) Survey

For those who do not know me personally, my name is Leon L. Foster and I have been taking graduate classes part time at the University of Kansas (KU) to obtain a Masters of Science in Architectural Engineering (MS ARCE) with an emphasis in Construction Management. I am currently working on my research Thesis at KU to fulfill my degree requirements. The research topic I have selected is **"Legal Issues and Risks Associated with BIM Technology"**. I thought this might be a good opportunity to get feedback from respected industry members who specialize and/or practice in these areas, specifically any experiences related to BIM which you feel are most practical and applicable to our industry.

Your firm has been identified as a progressive firm that may already be working with BIM in some capacity. As a result, your firm has been included in the initial "Legal Aspects of BIM" survey. Please take a moment in the next **two (2) weeks** and complete the enclosed two-page survey. The purpose of this short survey is to begin to gather information about BIM awareness, experience, and innovative best practices in the design and construction industry. This survey may be followed by a more detailed survey and possible telephone interview for those respondents indicating that they would be willing to participate further in this study. The results of this survey will be summarized in a report that will be shared to all respondents in appreciation for their participation.

After you have completed the survey, please return it via e-mail to myself at lfoste32@ku.edu. Mailed or faxed responses will also be accepted. If you would like to provide additional information, please attach additional pages to the survey as necessary.

Again, I appreciate your participation in this important research project for our industry. If you have any questions about the survey or research project, you can contact me by telephone at (816) 564-7508 or e-mail at *lfoste32@ku.edu*. Thank you for your continued help and support.

Sincerely,

Mr. Leon L. Foster, P.E., PMP
MS ARCE Candidate, August 2008
KU School of Engineering

LEGAL ASPECTS OF BIM SURVEY

PLEASE E-MAIL COMPLETED SURVEY TO: lfoste32@ku.edu

To: Leon L. Foster, P.E., PMP

Telephone: (816) 564-7508
Fax: (816) 474-4784
e-mail: *lfoste32@ku.edu*

Civil, Environmental & Architectural Engineering Department
2150 Learned Hall
1530 West 15th Street
Lawrence, Kansas 66045-7609

From: Name: _____ Telephone: _____

Title: _____ Telefax: _____

Company: _____ e-mail: _____

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences**

Legal Aspects of BIM Survey
Page 2 of 2

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

Thank you for your help. Use additional pages if you would like to expand on any of your responses. All responses will be held in the strictest confidence. No specific response or reference to a specific company and/or individual will be made without prior review and approval by the company and/or individual.

APPENDIX B

BIM SURVEY RAW DATA

From: Name: Carl E. Kurt Telephone: 785-218-3343

Title: Professor and President Telefax:

Company: CEAE KU and EnGraph LLC e-mail:ckurt@engraph.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   BIM is a modeling software system that in addition to supporting graphical entities it includes a relationship between those entities and all corresponding attribute data.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   It seems to me that the best use of BIM is when the decision is made early in the project life. I also know that some construction companies make BIM models in the planning phase of the construction project.

   For BIM to be successful, it needs to save time and money and not "cost" anyone. If no one wants to "pay" the costs, build the model and sell the knowledge gained by it. For example if there is an interference between the structural and HVAC ducts, approach both organizations, tell them there is a problem and charge them for it. Rather unconventional project management but it would probably encourage both organizations to build their respective models so the comparisons can be made.

   I suspect the biggest obstacle for implementation of BIM is fear of the unknown and the change that it requires.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   None, other than in the educational environment

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   If done right one gets a complete drawing and database. Not sure what the risks are. I can only think of advantages.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   Revit. As with any software application, there is a upfront effort to make sure all software shares data. Talk to the software developer and use the same package they are testing with. A little investment up front saves $$ and time in the future.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   Interesting question. I think that it will. Mainly, it will be the tool for all members to communicate with one another. We can all play in our own sandbox but everyone will be watching and observing. I think the owner will eventually win with a less expensive, but better, project.

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   Not sure I should answer this one.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   No Experience in this.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   Not Sure

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

    a) Absolutely. b) Not qualified to answer this one. C) From what I hear, BIM will bring in the job faster and lower cost. See GM article in ENR. Not sure when it was published. Probably 12 – 24 months ago.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    The industry is the big dog in building development field. Support the leaders. When they come in with the lowest bids, the rest of the industry will follow suit or drop out. Probably the best thing to do is sponsor seminars illustrating case studies and information.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Yes if I can contribute.

BIM SURVEY RAW DATA

From: Name:Ron Hesse Telephone:913-495-9558
Title:Chief Estimator Telefax: 913-495-9560
Company: HarenLaughlin e-mail:rhesse@harenlaughlin.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   BIM is the incorporation of three dimensions into design. This incorporation gives the builder the ability to order material more accurately, construct without conflicts, or the ability to find conflicts in the design stage in lieu of during construction which leads to changes orders, delays and additional costs.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   The decision to use BIM is in the concept stage of a project before drawings have begun. Since the owner will be the major benefactor of a BIM project the initial cost should be borne by the owner/developer. This cost will come back to the owner/developer in the form of lower construction costs and faster building delivery. It is our opinion that the principle problem is finding design firms with BIM knowledge.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   The construction industry made this move due to demand for a competitive edge. The aerospace industry has used BIM for decades. Only companies that are willing to "jump into" BIM will gain the largest projects and increase bottom line profits. We are currently entering into our first BIM project.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

Since we have just begun to work with BIM it would be unfair at this time to comment on this question. I will comment on one item and that is the design firm is "learning by design". In all fairness we are also.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   We currently do not use any in house.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   YES. We are in the very beginning and we can already see advantages of BIM for construction and design.

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   Design and construction have to be in sync with each other. We are currently working with Timberline Estimating software to incorporate BIM. This will be used to speed estimates and increase accuracy. The builder has to have in house software that can communicate with the design team software.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   At this time we have not seen any differences in contractual language. I went to a BIM seminar on Legal Aspects of BIM and this is new to everyone.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   I have seen changes in the last 30 years of being in this business. 30 years ago the designers/Architects took more responsibility for their drawings. During the last 10 years the trend has been to shift more "design" responsibility to the general contractor. BIM, I feel, will return that responsibility back to the designers. I also see more design/build projects with our firm. With this, it puts the general

contractor in the seat to direct the designers on how to design the project and with what materials.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

    Yes to all. The last questions as far as cost, it should be worth no more in front end costs.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    I believe that general contractors need to demand this from the designers that they hire when the general contractor or construction manager hires or recommends a designer to an owner.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Yes

BIM SURVEY RAW DATA

From: Name: David Campbell Telephone:917-335-3415
Title: Vice President Telefax: 866-743-0119
Company: Skanska e-mail:david.campbell@skanska.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   My definition is closely linked to the GSA's definition paraphrased as "a data model not only used to document building design but also to simulate construction and operation." The key to this is data, not just 3D CAD. As a company we have 50+ projects in which we have used some degree of 3D CAD to BIM. Right now I am specifically involved in four.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   Earlier the better. When choosing a designer, the owner should specify BIM. Generally the owner should bear the cost. However for d/b projects it has traditionally been up to us (the contractor). Successful implementation to me would be a process where the owner understands the potential for design/construction and operation and specifies it for the project, including ground rules for collaboration and minimum standards. Short of that the biggest obstacle is the conversion cost of 2D to 3D.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   3D is much better for visualizing the project. We read drawings but we all think in 3D anyway. I personally have been involved with 10, Skanska 50+.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   Common advantages: more comprehensive design validation or design coordination verification (finding problems in the design phase); coordination of

MEP trades is much faster and more comprehensive; and the link to operation and maintenance data for long term O&M.

Common disadvantages: Not enough buy-in from Sr. Management, subs and or the owner. With regard to the subs, if they don't have the capability we have supplemented them with outside vendors. We have overcome some of the disadvantages of legacy views with examples of BIM in action on other projects and created peer pressure.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   We primarily use Navisworks as a collaboration tool. Since we do not author our own work we do not have a standard authoring platform. However we do have experience with Revit, Archicad, Bentley, Catia, ADT. Compatibility issues do arise, however depending on the data we need certain file exports work better than others. With regard to the having the data in the model in the first place, it is best to work with the designers and ask them for the data to be included. Even then we need to experiment with export file formats to make sure we get what we need.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   There is a difference on a BIM project with regard to construction. With regard to responsibilities changing, I think the roles of BIM technicians, or VDC Managers, or project engineers are evolving. There is a new vocabulary and a new set of processes that we have employed. Based on ability and the size of the project team, we have decided on who will use this data. The other traditional roles of PM and Supt have not changed that much, however it has made the construction process easier to visualize and solve problems.

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   The integrated project delivery form of agreement is a great document to help align the project parties. Outside of a formal agreement to "get along" and share the risks and rewards, voluntary culture change doesn't happen that often.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   To my knowledge we have not signed any parallel agreements with regard to BIM, only the IPD agreement from the AIA.

   However each of our subs must comply with a 3D MEP spec which we have authored. We have signed indemnification agreements in order to get drawing files and or model files.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   I do not think there is a change. The requirement for design docs has not changed, a model is a means to an end in most cases. Documents are still produced from the model. For Construction models however, ones that we prepare, we make the statement in our agreements that the information contained here in is subject to the original design and is for coordination purposes only.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

    BIM does hold great promise, possibly the most promise of any change in the past 20 years or longer. Paying for it is another matter, and we have had some success where we can make those decisions. The cost varies however as a rule of thumb .5% is a good number.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    One of our clients said that they can't control labor costs, or material costs, nor land costs so their only solution is to make it functional faster. This is a great intro for BIM with regard to delivery faster and better design and ultimately constructed facilities.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Happy to help if I can.

BIM SURVEY RAW DATA

From: Name: Martin Viveros Telephone: 913-621-8311

Title: 3D BIM Coordinator / CAD Dept Mgr

Company: Fagan/ An Emcor Company e-mail: mviveros@faganco.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   BIM from the modeling perspective is drawing Virtual data rich models which use object drawing practices as opposed to vector based practices. (object = Pump, W10X30, Door / Vector = Line, Circle, 3D Surface). These elements contain data rich information that can be used for purposes such as estimating pricing, extracting material quantities, engineering calculations, manufacturer's specifications to fabrication from automated plasma cutters and even man hour calculations for fabrication and installation. These models have the capability to contain vast amounts of information as opposed to just lines, arc and surfaces to represent geometry of such items. BIM models are also promoted to encourage the project team members to add the variety of different 3D content in order to coordinate a Virtual Building Model first and resolve interferences that otherwise would be more costly to resolve on the job site between the disciplines. For example HVAC duct hitting steel beams.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   The earlier the decision is made the more beneficial the process is in order to reduce unforeseen project cost escalations and the sooner the project team has an understanding of project.

   I believe all the trades should be drawing with intelligent objects and should all bear the costs, share the risks and reap the benefits.

   In our region (Mid West) the paradyne shift of breaking away from traditional methods of doing business is the largest obstacle. The skeptical architectural and general contracting communities that are not embracing this transition are hindering the progress and movement into this era and way of doing business. Both communities also have a vested interest in protecting their positions such as owner's reps and in keeping a tiered business model which they are comfortable with, understand and is traditional.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   For those that have made the transition, they have seen the benefits and understand the processes. The more projects that they have completed the more experienced they have and see the benefits. I've been doing BIM since 1987. Too many to count.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   Benefits: Savings in Estimating time, construction coordination, shop fabrication, field labor, less rework, lower labor rates due to less experts needed in the field for problem solving. Other benefits include automated reports for change orders, digital RFIs, better installation planning which also creates safer working conditions, more fabrication done in the shop as opposed to the field, (more efficient in the shop). Schedules tied to BIM models. Owners and architects have clearer understanding of conditions and interferences when models are used.

   Risks: There is an investment to be made in order to make the transition which includes software, hardware, personnel, training and programming.

   Control Risk: Our Company was solid and could make the investment / also understood the importance of training.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   AutoCAD 2002, 2006, 2007, 2008, 2009, Building Systems, AutoCAD MEP 2008, 2009, Revit Arch, Revit MEP, Quickpen, East Coast, CAD Duct, CAD CAM, EST MECH, EST DUCT, CAD MEP, CAD MECH, Hydra CAD, FREEDOM, NAVIS,

   No compatability problems

   Hired competent candidates

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core**

responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?

No

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   First, it should be written into the contract and specifications. Next I would pre-qualify the subs to verity that they have the capability or will be delivering as expected.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   I've been on projects where it was a secondary consideration and additional scopes were written in and additional compensation for BIM-MEP coordinator.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   No.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

    Yes I do believe that BIM is/will be the next new process in design and construction. Our firm has paid a premium by investing in the tools, development and training. Not sure on the percentage question.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    Write it into the contracts and specifications.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Yes, Very interested.

BIM SURVEY RAW DATA

From: Name: Jack Hausback Telephone: 816-918-4253
Title: Project Manager Telefax: 816-241-1786
Company: Foley Company e-mail: johnh@foleycompany.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   In my opinion BIM would be fully coordinated model completed prior to construction.

   I have experienced this on one project which was the Sprint Center and I am currently involved in 2 other projects that it is being used.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   The decision to use BIM should be done during the design phase. The costs should be the owner or the designer. I believe with increase in change orders on projects today, an owner would save a substantial amount of money due to a fully coordinated building model. I believe the biggest obstacle is to get everyone on board. The model is ineffective unless all disciplines participate fully.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   The 3D process allows interferences to be identified a lot easier and it is a great tool for building owner who may know how to run a business but can't read blueprints. The 3D models are great tools for marketing. I have completed one project with BIM and involved with two others right now.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   The biggest advantages are explicit detailed drawings for the field and allows for more shop fabrication. The critical risks associated were time frame to complete

the model, finding qualified CAD operators and finally if one discipline has a mistake it can adversely affect every discipline that is following them.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   We are currently using CAD MECH it is marketed by TSI and runs on top of auto cad therefore it is autocad based and can be utilized by anyone with Auto Cad.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   No response.

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   No response.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   I have yet to see any construction agreements that address BIM. I think the design firms are worried about responsibility at this point and feel the models need to be generated by the contractors but they don't want to dictate any certain methods.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   No I think the ultimate responsibility is with the designer the contractor only coordinates the work. Anything that works in a scaled model has to work in the real world. The only difference with BIM is we first provide a trial run electronically.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for**

BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?

I believe this is the future and there is no way to avoid it. I don't feel that the cost would apply to my line of work.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    I have seen the increase in efficiency due to BIM. The biggest problem right now is qualified 3D designers who also understand constructability. There needs to be a large push to train operators for the many different types of software being developed but it is important that the designer understands how the job needs to be built when detailing the project.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Yes I would.

BIM SURVEY RAW DATA

From: Name: Patrick McManus, P.E. Telephone: 307-637-7177
Title: Head of Engineering/Detailing Telefax: 307-637-7176
Company: Puma Steel e-mail: patrick.mcmanus@pumasteel.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   The modeling of intelligent three dimensional building components resulting in a database available for many enhanced design, coordination, and construction processes. We use it on every job to detail and ultimately fabricate structural steel.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   It has to be decided at the very beginning. Cost (if any) depends on delivery system, but should be passed to contractor and ultimately the owner since they see the most benefit. Legality of who owns and is responsible for the model at which phase and contractors fully utilizing the model.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   Coordination and the use of CNC data. Probably around 50.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   (A) Accuracy and coordination speed of delivery, CNC and purchasing data transfer.
   (B) Legal liability, tracking of changes, accuracy of transferred models/level of detail and associated rework.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   We use SDS/2 steel detailing software by Design Data. We have imported models from RAM, ETABS, and Revit structure. We have exported to AutoCAD and Navisworks, but have not successfully exported to Revit. Settings and file formats are critical.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   Yes, when things go wrong someone will be blamed. Each entity will either need accept responsibility for the data and be compensated appropriately or limit their liability.

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   Design-build is the best delivery method to get everyone on the same team under one contract and working collaboratively toward a common goal.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   Yes, typically custom parallel agreements or blanket disclaimers provided at the time of transfer.

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   It can, but I many cases no. It primarily adds to the methods of delivering the same data.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

We do pay a premium, but it is typically to reduce schedule, not risk. No question it is the future, though not even close to fully utilized. If properly used it is easily worth a 30% premium to the design fees (2-3% of project).

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    Today most large designers are being forced to react by contractors and owners. The change is significant and inevitable, so designers really need to become educated and prepare for the time and money investment to their firm.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Sure.

BIM SURVEY RAW DATA

From: Name: Steven L. Allison Telephone: 816-360-4646
Title: Architectural Director Telefax: 816-561-2863
Company: Ellerbe Becket e-mail: Steve_Allison@ellerbebecket.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   Worked on construction administration for architect on Sprint Center project. Contractor and "main" subs created a 3D model and worked with them in interpretations and questions generated from their modeling of the project. Since; have worked on a smaller ($11M) project designed and carried through CD phase in Revit (a BIM software tool) including some hands on work with the software in creation of construction document level "drawings." All other consultants on this project are working in this software.

2. **When should the decision to use BIM on your project be decided?**

   At the very beginning; it should be determined if the design team will use BIM, and what consultants. If the contractor is part of the process at that point, they should also understand if the design team is using BIM, will they also go that route – to what extent will they want to use "the model" – and what level of accuracy they expect.

   Who should bear the costs to utilize BIM on the project and why?

   Not sure what "costs" you are referring to – up to a point there should be no "cost" as the use of BIM is for the benefit of all project participants. So; depending on what are identified as "cost" I guess that would start to determine who should pay.

   What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?

   We have made the decision to implement Revit on all of our new projects going forward. Obstacles include availability of consultants who understand and utilize the software (but they are catching up - some are ahead of us). Getting staff trained and up to an appropriate level of proficiency is one of the biggest obstacles – it is an ongoing process. We don't have enough experience with how contractors will use the model to see what impact that may have; but there is some

trepidation about how much liability may transfer to the architect if the contractor chooses to just "use" our model.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process?**

   "Clash detection" seems to be one of the biggest sources of problems, change orders and claims and the 3D based process at least holds the promise of reducing this element. From a design perspective it allows the architect to develop the design in 3D and at the same time develop the background detail that identifies scope, etc. - this holds promise of a richer development of project information at an earlier point in the process.

   How many projects have you been involved with that utilized BIM?

   Two – see above.

4. **Provide some common advantages (benefits) that you have experienced while using BIM?**

   During construction the contractor was able to determine where clashes were going to occur "in the model" instead of "in the field". This allowed for development of responses and solutions before they cost money (in many instances) – which was a big advantage.

   By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?

   Not sure if I can speak for the firm; I have found Revit to be somewhat laborious to use in the final stages of development of the last details to complete the CD's. This takes some getting used to and sometimes an early modeling decision comes back as a problem near the end. It is mostly a function of the level of education and experience the user has – as an architect and as a Revit user. These sorts of things are to be expected in any industry wide roll-out of a new tool that is catching hold as fast as BIM. I expect the most critical risk will arise from the interface of the design team (who has created a model); with the construction team (who would like to use it) – and an understanding of what level of accuracy and correctness is to be expected from one party of the other (when they typically don't have a straightforward contractual relationship).

5. **What BIM software/platform does your firm currently use?** Revit
   Have you experienced any compatibility issues when sharing with others?

Not that I am aware of; but we might have. When new versions come out, that will be an issue as to when you switch over to the new version – same thing happened in AutoCAD.

How has your firm dealt with issues?
Don't know.

How did you control the risks?

Don't really know what risks you are asking about, so can't really address this one.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM?**

   I don't think the "core" responsibilities of the project team will change because of BIM; necessarily. It may be that use of the tool redefines the roles of project team members and certainly different project delivery methods such as "design- build" would change those core responsibilities.

   If so, what are the differences?

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   A. An enlightened educated client who sees the advantages of the new approaches to work on projects. B. Bringing the major players on board early; and nearly at the same time. CM people need to be on board early in the design process to provide cost and level of needed information feedback to the design team. At some point, CM people might take over some of the details of the model to get it into a format that they need for bidding and use by their subs down the line. C. All the firms involved must be committed to project success, and the people must be trusting of each other – part of the same team and not an adversarial relationship.

8. **Have you experienced any modifications to construction agreements to address BIM?**

   Not to my knowledge.

If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks?**

   It may, depending on how the different team members expect to use information in the model; when they want to access it, and what level of completion and correctness they expect it to contain.

   If so, what is the difference?

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality?**

    It is part of a package of "tools" that can work toward these goals. The use of a "model" does not guarantee success – but it is a better tool than the ones available to the project teams in the past. Additional factors of equal importance are a collaborative and open atmosphere among all project team member firms and individuals; a project schedule that reflects the time requirements for creating the model to a proper level of completion at the various project stages; and project staff from all member firms with the proper level of general experience and understanding of the BIM software being utilized.

    If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk?

    We have "bitten the bullet" and jumped into the use of BIM. If a premium is being paid, we are absorbing it since I don't think we are asking for higher fees as a result of our decision to use Revit.

    What percentage do you feel BIM is worth as part of the overall total project cost?

    Why should it necessarily cost more for the project if there is a tool that provides a savings in time and problems down the road? This is how contractors think. (*Just kidding – we are trying to figure out a rationale for charging a higher fee for using BIM; just haven't come up with a strategy yet)*

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and**

construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?

Working closely together on the design and construction side makes the most difference I think. Sharing information in an open and non-confrontational environment is most effective, and when coupled with use of effective tools like BIM, this is compounded benefit. The biggest obstacle to all of this is the legal issues that pervade our industry and the prevailing attitudes of self-preservation and protection rather than open honest communication.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Probably not, this is about as deep as I can go on this.

BIM SURVEY RAW DATA

From: Name: Rob Stevenson, PE Telephone: 919-865-3547
Title: Structural Engineer Telefax: 919-865-3529
Company: FLAD Architects e-mail: rstevenson@flad.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   Description: 3D (or 4D) Representation of a building frame, shell, finishes and/or systems used to streamline and facilitate the design, construction and operation of the building.
   Experience: (1) Exporting structural steel framing model to design clash detection model (2) Exchanging data with steel fabricators.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   The decision to use BIM should be made early in the design process. I'm not convinced BIM should cost more to the owner. Internally to the team, savings in some areas should cover increased cost in others. Principal obstacle is probably challenges with interoperability.

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   I haven't witnessed the construction industry fully embracing 3D. I see more activity in the design industry and most of that is for design coordination, not construction. I have used BIM on two projects.

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   Advantages are time savings and improved quality. Disadvantages are software limitation and lack of buy-in from other parties. We control risk by working within our limits.

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   We use RAM Structural System linked with our CAD drawings via RAM CAD Studio. We collaborate with fabricators/detailers using SDS/2 and have the viewer from SD2/2 in house.

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   I think the core responsibilities are essentially the same but will expand to be directly linked with fabrication and construction (current link is indirect).

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   The ultimate practice is by utilizing lean construction methodologies – contractual arrangements that structure teams that are motivated to collaborate (not de-motivated). Regardless, all parties must be trained and equipped and fairly compensated.

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   No

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   Yes, but I think many in the industry exaggerates the change. In risk, our documents are historically verified and re-created by fabricators and constructors, buy now they are used directly.

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

It does hold promise, but the value is just as much if not more about relationships/project management than it is about technology. We would invest in BIM. We have not put a value on BIM.

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    (1) Demand/promote interoperability *
    (2) Draft sample contracts and financial models *
    (3) Educate clients and each other *
    *Achieved through collaboration of industry group organizations and national and local levels.

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Yes but keep in mind that my experience is limited.

BIM SURVEY RAW DATA

From: Name: Kimberly Hurtado Telephone: 414-727-6250
Title: Managing Shareholder Telefax: 414-727-6247
Company: Hurtado, S.C. e-mail: khurtado@hurtadosc.com

1. **Please provide a brief description (in your own words) what is Building Information Modeling (BIM)? Please provide your experience to-date with BIM?**

   Parametric computer-generated building modeling utilizing intelligent design elements for design, cost and scheduling development. Wrote Consensus Docs 2007 and commented on BIM Addendum, write contracts for construction using BIM.

2. **When should the decision to use BIM on your project be decided? Who should bear the costs to utilize BIM on the project and why? What does your firm view as the principal obstacle to implement BIM processes successfully in the design and construction industry?**

   At project inception; owner bears cost of producing project model – each modeler bears cost of hardware, software and interoperability of contributions to model; lack of software interoperability

3. **Please explain why you feel the construction industry has moved from a "2D Based" process towards a "3D Based" modeling process? How many projects have you been involved with that utilized BIM?**

   3-D modeling permits more advanced clash detection, reduces errors due to changes, permits life cycle and environmental analysis; 5

4. **Provide some common advantages (benefits) that you have experienced while using BIM? By contrast, what do you view as the top (3) critical risks (disadvantages) your firm experienced while using BIM? How did your firm control these same risks?**

   Superior clash detection and more cost effective clash resolution;
   1) Interoperability errors – particularly in round tripping of data;
   2) Difficulty depicting as built structures pre-existing to which new work will attach
   3) Architect fears of change and loss of design control

5. **What BIM software/platform does your firm currently use? Have you experienced any compatibility issues when sharing with others? How has your firm dealt with issues? How did you control the risks?**

   Have worked with Revit and Bently; Yes!; money and patch writing; slowly developing contract risk shifting language – insurers now provide expanded "valuable papers" coverage

6. **BIM is a "tool" that has already changed the ways projects are conceived, designed, communicated and constructed. Do you believe the core responsibilities of the members of the project team will ultimately change with BIM? If so, what are the differences?**

   Yes – group responsibility and buy in for design development is critical

7. **In order to optimize efficiencies from a tool such as BIM, a collaborative team structure must be in place to support its use. What are the best practices to ensure a collaborative team structure is in place to be effective?**

   Beat the project architect with the nearest blunt object until they remember to breathe (just kidding) – assign a model (master – responsible for edits to master model and getting updates to team; early structural, MEP and skin model impact

8. **Have you experienced any modifications to construction agreements to address BIM? If so, were they re-drafted standard construction documents or was BIM incorporated by parallel agreements? Explain?**

   Yes – most contracts have zero process ("prepare BIM model;" a single line in a 1000 pg. contract). Worked on US Army Corps of Engineers BIM Addendum and only form out there that gets into subcontractor terms right now

9. **Do you believe that BIM inadvertently changes risk allocation/mechanisms of risk allocation to parties who typically do not usually handle these types of risks? If so, what is the difference?**

   If contractors contribute to model they should get contractors professional liability coverage

10. **Do you believe that BIM is the next design and construction process that holds the most promise for saving time and money, reducing claims and increasing quality? If so, would your firm be willing to pay a premium for BIM to reduce the overall project risk? What percentage do you feel BIM is worth as part of the overall total project cost?**

Yes – but my firm doesn't actually model – we wrote contracts for people who do. People either get this and are willing to invest or they are stuck in 2D CADD land in my experience

11. **The reality still remains that the design and construction industry has historically reacted rather slowly to change, especially dramatic and fundamental change driven by technology. What can the design and construction industry do to expedite this revolution to offset significant market trends (i.e. rising construction costs and energy demands)?**

    Force software companies to use IFC platforms to permit robust interoperability; show larger developers pretty models and get them excited about energy analysis-life cycle O and M saving also have governments allow (or require) BIM model for permitting

12. **Would you be willing to participate in a more detailed follow-up survey regarding BIM and discuss some best practices for implementing BIM processes in the design and construction industry?**

    Sure.

APPENDIX C

BIM INTERVIEW RAW DATA

Interviewee Name: Paula Yancey

Title: Vice President

Company: PC Sports

Interviewer: Leon Foster

Date of Interview: 6/26/2008

Time of Interview: 4:30 p.m.

INTERVIEW QUESTIONS
Q: Are you familiar with Building Information Modeling (BIM)? A: Yes.
Q: How many projects have you been involved with that utilized BIM? A: Two (2) total since 2005.
Q: Did you find BIM to be beneficial to the project? A: Yes.
Q: Would you recommend BIM for implementation on future projects? A: Yes.
Q: Did you encounter any barriers and/or obstacles while implementing BIM? A: Yes.
Q: What were they? A: Costs, Interoperability, Confidentiality Issues and Intellectual Property Issues.
Q: Have you experienced additional costs with this technology? A: Yes; Increase in General Condition costs.
Q: If so, how much or what percentage? A: Less than 1% of overall project costs.
Q: Do you feel the Owner should bear the full costs since they receive the greatest benefit? A: No; there should be a shared burden of costs between all three (3) entities (Design Team, Construction Team & Owner). In another words, there is an added benefit to all project participants so there should be a sharing of costs.
Q: Do you feel there should be any added costs to the project for the implementation of this technology? A: No not really since the Owner already pays the Design Team for a completed design and also compensates the Contractor for coordination efforts. Owner is essentially burdened with paying for design and construction services twice in a sense.
Q: What can Owner do to expedite the revolution of BIM? A: Require the use of BIM technology in Request For Proposals (RFPs) and explicitly define the parameters of its use. Award contracts based on pre-Qualifications.

Q: Would you consider using Tri-Party (IPD) Agreements? A: Yes; as long as the Agreement provides fair and reasonable protection of the Owners rights.
Q: Do you feel that BIM is here to stay? A: Absolutely; the AEC industry must be prepared to make this transition.